Department of
Infrastructure, Planning and Natural Resources

A prototype toolkit for scoring the biodiversity benefits of land use change

Version 5.1
August 2003

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Acknowledgments

The genesis of ideas that have found a place within the needs of the NSW Environmental Services Scheme, for scoring the biodiversity benefits of land use change, began with early interactions with staff of the former NSW Department of Land and Water Conservation (DLWC) who were responsible for determining the negative impacts on biodiversity (disbenefits) due to the clearing of native vegetation. Peter Smith, Alan Ede, Wendy Hawes, Ken Turner and Ross Peacock were a source of immense knowledge, experience and enthusiasm in this early phase.

The prototype toolkit for scoring the biodiversity benefits (and disbenefits) resulting from land use change has profited greatly by the guidance and intellectual and practical input of a specially convened Technical Advisory Group (TAG). Sincere thanks are extended to all members of the TAG: Alan Ede (Department of Infrastructure, Planning and Natural Resources [DIPNR]), Phil Gibbons (NSW National Parkes and Wildlife Service), Wendy Hawes (DIPNR), Rod Kavanagh (State Forests of NSW), Ian Lunt (Charles Sturt University), Mark Sheahan (DIPNR), Peter Smith (DIPNR), Ken Turner (DIPNR), Phillipa Walsh (World Wide Fund for Nature, Australia), and Peter Wright (DIPNR).

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In the same vein, Phil Gibbons (NSW NPWS) and Phillipa Walsh (WWF, Australia) both of whom have given considerable thought to these issues in the development of their own systems, brought to the Technical Advisory Group process their expertise and knowledge and overwhelming willingness to collaborate in what promises to be an ongoing and important new challenge for integrated natural resource management for NSW.

As a prototype system, the toolkit will continue to evolve as new data and methodologies come to hand, and by incorporating the lessons learnt in practice. Changes from earlier (unpublished versions) of the Toolkit are captured in this current Version 5.1 which has benefited from the additional comments and suggestions of Doug Binns, Alan Ede, Phil Gibbons, Alastair Grieve, Wendy Hawes, Phil Redpath, and Darren Shelly.

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Contents

Page

Figures

Tables

Executive summary

This document is a prototype guide that can be used to assess the biodiversity benefits (and disbenefits) likely to result from a change in land use. This 'toolkit' aims to strike a balance between a meaningful, defensible and practical approach, and builds upon the *Habitat Hectares* methodology developed by the Department of Natural Resources and Environment (Victoria) and applied to the Victorian *BushTender* Trial.

It also incorporates recommendations from a specially convened *Technical Advisory Group*, as well as results generated by a *Vegetation Condition Expert Panel*.

The toolkit aims to capture the requirements of a broad range of flora and fauna rather than the specific requirements of individual (rare or threatened) species. It has been designed for use by experienced vegetation management staff including, but not restricted to, Department of Infrastructure, Planning and Natural Resources' terrestrial ecologists, botanists and experienced natural resource project officers (vegetation).

As a prototype system, the toolkit will continue to evolve as new data and methodologies come to hand, and by incorporating the lessons learnt in practice. To recognise this evolving nature, version updates and version histories will be available from the Department's Internet site, http://www.dipnr.nsw.gov.au/.

The toolkit has been designed to achieve three goals:

- Score the current biodiversity value of a site.
- Estimate the magnitude and direction of change in biodiversity value resulting from land use change.
- Incorporate these current and potential values into a Biodiversity Benefits Index.

The *Biodiversity Benefits Index* (BBI) is scored on the basis of three surrogate measures of biodiversity:

- vegetation condition
- conservation significance
- landscape context.

Vegetation condition is important for estimating the current biodiversity value at site scale. It is defined as the degree to which the current vegetation differs from a *vegetation condition benchmark* representing the average characteristics of the mature native vegetation predicted to have occupied the site before agricultural development. It describes the degree to which critical habitat components and other resources needed by indigenous plants and animals are present at the site. Predicted changes to vegetation condition due to land use change are also estimated and used to produce the BBI.

Conservation significance is important for estimating the biodiversity value of a site in a regional context. Some sites may represent elements of biodiversity that are common in the landscape, others may represent elements that are now rare. Conservation significance recognises the amount of each element now in the landscape compared with a time before agricultural development, as well as the likelihood of the element persisting. Changes to conservation significance are also scored and used to produce the BBI.

Landscape context recognises that the biodiversity value of an area of vegetation will vary depending on where the site is located in the wider landscape. Small sites surrounded by a 'sea' of agriculture will have poor landscape context compared with sites close to large semi-natural areas.

The BBI is scored as:

$$(CS\ t_0 + LC)\ VC\ t_0\ /\ 200 \qquad \textit{(the Biodiversity Significance Score)}$$

$$x$$

$$((CS\ t_n - CS\ t_0) + (VC\ t_n - VC\ t_0))\ /\ 2 \qquad \textit{(the Land Use Change Impact Score)}$$

$$x$$

$$ha$$

Where:

$CS\ t_0$, $CS\ t_n$	=	Current and Potential Conservation Significance
LC	=	Landscape Context
$VC\ t_0$, $VC\ t_n$	=	Current and Potential Vegetation Condition
ha	=	Area of land use change.

1. A conceptual framework for scoring the biodiversity benefits (and disbenefits) resulting from land use change

This document is a prototype guide that can be used to assess the biodiversity benefits (and disbenefits) likely to result from a change in land use.

This 'toolkit' was designed to achieve three goals:

- Score the current biodiversity value of a site.
- Estimate the magnitude and direction of change in biodiversity value resulting from land use change.
- Incorporate these current and potential values into a Biodiversity Benefits Index.

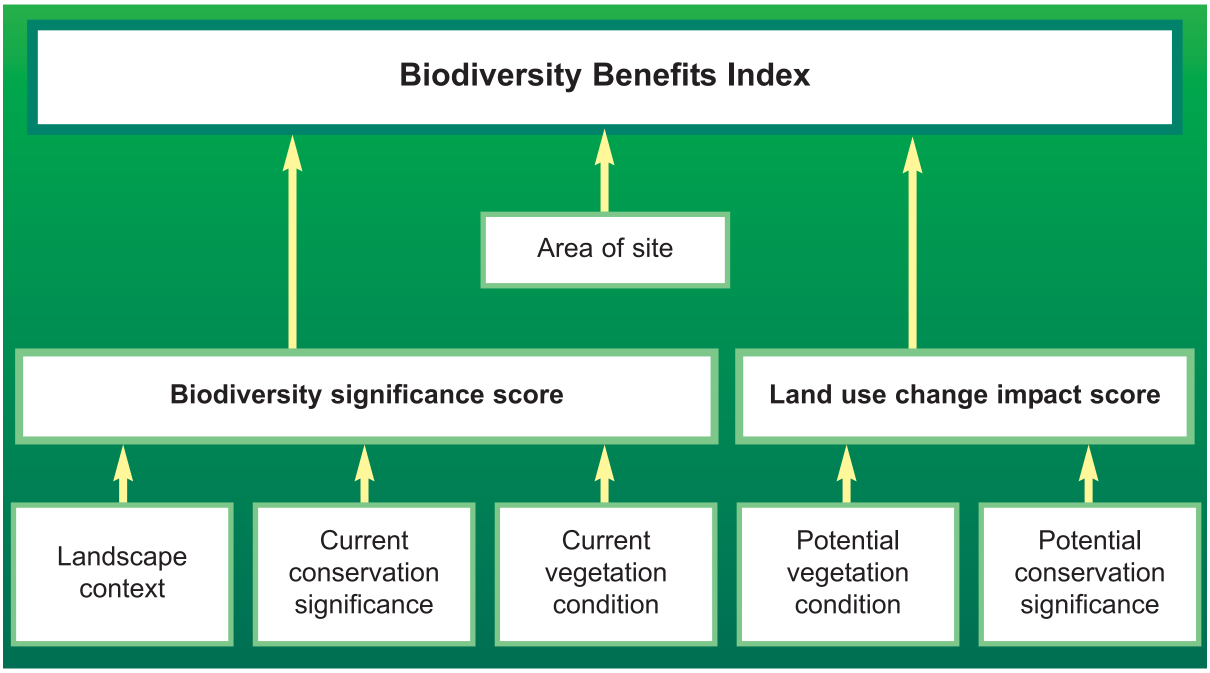
Assessment of the current value of a site for biodiversity must rely on surrogate measures because resources and expertise are rarely available to conduct representative ecological surveys.

There are three surrogates measures for assessing the current biodiversity value of a site incorporated into the toolkit (see Figure 1):

- *Vegetation condition* is defined as the degree to which the current vegetation differs from a benchmark representing the average characteristics of the type of mature native vegetation predicted to have occupied the site before agricultural development (Parkes *et al.* 2003). It describes the degree to which critical habitat components and other resources needed by indigenous plants and animals are present at the site.
- *Conservation significance* is important for estimating the biodiversity value of a site in a regional context. Some sites may represent elements of biodiversity that are common within the landscape, others may represent elements that are now rare. *Conservation significance* recognises the amount of each element now in the landscape compared with a time before agricultural development, as well as the likelihood of the element persisting. Within the prototype toolkit, vegetation types are used as the operational surrogate measure for the spatial distribution of elements of biodiversity throughout regions.
- *Landscape context* recognises that the biodiversity value of an area of vegetation will vary depending on where the site is located in the wider landscape. Small sites surrounded by a 'sea' of agriculture have poor landscape context compared with sites in close proximity to large semi-natural areas.

The three surrogate measures are used to score the current biodiversity value of a site which is expressed as the *Biodiversity Significance Score* (Figure 1). The predicted magnitude and direction of change in this value due to land use change is incorporated into the *Land Use Change Impact Score*. These scores, together with the area of land use change, are built into the *Biodiversity Benefits Index*.

Figure 1. The conceptual framework



2. An operational framework for scoring the biodiversity benefits (and disbenefits) resulting from land use change

Every site on the planet no matter how small or how degraded has biodiversity value, given that it will provide habitat and other resources for at least some indigenous animal, plant or microbial organisms. The toolkit scores the biodiversity value of sites under a broad range of land uses, and estimates how the value of such sites might change through time in response to land use change.

The conceptual framework presented in Section 1 was developed to operate under this wide range of scenarios of land use change. The toolkit was designed in the first instance for use by Department of Infrastructure, Planning and Natural Resources' terrestrial ecologists, botanists, and highly experienced natural resource project officers (vegetation). With some training, it is also likely to be appropriate for other decision makers. The formula, and points leading to the development of the *Biodiversity Benefits Index (BBI)* are:

$$BBI = \text{Biodiversity Significance Score} \times \text{Land Use Change Impact Score} \times ha$$
$$= (CS\,t_0 + LC)\,VC\,t_0\,/\,200 \times ((CS\,t_n - CS\,t_0) + (VC\,t_n - VC\,t_0))\,/\,2 \times ha$$

Where: $CS\,t_0$ = Initial Conservation Significance
$CS\,t_n$ = Potential Conservation Significance
LC = Landscape Context
$VC\,t_0$ = Current Vegetation Condition; that is, before land use change
$VC\,t_n$ = Potential Vegetation Condition after land use change and an agreed period of time
ha = Area of land use change.

Points leading to the development of the formula for the *Biodiversity Benefits Index:*

- To determine the biodiversity benefits (or disbenefits) of land use change it is essential to first determine the current value or biodiversity significance of the site that will be subject to land use change. The current biodiversity value for 1 ha of the current site is scored by the *Biodiversity Significance Score* = $(CS\,t_0 + LC)\,VC\,t_0\,/\,200$.
- *Vegetation condition* is contained within this formula as a multiplier because it is largely responsible for the variation in the status of biodiversity at site scale. It is also the most sensitive to land use change. In addition, higher initial condition is also likely to be related to a higher chance of achieving successful land use change for biodiversity (greater resilience). On this basis, it therefore has a large influence on the BSS.
- All terms within the BSS are scored from 0–100. Division by 200 results in scores from 1–100.
- Once the biodiversity significance of the area has been determined the predicted magnitude and direction of change is estimated by the *Land Use Change Impact Score*
  $= ((CS\,t_n - CS\,t_0) + (VC\,t_n - VC\,t_0))\,/\,2$
- A prediction of the magnitude and direction of change in the provision of habitat and other resources for indigenous plants and animals at a site scale is scored as the difference between the current and potential *Vegetation Condition*, i.e. $(VC\,t_n - VC\,t_0)$.

- In addition, when land use change involves the creation or loss of native vegetation it is important to score the change in vegetation type as the difference between the current and potential *Conservation Significance* score, i.e. $(CS\ t_n - CS\ t_0)$.
- All terms within the LUCIS are scored from 0–100. Division by 2 results in scores from 1 to 100.
- The *Biodiversity Benefits Index* is scored as the product of these two scores multiplied by the area of land use change in hectares.

3. The Biodiversity Significance Score

The *Biodiversity Significance Score (BSS)* estimates the current biodiversity value of a site (per hectare). Biodiversity value is defined as the degree to which the site contributes to the conservation of biodiversity at the scale of bioregions (Thackway and Cresswell 1995).

The *BSS* is scored as the sum of the current *Conservation Significance* score (CS t_0) and *Landscape Context* score (LC), multiplied by the current *Vegetation Condition* score (VC t_0). The product is divided by 200 to produce values that range between 1 and 100. High scores throughout represent higher benefit.

$$BSS = (CS\ t_0 + LC)\ VC\ t_0\ /\ 200$$

3.1 ASSESSMENT OF CONSERVATION SIGNIFICANCE

A primary feature of biodiversity is the change in ecosystems, and of the species supported by those ecosystems, along environmental gradients. For example, there are real and obvious changes in the communities of species of plants and animals with changes in altitude, rainfall or soils. Such spatial change in biodiversity along ecological gradients is referred to as beta diversity in the ecological literature (see Ferrier 2002). It is critical the Toolkit captures and prioritises land use change scenarios from the aspect of these regional patterns of biodiversity.

Vegetation types are considered an appropriate operational surrogate measure for the distribution of biodiversity at a regional scale (Saunders *et al.* 1998). Assessment of *Conservation Significance* (CS t_0) is therefore largely driven by the status and trends in the spatial distribution of vegetation types within bioregions. In its current form, the toolkit does not prioritise on the basis of individual (rare or threatened) species.

Conservation Significance categories (Table 1) are based on the Commonwealth of Australia's *Environment Protection and Biodiversity Conservation Act* (EPBC) *1999* regulations 7.06 2c and 7.02, the IUCN Species Threat Categories 1994 and 1999, and the NSW Royal Botanic Gardens' NSW Vegetation Classification Database in development (Benson, in prep.).

Table 1. Conservation significance categories and scores applied to vegetation types within bioregions

Categories	Score
Least concern	20
Near threatened	40
Vulnerable	60
Endangered	80
Critically endangered / presumed extinct	100

3.1.1 Allocation to Conservation Significance categories

Allocation to a *Conservation Significance* category requires data, information or knowledge on the three criteria shown in Table 2.

The criteria are largely based upon the:

- *extent* of the vegetation type in the bioregion compared with a time before agricultural development
- *vulnerability* of the remaining vegetation type in the bioregion to further loss or degradation.

Where *Conservation Significance* categorisation is not already available for a bioregion or vegetation type, Table 2 and Appendix 2 can be used by experienced vegetation management staff to categorise the vegetation type on-site.

If an assessment unit contains any native vegetation, as defined by the *Native Vegetation Conservation Act 1997*, it is eligible for a *Conservation Significance* score (see Appendix 1 for the specification of assessment units).

Table 2 Criteria used to allocate vegetation types to conservation significance categories
Modified from Benson (in prep.).

	Categories				
Criteria*	**Presumed extinct/ critically endangered**	**Endangered**	**Vulnerable**	**Near threatened**	**Least concern**
Category score:	100	80	60	40	20
The decline in its pre-clearing geographic distribution is:	> 90%	70–90%	50–70%	30–50%	< 30%
The current rate of detrimental change is:	very severe	severe	substantial	minor	insignificant
If threatening processes remain unchanged it may become regionally extinct in the:	immediate future (10 yr)	near future (20 yr)	medium term (50 yr)	long term (100 yr)	very long term (500 yr)

* See Appendix 2 for definitions of criteria and categories reproduced from Benson (in prep.).

On-site categorisation to the *Conservation Significance* category proceeds as follows:

- The vegetation type is allocated to a category for each of the three Table 2 criteria for the bioregion.
- The vegetation type receives the highest *Conservation Significance* category allocated above.

3.2 ASSESSMENT OF LANDSCAPE CONTEXT

The component *Landscape Context* (LC) recognises the biodiversity value of a site will vary depending on where the site is located in the landscape. For example, sites that are located adjacent to existing native vegetation (NVAC 1999), or in localities where landscapes can be described as variegated rather than fragmented (McIntyre & Hobbs 1999) and therefore have not experienced major biodiversity decline (Smith & Sivertsen 2002), or in regionally important areas such as wildlife corridors (Drielsma & Wish 2000), need to be prioritised by the Toolkit.

Sites do not need to contain native vegetation to receive points under the component *Landscape Context*. The aim is to prioritise the siting of activities for maximum biodiversity benefit. For example, the toolkit needs to prioritise the siting of a revegetation activity adjacent to an existing patch of native vegetation compared with the siting of the same patch of revegetation within a 'sea' of cropping where its biodiversity value will be compromised.

For the Biodiversity *Benefits* Toolkit, the component *Landscape Context* recognises that different groups of species respond to their environments at different spatial scales. *Landscape Context* is therefore assessed at three spatial scales. The value of each spatial scale was agreed by the Technical Advisory Group (Table 3).

Table 3. Landscape context assessment scales and values

Assessment scales	Value (%)
Site scale	30
Local scale	60
Regional scale	10

- Site inspection will normally be required for the assessment of *Landscape Context* at the *site scale*.
- Aerial photographs or GIS are required for the assessment of *Landscape Context* at the *local scale.*
- Spatially explicit regional planning documents are required for the assessment of *Landscape Context* at the *regional scale*.

3.2.1 Site scale (value 30%)

Site-scale assessment recognises the biodiversity benefits derived from land use change can be increased at the site level if activities are located so that they satisfy as many of the following criteria as possible. Given that these criteria are all related to the site under application, the number that will be satisfied by an activity are largely at the discretion of the landholder.

Adjacent to an existing remnant (0–6 points)

The objective of this criterion is to increase the size of existing remnants. To qualify for points, at least one edge of the proposed site must be within 10 m of an extant area of native vegetation, as defined by the NVC Act, 1997.

Points are allocated as follows:

- If the remnant is considered by the field-officer to be in poor condition, the score is 2 points.
- If the condition is considered to be moderate, the score is 4 points.
- If the condition is considered to be good, the score is 6 points.

Condition assessment of the remnant is by observation only.

Connects two or more remnants (0–6 points)
The objective of this criterion is to both increase the size of existing remnants and to improve connectivity between remnants. To qualify for points, at least two separate areas of native vegetation as defined by the NVC Act (1997) must be within 10 m of an edge of the proposed site. To be classed as separate areas of native vegetation, the remnants must be separated by non-native vegetation as defined by the NVC Act (1997).

For this criterion the proposed activity receives the score for the highest condition remnant where remnants are scored as follows:

- If the remnant is considered by the field-officer to be in poor condition, the score is 2 points.
- If the condition is considered to be moderate, the score is 4 points
- If the condition is considered to be good, the score is 6 points.

Condition assessment of the remnants is by observation only.

Incorporates a riparian zone (0–6 points)
The objective of this criterion is to provide habitat for flora and fauna that may be specifically associated with watercourses. To qualify for points under this criterion the site must incorporate a drainage line classed as *Stream Order 2* or greater using the 'Strahler System' of classification (Strahler 1964). Operationally, this means any intermittent or permanent watercourse shown on a topographical map of scale 1:50,000.

Points are allocated as follows:

- If the riparian zone is considered by the field-officer to be in poor condition, the score is 2 points.
- If the condition is considered to be moderate, the score is 4 points.
- If the condition is considered to be good, the score is 6 points.

Condition assessment of the riparian zone is by observation only.

Contains large trees (0–6 points)
The objective of this criterion is to recognise the value of large trees for provision of habitat, as seed sources, and as foci for revegetation (Gibbons & Boak 2002). To qualify for points under this criterion the site must include at least one large tree. Large trees are defined (minimum DBH [diameter at breast height]) by the appropriate benchmark for the site. They need not be living but must be standing at the time of initial assessment, and the landholder must commit to their retention on site (standing or fallen).

Points are allocated as follows:

- If all standing trees within the site under application are dead (no green foliage), the score is 2 points.
- If more than 50% of all standing trees are dead, the score is 4 points.
- If less than 50% of all standing trees are dead, the score is 6 points.

Has a ratio of area to perimeter greater than 20 (0 or 6 points)
The objective of this criterion is to recognise that the reduction of habitat value due to 'edge-effects' (Sisk *et al*. 1997) is greater for long thin areas compared with circular areas. To qualify for points under this criterion the site must have a ratio of area to perimeter greater than 20. For example, a 25 m wide site cannot have an area : perimeter ratio greater than or equal to 20, a 50 m wide site of length 200 m has an area : perimeter ratio of 20, and a square site with sides of length 100 m has an area : perimeter ratio of 25.

3.2.2 Local scale (value 60%)

Assessment at the local scale is based on Parkes *et al.* (2003) with minor modifications as described. The rationale for the methodology is described in full in Parkes *et al.* (2003) and is therefore not reproduced here.

Patch size (0–25 points)

The size of a patch is important to the long term survival of the populations of species within it. Bigger patches are less susceptible than smaller patches to edge effects, and the effects of storms, wildfires and invasions by weeds. From the aspect of biodiversity benefits, increasing the size of an existing patch through revegetation with the same type of vegetation will be prioritised by the toolkit (providing it is appropriate to the site). To qualify for *patch size* points the area under application must be contained within or adjacent to (edges < 10 m apart) a patch of remnant native vegetation.

The calculation of *patch size* includes both the area under application and all adjacent native vegetation that can be discriminated from current aerial photographs (see Box 1). The scores for patch size categories are as shown in Table 4.

Table 4. Patch size categories and scores

Category	Score
Patch between 1 and 2 ha	5
Patch between 2 and 5 ha	10
Patch between 5 and 10 ha	15
Patch between 10 and 20 ha	20
Patch greater than 20 ha	25

Box 1. Native vegetation discrimination on the basis of aerial photograph interpretation

For the purposes of the toolkit it is proposed that for coastal and southern NSW (DSNR Regions – Sydney / South Coast, North Coast, Murray and Murrumbidgee) where discrimination of native versus exotic dominated pastures from aerial photographs or satellite images is problematic, a woody versus non-woody vegetation mask be used as a surrogate measure for native versus non-native vegetation respectively unless grassland mapping is specifically available. In northern inland NSW (DSNR Regions – Central West, Far West and Barwon) where many of the pastures are native, a non-cultivated versus cultivated mask is proposed as the surrogate measure for native versus non-native vegetation respectively.

Neighbourhood (0–25 points)

Organisms and their propagules can disperse to varying degrees across spaces that may be considered to be unsuitable habitat. However, as patches of native vegetation become further apart, they become more isolated from a biological perspective for an increasing number of species. An assessment of the *neighbourhood* aims to quantify the degree of isolation of an individual site or patch of native vegetation.

However, because different groups of organisms can move to varying degrees across unsuitable habitat, three nested neighbourhoods (100, 1,000 and 10,000 ha) are assessed. Assessment is based on the approximate area of native vegetation (see Box 1), as a proportion of the total area within each neighbourhood at intervals of 20% (i.e. 0%, 20%, 40%, 60%, 80%, 100%). Assessment is based on aerial photograph interpretation or satellite imagery with appropriate resolution (e.g. SPOT). The value for the proportion of native vegetation within each neighbourhood is then weighted, as shown in Table 5, to provide a score between 0 and 25.

Table 5. Example calculation of the neighbourhood score

Neighbourhood radii (km)	Neighbourhood radii on photo* (cm)	Approximate neighbourhood area (ha)	Proportional area of native vegetation within each neighbourhood (for example) (%)	Weighting	Score (for example)
0.50	1.0	100	80	0.10	8.0
1.75	3.5	1,000	40	0.10	4.0
5.50	11	10,000	40	0.05	2.0
TOTAL NEIGHBOURHOOD SCORE (maximum score = 25)					14

* Neighbourhood radii on standard size 1:50,000 aerial photograph (for 1:25,000 aerial photos use 2, 7, 22 cm radii)

Distance to core area of more than 50 ha (0–10 points)

The final assessment criterion under the *Landscape Context—Local* is an estimation of the distance to the nearest large patch of native vegetation referred to as a 'core area' by Parkes *et al*. (2003). For the purposes of the toolkit, a 'core area' is defined as a patch of native vegetation greater than 50 ha (see Box 1).

Table 6. Distance to core area categories and scores

Category (km)	Score
> 5	0
3–5	2
1–3	5
< 1	8
contiguous	10

3.2.3 Regional scale (value 10%)

At this scale, *Landscape Context* aims to prioritise areas such as regional corridors, from the aspect of biodiversity conservation. Documents such as Regional Vegetation Management Plans, Catchment Blueprints and Bioregional Assessments may provide this information, and should be consulted. These sources of information are used to place each particular area that is under assessment into one of three regional priority categories for biodiversity conservation: low priority (score 3), moderate priority (score 6), and high priority (score 10).

3.3 CURRENT VEGETATION CONDITION ASSESSMENT

The Toolkit's approach to vegetation condition assessment (VC t_0) was developed with reference to three resources:

- The *Habitat Hectares* methodology and *BushTender* Trial developed by the Victorian Department of Natural Resources and Environment (NRE, Parkes *et al.* 2003).
- Contributions from a specially convened *Technical Advisory Group (Biodiversity)* for the NSW Environmental Services Scheme.
- Results generated by a *Vegetation Condition Expert Panel* that is contributing to a Department of Infrastructure, Planning and Natural Resources investigation designed to develop a transparent,

repeatable and scientifically defensible approach to vegetation condition assessment (see Oliver 2002 a, b; Oliver *et al.* 2002).

Within the biodiversity conservation context (see Box 2) two challenges need to be overcome to enable transparent, repeatable and defensible vegetation condition assessment:

- The attributes of vegetation condition that can most usefully be used as surrogate measures for the presence of species indigenous to the site need to be determined.
- *Vegetation Condition Benchmarks* that recognise and capture the appropriate state of each of these attributes for different types of vegetation need to be developed.

Vegetation Condition Benchmarks
Vegetation Condition Benchmarks (VCBs) are currently under development for New South Wales. Their aim is to provide information on the average characteristics of a mature and long undisturbed stand of particular types of vegetation (Parkes *et al*. 2003). For the condition attributes, *Richness* and *Cover of benchmarked plant groups*, benchmarks will also provide a range of values for vegetation considered to be in very poor, poor, moderate, high and very high condition (see Appendix 3).

Vegetation Condition Benchmarks provide for non-linear relationships between attribute status and condition rating. For example, for a hypothetical shrubby woodland benchmark, the condition class may improve from very low to very high with increasing tree cover, but only to a point (e.g. up to 30% cover). For higher levels of tree cover, for example associated with dense woody regrowth, the condition rating may decline (e.g. more than 30% cover. See Table 9 and Appendix 3).

Appendix 3 presents a hypothetical example of a VCB for one vegetation type in NSW.

- Where a *Vegetation Condition Benchmark* does not exist for the bioregion, experienced vegetation management staff should be consulted and a request placed to generate the particular *Vegetation Condition Benchmark* for the bioregion.

Box 2. Vegetation condition assessment within the context of biodiversity conservation

Vegetation condition is a context dependent concept and has been assessed in terms of sustainable production capability (Wilson 1984), ecological function (Ludwig *et al.* 1997) or biodiversity conservation (Goldney & Wakefield 1997; Morsley 2000). The toolkit's approach to the assessment of vegetation condition was developed specifically for application to the biodiversity conservation context. The application of this toolkit to other contexts (e.g. productivity) is therefore likely to be compromised (see Oliver *et al.* 2002).

Attributes and relative values of vegetation condition
The approach to vegetation condition assessment builds upon the Victorian approach documented in Parkes *et al.* (2003).

Three important changes were made:

1. *Richness* and *Cover* of benchmarked plant groups are assessed separately in the NSW Toolkit. This was considered necessary so that non-indigenous and exotic vegetation could still be recognised as providing structural benefits, e.g. cover and habitat, to fauna and flora. Non-indigenous and exotic vegetation do not, however, score benefit points under the richness criterion.
2. The attribute *density of hollow-bearing trees* was added based largely on the recommendation of the vegetation condition expert panel (Oliver 2002b) and because the provision of artificial hollows is one management action available to landholders that can increase the biodiversity value of a site (Gibbons & Lindenmayer 1997, 2002; Smith & Agnew 2002).
3. The scoring system for some attributes was altered to cater for benchmark ranges, rather than a single figure as used in the *Habitat Hectares* methodology. A range is considered preferable as it better reflects natural variability in species richness and vegetative cover at the plot level. It also caters for different degrees of variability among vegetation types. For example, for vegetation types of a 'patchy' nature, a benchmark richness of tussock grasses of 15–30 species (within a 20 x 20 m plot) may be appropriate, whereas for a less variable vegetation type the benchmark may be 15–20 species.

Table 7. Vegetation condition attributes and values

Attributes	Value (%)
Richness of benchmarked plant groups	25
Cover of benchmarked plant groups	20
Cover or density of:	
recruitment	10
weeds	15
organic litter	05
large trees	15
hollow-bearing trees	05
wood load	05
TOTAL	100

3.3.1 Richness of benchmarked plant groups (value 25%)

Identification of all plant species within a plot is difficult, requires considerable botanical expertise and is time-consuming. To simplify assessment, richness of native plants is visually estimated for five plant groups: trees, shrubs, forbs, perennial grasses and 'other' (see Appendix 4 for life-forms contained within each).

Although a knowledge of all species at a site is considered unrealistic, assessors should be able to identify those characteristic species identified within the *Vegetation Condition Benchmarks* within their region. This level of expertise is required for the correct identification of the vegetation types on sites, and therefore the selection of the correct *Vegetation Condition Benchmarks* for sites. Assessors should also be able to discriminate between native and exotic species. Where a management unit consists of vegetation types representative of different *Vegetation Condition Benchmarks*, separate assessment units are required (see Appendix 1).

Assessment is based on the average number of *indigenous native species* observed within 20 x 20 m plots for each benchmarked plant group. Scores within plant groups are averaged among one to several survey plots within assessment units. The number of plots is guided by the size of the assessment unit (see Appendix 1).

The Table 8 shows how the richness score is calculated for one survey plot. Observed richness (unshaded row) is shown in the cell corresponding to the condition class (and condition score) specified by the *Vegetation Condition Benchmark* (see Appendix 3). For example, at the plot, three *indigenous native species* of shrubs were observed. The benchmark shows that 3–4 species corresponds to the *moderate* class and receives a score of 15. The process is repeated for each stratum identified in the benchmark and the total *Richness Score* is calculated as the total of the scores divided by the number of benchmarked groups.

Where insufficient material is present to estimate richness of grasses or forbs, either due to grazing pressure or environmental conditions, no assessment of these components is made. The total score would then be divided by 3 or 4, rather than by 5.

Table 8. Example calculation of current richness score

Current richness							
	Condition class	Very low	Low	Moderate	High	Very high	
	Condition score	5	10	15	20	25	Score
Trees	VCB	1	1	2–3	4	> 4	–
	Observed	*1*	*1*				*7.5*
Shrubs	VCB	1	2	3–4	5–6	> 6	–
	Observed			*3*			*15*
Forbs	VCB	1	1	2–5	6–10	> 10	–
	Observed	*0**					*0**
Perennial grasses	VCB	< 5	5–10	11–20	21–30	> 30	–
	Observed			*12*			*15*
Other (geophytes)	VCB	0	0	1	2	> 2	–
	Observed	*0**					*0**
						TOTAL	*37.5 / 5*
TOTAL CURRENT RICHNESS SCORE (maximum score = 25)							*7.5*

VCB Expected average richness (among 20 x 20 m plots) from Vegetation Condition Benchmark.
Observed Observed average richness (among 20 x 20 m plots) from site assessment.
* Where the group is present in the VCB but is not observed score = 0

3.3.2 Cover of benchmarked plant groups (value 20%)

Cover of benchmarked plant groups is assessed in the same way as richness (within a 20 x 20 m plot) but against the cover benchmark for each plant group. The cover of cryptogams (mosses, lichens, liverworts and algae) is also assessed when cryptogams are listed in the *Vegetation Condition*

Benchmark. As for richness, the score total is divided by the number of groups (a maximum of 6) to yield a total score out of 20. In comparison with the richness assessment, *species do not have to be native or indigenous,* but in this case *Exotic Species Debits* are applied. *Health Debits* are also applied.

Health Debits
The cover of trees is discounted by the 'health' of trees as evidenced by canopy loss or mistletoe infestation. The health of trees should be taken into account by estimating the proportion of an expected healthy canopy cover that is, on average among trees, missing due to tree death, or decline, or mistletoe infestation. Cover is discounted due to health as follows:

- Where 30–70% of the canopy is missing or comprises mistletoe, subtract 2 points.
- Where more than 70% of the canopy is missing or comprises mistletoe, subtract 4 points.

Exotic Debits
Non-indigenous and non-native species can still gain benefit points (albeit discounted) under this category as they provide structural characteristics of biodiversity value to indigenous plants and animals. Where the average cover of a plant group is *less than 50% indigenous*, discount as follows:

- for mixed species non-indigenous native, multiply by 0.75
- for single species non-indigenous native or exotic species, multiply by 0.50.

Table 9. Example calculation of current cover score

Current cover								
	Condition class	Very low	Low	Moderate	High	Very high		
	Condition score	4	8	12	16	20	Debit	Score
Trees	VCB	< 5	< 5	5–10, > 40	11–20, 31–40	21–30	health	
	Observed			*10*			*12–2*	*10*
Shrubs	VCB	< 5	< 5	5–15, > 70	16–30, 51–70	31–50		
	Observed				*20*			*16*
Forbs	VCB	< 5	< 5	< 5, > 30	5–15	16–30		
	Observed				*13*			*16*
Perennial	VCB	< 15	15–30	31–50	51–70	> 70	exotic	
Grasses	Observed					*85*	*20 x .75*	*15*
Other	VCB	0, > 20	0–1, 15–20	1–5, 10–15	5–10	5–10		
(geophytes)	Observed	*0*						*0*
Cryptogams	VCB	< 5	< 5	5–15	16–30	> 30	–	
	Observed			*5*				*12*
							TOTAL	*69 / 6*
TOTAL CURRENT COVER SCORE (maximum score = 20)								*11.5*

Debit Raw score adjusted on the basis of reduced tree health or non-indigenous structural components.
VCB Expected average cover (among 20 x 20 m plots) from Vegetation Condition Benchmark.
Observed Observed average cover (among 20 x 20 m plots) from site assessment.

Table 9 shows the calculation of the cover score for one survey plot. Observed cover (unshaded row) is shown in the cell corresponding to the condition class (and condition score) as specified by the benchmark. For example, at the plot, tree cover was assessed at 10% placing it in the moderate condition class. However, the condition score of 12 is reduced by 2 due to reduced tree health at the plot. Grass cover was in the very high class but as it was dominated by non-indigenous native species, the score is multiplied by 0.75.

3.3.3 Recruitment (value 10%)

The potential for the recruitment of plant species within all major life-forms and strata is an essential part of the condition of a site. Ideally, recruitment would be assessed across all plant species. However, single visits to sites do not permit the consistent assessment of recruitment for ephemeral species. Therefore, this assessment is focused upon woody perennial species to maintain consistency with assessments at other sites. For most vegetation types woody perennial species will be limited to trees and shrubs. However, other life-forms may need to be included for some vegetation types.

The question of whether or not a recruitment event has occurred 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 or flooding), where these are known to initiate recruitment (Parkes *et al.* 2003). The *Vegetation Condition Benchmark* identifies whether or not recruitment is episodically driven (see Appendix 3). Assessment is undertaken within the 20 x 20 m plot.

Table 10. Recruitment categories and scores

First decision	Second decision	Third decision	Proportion of benchmark number of woody species*	
			≥ 50%	< 50%
No evidence of a recruitment ‘cohort’ **	If recruitment is being assessed within a vegetation type that is not driven by episodic events	–	0	0
–	If recruitment is being assessed within a vegetation type that is driven by episodic events ***	There is clear evidence of an appropriate episodic event	0	0
–	–	There is not clear evidence of an appropriate episodic event	5	5
Clear evidence of at least one recruitment ‘cohort’ in at least one woody life-form	Proportion of native woody species present that have ‘adequate’ recruitment****	< 30%	3	1
–	–	30–70%	6	3
–	–	> 70%	10	5

* Use sum of mid-point richness values for trees and shrubs in the *high* category within the appropriate *Vegetation Condition Benchmark* (see Appendix 3).

** A group of woody plants that have established in a single episode.

*** Use individual vegetation condition benchmark data for clarification.

**** *For overstorey species*: if the tree canopy cover is less than the 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.

For understorey species: with continuous recruitment, ‘adequate’ means the number of immature plants is at least 10% of the number of mature plants.

3.3.4 Weed cover (value 15%)

Most weed species are derived from overseas, but may also include native species found outside their natural geographic range or habitat. Weeds that represent a serious problem can dominate a site to the exclusion of indigenous native plants (and animals). They may do so directly through competitive advantage over indigenous plants, or indirectly by altering the site conditions to be less favourable to indigenous plant and animal species, or by cross pollinating with similar local native plants creating sterile hybrids. The impact of weeds on a site's biodiversity can be high, consequently, this component receives a relatively high proportional weighting in the total score.

Assessment is based on the cover of weed species within the 20 x 20 m plot, but also the threat posed due to invasiveness and direct physical impact for each vegetation type. A list of weed species and their threat level (low, moderate, high) will be included within each *Vegetation Condition Benchmark*.

Table 11. Weed cover categories and scores

	Proportion of weed cover represented by 'high-threat' weed species		
Weed cover (%)	**None**	**< 50%**	**> 50%**
> 50	3	1	0
25–50	7	5	3
5–25	11	9	7
< 5	15	13	11

3.3.5 Cover of organic litter (value 5%)

Litter is defined here as including both coarse and fine plant debris, and organic material such as fallen leaves, twigs and small branches less than 10 cm in diameter. It provides habitat for invertebrates and can be important to successful regeneration for plant species through its influences on the soil microclimate, structure and composition. Litter depth also affects the score.

Assessment is by estimation of the proportion of litter within the 20 x 20 m plot compared with the benchmark value. As the benchmark values for litter cover are difficult to derive, the primary inflection point in determining the values is a coarse level.

Table 12. Organic litter cover categories and scores

Organic litter cover (percentage of benchmark litter cover)	Depth of litter (cm)	
(%)	**< 1**	**> 1 ***
< 10	0	1
10–50	2	3
≥ 50	4	5

* Where there are, on average, several or more layers of leaves and other litter.

3.3.6 Density of large trees (value 15%)

Large trees are a particularly difficult habitat feature to replace, once they are lost. For this reason, and because of their critical importance as habitat for some species (including for nesting and feeding), a relatively high proportional weighting is warranted for the retention of large trees, even though they comprise only relatively few species within most vegetation types. Large trees provide nesting sites, as well as other resources (e.g. pollen or nectar) that are sought by fauna over a wide area.

A large tree is defined by its diameter at breast height (1.3 m), which is specified as part of each benchmark. Assessment is conducted over the belt transect (Appendix 5) and extrapolated to density per hectare.

Health Debits
The large tree density score may be discounted due to poor tree health as evidenced by canopy loss or mistletoe infestation. The health of large trees should be taken into account by estimating the proportion of an expected healthy canopy cover that is, on average among trees, missing due to tree death, or decline, or to mistletoe infestation (Parkes *et al*. 2003). The density score is discounted as follows:

- Where < 30% of the canopy is missing or comprises mistletoe, subtract 0 points.
- Where 30–70% of the canopy is missing or comprises mistletoe, subtract 2 points
- Where more than 70% of the canopy is missing or comprises mistletoe, subtract 4 points.

Table 13. Large tree density categories and scores

	Score (discounted by the amount of canopy missing)		
Large tree density (percentage of the benchmark number of large trees per hectare) (%)	**< 30%**	**30–70%**	**> 70%**
None present	0	0	0
0–20	6	4	2
20–40	9	7	5
40–70	12	10	8
70–100	15	13	11

3.3.7 Density of hollow-bearing trees (value 5%)

Although the difficulty of accurately assessing the density of hollow-bearing trees is acknowledged, their importance as critical habitat for hollow-dependent fauna has been expressed by an expert panel specially convened to determine an optimum suite of site-attributes for condition assessment within the context of biodiversity conservation (Oliver 2002 a, b). Therefore, for the prototype toolkit an assessment of the density of hollow-bearing trees will be incorporated into the *Vegetation Condition* score. A hollow-bearing tree is defined as a tree with at least one hollow (at any location on the tree) with a minimum entrance width greater than 5 cm and apparent depth below the entrance. Assessment is conducted over the belt transect and extrapolated to density per hectare.

Table 14. Hollow-bearing tree density categories and scores

Hollow-bearing tree density (percentage of the benchmark number of hollow-bearing trees per hectare) (%)	Score
None present	0
0–20	2
20–40	3
40–70	4
70–100	5

3.3.8 Wood load (value 5%)

Wood load includes logs and old cut stumps which have considerable influence upon plant and animal species through their effects on soil moisture, structure and nutrition, and by providing habitat for many fauna species, ranging from invertebrates to reptiles and ground-dwelling mammals. They may also be important regeneration sites for plant species.

Logs are defined here as timber fallen to the ground (substantially detached from the parent tree) with a diameter greater than 10 cm. Old cut stumps must have cracks and fissures at least 10 mm wide to be included. State of decay also influences the score.

Assessment is by estimation of the wood load of logs and other coarse woody debris within the belt transect extrapolated to lineal metres per hectare. As the benchmark values for log densities are difficult to derive, the primary inflection point in determining the values is at a coarse level.

Table 15. Wood load categories and scores

Wood load (percentage of benchmark per hectare) (%)	Percentage of wood load in advanced state of decay*	
	< 25%	>25%
< 10	0	1
10–50	2	3
≥ 50	4	5

* Logs or stumps with openings of at least 5 cm, and/or friable in nature.

4. The Land Use Change Impact Score

The aim of the Biodiversity *Benefits* Toolkit is to provide a methodology that:

- Scores the current biodiversity value of a site.
- Estimates the magnitude and direction of change in biodiversity value as a result of land use change.
- Incorporates these current and potential values into a Biodiversity *Benefits* Index.

The *Biodiversity Significance Score* provides a measure of the current biodiversity value of a site from which the significance of change, either positive or negative, can be gauged. The magnitude and direction of change is scored by the *Land Use Change Impact Score*.

The impact of change in land use is estimated as the differences between current and potential *Vegetation Condition* and current and potential *Conservation Significance*. Scores range from 1 to 100, with higher scores representing higher positive impact.

$$LUCIS = ((CS\ t_n - CS\ t_0) + (VC\ t_n - VC\ t_0)) / 2$$

All changes in land use are likely to affect *Vegetation Condition*, either through the regeneration or replacement of various components of habitat, or via their removal. A prediction of *Potential Vegetation Condition,* given an agreed scenario in land use change (i.e. time-frame and suite of management inputs), is required to calculate the magnitude of change in this component (see Box 4).

In addition, and particularly for revegetation or restoration efforts, land use change may involve the conversion of non-native or non-indigenous vegetation to a vegetation type considered ‘ecologically appropriate’ for the site.

‘Ecologically appropriate’ means those types of vegetation that may have existed on-site before agricultural development. Where land use change involves conversion to or from indigenous native vegetation, the difference between current and *Potential Conservation Significance Scores* is also calculated and included in the *Land Use Change Impact Score*.

Box 3. The process of prediction

Given the infinite variability of management history among sites, climates and soils together with the variable desires of landholders regarding the future management of their sites, it is not possible to construct management suite guidelines that are appropriate for all scenarios.

Because estimation of Potential Vegetation Condition is a professional judgement made by the field-officer, experienced personnel are required for LUCIS assessment.

Prediction of potential richness (and other attributes) is dependent on time-frame. The toolkit provides for flexibility of time-frames which are likely to be determined by the program, requiring implementation of the Biodiversity Benefits Toolkit.

Given the importance of time-frame on the prediction of potential status of attributes, time-frame in years must be clearly specified before LUCIS assessment.

4.1 POTENTIAL CONSERVATION SIGNIFICANCE

As stated earlier, it is important to recognise changes to biodiversity value from a regional perspective. Changes to or from native vegetation are obvious examples. For example, if cultivated and cropped land is returned to native vegetation, it is important to recognise the *Conservation Significance* (CS t_n) of the replaced vegetation type.

To score points under the *Potential Conservation Significance* category, the replaced native vegetation must be ecologically appropriate to the site. In other words, is it reasonable to expect that the particular vegetation to be replaced (in part, or in total) would have been present on site before agricultural development?

If the particular vegetation type is considered ecologically appropriate, it is scored as for *Initial Conservation Significance* from *Critically Endangered* to *Least Concern*.

Replanting or regeneration which aims to mimic both the ultimate structure and composition of the benchmarked vegetation type are eligible for *Potential Conservation Significance* points. Commercial plantations of mixed, native species are also eligible for points under this category if the species used are listed under the *Vegetation Condition Benchmarks* appropriate to the sites.

4.2 POTENTIAL VEGETATION CONDITION

Potential vegetation condition (VC t_n) depends on the following factors.

4.2.1 Potential richness of benchmarked plant groups (value 25%)

The recovery of species richness of plant groups commensurate with the benchmark for the appropriate vegetation type depends on some or all of the following four factors:

- The status of the seed bank in the soil from which plants can germinate.
- The proximity of sources of new plant propagules, (i.e. areas of native vegetation producing viable seeds).
- Suitable environmental conditions for plant germination, establishment and survival.
- The particular, agreed suite of management actions and inputs.

Management actions and inputs likely to influence potential species richness may include:

- increasing or reducing grazing pressure by domestic stock
- reducing grazing pressure by rabbits and other feral animals
- supplementary planting and watering
- weed control
- management of fire
- management of mistletoe
- management of regrowth.

The *Total Potential Richness Score* is calculated in the same manner as for current richness; that is, against the benchmark. Sown or planted trees are assessed as trees for the *Potential Richness* criterion regardless of their predicted height after the agreed period of time. Prediction is to condition class only, as shown by the ‘Xs’ in the ‘Potential’ rows of the following example.

Table 16. Example calculation of potential richness score

Potential richness							
	Condition class	Very low	Low	Moderate	High	Very high	
	Condition score	5	10	15	20	25	Score
Trees	VCB	1	1	2–3	4	> 4	–
	Observed	*1*	*1*				
	Potential			*X*			*15*
Shrubs	VCB	1	2	3–4	5–6	> 6	–
	Observed			*3*			
	Potential				*X*		*20*
Forbs	VCB	1	1	2– 5	6–10	> 10	–
	Observed	*0**					
	Potential			*X*			*15*
Perennial grasses	VCB	< 5	5–10	11–20	21–30	> 30	–
	Observed			*12*			
	Potential				*X*		*20*
Other (geophytes)	VCB	0	0	1	2	> 2	–
	Observed	*0*					
	Potential	*0*					*0*
						TOTAL	*70/5*
TOTAL POTENTIAL RICHNESS SCORE (maximum score = 25)							*14*

VCB Expected average richness (among plots) from Vegetation Condition Benchmark.
Observed Observed average richness (among plots) from site assessment.
Potential Potential average richness predicted on the basis of land use change scenario.
* Where the group is present in the VCB but is not observed, the score = 0.

Natural regeneration
Where the change in land use includes natural regeneration, the likely status of the soil seed bank and the proximity to regenerating native vegetation will guide the negotiation of the management suite that is necessary to deliver the predicted potential richness score.

Revegetation
Where revegetation is part of the management suite only species appropriate to the *Vegetation Condition Benchmarks* for the sites (native indigenous species) score points under the *Potential Richness* criterion.

Plantation
If the change in land use is the establishment of a native plantation, *Potential Richness* points are awarded only if the planted species are identified within the *Vegetation Condition Benchmarks* appropriate for the sites.

Box 4. Management contracts

It is important to acknowledge that management inputs alone do not guarantee the predicted vegetation condition will be reached after the agreed period of time. Climatic and other stochastic events beyond the control of the landholder may result in a lower, or even higher, condition state being reached. Consequently, the toolkit refers to a 'potential', vegetation condition state. Any contractual agreements, therefore, need to be phrased in terms of management inputs rather than management outcomes.

However, assessment of outcomes will require documentation of management and monitoring actions as well as the recording of sufficient ancillary data over the period of the agreement. 'Sufficient ancillary data' are those data determined to be the minimum data needed for informed assessment of outcomes. They will need to be determined on a case-by-case basis.

Table 17. Example calculation of potential cover score

Potential cover								
	Condition class	Very low	Low	Moderate	High	Very high		
	Condition score	4	8	12	16	20	Debit	Score
Trees	VCB	< 5	< 5	5–10, > 40	11–20, 31–40	21–30		
	Observed			*10*				
	Potential				*X*			*16*
Shrubs	VCB	< 5	< 5	5–15, > 70	16–30, 51–70	31–50		
	Observed				*20*			
	Potential					*X*		*20*
Forbs	VCB	< 5	< 5	< 5, > 30	5–15	16–30		
	Observed				*13*			
	Potential					*X*		*20*
Perennial grasses	VCB	< 15	15–30	31–50	51–70	> 70		
	Observed					*85*		
	Potential					*X*		*20*
Other (geophytes)	VCB	0, > 20	0–1, 5–20	1–5, 10–15	5–10	5–10		
	Observed	*0*						
	Potential	*X*						*0*
Cryptogams	VCB	< 5	< 5	5–15	16–30	> 30		
	Observed			*5*				
	Potential				*X*			*16*
							TOTAL	*92 / 6*
TOTAL POTENTIAL COVER SCORE (maximum score = 20)								*15.3*

Debit Raw score adjusted on the basis of reduced tree health or non-indigenous structural components.
VCB Expected average cover (among 20 x 20 m plots) from condition benchmark for hypothetical vegetation type.
Observed Observed average cover (among 20 x 20 m plots) from site assessment.

4.2.2 Potential cover of benchmarked plant groups (value 20%)

Potential Cover of plant groups is assessed in a similar manner to *Potential Richness*; that is, against the cover benchmark for each plant group and to condition class only, as shown by the Xs in Table 17.

The predicted cover of non-indigenous and non-native species gain benefit points under this category as they provide structural characteristics of biodiversity value to indigenous plants and animals. However, as for *Initial Cover* the benefit of a predicted *Potential Cover* of non-indigenous and non-native species is discounted compared to the same cover provided by indigenous species (score multiplied by 0.75 for mixed non-indigenous native species, and by 0.50 for single non-indigenous native species and exotic species). For *Potential Cover* tree 'health' is not predicted.

Where planted trees are predicted to be less than 80% of the canopy height as specified in the benchmark (over the agreed time-frame) they are assessed within the stratum in which they will dominate over the duration of the agreement, for example, as shrubs.

4.2.3 Potential recruitment (value 10%), potential weed cover (value 15%), and potential organic litter cover (value 5%)

The initial vegetation condition, the particular land use change, the management suite, and time-frame will guide the prediction of *potential recruitment, potential weed cover,* and *potential organic litter cover*. As with other predictions of potential attribute status, expert, and preferably local, ecological knowledge is required.

4.2.4 Potential density of large trees (value 15%)

Large trees are a particularly difficult habitat feature to replace, once lost. Management actions will not improve the density of large trees unless 'in perpetuity' agreements are entered into. However, it is conceivable that management actions could reduce the density of large trees during the period of agreement either through their death and removal or fall and removal. It is therefore important that as part of the management suite the landholder leaves in place any trees that die or fall. If this is not the case a predicted reduction in *Potential large tree density* may result. If the landholder agrees to the above, and the agreement is not 'in perpetuity', then the *Potential Large Tree Density* score is the same as the current large tree density score.

4.2.5 Potential hollow-bearing tree density (value 5%)

The presence, density and diversity of tree hollows is correlated with the age and species of trees. However, given that large, and therefore old, trees are particularly difficult to replace, the challenge is to replace some of the components associated with large trees that are of importance to the conservation of biodiversity.

Artificial hollows or nest boxes are one component that can be replaced, and have been shown to have value to the conservation of biodiversity (Gibbons & Lindenmayer 1997; Smith & Agnew 2002; Gibbons & Lindenmayer 2002). Provision of artificial nest boxes must adhere to best management practice guidelines (under development). To achieve the maximum points under this criterion the density of nest boxes needs to be twice the density of *Hollow Bearing Trees* as specified in the appropriate *Vegetation Condition Benchmark*.

4.2.6 Potential wood load (value 5%)

Logs, or coarse woody debris, are a critical resource for ground-active vertebrate and invertebrate fauna and the animals for which these fauna are a food resource. Because an increase in the density of logs is largely dependent on an increase in the density of large and senescing trees, this component is unlikely to improve in the short-term without management input. However, as with large trees, it is conceivable that management actions could reduce the density of coarse woody debris on the site during the period of agreement. For example, the removal of logs for firewood (which has been listed as a Key Threatening Process under the Threatened Species Conservation Act 1995), and the 'cleaning-up' of paddocks through piling and burning may reduce the density of coarse woody debris on the site. It is therefore important that as part of the management suite the landholder agrees to leave in place all coarse woody debris on the site. If this is not the case, a predicted reduction in *potential wood load* may result. If the landholder does agree to the above, then the *Potential Wood Load* score is the same as the current wood load score unless management inputs aim to improve wood load.

A redistribution of coarse woody debris may be beneficial for biodiversity conservation if logs, old fence posts, tree stumps, etc are relocated from a site with little biodiversity value to one with greater potential for biodiversity conservation. Provision of coarse woody debris must adhere to best management practice guidelines (under development). To achieve the maximum points under this criterion the additional coarse woody debris added by the landholder should aim to achieve the wood load as specified in the appropriate *Vegetation Condition Benchmark.*

5. Evaluating the Biodiversity Benefits Index using scenarios in change of land use

$$BBI =$$

$$(CS\ t_0 + LC)\ VC\ t_0\ /\ 200 \qquad \textit{(the Biodiversity Significance Score)}$$

$$x$$

$$((CS\ t_n - CS\ t_0) + (VC\ t_n - VC\ t_0))\ /\ 2 \qquad \textit{(the Land Use Change Impact Score)}$$

$$x \quad ha$$

Where:

$CS\ t_0$ = Current Conservation Significance, i.e. before land use change
$CS\ t_n$ = Potential Conservation Significance, i.e. after land use change
LC = Landscape Context
$VC\ t_0$ = Current Vegetation Condition, i.e. before land use change
$VC\ t_n$ = Potential Vegetation Condition, i.e. after land use change and an agreed period of time
ha = area of land use change.

5.1 A HYPOTHETICAL EXAMPLE

A landholder in NSW operates a 5,000 ha farm comprised of the following land uses:

LU1[1] 3,500 ha are grazed pastures that were cleared and sown to exotic pasture species 30 years previously.

LU2 1,000 ha are grazed pastures dominated by native ground cover. Scattered large trees are present.

LU3 500 ha are remnant woodland which was thinned over the past 100 years and is grazed sporadically.

The landholder is interested in calculating the likely biodiversity benefits over a *10-year time-frame* of the following land use changes (LUC) for 100 ha within each of the current land uses:

LUC1 From exotic pasture to *deep rooted non-indigenous native perennial pasture*.

LUC2 From exotic pasture to *commercial plantation of non-indigenous native trees*.

LUC3 From exotic pasture to *environmental planting*.

LUC4 From grazed native pasture to *commercial plantation of non-indigenous native trees*.

LUC5 From grazed native pasture to *environmental planting*.

LUC6 From grazed native pasture to *natural regeneration of shrubby woodland*.

LUC7 From grazed woodland to *natural regeneration of shrubby woodland*.

[1]LU = land use, LUC = land use change

A hypothetical *Shrubby Woodland Benchmark* (see Appendix 3) is applicable to the entire property. The following pages provide worked examples of possible BBI scores that may result from each of the land use change scenarios described here.

5.1.1 Current biodiversity value—the Biodiversity Significance Score

$$BSS = (CS\ t_0 + LC)\ VC\ t_0\ /\ 200$$

LU1 Grazing pasture sown to annual pasture species 30 years previously

CS = 0 The *Conservation Significance category* for the vegetation type appropriate to the site is *endangered* (=100). However, as the current site is classed as non-native vegetation, the score = 0.

LC = 20 A square site adjacent to a large remnant woodland.

VC t_0 = 1 Condition score less than zero. Receive minimum score = 1.

BSS = 20 / 200 = 0.1 ≈ 1 (minimum allowable score).

LU2 Grazing pasture dominated by native plant species

CS = 100 The *Conservation Significance category* for the vegetation type on site is *endangered* (=100).

LC = 30 A square site that includes large trees and a watercourse, and is adjacent to the remnant woodland.

VC t_0 = 30 Large trees bearing hollows, and indigenous ground cover in poor condition.

BSS =3,900 / 200 = 20

LU3 Remnant woodland that has been thinned over the past 100 years and is lightly grazed

CS = 100 The *Conservation Significance category* for the vegetation type on site is *endangered* (=100).

LC = 50 A square site that includes large trees and a watercourse, and is within the remnant woodland.

VC t_0 = 60 All components present but in moderate condition.

BSS =9,000 / 200 = 45

5.1.2 The magnitude and direction of change—the Land Use Change Impact Score

$$LUCIS = ((VC\ t_n - VC\ t_0) + (CS\ t_n - CS\ t_0)) / 2$$

LUC1 ***From exotic pastures to deep rooted non-indigenous native perennials***

$VC\ t_n$ = 1 (no recordable change in condition).

$VC\ t_0$ = 1

$CS\ t_n$ = 0 (no change in status).

$CS\ t_0$ = 0

$$LUCIS = ((1 – 1) + (0 – 0)) / 2 = 0 \approx 1 \text{ (minimum allowable score)}$$

LUC2 ***From exotic pastures to commercial plantation of non-indigenous native trees***

$VC\ t_n$ = 25 (increase due to potential improved cover score of trees and litter, increase in richness and cover of shrubs, forbs and grasses due to reduced domestic stock).

$VC\ t_0$ = 1

$CS\ t_n$ = 0 (no change in status as trees used are not listed in the condition benchmark).

$CS\ t_0$ = 0

$$LUCIS = ((25 – 1) + (0 – 0)) / 2 = 12$$

LUC3 From exotic pastures to environmental planting

$VC\ t_n$ = 65 (increase due to improvements in most components).

$VC\ t_0$ = 1

$CS\ t_n$ = 100 The Conservation Significance category for the vegetation type appropriate to the site is *endangered* (=100).

$CS\ t_0$ = 0

$$LUCIS = ((65 – 1) + (100 – 0)) / 2 = 82$$

LUC4 ***From grazed native pastures to commercial plantation of non-indigenous native trees***

$VC\ t_n$ = 40 (Increase due to potential improved cover score of trees and litter, increase in richness and cover of shrubs, forbs and grasses due to reduced domestic stock numbers. The increase is greater than from annual pasture, due to the presence of native plants and a viable seed bank from which plants recruit rapidly.).

$VC\ t_0$ = 20

$CS\ t_n$ = 100 (no change in status as existing native vegetation will not be extinguished).

$CS\ t_0$ = 100

$$LUCIS = ((40 – 20) + (100 – 100)) / 2 = 10$$

LUC5 From grazed native pastures to environmental planting

VC t_n = 60 (Increase due to improvements in most components.)

VC t_0 = 20

CS t_n = 100 (No change in status as existing native vegetation will not be extinguished.)

CS t_0 = 100

$$LUCIS = ((60 - 20) + (100 - 100)) / 2 = 20$$

LUC6 From grazed native pastures to natural regeneration of shrubby woodland

VC t_n = 70 (Increase due to improvements in most components.)

VC t_0 = 20

CS t_n = 100 (No change in status.)

CS t_0 = 100

$$LUCIS = ((70 - 20) + (100 - 100)) / 2 = 25$$

LUC7 From lightly grazed woodland to natural regeneration of shrubby woodland

VC t_n = 80 (Increase due to improvements in most components.)

VC t_0 = 45

CS t_n = 100 (No change in status.)

CS t_0 = 100

$$LUCIS = ((80 - 45) + (100 - 100)) / 2 \approx 18$$

5.1.3 The biodiversity benefits of land use change—the Biodiversity Benefits Index

BBI =BSS x LUCIS x ha

LUC1 From exotic pastures to deep rooted native non-indigenous perennials

BBI = 1 x 1 = 1 x ha

LUC2 From exotic pastures to commercial plantation of non-indigenous native trees

BBI = 1 x 12 = 12 x ha

LUC3 From exotic pastures to environmental planting

BBI = 1 x 82 = 82 x ha

LUC4 From grazed native pastures to commercial plantation of non-indigenous native trees

BBI = 20 x 10 = 200 x ha

LUC5 From grazed native pastures to environmental planting

BBI = 20 x 20 = 400 x ha

LUC6 From grazed native pastures to natural regeneration of shrubby woodland

BBI = 20 x 25 = 500 x ha

LUC7 From lightly grazed woodland to natural regeneration of shrubby woodland

BBI = 45 x 18 = 810 x ha

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Appendix 1. Specifying management and assessment units

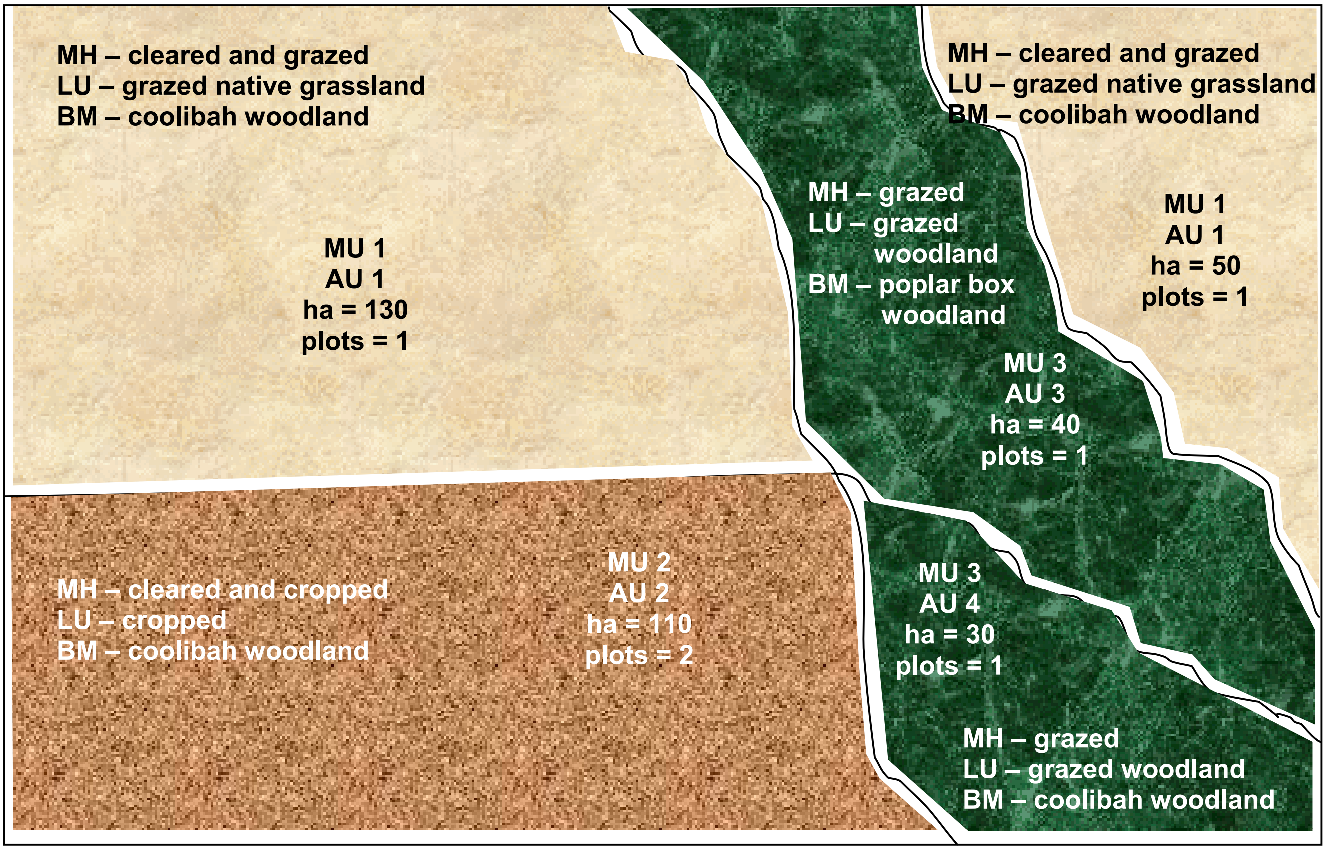
A management unit need not be contiguous but must:

1. have a similar management history (e.g. cleared and cropped opportunistically, cleared and grazed native pastures, or sporadically grazed woodland)
2. be identified to undergo the same land use change (e.g. conversion from cropping to deep rooted perennial pastures, or regeneration of native vegetation)
3. be identified to receive the same management inputs (e.g. fertilizer rates, domestic grazing pressure, erection of artificial hollows).

Within a management unit, separate assessment units are required where different *Vegetation Condition Benchmarks* apply. For example, if an area of sporadically grazed woodland contains two vegetation types that have different *Vegetation Condition Benchmarks*, two assessment units will be required (see Figure 2, MU 3).

In addition, where a single management unit is not contiguous and requires more than one survey plot, assessment units should be placed in each area (see Figure 2, MU 1).

Figure 2. Management Unit (MU) and Assessment Unit (AU) specification



MH = management history LU = current land use BM = Vegetation Condition Benchmark
ha = hectares Plots = minimum number of survey plots required

The number of plots required in each assessment unit is determined by the size of the assessment unit. As a guide one 20 x 20 m survey plot and associated belt transect is required for every 100 ha of assessment unit (see Figure 2), however, more intensive sampling is preferable but at the discretion of the assessor.

Appendix 2. Definitions of criteria and categories for conservation significance

John Benson Royal Botanic Gardens, Sydney (extract from version 1, 29/11/2000)

Geographic distribution

Geographic distribution of an ecological community can be considered in terms of 'extent of occurrence' and 'area of occupancy' in the sense defined in the IUCN (1999) Red List Criteria for species. Extent of occurrence (sometimes called range) is the total area contained within the shortest continuous boundary that can be drawn to encompass all the areas where the ecological community occurs. Area of occupancy is defined as the area within its extent of occurrence that is actually occupied by the community.

The distinction reflects the fact that a community will not usually occur throughout its extent of occurrence, which may for example, contain areas of unsuitable habitats. Area of occupancy is the more precise measure, but the size of the area of occupancy is a function of the scale at which it is measured, which should be relevant to the attributes of the particular community being considered.

It is important to demonstrate that the ecological community has declined to its current state from a defined former state, usually set at 1750 (onset of the Industrial Revolution and before European settlement of Australia).

Where possible, a measurable contraction in distribution should be demonstrated by an appropriate scale of mapping. Where it is not possible to provide precise spatial information on the distribution of an ecological community, particularly at the map scale available (e.g. a very narrow riparian ecosystem), other supporting evidence demonstrating a contraction in distribution may be considered.

Rate of continuing, detrimental change

The rate of continuing, detrimental change may be evidenced by:

- a rate of continuing decline in geographic distribution;
- a rate of continuing decline in a population of native species that is believed to play a major role in the community; or
- intensification across most of its geographic distribution, in degradation, or disruption of important community processes.

A continuing change refers to a recent, current or projected future change whose causes are either not known or not adequately controlled, and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normally count as a continuing change, but an observed change should not be considered to be part of a natural fluctuation unless there is evidence for this.

Changes:

1. **Very severe:** an observed, estimated, inferred or suspected detrimental change of at least 80% projected for the immediate future.
2. **Severe:** an observed, estimated, inferred or suspected detrimental change of at least 50% projected for the immediate future.

3. **Substantial:** an observed, estimated, inferred or suspected detrimental change of at least 30% projected for the immediate future.
4. **Minor:** an observed, estimated, inferred or suspected detrimental change of at least 10% projected for the immediate future.
5. **Insignificant:** an observed, estimated, inferred or suspected detrimental change of less than 5% projected for the immediate future.

‘Detrimental change’ may refer to points (1), (2), or (3).

Time scales**:**

- Immediate future: the next 10 years, or three generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 60 years.
- Near future: the next 20 years, or 5 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 100 years.
- Medium-term: the next 50 years, or within 10 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 100 years.
- Long-term: the next 100 years, or within 20 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 200 years.
- Very long term: the next 500 years, or within 50 generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 1000 years.

Appendix 3. Hypothetical vegetation condition benchmark for shrubby woodland in NSW

Modified from the EVC Benchmark 'Riverina Plains Grassy Woodland' within the Goldfields Biogeographic Region of the North Central Bush Tender Trial Area, NRE Victoria.

General description

Within the Goldfield Biogeographic Region *Riverina*, Plains Grassy Woodland is restricted to the alluvial plains of the upper reaches of the major rivers and their main tributaries. It is an open woodland of grey box *Eucalyptus microcarpa* with scattered stands of buloke *Allocasuarina luehmannii* and the occasional yellow box *Eucalyptus melliodora*. Remnants tend to have few if any shrubs, but it is thought that this community may have been fairly shrubby before European settlement. Grasses with an array of herbs, including several chenopods, dominate the ground layer.

Table 18. Richness benchmarks for a hypothetical shrubby woodland

Condition class	Very low	Low	Moderate	High	Very high
Condition score	**5**	**10**	**15**	**20**	**25**
Trees*	1	1	2–3	4	> 4
Shrubs*	1	2	3–4	5–6	> 6
Forbs*	1–2	3	4	4	> 4
Perennial grasses*	< 5	5–10	11–20	21–30	> 30
Other (geophytes)*	0	0	1	2	> 2

* Expected average richness per 20 x 20 plot

Table 19. Cover benchmarks for a hypothetical shrubby woodland

Condition class	Very low	Low	Moderate	High	Very high
Condition score	**4**	**8**	**12**	**16**	**20**
Trees	< 5	< 5	5–10, > 40	11–20, 31–40	21–30
Shrubs	< 5	< 5	5–15, > 70	16–30, 51–70	31–50
Forbs*	< 5	< 5	< 5, > 30	5–15	16–30
Perennial grasses*	< 15	15–30	31–50	51–70	> 70
Other (geophytes)*	0, > 20	0–1, 15–20	1–5, 10–15	5–10	5–10
Cryptogams*	< 5	< 5	5–15	16–30	> 30

* Expected average cover per 20 x 20 plot.

Highly threatening weeds:	*Avena spp., Bromus spp., Trifolium spp., Gynandriris setifolia, Poa bulbosa*
Recruitment	episodically driven (requires fire, approximate frequency = 15 yrs)
Large trees:	80 cm DBH; 8 per ha; mature tree height 10 m
Hollow-bearing trees:	16 per ha

Wood load:	150 m per ha
Litter:	5%.

Table 20. Botanical composition of the hypothetic shrubby woodland

Life-form	Common species
Trees	*Eucalyptus microcarpa, Allocasuarina luehmannii*
Shrubs—tall	*Acacia genistifolia, Acacia pycnantha, Bursaria spinosa, Cassinia arcuata*
Shrubs—short	*Acacia acinacea*
Perennial grasses—tussock	*Austrodanthonia caespitosa, Chloris truncata, Themeda australis, Enteropogon acicularis*
Forbs	*Vittadinia spp., Einadia hastata, Maireana enchylaenoides, Calotis anthemoides, Calocephalus citreus, Dichondra repens, Chenopodium desertorum ssp. microphylla, Crassula decumbens, Sida corrugata*

Appendix 4. Life-forms within each plant group, benchmarked for vegetation condition

Modified from Walker and Hopkins 1998.

Table 21. Life forms within each vegetation condition, benchmarked plant group

Vegetation condition benchmark group	Life-forms	Definition
Trees	tree	Woody plant > 4 m tall with a single stem or branches well above the base.
	tree—understorey	Woody plant 2–4 m tall with a single stem or branches well above the base.
	tree—mallee	Woody perennial plant, usually of the genus *Eucalyptus* and usually > 8 m tall. Multi-stemmed with fewer than 5 trunks of which at least 3 exceed 100 mm DBH.
Shrubs	shrub—tall	Woody plant, multi-stemmed at the base (or within 200 mm from the ground level) or, if single stemmed, it is less than 2 m tall but greater than 0.5 m tall.
	shrub—short	Woody plant, multi-stemmed at the base and less than 0.5 m tall.
	shrub—mallee	Woody perennial plant usually < 8 m tall. Multi-stemmed, with more than 5 trunks, at least 3 of the largest trunks do not exceed 100 mm DBH.
	shrub—chenopod	Xeromorphic (adapted to dry conditions) single or multi-stemmed plants exhibiting drought and salt-tolerance, of the family Chenopodiaceae.
Grasses	grass—hummock	Coarse xeromorphic grass with a mound-like form, often dead in the middle, of the genera *Triodia* and *Plectrachne*.
	grass—tussock	Forms discrete tussocks.
	grass—non tussock	Does not form discrete tussocks (e.g. most agricultural grasses).
Forb	forb	Herbaceous or slightly woody annual, or sometimes a perennial plant. Not grasses.
Other	sedge	Herbaceous, usually perennial, erect plant generally with a tufted habit and of the families Cyperaceae and Restionaceae.
	rush	Herbaceous, usually perennial, erect plant. Rushes are grouped in the families Juncaceae, Typhaceae, Restionaceae and the genus *Lomandra.*
	fern	Characterised by large and usually branched leaves (fronds), spores are carried in sporangia on leaves.
	vine	Climbing, twining, winding or sprawling plant usually with a woody stem.
	cycad	Includes members of the genus *Macrozamia*.

Vegetation condition benchmark group	Life-forms	Definition
	palm	Includes members of the family Arecaceae.
	xanthorrhoea	Includes members of the genus *Xanthorraceae*. For example the Australian grass tress.
	epiphyte	Plant living on the surface of another plant but not deriving water or nutrients from the host.
	parasite	Plant living on the surface of another plant and deriving water or nutrients from the host.
	geophyte	Plant with dormant parts (e.g. tubers, bulbs, rhizomes) underground.

Appendix 5. Field assessment: plot and belt transect location

Assessment of vegetation condition attributes is undertaken either within a *plot* or within a *belt transect*. Plot and transect location aims to provide data representative of the assessment unit. Random location techniques will achieve this goal provided enough plots are used. However, random location techniques take time and can result in sampling areas that are not representative of the assessment unit (e.g. small disturbances, such as vehicle tracks and gravel pits). Professional judgement should be used to ensure that the sample plots are representative of the assessment units. Plots and transects must be a minimum of 100 m from the edge of the assessment unit. For small assessment units (< 5 ha) plots and transects should be located centrally. Record the plot location with GPS derived co-ordinates and run out a 20 m tape.

At the *plot,* record data for the following attributes:

- richness of benchmarked plant groups (20 x 20 m)
- cover of benchmarked plant groups (20 x 20 m)
- recruitment (20 x 20 m)
- cover of weeds (20 x 20 m)
- cover of organic litter (20 x 20 m).

Some condition attributes are best assessed over a spatial scale larger than the plot due to low abundance or patchiness of attributes. These attributes are assessed along a belt transect. On completion of the first plot-based assessment, choose and record a bearing directed into the assessment unit and walk 100 m following this bearing. While walking the belt transect, the following attributes are recorded.

Along the *belt transect* record data for the following attributes:

- large trees (and tree health)
- hollow-bearing trees
- wood load.

The width of the belt transect is dependent on the density of the woody vegetation as this will determine how far into the vegetation good visibility persists. Three belt transect widths can be used depending on visibility:

- 100 m when there is 50 m of good visibility on both sides of the 100 m transect; area = 1.0 ha (multiply by 1)
- 50 m when there is 25 m of good visibility on both sides of the 100 m transect; area = 0.5 ha (multiply by 2)
- 20 m when there is 10 m of good visibility on both sides of the 100 m transect; area = 0.2 ha (multiply by 5).

At the end of this 100 m transect, and if a second plot is required, record the location with GPS derived coordinates as *plot 2* and run out a 20 m tape from this point following the same bearing as walked. Continue the process until sufficient plots and belt transects have been sampled.