Biodiversity Benefits of Commercial Environmental Forestry

The Plantation Biodiversity Score

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Executive Summary

Within CSIRO Forestry and Forest Products, the Commercial Environmental Forestry Program is developing a Scenario Planning and Investment Framework (SPIF), an integrated modelling tool for the assessment of the hydrological, forest productivity and economic performance of alternative forestry designs, at the scales of sub-catchment, or 'landscape scale', and of individual management units within sub-catchments, or 'site scale'. There is also a need to develop, within SPIF, the capability to assess the potential benefits to biodiversity of various forestry designs.

This report presents the latest version of the Plantation Biodiversity Score, adapted from the draft version in the Milestone 4 report (Cawsey and Freudenberger 2005c) after feedback from stakeholders (Appendix 1).

The Plantation Biodiversity Score is simply a raw index of potential biodiversity benefit for a plantation, based on the design themes and principles and the management guidelines from Salt et al. (2004), a book which provides a comprehensive guide describing how farm forestry plantings on farms might be designed and managed to benefit native biota. The components of the Plantation Biodiversity Score are summarised in Table 1.

Table 1 The components of the Plantation Biodiversity Score and their weightings.

Site-Scale Components	Maximum value
Incorporate paddock trees	10
Site preparation	10
Preserving biological legacies	10
Install artificial hollows	5
Thinning and pruning	5
Rotation times	5
Mosaics: mixed age stands	5
Mixed plantings	5
Planting with local species	5
Control escapees	5
Control weeds	5
Control animal pests	5
Total Plantation Biodiversity Score at the site scale	**75**
Landscape-Scale Components	**Maximum value**
Landscape connectivity	15
Plantation width	10
Total Plantation Biodiversity Score at the site scale	**25**
Total Plantation Biodiversity Score	**100**

The Plantation Biodiversity Score is not linked to specific policy. It simply assesses the potential and relative biodiversity benefits of plantations. It does not assess whether the plantation meets all state assessment requirements. The Plantation Biodiversity Score assumes that all state-regulated requirements with regard to codes-of-practice, clearing assessments, duty of care etc. have been fulfilled.

The next step should be a series of field trials of the prototype Plantation Biodiversity Score method, over a range of different plantation types. This will lead to further modification, resulting in a more robust version of the Plantation Biodiversity Score method which will be explicit and repeatable, yet practical and flexible to meet users' needs.

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Chapter 1 Introduction

Background

Within CSIRO Forestry and Forest Products, the Commercial Environmental Forestry Program is developing a Scenario Planning and Investment Framework (SPIF), an integrated modelling tool for the assessment of the hydrological, forest productivity and economic performance of alternative forestry designs, at the scales of sub-catchment, or 'landscape scale', and of individual management units within sub-catchments, or 'site scale'. There is also a need to develop, within SPIF, the capability to assess the potential benefits to biodiversity of various forestry designs.

Approaches to landscape design

There are two fundamental approaches to landscape design:

1. Optimisation of 'top-down' allocation of land uses (e.g. Wilson et al. 2003, Ive and Nicholls 2001); and
2. Assessment and subsequent refinement of 'bottom-up' proposals for alternative land uses (e.g. Parkes et al. 2003, Oliver and Parkes 2003, Gibbons et al. 2004 and Salt et al. 2004 *sensu latu*).

The proposed approach for this research project is the second; assessment and refinement rather than optimisation. This latter approach will be taken because:

1. function takes priority over biodiversity, that is improving the hydrological balance to reduce salinity is fundamental to conserving biodiversity;
2. this project is focused on agricultural landscapes entirely dominated by thousands of individual land titles where 'top-down' land use designs are indicative visions at best and more often antagonistic to key stakeholders; and
3. many elements of plantation design occur at a scale or pertain to features that cannot be mapped or predicted spatially.

The current project will be based on the application of an existing method of assessing biodiversity benefits.

The project

CSIRO Sustainable Ecosystem (CSE) has assisted CSIRO Forestry and Forest Products (CFFP) by developing a biodiversity assessment capability which can be integrated with Farm-Scale SPIF and its GIS modelling platform. The biodiversity module has the capability to assess (i.e. score) plantations according to the fundamental design and management principles that drive biodiversity values of agroforestry plantations (Salt et al. 2004). Clients for this integrated and comprehensive assessment capability are Catchment Management Authorities (CMAs) seeking to prioritise their investment in improved natural resource management, as well as private foresters examining ways to improve the mix of commercial and non-commercials goods and services that could be derived from alternative forestry plans.

In consultation with our collaborators, Bob McCormack and Gavan Thomas from CFFP, we designed this project with the objective to:

> *Develop a capability to assess the potential biodiversity benefits of agroforestry designs which can be integrated into a system that also assesses the economic potential (production) and hydrological function services of forestry designs.*

We have addressed this objective through the following tasks:

1. Review of approaches and methods to assess/model the biodiversity benefits of native vegetation and assess their applicability to the assessment of the value to biodiversity of commercial environmental forestry revegetation proposals;
2. Based upon one or more of these approaches, develop a draft assessment method and a worked example of the draft method;
3. Test the suitability of the biodiversity assessment capability through a 'fit for purpose' assessment by stakeholders; and
4. Modify the draft method on the basis of stakeholder feedback, producing a prototype Plantation Biodiversity Score suitable for incorporation into Farm-scale SPIF.

Framework for the assessment of biodiversity benefits

The variables relevant to the assessment of biodiversity benefits depend on the scale of the analysis. Some variables are only relevant at particular scales. Freudenberger and Harvey (2003) have developed a table which is convenient for examining the relevance of variables at different scales, for the assessment of biodiversity benefits (Table 2).

Table 2 The relationships between geomorphic/geographic, ecological, institutional scales and management units (after Freudenberger and Harvey 2003).

DEFINING SCALE					
Geomorphic/ Geographic	**Biological**	**Institutional / Jurisdictional**	**Management Unit**		**Term used here**
Micro (μm^2-m^2)	Genes and individual organisms,	Crown (State & Commonwealth) e.g. protected species			
Slope (Catena) (1-1000ha)	Patch or population	Individuals (e.g. Farmers) some agencies (e.g. State Forests)	Paddock, Forest coup		**Site**
Landscape/ Subcatchment (100 - 1000ha)	Communities and some ecosystems	Local Government, Community groups (e.g. Landcare), some State Agencies	Farms, Forest blocks, National Parks		**Landscape**
Catchment (1000 - millions km^2)	Biomes, some ecosystems, threatened species	Regional Associations (e.g. MDBC), Catchment Management Boards, Local Government	Catchment		**Region**
Continental/ Transcontinental	Threatened species	States, Commonwealth Government and International Treaties			**National**

The scale of the process

The SPIF approach is described in McCormack et al. (2004). Figure 3 in McCormack et al. (2003) illustrates the structure of the Scenario Planning and Support Tool. This tool is designed to assess the benefits of designs for commercial environmental forestry tenders.

The SPIF process operates in a spatial (GIS) environment, using spreadsheet data to augment the assessment processes. Farm-scale SPIF operates from the paddock or site scale, the 1:100,000 or landscape scale and the regional scale.

For this project, the assessment of the potential biodiversity benefits of commercial environmental forestry focuses at the site and landscape scales, not on the regional scale. This is because commercial environmental forestry proposals will be located within a given region on the basis of commercial (i.e. tree productivity) and hydrological criteria. Once located within a sub-catchment, the Plantation Biodiversity Score can be used to assess, and perhaps modify, a forestry design within a landscape context.

Chapter 2 Review of existing methods for the assessment of biodiversity benefits

There are three possible approaches to assessing the biodiversity benefits of commercial forestry; 1. the use/adaptation of an existing assessment system developed specifically for native vegetation (both remnants and plantings); 2. the use of the only pre-existing assessment method for plantations; and 3) the development of a new assessment system based on a recent and comprehensive guide which describes how farm forestry plantings on farms might be designed and managed to benefit native biota. We review these approaches in this order.

Biodiversity values of native vegetation

All existing explicit methods for assessment/scoring of biodiversity benefits of native vegetation in Australia have their origin in the 'Habitat Hectares' approach of Parkes et al. (2003), which was developed for use in Victoria. This method has been further adapted by Oliver and Parkes (2003) and by Gibbons et al. (2004) for application in NSW. Table 3 (equivalent to Table 1 from Parkes et al. 2003) presents the components of the 'Habitat Hectares' score.

Table 3 Components and weightings of the habitat score from Parkes et al. (2003) Table 1.

	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.

The original 'Habitat Hectares' approach (Parkes et al. 2003) has been applied to the assessment of existing vegetation on a site/stand-based appraisal of current conditions. The 'Habitat Hectares' approach is based upon the assumption that there are structural and compositional indicators of biodiversity. The Parks et al. (2003) components of 'site condition' (see Table 3), except composition, weediness and recruitment, relate closely to the habitat score originally developed by Newsome and Catling (1979), which they used to assess the suitability of habitat for small ground-dwelling mammals. Variants of the Newsome and Catling habitat score have since been shown to be very useful for prediction of the presence of these mammals in tracts of forests and woodlands in south-eastern Australia (Catling and Burt 1995, Coops and Catling 2002). Watson et al. (2001) found this simple scoring system to be a useful predictor for the presence of woodland birds. These studies support Parkes et al. (2003) in their adoption of a similar scoring system to assess the biodiversity value at the stand level.

The 'Habitat Hectares' approach relies on benchmarks. In Victoria, the benchmarks are derived from the standards for the Ecological Vegetation Class (EVC) for each Bioregion. The EVC is the principal unit for vegetation circumscription and mapping for land-use planning and management in Victoria. Also EVCs represent the only comprehensive vegetation mapping in Victoria. The method has been adapted and is being tested in the Victorian *BushTender Mark II* process to assess the potential gains from some kind of activity intended to enhance or maintain the biodiversity values of a piece of land. Theoretically this could apply to cleared land as well as a patch of native bushland.

The original 'Habitat Hectares' approach of Parkes et al. (2003) was adapted by Oliver and Parkes (2003) for New South Wales although their Biodiversity Benefits Index has not been implemented.

McElhinny (2002) has produced an extensive review of the important elements of forest and woodland structure for biodiversity. His work has been used in the ***BioMetric*** method of Gibbons et al. (2004) is also based on an adaptation of the Parkes et al. (2003) 'Habitat Hectares' approach. The ***BioMetric*** method uses benchmarks derived specifically for NSW, and is currently being tested for use in New South Wales. The ***BioMetric*** decision support tool is designed to assess losses of biodiversity from proposed clearing, gains from proposed offsets and gains from management actions proposed for incentives. ***BioMetric*** is designed specifically to deal with the legislative requirements extant in New South Wales. ***BioMetric*** can be applied to cleared land as well as a patch of native bushland; it is also possible to predict the pre-European vegetation type in NSW. ***BioMetric*** explicitly includes the concept of *regional significance*. Like the Parkes et al. (2003) method, it is reliant on physical site inspections for the collection of the data necessary to form part of the assessment.

The 'Habitat Hectares' approach addresses biodiversity benefits assessment at three scales; the site, landscape and regional scales. Of the papers reviewed, only four (Parkes et al. 2003, Oliver and Parkes 2003, Gibbons et al. 2004 and Newell et al. 2004) address site-scale variables measured in an assessment of biodiversity value.

In general, the GIS applications of the 'Habitat Hectares' approach (Ferwerda 2003 and Shelton et al. 2004) have concentrated only on the landscape scale, in the absence of specific site-scale spatial data layers.

Recently Newell et al. (2004) have produced a statistical model of vegetation condition (site scale data), based on habitat hectare assessments from 3449 sites in Northern Victoria, from which they have derived 5 condition states necessary to assess the site-scale components of the 'Habitat Hectares' method (i.e. 75% of the habitat hectare score). The remaining 25% of the score from the landscape context scale was derived using the spatial methods based on Ferwerda (2003). This vegetation condition map applies to the existing native vegetation cover in northern Victoria. The usefulness of this method in the present context is questionable at this point in the project. As the components addressed by Newell et al. (2004) are the same as those from Parkes et al. (2003) this work will not be treated separately for the purposes of this report.

Biodiversity benefits for agroforestry plantations

There exists one scoring method devised for the assessment of biodiversity benefits of plantations in South Australia (New and England 2002). Rather than explicitly scoring the potential biodiversity benefits which might be derived from specific management activities, this method scores a farm forestry design under three headings, 1. Farm Forestry Design; 2. Remnant Vegetation and Revegetation; and 3. General, and provides a diagnosis of the 'condition' of the forestry design based on increments in the final score achieved. Table 4 presents this scoring method.

Table 4 The 'Biodiversity Value' scoring method from New and England (2002).

Farm Forestry Design			
Positive Features	√	**Negative features**	X
Patchiness of planting – e.g. mixed age of forestry blocks and staggered harvest planned		Monoculture of one farm forestry species **greater than 10 ha**	
Patchiness of forestry planting through using variety of forestry species		Monoculture of one farm forestry species **greater than 20 ha**	
Local understorey revegetated/recolonised under farm forestry		Bushlands weeds present	
Local tree species grown for farm forestry		Non local species used	
Remnant Vegetation and Revegetation			
Positive Features	√	**Negative features**	X
Remnant vegetation/revegetation present		Livestock have access to remnant vegetation/revegetation	
Blocks of remnant vegetation/revegetation present, **greater than 5 ha**		Die back due to salinity or soil diseases	
Blocks of remnant vegetation/revegetation present, **greater than 5 ha**		Remnant vegetation damaged by forestry activities	
All remnant vegetation and revegetation protected from livestock – e.g. fenced, not running stock		Bushland weeds present in remnant vegetation and revegetation	
Range of remnant vegetation associations represented across property		Bushland weeds present in remnant vegetation and revegetation	
General			
Positive Features	√	**Negative features**	X
Boundary fences in good repair		Weedicide damage to native and forestry plants	
Branches, leaf and twig material on the ground in farm forestry, remnant and revegetated areas		Signs of human impact – litter, rubbish, tracks, trampling	
Remnant vegetation, revegetation and forestry linked across property		Rabbits present	
Remnant vegetation, revegetation and forestry linked across property		Signs of feral foxes and/or cats	
Remnant vegetation, revegetation and forestry free of weeds		Unnatural soil erosion event	
Score 5 points for every tick and **Deduct** 2 points for every cross		**Maximum Score possible = 70 points**	

An important aspect of the New and England (2002) scoring method is that it not only rewards positive features of a farm forestry design but also penalises negative features by deducting points. In effect, this means that two different farm forestry designs could conceivably achieve precisely the same score value where one design scored only positive values and the other scored a mixture of positive and negative values. The implication of this is that this scoring system might not be appropriate for comparing the relative benefits of two or more commercial environmental forestry proposals i.e. by comparing final gross score values. The only way a comparison between proposals could be assessed would be by comparing the scores for the positive and negative features separately.

Another facet of this method is that more than a third of the biodiversity assessment score comes from assessment of the native vegetation components of the farm forestry design.

However, it is clear that this method operates across site and landscape scales, and that it does address important ecological principles which are likely to increase the biodiversity benefits of plantations.

The most recent and comprehensive publication which provides simple guidelines for improving the biodiversity benefits of farm forestry designs is *Trees and Biodiversity* (Salt et al. 2004). In Chapter 2, Salt et al. (2004) argue that farm forestry can enhance biodiversity by addressing a set of design principles, grouped under 5 themes. Table 5 relates these design principles to the site and landscape scales.

Table 5 The farm forestry design principles from Salt et al. (2004), related to the scale at which these principles operate.

Scale	Theme	Design Principle
Site	Composition	• Mix of species • Local species
	Complexity	• Structure • Time and age • Patchiness
	Ecological management	• Monitoring of biodiversity • Adaptive management • Simulating natural processes • Variability in management actions • Weed control
Landscape	Location	• Adjacency • Connectivity • Landscape context • Protection of waterways
	Configuration	• Size of plantings • Shape of plantings

These design principles are based on basic ecological principles relevant to an 'unmodified native forest', unconstrained by the precise species composition and configuration of the original native vegetation which used to occupy the site. Although biodiversity values set against the standards for an unmodified native forest may not be generally applicable across the range of environments, i.e. Ecological Vegetation Classes, where commercial environmental forestry plantations are likely to be implemented, the basic ecological principles inherent in the Salt et al. (2004) guidelines provide a useful generalisation for the improvement of biodiversity value of a managed commercial forest. Even though the original native vegetation on any given site may not have been forest in the first place, the final management goal of commercial environmental forestry will be to produce a forest of sorts. On this basis, it is only relevant to improve the biodiversity value in the forest context as opposed to any other benchmark.

Any method of assessing the biodiversity benefits of commercial environmental forestry plantations should be capable of assessing forestry proposals across the five themes of Salt et al. (2004). It can be seen that the method devised by New and England (2002) also generally addresses the Salt et al. (2004) design themes and principles, although it is less structured by scale in its presentation.

Scale

The different scales of assessment of biodiversity benefits present different issues when considering them for incorporation into the SPIF process.

The site scale

The original 'Habitat Hectares' approach (Parkes et al. 2003), was developed specifically in the Victorian land management and legislative context. It was designed to assess the current *quality, condition or status* of a stand of native vegetation or habitat, in relation to benchmark data collected from (relatively) undisturbed examples of vegetation from the same EVC in the same Bioregion. Parkes et al. (2003) based their first level of assessment upon site condition at the stand level (i.e. site scale). This is used to assess the retention of appropriate characteristics within a site against the appropriate benchmarks.

Oliver and Parkes (2003) built further upon the components for the assessment of vegetation condition, equivalent to the Parkes et al. (2003) site condition components.

Gibbons et al. (2004) adapted the approach of Parkes et al. (2003) to cope with the very different data availability and legislative frameworks extant in New South Wales, implemented within the ***BioMetric*** Decision Support Tool, a Microsoft ™ Excel-based tool which uses very similar components for the assessment of vegetation condition at the site scale.

Table 6 compares and contrasts the site-scale components from the three methods which are based on 'Habitat Hectares'.

Table 6 Site-scale components for the assessment of biodiversity benefits from the three related methods.

Parkes et al. 2003	Oliver and Parkes 2003	Gibbons et al. 2004
large trees	cover or density of large trees	native over-storey cover
tree canopy cover	cover of benchmarked plant groups	native over-storey cover
cover of plant life forms	cover of benchmarked plant life forms	• native ground cover (shrubs) • native ground cover (grasses) • native ground cover (other)
weediness	cover or density of weeds	exotic plant cover
recruitment	cover or density of recruitment	number of overstorey species occurring as recruitment
litter	cover or density of organic litter	organic litter cover derived from other measurements
logs	cover or density of wood load	total length of fallen logs
richness of plant life forms	richness of benchmarked plant groups	native plant species richness
-	hollow-bearing trees	number of trees with hollows
-	-	native mid-storey cover
-	-	percent bare ground derived from other measurements

These components address the site-scale issues of plant species composition, habitat complexity and some elements of function; that is, vegetation condition (Table 3). The desired state in terms of the values applied to the components depends on the benchmark for the Ecological Vegetation Community in the bioregion of concern in Victoria and to the benchmarks developed by Gibbons et al. (2004) in New South Wales. For example, an area which was originally a native grassland would not score highly in an assessment of a plan which intended to enhance/replace it with closely spaced large trees with an extensive shrub understorey.

In the philosophy of the 'Habitat Hectares' approach, biodiversity benefits for vegetation condition cannot be scored for either species composition or habitat complexity in isolation. Native species provide unique structures that exotic species generally do not. For example, Box Eucalypts provide hollows in time whereas exotic pines do not. However, the 'Habitat Hectares' approach suggests that a canopy made up of non-indigenous species can be scored if it is considered to be functionally similar.

The site-scale design principles from the Salt et al. (2004) (Table 5) components do not map to the methods based upon the 'Habitat Hectares' approach and thus we have not attempted to place them into Table 6. Neither have we attempted to equate the New and England (2002) features to either the 'Habitat Hectares' method or the Salt et al. (2004) approach, although it is clear that the structure of the Salt et al. (2004) framework encompasses the intentions of New and England (2002).

The landscape scale

The GIS applications of the 'Habitat Hectares' approach (Ferwerda 2003 and Shelton et al. 2004) have concentrated on the landscape scale, in the absence of specific site-scale spatial data layers. Newell et al. (2004) have also applied a method based on Ferwerda (2003).

Ferwerda (2003) developed a method of automated assessment of landscape context i.e. the landscape scale components of the habitat hectare score of Parkes et al. (2003), in a GIS environment. Shelton et al. (2004) have also assessed some of these landscape scale components in a GIS environment. Table 7 shows the components assessed by each study.

Table 7 Landscape scale components for the assessment of biodiversity benefits from the two related methods.

Ferwerda (2003)	Shelton et al. (2004)
patch size	patch size
patch shape	-
amount of surrounding vegetation	amount of surrounding vegetation
connectivity between patches	-
proximity to core area	distance to core area

As demonstrated by Ferwerda (2003), Shelton et al. (2004) and Newell et al. (2004), the landscape scale components of the 'Habitat Hectares' approach are the most amenable to application in an automated geospatial environment like the SPIF GIS.

The landscape-scale design principles from the Salt et al. (2004) (Table 5) do not map neatly against the components of the 'Habitat Hectares' approach and thus cannot be directly compared with them. Again, the Salt et al. (2004) landscape-scale components generally encompass the relevant features of the New and England (2002) approach.

The regional scale

The concept of *conservation significance* (see Oliver and Parkes 2003) is used to estimate the biodiversity value of a patch of vegetation at the regional scale. The level of conservation significance depends on the rarity or otherwise of the benchmark vegetation type (e.g. EVC) in the landscape across a given region (e.g. bioregion). A rare vegetation type will receive a higher score for conservation significance that a more common type.

As a commercial environmental forestry plantation would be unlikely to attempt to reproduce the benchmark vegetation type, it would have no regional conservation significance at all, and a score for the regional scale component would be effectively zero unless conservation plantings are included as part of the overall plantation design.

The New and England (2002) approach does address the regional scale, by rewarding farm forestry designs where 'remnant vegetation, revegetation and forestry' are 'linked regionally'. However, they do not provide explicit method of assessing spatial linkages.

Discussion

The 'Habitat Hectares' approach originated by Parkes et al. (2003) is designed specifically for the data and legislative requirements in Victoria. Methods for the automated assessment of the landscape scale components 'Habitat Hectares' have already been implemented for the *BushTender Mark II* approach. The method also forms the basis for the Gibbons et al. (2003) method which is in the process of being implemented in New South Wales.

McCarthy et al. (2004) have made four principle criticisms of the 'Habitat Hectares' approach described in Parkes et al. (2003). They were i) that measurement differences between operators lead to errors; ii) that comparison with a single benchmark does not accommodate different disturbance regimes; iii) that the combination of attributes lead to internal inconsistencies within the final score; and iv) that it was not clear how the method was to be used in practice. They suggest ways in which they believe that 'Habitat Hectares' might be improved.

In reply, Parkes et al. (2004) point out that the intention of 'Habitat Hectares' was not to provide an accurate and precise assessment of site characteristics, but to provide the capability for rapid assessment of vegetation 'condition', in a general sense, and to make it possible to contrast different sites, vegetation types and condition states through a practical and relatively simple tool. This intention would also apply to all of the biodiversity assessment methods based upon 'Habitat Hectares'. Further, the method has now been put into practice in two States, ('Habitat Hectares' in Victoria and ***BioMetric*** in NSW), and the practicality of the method has therefore been demonstrated in the field.

This project also requires a simple tool which makes it possible to contrast different sites (i.e. commercial environmental forestry proposals) and which can be readily adapted to the operating environment of the SPIF. The requirements of a biodiversity benefits assessment of a commercial environmental forestry proposal requires that the biodiversity benefits of each discrete vegetation management unit i.e. contiguous area of vegetation which will be subjected to the same management regime, whether of native or plantation vegetation, be assessed separately. Figure 1 diagrammatically presents the possible vegetation management units of a hypothetical commercial environmental forestry proposal.

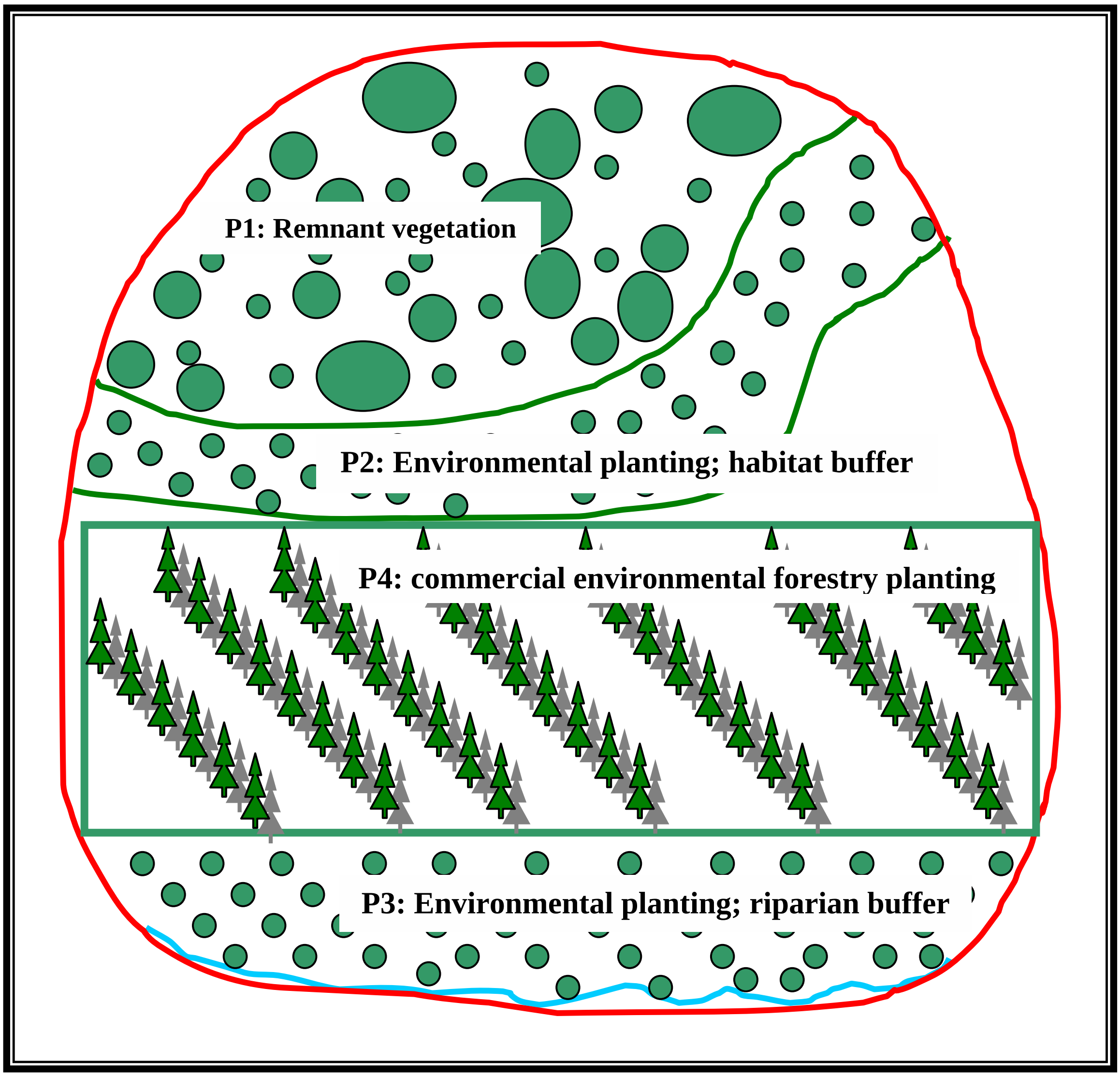

Figure 1 The vegetation management units of a hypothetical commercial environmental forestry proposal.

Each patch in Figure 1 represents a different vegetation management unit of a commercial environmental forestry proposal. There are four hypothetical vegetation management units, represented by patches in the illustration. P1 represents an existing native vegetation remnant which will be managed for enhancement (e.g. livestock fenced out), P2 represents a native habitat buffer, P3 is a patch representing a native riparian buffer and P4 represents the actual commercial environmental forestry plantation. The different sizes, vegetation compositions and management regimes of each patch will lead to different biodiversity benefit outcomes for each.

At the outset it was our intention to apply a single metric for the assessment of biodiversity benefits to all vegetation management units comprising a commercial environmental forestry proposal, be they of native or plantation vegetation type. We had intended to choose an existing scoring system and adapt it to deal with plantations as well as with native vegetation, taking into account the design themes and principles of Salt et al. (2004). However, after discussions with David Parkes and James Todd (Victorian Department of Sustainability and Environment), Tim Barlow (Goulburn Broken Catchment Management Authority) and Phil Gibbons (NSW Department of Environment and Conservation) it became clear that there are significant legislative and data-incompatibility constraints to applying a single metric to native vegetation in different Australian States.

With regard to legislation, 'Habitat Hectares' which has been made operational in Victoria for BushTender Mark II has been designed around the legislation and policy extant in Victoria, and, as such, does not meet the legislative and policy requirements in NSW. The converse is also true for the ***BioMetric*** method, which meets the legislative and policy requirements for NSW and not for Victoria.

In addition, the data for benchmarking required for the version of 'Habitat Hectares' which has been made operational in Victoria for *BushTender Mark II*, are not available in the same format for NSW, so 'Habitat Hectares' in it's current form cannot be applied in NSW. Likewise, the data and benchmarks required for ***BioMetric*** are not available in the appropriate form for Victoria, so ***BioMetric*** cannot readily be applied in Victoria at this time.

New and England (2002) provide a hybrid method which scores the biodiversity benefits of both native and plantation vegetation components of a farm forestry design. While it is clear that the ecological principles inherent in the part of their score pertaining to plantation vegetation are also encompassed by the Salt et al. (2002) approach, their method for scoring native vegetation is clearly not as comprehensive or explicit as any of the methods derived from the 'Habitat Hectares' method of Parkes et al. (2003). Further, there are inherent problems in the structure of their scoring system which would make it difficult to compare the relative biodiversity benefits of two or more farm forestry designs, for both native and plantation vegetation.

Salt et al. (2004) present a different approach, providing more general ecological design principles which might be followed to enhance the attributes of a plantation from a biodiversity viewpoint, without the requirement to attempt to exactly reproduce the original native conditions. These design principles are based on basic ecological principles, unconstrained by the precise species composition and configuration of the original native vegetation which used to occupy the site. The Salt et al. (2004) design themes and principles could be used to devise a generic method which is not inextricably linked to legislation and/or policy. Such a method could start from the premise that all state-regulated requirements with regard to codes of practice, clearing assessment, duty-of-care etc. have already been fulfilled.

The aim of this project was to produce a generic method, which could be applied to any plantation anywhere in Australia, regardless of policy, legislation and specific benchmarking data requirements. For this reason, it was not appropriate to attempt to adapt either or both of the 'Habitat Hectares' or the ***BioMetric*** methods for generic application. Therefore we concluded that a more useful approach would be to assess the native vegetation managements units of a commercial environmental forestry design to be scored using a method acceptable to the State in which the proposal was located and that we should develop a separate biodiversity assessment system specifically for commercial plantings.

The issue of comparing the relative biodiversity benefits derived from native vegetation patches on one hand and plantations on the other could be addressed by the use of a 'benefits profile', illustrated in Figure 2. Figure 2 shows how the relative benefits of two (or more) commercial environmental forestry proposals might be logically compared, without attempting to directly equate the biodiversity benefits of native vegetation against those of a plantation. Figure 2 also demonstrates a possible approach to comparing all environmental benefits which might be derived from commercial environmental forestry proposals, i.e. not only the biodiversity benefits, but those accruing from production, water yield and salinity. This approach avoids the dangers inherent in a single 'environmental index', in which the relative benefits derived from any given component of the index (e.g. water yield, native habitat, plantation habitat etc.) would be subsumed by the value of the index as a whole. A benefits profile allows the benefits for each component to be explicitly examined, while still allowing 'assessment at a glance' of the overall benefits likely to accrue from a single commercial environmental forestry proposal, or the comparison of the relative benefits from two or more commercial environmental forestry proposals.

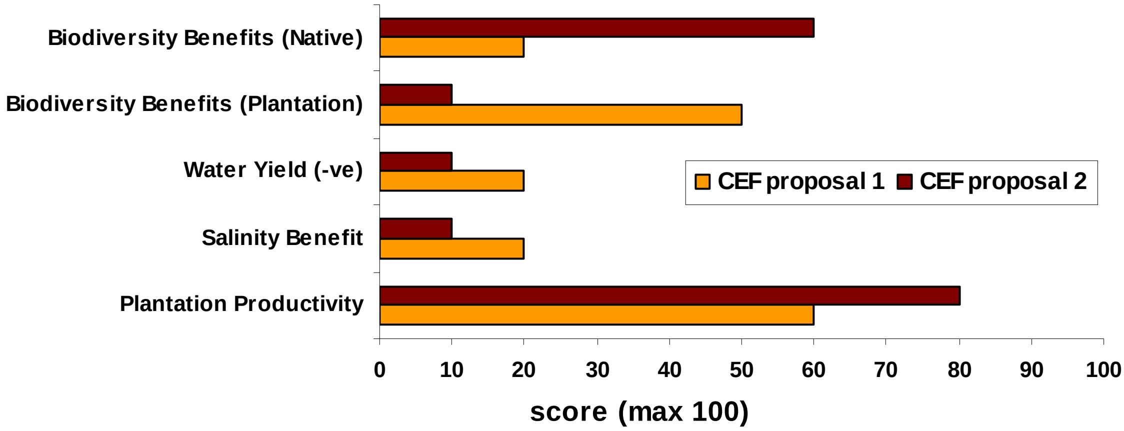

Figure 2 Hypothetical benefits profile for two commercial environmental forestry proposals. The scoring of the biodiversity benefits of native vegetation would be scored using existing State systems (e.g. 'Habitat Hectares' or *BioMetric*). The other benefits would be assessed with the SPIF modelling tool set.

Conclusions

The primary study area for the development of the SPIF tool is the Goulburn Broken Catchment in Victoria. The 'Habitat Hectares' approach has already been implemented for *BushTender Mark II*. Therefore, we decided that the 'Habitat Hectares' approach should be applied to the native habitat plantings or enhancements which form part of a commercial environmental forestry proposal (e.g. P1, P2, P3 in Figure 1), while devising a separate assessment method for the plantation vegetation management units of the commercial environmental forestry proposal (e.g. P4 in Figure 1), based upon the design themes and principles put forward by Salt et al. (2004), in the form of a Plantation Biodiversity Score.

Should the focus of the SPIF be redirected to areas of NSW for future applications, the ***BioMetric*** tool could be used to assess the biodiversity benefits of the native vegetation management units of a commercial environmental forestry proposal, with the Plantation Biodiversity Score supplying the biodiversity benefits assessment for the plantation vegetation management units, as in Victoria.

Comparison of the relative native vegetation biodiversity values for commercial environmental forestry proposals from different states (i.e. Victoria and NSW) should be feasible. The values are based on different benchmarks and are achieved in slightly different ways, but the components of each method are much the same and have the same weightings.

However, there are as yet no explicit methods for scoring the biodiversity benefits of native vegetation in the other Australian States or the Territories, although the ***BioMetric*** tool should be adequate for the Australian Capital Territory. Tasmania is currently developing a method based directly upon the 'Habitat Hectares' approach. Queensland is developing a method (***Biocondition***) which, like 'Habitat Hectares' addresses site attributes and is based upon benchmarks. South Australia is in the process of developing a method but it is not clear yet whether this method will be based upon benchmarks. Until these methods are finalised, it will impossible to calculate and compare the biodiversity benefits for native vegetation outside the borders of Victoria and NSW (including the ACT), although use of the Plantation Biodiversity Score as proposed will allow comparison of the biodiversity benefits of plantations anywhere in Australia.

The next step was to develop a draft scoring method for a Plantation Biodiversity Score from the Salt et al. (2004) design themes, principles and management guidelines, with reference to the 'Habitat Hectares' method of Parkes et al. (2003), which guided us as to the general approach to how a scoring system should be designed.

Chapter 3 The Plantation Biodiversity Score *Mark I*

This section describes the methods employed to develop a draft approach for calculating a Plantation Biodiversity Score .

Methods

The Plantation Biodiversity Score is calculated within the framework defined by the agroforestry design themes and principles and the agroforestry guidelines of Salt et al. (2004; *Trees and biodiversity: A guide for Australian farm forestry*).

We tabulated the design themes and principles from Salt et al. (2004), Chapter 2, pages 38-39. Salt et al. (2004) Chapter 3 lists management guidelines and suggests concrete and practical ways to comply with the design themes and principles. We mapped these management guidelines from Chapter 3 against the design themes and principles from Chapter 2. We then assessed which of the design themes and principles operated at site scale and which operated at the landscape scale.

We then derived explicit criteria, related to specific management activities, which could be scored against each management guideline, generating the Plantation Biodiversity Score *Mark 1*. Finally, we produced a 'manual' describing each component of the score in detail, providing the rationale behind a) each component of the score and b) the relative weightings placed against each of the criteria within each component. We also prepared a PowerPoint presentation which, in conjunction with the manual, could be used to coach stakeholders through an explanation of the scoring method.

The following sections summarise the final scores at each scale of the exercise. Appendix 1 presents the manual for the first draft of the Plantation Biodiversity Score Method, as it was presented to stakeholders for their assessment and feedback (see next Chapter). Refer to Appendix 1 for a complete description of the Plantation Biodiversity Score *Mark I*. We do not include this version in the text of the report to avoid confusion, because the final prototype of the Plantation Biodiversity Score is presented in the text (Chapter 5) and represents a substantial modification of the Plantation Biodiversity Score *Mark I*.

Site-scale components

The site-scale components of the Plantation Biodiversity Score, equivalent to the Salt et al. (2004) 'management guidelines' for agroforestry, are summarised in Table 8. In this table, management guidelines numbers (MG2-MG10) show the order in which they are presented on Salt et al. (2004) page 108, although they appear in the table and in the following descriptive sections in the order in which they are presented in the table.

Table 8 The juxtaposition of the Salt et al. (2004) site-scale themes and design principles with their relevant site-scale management guidelines.

Theme	Design Principle	Management Guideline (= Component of the Plantation Biodiversity Score *Mark I* Score)	Max value (%)
Composition	Mix of species	1. Mixed plantings (MG5)	5
	Local species	2. Planting with local species (MG6)	5
Complexity	Structure	3. Incorporate remnant trees (MG2)	15
		4. Install artificial hollows (nest boxes) (MG4)	5
		5. Site preparation (MG8; includes MG7; protection of waterways)	10
		6. Thinning and pruning (MG9)	5
		7. Preserving biological legacies (MG10 - harvesting)	5
	Time and age	8. Rotation times (MG10 - harvesting)	5
	Patchiness	9. Mixed age stands, connectivity (MG10 - harvesting)	5
Ecological Management	Weed control	10. Control escapees (MG11)	5
		11. Control weeds (MG12)	5
		12. Control animal pests (MG11)	5
		Total Plantation Biodiversity Score at the site scale	**75**

Note that management guideline 1 (Incorporating remnant patches in plantations) is not relevant to the Plantation Biodiversity Score; the biodiversity benefits of any patch of native vegetation would be scored by the 'Habitat Hectares' method in Victoria or the ***BioMetric*** method in NSW, not the Plantation Biodiversity Score method. Also, guideline 3 (increasing structural complexity of a plantation) is encompassed by the other guidelines under the structure and complexity themes.

Management guideline 7 (Site Location) is encompassed by the landscape-scale components of the Plantation Biodiversity Score methods except with regard to the protection of waterways, which for the purposes of the Plantation Biodiversity Score we have dealt with under the site-scale management guideline 5 (Site Preparation), where it appears to fit more logically.

Landscape-scale components

The Salt et al. (2004) design principles under the Location and Configuration themes were allocated to the landscape scale, except the principle 'protection of waterways' which was dealt with under site-scale management guideline 5 (see Site preparation in the previous section).

All other design principles under the Location and Configuration themes fit into the landscape scale. The values for these components may be derived with assistance from maps and other information sources (e.g. GIS).

Initially we assumed that the landscape-scale components of the Plantation Biodiversity Score could readily be achieved using exactly the same method as that employed by the 'Habitat Hectares' Method (Department of Sustainability and Environment, 2004). However, it became clear that this would not be a rational approach. Therefore, for the Plantation Biodiversity Score *Mark I*, we decided that only those Plantation Biodiversity Score components which we could map to 'Habitat Hectares' Landscape Context components would be used, and that they would be calculated using the same approach as the 'Habitat Hectares' method for assessing landscape context.

Table 9 shows the landscape-scale themes and design principles from Salt et al. (2004) mapped against the relevant landscape-scale components of the 'Habitat Hectares' Method.

Table 9 The juxtaposition of the landscape-scale themes and design principles from Salt et al. (2004) with the landscape context components of Parks et al. (2003).

Salt et al. (2004)		Parkes et al. (2003)
Theme	**Design Principle**	**Landscape Context Component**
Location	Adjacency	Neighbourhood
	Connectivity	
	Landscape context	
	Protection of waterways*	-
Configuration	Size of plantings	Patch size
	Shape of plantings**	-

* This design principle has been dealt with under the site-scale management guideline 5.
** This design principle has not been dealt with by Habitat Hectares. See below for suggestion.

The Parkes et al. (2003) 'Habitat Hectares' component 'distance to core area' did not map specifically to any of the Salt et al. (2004) design principles. A 'core area' is defined by Parkes et al. (2003) as a block of native vegetation greater than 50 hectares in area. With the 'Habitat Hectares' Method, the closer a patch of native vegetation to a core area, the higher the score for this component because the movement of native biota and propagules from the core area to the patch will be more effective, the closer the core area.

However, for a patch of commercial environmental forestry, the component was not so logical because, with regard to native vegetation, the spread of propagules into the plantation is not likely to be encouraged. Movement of animals from the core area was relevant, but for the purposes of plantations we believed that this biodiversity benefit will be adequately covered by the Neighbourhood Score and Proportion of Native Vegetation Scores (see below) and we decided that the Distance to Core area should be ignored for plantation patches and that it would not form part of the Plantation Biodiversity Score.

It is logical that the larger the size of a patch of native vegetation, the greater the biodiversity benefit it is regarded to confer. Current theory has it that larger patches will support a greater variety of native biodiversity, e.g. vertebrates with larger territorial requirements etc., than smaller patches. Also, the larger the patch, the less the "edge effect" (Salt et al. 2004).

However, it does not follow from this that the bigger the plantation size the greater the biodiversity benefit. Although they include size in their design principles, Salt et al. (2004) point out that the biodiversity benefits of size are more relevant to patches of native vegetation. For example, a large patch of Tasmanian Blue Gum planted outside of Tasmania will not necessarily confer greater biodiversity benefits than a smaller mixed planting. What does appear to be important, however, is width of vegetation patches or corridors and the mosaic of plantation and native vegetation in the landscape (Salt et al. (2004). A diverse landscape, consisting of many patches of different vegetation types, even if some of them are plantations of exotic species, is likely to confer a higher biodiversity benefit than a landscape consisting mainly of degraded exotic pasture.

For these reasons, we chose not to include patch size in the PBA Score. Instead, in this phase of the project, we replaced it with two components, namely Patch Width and Proportion of Native Vegetation. The wider a plantation the more protection it provides for wildlife movement in the landscape by reducing the 'edge effect'. Similarly, a commercial environmental forestry proposal which includes some proportion of native vegetation plantings as well as commercial plantations would be likely to provide more habitat and capability for movement of wildlife than would a proposal which includes only plantation, so we chose to weight commercial environmental forestry proposals on the basis of the proportion (by area) of native vegetation plantings/enhancements to plantation.

For the Plantation Biodiversity Score *Mark I*, we assumed that the Neighbourhood Score, exactly as described by Parkes et al. (2003), would be suitable for assessing the landscape-scale components of adjacency, connectivity and landscape context.

Table 10 presents the proposed landscape-scale components of the Plantation Biodiversity Score with their weightings.

Table 10 Score values for the landscape-scale components of the Plantation Biodiversity Score.

Component	Maximum value
Neighbourhood	10
Patch width	5
Proportion of Native Vegetation	10
Total	25

The above score values sum to 25, a total value of 100 for the sum of the site-scale and landscape-scale components of the Plantation Biodiversity Score.

The Plantation Biodiversity Score *Mark I* was then presented to stakeholders, with the assistance of the ‘manual’ (Appendix 1) and a PowerPoint presentation.

Chapter 4 'Fit for purpose' assessment and CSE responses

Feedback on the Plantation Biodiversity Score *Mark I* was elicited from a selection of stakeholders (Appendix 2).

Methods

The 'fit for purpose' assessments were conducted in three separate briefing sessions, either in person or by phone, for all but one stakeholder (David Salt), who provided his comments by email after reading an early draft of the manual. David Salt's advice was incorporated into the manual prior to the interactive briefing sessions undertaken with the other stakeholders.

During the interactive briefing sessions, each stakeholder had access to a the 'manual' (Appendix 1) and a PowerPoint presentation. The authors of this report guided the stakeholders through the draft method using the PowerPoint presentation, noting the comments and feedback from the stakeholders. Stakeholders were encouraged to provide further comments by email.

Feedback from the reviewer of this report (Paul Ryan, CSIRO Sustainable Ecosystems) has also been included in this section and, where indicated in the following tables, the Plantation Biodiversity Score *Mark I* has been modified in accordance with his suggestions.

Results

The feedback from the stakeholders was wide-ranging and extremely useful in highlighting the inadequacies in the Plantation Biodiversity Score *Mark I* and in suggesting more effective scoring criteria. The feedback included general comments on the overall method and more specific suggestions about the individual components of the score.

General comments

Table 11 presents the feedback and CSE responses to the general comments.

Table 11 General comments about the overall approach.

Comment	Response from CSE
There should be a single metric which can be used to score the biodiversity benefits of any patch of land 'from a football field to a plantation, from a degraded grassland to a pristine native woodland or forest'.	We would have preferred this also. However, the data do not exist for any of the existing metrics to be applied anywhere except in the Australian States in which they were developed. Also, the policy and legislative requirements for each State (also different for each State) are already embedded in the existing metrics as they are currently applied. We need a generic method which can be applied anywhere, regardless of local policy, duty-of-care and codes of practice constraints.

Comment	Response from CSE
Concern that plantations will foreclose on options to place native vegetation in the future.	The Plantation Biodiversity Score is predicated upon the fact that local (i.e. State) regulations with regard to codes of practice, clearing assessments, duty-of-care, offsets etc. will have been fulfilled before any plantation could even be considered. Therefore, the Plantation Biodiversity Score will only assess the potential biodiversity benefits of a proposed plantation after all permissions have been given.
Many of the components of the score are giving points for things that must be done anyway, i.e. under State regulations with regard to codes of practice, clearing assessments, duty-of-care, offsets etc. In this sense, the Plantation Biodiversity Score is double-scoring.	We need a generic method which can be applied anywhere, regardless of the existence (or otherwise) of local policy, duty-of-care and codes of practice. Further, we believe it to be a good cross-comparison for whether State codes of practice etc. meet the exigencies of the ecological design themes and principles which are thought to be important by leading ecologists.
Any Plantation Biodiversity Score is ‘really powerful stuff’; despite best intentions it could be misused e.g. in directly comparing the biodiversity benefits of native vegetation to the biodiversity benefits of a plantation. This is not appropriate.	Agreed. This is another rationale for having a completely separate metric for scoring biodiversity benefits of plantations. Also, this is a good reason for using a ‘benefits profile’ to compare different kinds of benefits (see Chapter 2, Discussion).
The components of the Plantation Biodiversity Score are very ‘vertebrate fauna centric’ i.e. there is a strong emphasis on habitat components traditionally associated with vertebrate fauna (trees, hollows, predator control) with little emphasis on flora or invertebrate habitat. For example Site preparation components focus on protection of remnant trees and waterways, however issues like cultivation, access roads and earthworks that destroy soil structure or the use of herbicide/pesticide that could impact on flora or invertebrate species are for the most part not addressed by the components.	As plantations are unlikely to attempt to recreate native vegetation, the Plantation Biodiversity Score does not specifically address native flora except in regard to the Biological Legacies (new Tree Environment Score) and the Local Species Score. Invertebrate habitat is partially addressed by the Dead Wood Score. We have not specifically addressed cultivation, access roads and earthworks because we can find no specific guidelines to assist in quantifying how much is too much. Forestry codes of practice are currently under development in Victoria. It is possible that these will assist us to quantify these issues during field testing of the prototype Plantation Biodiversity Score, so they can be incorporated into the scoring system.

Comment	Response from CSE
There should be capacity to earn bonus points – its difficult to anticipate all the possible management actions that a manager may be able to undertake to improve the habitat value of a site, controlling kangaroos, wombats or wallabies, a predator proof fence or other action may have more benefit than some of the actions outline in the approach if they are particular management issues in that landscape. Similarly extra points could be given for a plantation plan – a written document that spells out the management actions, location of tracks, log landings, loading areas etc in a manner that minimises environmental impact could be acknowledged in an 'extra bonus points' sections.	Although it is difficult to anticipate all the aspects of a commercial environmental forestry proposal which might contribute biodiversity benefits, we do not propose to alter the design of the Plantation Biodiversity Score by allowing the addition of bonus points. The main feature of this scoring system is that all proposals are subject to exactly the same criteria for judgement against the method and therefore different proposals can be compared in terms of the value of the final score, or by comparison of the various components. Extra bonus points would remove the direct comparability. Further, the score has been carefully structured. Addition of scores for undefined management actions run the risk of double-counting and other structural damage to the method. If future field testing of the score identifies additional management actions e.g. location of tracks, log landings etc. which enhance biodiversity benefits, then components which explicitly address these management actions should be added to the score.

Specific comments

The following points document the comments and suggestions from the stakeholders against each of the Plantation Biodiversity Score *Mark I* components, and the actions taken in response to the feedback. Please refer to Appendix 1, the Plantation Biodiversity Score *Mark I* manual, for the descriptions of the component scores as they appear in the next sections.

Site-scale components

Incorporate remnant trees

Table 12 documents the feedback and CSE responses to the feedback for the Incorporate Remnant Trees Score of the Plantation Biodiversity Score *Mark I*.

Table 12 Feedback and CSE responses for the Incorporate Remnant Trees Score.

Comment	Response from CSE
There was dislike for the term 'remnant tree' as it might equally refer to groups of native trees in what is known as a 'native remnant' i.e. a patch of contiguous native trees.	The terminology was changed to 'paddock tree' and the score renamed accordingly to the 'Paddock Tree Score'.

Comment	Response from CSE
There was a need to define a ‘paddock tree’; concern that without definition, small regrowth could be claimed and scored as paddock trees. There was one suggestion that a paddock tree should be defined as having a diameter at breast height (DBH) ≥ 50cm. However, this would exclude some species (e.g. Mallee species which are already being considered for use in commercial environmental forestry plantations in the very low rainfall areas). Another suggestion was to use the DBH criterion of single stem trees and a height criterion for multi-stemmed trees. Another suggestion was to keep it as simple as possible and define a paddock tree as any native tree greater than 5 metres in height, because they have a greater potential to develop hollows and have other significant biodiversity benefits.	To keep it as simple and practical as possible, a ‘paddock tree’ was defined to be any native tree greater than 5 metres in height. This should be reviewed in future field trials.
There was some confusion between the Paddock Tree Score, the Site Preparation Score and the Biological Legacies Score, with regard to the contribution of paddock trees.	This has been resolved by altering the component scores relating to paddock trees in both the Site Preparation Score and the Biological Legacies Score (see those sections below). The weighting applying to the Paddock Trees Score has been reduced to 10, with the extra 5 points assigned to the Biological Legacies Score. For the now Paddock Trees Score, the emphasis has been placed on the retention of the paddock trees.
There was concern that the specification ‘dead or alive’ might encourage the killing of living paddock trees because they use fewer resources.	The intentional killing of living paddock trees is proscribed by state regulations. The purpose of this criterion is to emphasise that dead paddock trees provide highly significant biodiversity benefits and to encourage their retention.
There was concern that weighting the retention of > 4 paddock trees per hectare might encourage the placement of plantations into areas of better quality native vegetation.	The placement of plantations in better quality native vegetation is proscribed by state regulations. The purpose of this criterion is to emphasise that the retention of paddock trees is crucial to the biodiversity benefits of a plantation, and to encourage the retention of as many of them as possible without encouraging the placement of plantations in areas of higher quality native vegetation i.e. in areas with higher numbers of large native trees.
There was also a conflicting concern that the categories for paddock trees are too low and will not encourage managers to change plantation design greatly to incorporate as many paddock trees in the design as possible. It was suggested that the scoring categories to be changed *vis.* 1-5, 5-15; 15+.	
There was a suggestion that the definition of a small remnant versus a group of paddock trees might be required to define whether planting around the trees might be permitted or not.	This definition is supplied by the various State codes-of-practice and should not be part of the Plantation Biodiversity Score.

Site preparation

Table 13 documents the feedback and CSE responses to the feedback for the Site Preparation Score of the Plantation Biodiversity Score *Mark I*.

Table 13 Feedback and CSE responses for the Site Preparation Score components.

Comment	Response from CSE
It is impractical to attempt to preserve logs and rocks as part of site preparation. Damage to native remnants is proscribed.	These elements have been removed from the criteria.
The most important element of habitat complexity in plantations are the retained paddock trees. Therefore it is most important to protect them from damage during site preparation. Therefore need to specify some distance to be left as a buffer between paddock trees and the plantation trees.	The original Preserve Habitat Complexity Score component has been changed to the Tree Protection Score. The criteria for protection now specifies that, to gain any score in this component score, a buffer must be placed about each paddock tree, extending from the trunk to a distance of 3 metres beyond the drip-line.
Forestry codes of practice regulate erosion control so no need to include this as part of the score.	The Control Erosion Score has been removed as a component of the Plantation Biodiversity Score.
The Control Riparian Pollution Score is not sufficiently explicit.	The original Control Riparian Pollution Score component has been renamed to the Waterway Protection Score, to fall more in line with the Salt et al. (2004) terminology. The criteria have been reworded, and now specify that to gain any score in this component, vegetation buffers must be retained, encouraged or planted between the plantation and the waterways.
Buffer widths along waterways should be specified to encourage managers to leave wider strips (i.e. more points for wider buffers) with 2 categories of widths (eg <20m, >20m) suggested.	The new Waterways Protection Score has been modified to quantify the criteria as suggested.

Install artificial hollows

documents the feedback and CSE responses to the feedback for the Artificial Hollows Score of the Plantation Biodiversity Score *Mark I*.

Table 14 Feedback and CSE responses for the Artificial Hollows Score.

Comment	Response from CSE
Nest boxes which are not monitored for feral species are as bad or worse than no nest boxes at all.	The criteria have been altered to reflect this.
Few managers include artificial hollows because they can interfere with tree growth, can be dangerous for contractors/mill workers (if wire/nails are left in trunk) and most are never maintained. It remains open to question whether artificial hollows should be included as an integral component of the score, although they could provide extra bonus points.	We agree with these concerns and have added comment to the section in this score accordingly. Future field testing of the Plantation Biodiversity Score may lead to the removal of this component of the score.
	See Table 11 (general comments) for a response to the suggestion of extra bonus points.

Comment	Response from CSE
The criteria for artificial hollows quantify numbers at the very low end of what could be considered sufficient to provide adequate habitat for typical hollow using species (eg gliders and possums may use as many as 20 hollows in their territory. The categories could be increased up to 0-5, 5-10 per hectare or similar to encourage more artificial hollows.	There is no substitute for paddock trees with regard to the provision of hollows. Further, it is most unlikely that plantation managers will consider installing artificial hollows in large numbers, particularly with regard to the caveats enumerated above. However, future field testing of the Plantation Biodiversity Score should identify whether artificial hollows should contribute to the score at all, and if so, whether the quantities should be increased as suggested.

Thinning and pruning

Table 15 documents the feedback and CSE responses to the feedback for the Thinning and Pruning Score of the Plantation Biodiversity Score *Mark I*.

Table 15 Feedback and CSE responses for the Thinning and Pruning Score components.

Comment	Response from CSE
Standard thinning is the norm, but variable density thinning sometimes follows/precedes standard thinning practices.	The criteria have been altered to take account of this.
The rationale and criteria are not sufficiently clear for the Dead Tree component of the Thinning and Pruning Score. The criteria need to be altered to indicate that it is deformed trees which should be ringbarked or poisoned and left as standing dead.	The criteria have been altered in accordance with this.
Felled dead trees should be included in the Pruning Score component of the Thinning and Pruning Score.	The criteria have been altered in accordance with this.

Preserving biological legacies

Table 16 documents the feedback and CSE responses to the feedback for the Biological Legacies Score of the Plantation Biodiversity Score *Mark I*.

Table 16 Feedback and CSE responses for the Biological Legacies Score components.

Comment	Response from CSE
There should be some quantification of the amounts of boulders and fallen logs which are to be retained at time of harvesting.	The criteria for the Dead Wood Score have been altered accordingly.

Comment	Response from CSE
There is some confusion between the Paddock Tree Score, the Site Preparation Score and the Biological Legacies Score, with regard to the contribution of paddock trees.	This has been resolved by altering the component scores relating to paddock trees in both the Paddock Trees Score and the Site Preparation Score (see those sections above). The weighting applying to the Paddock Trees Score has been reduced to 10, with the extra 5 points assigned to the Biological Legacies Score. For the Biological Legacies score, the emphasis has been placed upon a) enhancing the environment around paddock trees to increase their chances of survival and to improve their habitat effects, and b) retaining the paddock trees and their environments undamaged at time of harvesting.
The paddock trees in a plantation can provide critical environment. The small weighting for the Biological Legacies Score is not a huge motivator.	The weighting for the Biological Legacies Score has been increased by 5 points.
There was dislike of the term 'biological legacy'.	As the Plantation Biodiversity Score is designed around the management guidelines of Salt et al. (2004), we would prefer to retain their terminology.
Scoring points for retaining paddock trees at harvest could be seen as double counting with the paddock tree component – while it is understood that the Incorporate Paddock Tree Score is for retention of the paddock trees during establishment and growing period of the plantation and the Paddock Tree Legacy Score scores the retention of those trees at harvest, you could also just score paddock trees once on the proviso they will be retained. This approach could be taken for dead wood as well.	The scoring system is structured around 'management guidelines' (Salt et al. 2004) not particular habitat entities. If we change the approach in this case we will have to restructure the whole scoring system. We prefer a scoring system which directly links biodiversity benefits to discrete and explicit management actions. We are, intentionally, weighting the value of paddock trees very heavily via the management guidelines, rather than double-counting. The Incorporate Paddock Trees Score rewards incorporation of these trees as part of plantation design; the Site Preparation Score rewards not damaging them at the beginning; and the Biological Legacies Score rewards enhancing their environment through the life of the plantation and not damaging them at time of harvest. Similar reasons apply to retaining the current scoring structure for dead wood.
The difficulty with the current approach is that you are scoring something that will not take place for 15-30 years. A more practical approach would be to score these elements if they are retained or will be retained during the establishment phase of the plantation, then make the assumption that they will be retained.	We understand that in some cases we are scoring for benefits that may not be realised for many years. This also applies to the various methods based upon the 'Habitat Hectares' approach. The presumption is that adherence to the management guidelines will allow some level of biodiversity benefit to be eventually achieved.

Rotation times

Table 17 documents the feedback and CSE responses to the feedback for the Rotation Time Score of the Plantation Biodiversity Score *Mark I*.

Table 17 Feedback and CSE responses for the Rotation Time Score.

Comment	Response from CSE
Longer rotation times are preferable. Instead of scoring rotation time as a component of the Plantation Biodiversity Score, it would be preferable to use rotation time as a multiplier of the final Plantation Biodiversity Score, to weight overall biodiversity benefits by the length of time they have to develop.	We chose not to follow this suggestion because rotation time is likely to be consistent i.e. always between 15-25 years. Adoption of the weighting approach would otherwise require a major redesign of the score, to no net effect.

Mixed age and connectivity

Table 18 documents the feedback and CSE responses to the feedback for the Mixed Age and Score of the Plantation Biodiversity Score *Mark I*.

Table 18 Feedback and CSE responses for the Mixed Age and Connectivity Score.

<table>
<tr><th>Comment</th><th>Response from CSE</th></tr>
<tr><td>There was some concern that mosaics of different aged stands was simply spreading the disturbance.</td><td rowspan="3">A landscape of more diverse vegetation types, whether native or plantation in origin, is likely to harbour a greater diversity of wildlife than large areas of vegetation of exactly the same age and structure. Therefore the intent of this score is to encourage a mosaic of diverse vegetation in the landscape. To this end, the score was renamed to the Mosaic Score and the criteria adapted accordingly, replacing the term ‘stand’ with the term ‘coupe’.</td></tr>
<tr><td>There may be a feedback loop between this score and rotation time, with regard to connectivity.</td></tr>
<tr><td>The term “stand” is not the correct one in a forestry context. It would be more relevant to foresters to substitute the word ‘coupe’.</td></tr>
<tr><td>It was recognised that there was some confounding between the Connectivity Score and the landscape-scale components of the Plantation Biodiversity Score.</td><td>The connectivity component of the original Mixed Age and Connectivity Score was removed.</td></tr>
</table>

Mixed planting

Table 19 documents the feedback and CSE responses to the feedback for the Mixed Planting Score of the Plantation Biodiversity Score *Mark I*.

Table 19 Feedback and CSE responses for the Mixed Planting Score.

Comment	Response from CSE
This is a very cost effective way of bringing in diversity at the outset, for example using and interplanting of legumes e.g. Acacias. There are multiple benefits here i.e. carbon, multi-product outputs. However, it would be better to quantify the proportions of species for the different weightings.	The score has been modified accordingly.

Planting with local species

documents the feedback and CSE responses to the feedback for the Local Species Score of the Plantation Biodiversity Score *Mark I*.

Table 20 Feedback and CSE responses for the Local Species Score.

Comment	Response from CSE
It would be better to quantify the proportions of local species for the different weightings.	The score has been modified accordingly

Control escapees

Table 21 documents the feedback and CSE responses to the feedback for the Control Escapees Score of the Plantation Biodiversity Score *Mark I*.

Table 21 Feedback and CSE responses for the Control Escapees Score components.

Comment	Response from CSE
The use of non-hybridising species is very important.	The weighting for this component of the Control Escapees Score has been slightly increased.
It is important to choose plantation species which do not hybridise with ‘local’ species, not merely ‘native’ species.	The wording of the criteria have been changed accordingly. Also, as plantation species may be other than eucalypts, e.g. Acacias, the word ‘eucalypt’ has also been removed.
Native vegetation buffers are taken into account by the intention to separately score the biodiversity benefits of the native vegetation management units which form part of a commercial environmental forestry proposal. Therefore the Buffers Score component is redundant.	The Buffers Score component has been removed.
As well as monitoring for the control of wildlings, weeds should also be monitored and controlled.	No action taken; this is already taken into account by the Control of Weeds Score (see next section).

Control weeds

Table 22 documents the feedback and CSE responses to the feedback for the Control Weeds Score of the Plantation Biodiversity Score *Mark I*.

Table 22 Feedback and CSE responses for the Control Weeds Score.

Comment	Response from CSE
Change the wording to indicate that the weed control should also apply to the native vegetation management units of the commercial environmental forestry proposal.	The Control Weeds Score of the Plantation Biodiversity Score applies only to the vegetation management units which are plantations. Control of weeds for the native vegetation management units of a commercial environmental forestry proposal will be scored by the ‘Habitat Hectares’ method in Victoria, and by other relevant methods in the other States.

Comment	Response from CSE
Perhaps rather than specify weed control categories, a simple yes/no approach could be used, where 'appropriate or adequate weed control strategy' receives points, no weed control strategy receives 0.	In line with the 'Habitat Hectares' method, the structure of which has contributed heavily to the Plantation Biodiversity Score, and on advice from other stakeholders, we have purposely provided quantifiable categories for the criteria for as many of the component scores as possible.

Control animal pests

Table 21 documents the feedback and CSE responses to the feedback for the Control Animal Pests Score of the Plantation Biodiversity Score *Mark I*.

Table 23 Feedback and CSE responses for the Control Animal Pests Score.

Comment	Response from CSE
Deer and hares are also important pests to control.	The Control Animal Pests Score has been broken into two component scores; the Feral Herbivores Score (which now includes deer and hares) and the Feral Predators Score.

Landscape-scale components

The earlier feedback sessions led to a complete rethink of the proposed methods and a complete redesign of the approach for the landscape-scale components of the Plantation Biodiversity Score *Mark I*. The results of this redesign were then presented to Bernard Young and his comments led to the final design. The feedback from all stakeholders tended to address all of the components of the score simultaneously, so we have tabulated the comments overall rather than dealing with each component separately (Table 24).

Table 24 Feedback and CSE responses for the Landscape-scale components scores.

Comment	Response from CSE
The Neighbourhood Score of the 'Habitat Hectares' method, as it applied by the Victorian Department of Sustainability and Environment (2004) is not appropriate for the Plantation Biodiversity Score. In a sense, what is required is an inverse of this approach, with higher weightings given to plantations placed in less connected landscapes, so as not to foreclose on options for future revegetation with native vegetation types.	We have removed the Neighbourhood Score from the Plantation Biodiversity Score. It has been replaced by a Landscape Connectivity Score which takes account of the stakeholder's comments with regard to current landscape connectivity at three neighbourhood sizes (equivalent to the three radius sizes used by the Neighbourhood Score component of 'Habitat Hectares'. In addition, the weightings for the neighbourhood sizes have been 'inverted' to reward improvements in landscape connectivity at the 100m neighbourhood size where current vegetation cover is high and to reward improvements in landscape connectivity at the larger neighbourhood sizes where current vegetation cover is low. The final score is achieved by adding the scores for the different neighbourhoods and weighting the result by plantation size.
It is important for a plantation to be connected to native or other vegetation at the 100m radius so that plantations actually do facilitate the passage of wildlife at the finer scales. 'Set-back' areas, i.e. cleared buffers prescribed by some forestry practices actively militate against this.	
The size of a plantation is good for biodiversity in less connected landscapes and not so good in well connected landscapes.	

Comment	**Response from CSE**
Concern that width *per se* is not particularly relevant. Take 2 hypothetical plantations, Plantation A is 9 ha, 40m wide – it scores very low – but its 2250 metres long, Plantation B is 60ha, 100m wide – it scores high, but is 6000m wide – which one is better for biodiversity? Both are narrow compared to their length, the second one actually has more edge habitat than the first. Would edge:area ratio be better? Or higher score for more consolidated shapes, so blocks score higher than strips?	Ratios are difficult to interpret. We think that it is absolute width i.e. the length of the shortest dimension of a patch of vegetation, which is important. Size is taken into account in the landscape connectivity score.
The Proportion of Native Vegetation Score is confounded with the proposed use of the 'Habitat Hectares' or ***BioMetrics*** method to score biodiversity benefits for native vegetation. The more hectares of native vegetation, the greater the native biodiversity benefits score will be.	This score has been removed from the Plantation Biodiversity Score.

Conclusion

The comments and advice from the stakeholders has led to a much improved prototype Plantation Biodiversity Score which is now ready to be tested in the field. The prototype Plantation Biodiversity Score is described in detail in Chapter 5.

Chapter 5 The prototype Plantation Biodiversity Score

Introduction

This chapter presents the prototype version of the Plantation Biodiversity Score after modification from the Plantation Biodiversity Score *Mark I* (Appendix 1) following feedback from stakeholders (Chapter 4). This chapter can be used as a stand-alone 'manual' for the prototype Plantation Biodiversity Score. An accompanying explanatory PowerPoint presentation is available on request from the authors.

The Plantation Biodiversity Score is a raw index of potential biodiversity benefit for a plantation, based on the design themes and principles and the management guidelines from Salt et al. (2004; *Trees and biodiversity: A guide for Australian farm forestry*).

The Plantation Biodiversity Score is not linked to policy. It takes no account of any 'duty of care' requirements prescribed by the policies, codes or legislation of any Australian State. The duty of care requirements are different in each state, but the Plantation Biodiversity Score can be applied to any plantation design anywhere in Australia. For this reason, it is impossible to design a generic scoring system which would take account of policies in all States. Therefore we have taken the decision to devise a method which will score the biodiversity benefits for any given patch of plantation forestry from a generic set of principles. As such, it is similar to the raw 'Habitat Hectares' Scoring method in the form presented by Parkes et al. (2003).

The Plantation Biodiversity Score simply assesses the biodiversity benefits of a plantation. The Plantation Biodiversity Score assumes that all state-regulated requirements with regard to codes-of-practice, clearing assessments etc. have already been fulfilled.

This document provides a detailed description of the proposed method for scoring the latest version of the Plantation Biodiversity Score and illustrates the method with a hypothetical commercial environmental forestry proposal.

The Plantation Biodiversity Score is scored at two scales; the site scale and the landscape scale.

The site scale portion of the Plantation Biodiversity Score is calculated within the framework defined by the agroforestry design themes and principles and the agroforestry guidelines of Salt et al. (2004).

Part of the landscape scale portion of the Plantation Biodiversity Score is based loosely upon the landscape context portion of the 'Habitat Hectares' Score (Department of Sustainability and Environment 2004). The rest is based upon ecological principles of connectivity and configuration for each commercial environmental forestry proposal (Salt et al. 2004, *sensu lato*).

The Plantation Biodiversity Score has been designed to assist in the planning and ongoing management of plantations. The Plantation Biodiversity Score is also a tool to transparently and repeatably assess the relative biodiversity benefits likely to be derived from alternative plantation designs and management commitments.

Site-scale components; ‘management guidelines’

The site-scale components of the Plantation Biodiversity Score, equivalent to the Salt et al. (2004) ‘management guidelines’ for agroforestry, are summarised in Table 25. In this table, management guidelines numbers (MG2-MG10) show the order in which they are presented on Salt et al. (2004) page 108, although they appear in the following descriptive sections in the order in which they are presented in the Table 25.

Table 25 The juxtaposition of the Salt et al. (2004) site-scale themes and design principles with their relevant site-scale management guidelines.

Theme	Design Principle	Management Guideline	Max value (%)
Complexity (50)	Structure	1. Incorporate paddock trees (MG2)	10
		2. Site preparation (MG7 and MG8)	10
		3. Preserving biological legacies (MG10 - harvesting)	10
		4. Install artificial hollows (nest boxes) (MG4)	5
		5. Thinning and pruning (MG9)	5
	Time and age	6. Rotation times (MG10 - harvesting)	5
	Patchiness	7. Mosaics: mixed age stands (MG10 - harvesting)	5
Composition (10)	Mix of species	8. Mixed plantings (MG5)	5
	Local species	9. Planting with local species (MG6)	5
Ecological Management (15)	Weed control	10. Control escapees (MG11)	5
		11. Control weeds (MG12)	5
		12. Control animal pests (MG11)	5
		Total Plantation Biodiversity Score at the site scale	**75**

Note that management guideline 1 (Incorporating remnant patches in plantations) is not relevant to the Plantation Biodiversity Score; any patch of native vegetation would be scored by the relevant State method i.e. ‘Habitat Hectares’ in Victoria or ***BioMetric*** in NSW, not the Plantation Biodiversity Score. Also, guideline 3 (increasing structural complexity of a plantation) is encompassed by the other guidelines under the structure and complexity themes.

Management guideline 7 (Site Location) is encompassed by the landscape-scale components of the Plantation Biodiversity Score, except with regard to the protection of waterways, which for the purposes of the Plantation Biodiversity Score we have dealt with under the site-scale management guideline Site Preparation, where it appears to more logically reside.

The next sections address the scoring methods for each management guideline, or component score of the Plantation Biodiversity Score, describing the scoring increments and the rationale behind the proposed scores. In most cases the rationale has been quoted directly from Salt et al. (2004). The maximum score over all site-scale components of the Plantation Biodiversity Score is 75 points, or 75% of the total Plantation Biodiversity Score.

1. Incorporate paddock trees (MG2)

Table 26 shows how to determine the Paddock Tree Score.

Table 26 Criteria and scores for the Paddock Tree Score of the Plantation Biodiversity Score.

Criteria	Paddock Tree Score
no paddock trees (alive or dead) within the plantation	0
1 paddock tree/ha[a] (alive or dead) within the plantation	5
2-3 paddock trees/ha[a] (alive or dead) within the plantation	7
≥ 4 paddock trees/ha[a] (alive or dead) within the plantation	10

[a] Tree density is defined as the mean number of trees for the whole area of the plantation, only including trees surrounded by plantation plantings.

The retention of mature isolated native paddock trees, whether alive or standing dead prior to plantation establishment (note; living trees should be retained alive and not killed), contributes more than any other component to the diversity value of any planting, whether of native vegetation or plantation forestry. They provide an almost irreplaceable and diverse habitat for a variety of species, invertebrate and vertebrate. They are often the only available source in the landscape of valuable hollows which are used by over 300 wildlife species (Salt et al. 2004). Similarly, nearly 300 different species of invertebrates have been associated with the bark of a single remnant eucalypt tree (Recher et al.1996). Consequently, it is important to retain in a plantation as many dead or living paddock trees as possible.

For simplicity's sake, we define a remnant paddock trees as any native tree greater than 5 metres in height, regardless of diameter at breast height (DBH). Use of the more usual DBH ≥ 50 cm criterion would exclude some species e.g. Mallee species which are already being considered for use in commercial environmental forestry plantations in the very low rainfall areas. Even if trees of this height do not contain hollows, if they are retained they have the potential to develop them sooner than smaller trees. They also provide significant habitat other than that related strictly to hollows.

In Victoria, the retention of paddock trees in a plantation is currently part of draft forestry codes of practice. In NSW, the removal of paddock trees is required to be offset against extra native planting and/or enhancements. For these reasons it has been suggested to us that the scoring of a biodiversity value for remnant paddock trees could constitute 'double-counting', rewarding the plantation proposal for something which is required by law anyway.

However, the aim of the Plantation Biodiversity Score is to score the biodiversity benefits of a plantation, and the presence of remnant trees will contribute greatly to the biodiversity value of a plantation *per se*, regardless of offsets and legal requirements. Because of the importance of paddock trees to the maintenance of native biodiversity, we have weighted the Paddock Tree Score heavily in its contribution to the Plantation Biodiversity Score, giving it a maximum value of 10 (out of a total of 75). We have given a large value (5) for the first category to encourage the retention of ANY large trees.

2. Site preparation (MG8)

The Site Preparation Score has 2 components; the Tree Protection Score and the Waterway Protection Score. The values for the component scores are summed to give the final Site Preparation Score. Table 27 shows how to determine the Site Preparation Score.

Table 27 Criteria and scores for the Site Preparation Score of the Plantation Biodiversity Score.

Component	Criteria	Tree Protection Score
Protection of paddock trees	No buffer[a] around remnant paddock trees	0
	Site preparation to leave a buffer[a] around all remnant paddock trees at least 3 m beyond the drip-lines of remnant trees.	6
		Waterway Protection Score
Protection of waterways	No protection measures	0
	Retain, encourage or plant native vegetation buffers < 20m wide along watercourses to prevent/reduce water pollution from plantation area	2
	Retain, encourage or plant native vegetation buffers ≥ 20m wide along watercourses to prevent/reduce water pollution from plantation area	4
Site Preparation Score = Tree Protection Score + Waterway Protection Score		

[a] ‘Buffer’ defined as area not disturbed during site preparation and plantation establishment.

Site preparation for a plantation is crucial in preserving and maintaining biodiversity benefits. It is most important to prepare the site in such a manner to preserve as much habitat complexity as possible by minimising the damage to existing native vegetation, paddock trees, logs and rocks, and to minimise erosion to prevent damage to aquatic ecosystems (Salt et al. 2004).

It is difficult to quantify over all possible sites a scoring method to take account of all levels of coarse woody debris, rocks and other components of habitat complexity. Therefore we have chosen to concentrate again on the remnant paddock trees which might be retained within the precincts of a plantation, scoring heavily for plantation designs and management practices which protect them from damage.

A practical measure for the protection of paddock trees during site preparation and plantation establishment is to leave an undisturbed area around each tree, to buffer it from the disturbance e.g. ripping. We have adopted the criterion that an appropriate width for this undisturbed buffer area should be the distance 3 m beyond the edge of the canopy drip-line.

Protection of waterways through the planting of native vegetation riparian buffers is a good management practice which contributes to biodiversity benefits, both on plantation and off-site in neighbouring native vegetation and aquatic ecosystems.

For these reasons we have weighted the Site Preparation Score heavily in its contribution to the Plantation Biodiversity Score, giving it a maximum value of 10 (out of a total of 75).

3. Biological Legacy Score (MG10)

The Site Preparation Score has 3 components; the Paddock Tree Legacy Score, the Tree Environment Score and the Dead Wood Score. The values for the component scores are summed to give the final Biological Legacy Score. Table 28 shows how to determine the Biological Legacy Score.

Table 28 Criteria and scores for the Biological Legacy Score of the Plantation Biodiversity Score.

Component	**Criteria**	**Paddock Tree Legacy Score**
Retain paddock trees at harvesting	No retention of paddock trees (alive or dead) at time of harvesting	0
	Retention of all paddock trees (alive or dead) at time of harvesting	4
		Tree Environment Score
Tree Environment Score	No enhancement of the environment around the remnant paddock trees	0
	Enhancement of environment around remnant paddock trees with addition and/or retention of coarse woody debris around the trees.	2
	Enhancement of environment around remnant paddock trees with the planting of local shrubs and addition of coarse woody debris around the trees.	3
		Dead Wood Score
Retain dead wood at harvesting	No retention of boulders and fallen logs at time of harvesting	0
	Retention of 20% of boulders and fallen logs at time of harvesting	1
	Retention of 50% of boulders and fallen logs at time of harvesting	2
	Retention of 100% of boulders and fallen logs at time of harvesting	3
Biological Legacy Score = Paddock Tree Legacy Score + Tree Environment Score + Dead Wood Score		

The biodiversity value of plantations can be enhanced by the preservation of 'biological legacies', that is any natural elements of the landscape which existed prior to the plantation. These might include paddock trees (alive or dead), fallen wood and boulders (Salt et al. 2004) which might have been preserved as part of the site preparation (see point 3 above). It is important that as many as possible of these legacies remain in good condition during the lifetime of the plantation and after harvesting and to contribute biodiversity benefit to the next planting.

The most important biological legacy is the remnant paddock tree. The first component of the Plantation Biodiversity Score (the Paddock Tree Score) scored the biodiversity benefits from the retention of large paddock trees within a plantation. The second part (the Tree Protection component of the Site Preparation Score) scored the biodiversity benefits for not damaging these trees. The Biological Legacy Score scores components for retaining these trees at time of harvesting to maintain their biological legacy contribution, for enhancing their environments and for encouraging the retention of coarse woody debris in their vicinity and elsewhere within the plantation.

The importance of biological legacies for biodiversity is reflected in the size of the Biological Legacy Score. The maximum contribution to the Plantation Biodiversity Score from the Biological Legacy Score = 10 (out of a total of 75).

4. Install artificial hollows (nest boxes) (MG4)

Table 29 shows how to determine the Artificial Hollows Score.

Table 29 Criteria and scores for the Artificial Hollows Score of the Plantation Biodiversity Score.

Criteria	Artificial Hollows Score
no nest boxes installed OR no monitoring of nest boxes	0
1-3 nest boxes per hectare with appropriate monitoring	3
≥4 nest boxes per hectare with appropriate monitoring	5

As plantation trees rarely mature to the extent that they the develop hollows, the importance of which is described in the previous section, the installation of artificial hollows (nest boxes) can be considered as a strategy to increase the biodiversity value of a plantation.

However, nest boxes are not a quick fix or a cheap solution. They must be properly designed and carefully monitored as they can provide refuge for undesirable pest species. They are therefore high-maintenance and expensive to build. Further, artificial hollows can interfere with tree growth and can be dangerous for contractors/mill workers e.g. if wire/nails are left in trunk.

For these reasons, artificial hollows are unlikely to have a significant long-term role in improving biodiversity in commercial tree plantations. It remains open to question whether artificial hollows should be included as an integral component of the score. Future field testing of the Plantation Biodiversity Score may lead to the removal of this component of the score.

On this basis the maximum contribution to the Plantation Biodiversity Score from the Nest Boxes Score= 5 (out of a total of 75).

5. Thinning and pruning (MG9)

The Thinning and Pruning Score has 3 components; the Thinning Score, the Dead Tree Score and the Pruning Score. We have given the largest value to the Pruning Score because leaving pruning residues on the ground is likely to provide the greatest habitat benefit and may prove to be economically costly, in that prunings may be a lost resource in terms of timber and firewood (Salt et al. 2004). The values for the component scores are summed to give the final Thinning and Pruning Score. Table 30 shows how to determine the Thinning and Pruning Score.

Table 30 Criteria and scores for the Thinning and Pruning Score of the Plantation Biodiversity Score.

Component	Criteria	Thinning Score
Thinning	No thinning	0
	Standard thinning only	1
	Variable density thinning at some stage	2
		Dead Tree Score
Dead trees	No ringbarking/poisoning of deformed trees	0
	Some ringbarking/poisoning of deformed trees	1
		Pruning Score
Pruning	No prunings or felled dead trees left on the ground	0
	Prunings and/or felled dead trees left on the ground	2
Thinning and Pruning Score = Thinning Score + Dead Tree Score + Pruning Score		

Thinning and pruning can play a role in improving the biodiversity value of a plantation by increasing the structural complexity and diversity of the vegetation (Salt et al. 2004). Thinning can introduce structural complexity by making the tree spacing more variable i.e. more like the tree spacing in natural vegetation. Killing (deformed) trees and leaving them *in situ* can provide diversity and habitat. Prunings left on the ground can provide shelter and habitat.

The maximum contribution to the Plantation Biodiversity Score from the Thinning and Pruning Score = 5 (out of a total of 75).

6. Rotation times (MG10)

Table 31 shows how to determine the Rotation Time Score.

Table 31 Criteria and scores for the Rotation Time Score of the Plantation Biodiversity Score.

Criteria	Rotation Time Score
Rotation time < 15yrs	0
Rotation times ≥ 15 years and < 25yrs	3
Rotation times ≥ 25 years	5

The biodiversity benefits of a plantation increase with the age of the trees. Older trees confer more biodiversity value to a stand (Salt et al. 2004).

The maximum contribution to the Plantation Biodiversity Score from the Rotation Time Score = 5 (out of a total of 75).

7. Mosaics: mixed age stands (MG10)

Table 32 shows how to determine the Mosaic Score.

Table 32 Criteria and scores for the Mosaic Score of the Plantation Biodiversity Score.

Component	Criteria	Mosaic Score
Mosaic of harvesting	All stands (coupes) of one age	0
	Harvest to ensure a mosaic of stands (coupes) of 2 different ages	3
	Harvest to ensure a mosaic of stands (coupes) of more than 2 different ages	5

Mosaics of different-aged stands (or 'coupes') increase the diversity of the landscape, which in turn allow a greater diversity of use by wildlife because different wildlife species use stands of vegetation of different ages in different ways (Salt et al. 2004). Young stands can provide cover and habitat for species which live and move near the ground. Older stands can provide cover and habitat for species which operate in upper habitat strata. A mix of different aged stands may therefore produce greater native species richness than single-aged stands.

The diversity of the landscape, in terms of an age mosaic, can be viewed at both the site (i.e. single plantation) scale and the landscape scale. We have chosen to score it at the site scale because landowners do not have control over the management practices of their neighbours and therefore cannot commit their neighbours to harvest at particular life stages in order to preserve a mosaic of different-aged stands across property boundaries.

The maximum contribution to the Plantation Biodiversity Score from the Mosaic Score = 5 (out of a total of 75).

8. Mixed plantings (MG5)

Table 33 shows how to determine the Mixed Planting Score.

Table 33 Criteria and scores for the Mixed Planting Score of the Plantation Biodiversity Score.

Criteria	Mixed Planting Score
1 plantation species in the plantation	0
2 species in the plantation; 2nd species comprises a minimum 20% of plantation area	3
> 2 species in the plantation; 2nd and 3rd species comprise a minimum of 20% of plantation area	5

In a similar way to a mosaic of different aged stands, plantations with a diversity of plant species tend to increase the diversity and abundance of a range of native wildlife (Salt et al. (2004). One potentially cost-effective way of increasing this diversity is by planting a variety of species, for example mixtures of eucalypt and acacia species.

The maximum contribution to the Plantation Biodiversity Score from the Mixed Planting Score = 5 (out of a total of 75) because mixed plantings are unlikely. We have given a large increment in the score for the use of 2 species in a plantation to encourage ANY mixed planting.

9. Planting with local species (MG6)

Table 34 shows how to determine the Local Species Score.

Table 34 Criteria and scores for the Local Species Score of the Plantation Biodiversity Score.

Criteria	Local Species Score
No local species	0
1 local species comprising 20% of the plantation	3
> 1 local species comprising 20% of the plantation	5

Local species of trees are best adapted to local conditions and provide the best habitat for local wildlife (Salt et al. 2004). Local species are defined as those recognised by botanists or seed collectors as local provenances.

The maximum contribution to the Plantation Biodiversity Score from the Local Species Score = 5 (out of a total of 75) because it is unlikely that local species will be suitable for most plantation forestry. We have given a large increment in the score for use of a single local species to encourage ANY use of local species.

10. Control escapees (MG11)

The Control Escapees Score has 2 components; the Wildlings Score and the Non-Hybrid Score. The values for the component scores are summed to give the final Control Escapees Score. Table 35 shows how to determine the Control Escapees Score.

Table 35 Criteria and scores for the Control Escapees Score of the Plantation Biodiversity Score.

Component	Criteria	Wildlings Score
Wildlings	No monitoring and control of wildlings	0
	Monitor and eliminate wildlings	2.5
		Non-Hybrid Score
Non-Hybrid	Plantation species can hybridise with local species	0
	All plantation species are non-hybridising species	2.5
Control Escapees Score = Wildlings Score + Non-Hybrids Score		

As most plantations consist of species which are exotic, these species have the potential to become environmental weeds which displace native vegetation (Salt et al. (2004). For this reason it is important to control the escape of wildlings.

For the same reason it is also important to recognise the potential for the escape of genes i.e. genetic pollution, through hybridisation of plantation species with native species. One suggested strategy to deal with this is to physically separate the plantation from patches of native vegetation. This is at odds with recommendations for increasing the connectivity in the landscape (see point 7 above) (Salt et al. 2004). It may be possible to choose non-hybridising genotypes when selecting plantation species.

Another approach is to plant native vegetation buffers between the plantation and native remnants, which may make it easier to monitor the escape of both wildlings and hybrids, assisting in the control of escapees by buffering native remnants from pollen and seed rain from the plantations. However, the placement of native plantings will contribute to the ‘Habitat Hectares’ Score for native vegetation components of a commercial environmental forestry planting and therefore does not contribute to the Plantation Biodiversity Score.

The maximum contribution to the Plantation Biodiversity Score from the Wildlings Score = 5 (out of a total of 75).

11. Control weeds (MG12)

Table 36 shows how to determine the Control Weeds Score.

Table 36 Criteria and scores for the Control Weeds Score of the Plantation Biodiversity Score.

Criteria	Control Weeds Score
No weed control	0
Reduce all high threat herb/grass weed cover and all woody environmental weeds to 10% cover	3
Eliminate all high threat herb/grass weed cover and all woody environmental weeds (i.e. reduce to <1% cover)	5

Plantation forestry can become a major source of environmental weeds which can invade native vegetation. Environmental weeds can displace native species and reduce the biodiversity value of both plantations and native remnants alike.

Salt et al. (2004, p120) address weed management only with reference to softwood plantations and the control of blackberry. The scoring for weed control devised for the 'Habitat Hectares' approach (Parkes et al. 2003, Department of Sustainability and Environment 2004) addresses the issues of both grass/herb weeds and woody weeds (which would include blackberry) and, as such, presents a useful approach to the scoring of weed control in plantations. Therefore we have adapted this approach for scoring weed control against the Salt et al. (2004) design principles. It should be noted that the Control Weeds Score of the Plantation Biodiversity Score applies only to vegetation management units which are plantations. Control of weeds for the native vegetation management units of a commercial environmental forestry proposal will be scored by the 'Habitat Hectares' method in Victoria, and by other relevant methods in the other States.

The maximum contribution to the Plantation Biodiversity Score from the Control Weeds Score = 5 (out of a total of 75). The score conditions and increments are based upon the Lack of Weeds scoring shown in Department of Sustainability and Environment (2004).

12. Control animal pests (MG11)

Table 37 shows how to determine the Control Animal Pests Score.

Table 37 Criteria and scores for the Control Animal Pests Score of the Plantation Biodiversity Score.

Component	Criteria	Feral Herbivores Score
Feral herbivores	No feral herbivore control	0
	Control of rabbits/hares OR deer	2
	Control of rabbits/hares AND deer	3
		Feral Predators Score
Feral predators	No feral predator control	0
	Baiting for cats OR foxes	1
	Baiting for cats AND foxes	2
Control Animal Pests Score = Feral Herbivores Score + Feral Predators Score		

Feral vertebrate herbivores, (e.g. rabbits, hares, deer) have the potential to harm both plantations and the native biodiversity value of an area. Also, plantations can provide shelter for feral predators (e.g. cats and foxes) which prey upon native wildlife. For this reason, it could be considered a biodiversity benefit to control them.

The maximum contribution to the Plantation Biodiversity Score from the Control Animal Pests Score = 5 (out of a total of 75).

The Control Animal Pests Score has 2 components; the Feral Herbivores Score and the Feral Predators Score. The values for the component scores are summed to give the final Control Animal Pests Score.

Landscape-scale components

The Salt et al. (2004) design principles under the Location and Configuration themes have been allocated to the landscape scale, except the principle 'protection of waterways' which has been dealt with under site-scale management guideline 5 (Site preparation) in the previous section.

All other design principles under the Location and Configuration themes fit into the landscape scale. The values for these components may be derived with assistance from maps and other (e.g. GIS) information sources.

Initially we had assumed that the landscape-scale components of the Plantation Biodiversity Score could readily be achieved using exactly the same method as that employed by the 'Habitat Hectares' Method (Department of Sustainability and Environment, 2004). However, closer examination of the issues indicates that this would not be a rational approach.

The Parkes et al. (2003) 'Habitat Hectares' component 'distance to core area' does not map specifically to any of the Salt et al. (2004) design principles. A 'core area' is defined by Parkes et al. (2003) as a '*block of native vegetation greater than 50 hectares in area*'. With the 'Habitat Hectares' Method, the closer a patch of native vegetation is to a core area, the higher the score for this component will be, because the movement of native biota and propagules from the core area to the patch will be more effective, the closer the core area.

However, for a patch of commercial environmental forestry, the component is not so logical because, with regard to native vegetation, the spread of propagules into the plantation area is not likely to be encouraged. Movement of animals from the core area is relevant, but for the purposes of plantations we believe that this biodiversity benefit will be adequately covered by the Landscape Connectivity Score developed for the Plantation Biodiversity Score (see below).

With regard to landscape connectivity, the philosophy behind landscape connectivity for the 'Habitat Hectares' Method, inherent in that method's Neighbourhood Score, is different to the philosophy behind the Plantation Biodiversity Score equivalent, which we have called the Landscape Connectivity Score. This will be discussed in detail in the next section.

Also, although it is logical for the 'Habitat Hectares' Method to score patch size as a biodiversity benefit, it does not necessarily follow that the bigger the plantation size the greater the biodiversity benefit.

For the 'Habitat Hectares' approach, the larger the size of a patch of native vegetation, the greater the biodiversity benefit it is regarded to confer. Current theory has it that larger patches will support a greater variety of native biodiversity, e.g. vertebrates with larger territorial requirements etc., than smaller patches. Also, the larger the patch, the less the 'edge effect' (Salt et al. 2004).

However, although they include size in their design principles, Salt et al. (2004) point out that the biodiversity benefits of size are more relevant to patches of native vegetation and state that a large area plantation of exotic monoculture will not necessarily confer greater biodiversity benefits than a small plantation of mixed exotic species. A diverse landscape, consisting of many patches of different vegetation types, even if some of them are plantations, is likely to confer a higher biodiversity benefit than a landscape consisting mainly of exotic pasture or plantation monoculture. Therefore, we have not scored patch size in isolation in the Plantation Biodiversity Score. Instead we have used it to weight the results of a new Landscape Connectivity Score (see Table 41).

What does appear to be important, however, is width (i.e. 'shape') of vegetation patches or corridors (Salt et al. 2004). On this basis, we have added 1 other landscape scape component, namely Plantation Width. The wider a plantation the more protection it provides for wildlife movement in the landscape by reducing the 'edge effect'.

Table 38 presents the proposed landscape-scale components of the Plantation Biodiversity Score with their weightings.

Table 38 Score values for the landscape-scale components of the Plantation Biodiversity Score.

Component	Maximum value
Landscape connectivity	15
Plantation width	10
Total	**25**

The above score values sum to 25, a total value of 100 for the sum of the site-scale and landscape-scale components of the Plantation Biodiversity Score.

Table 39 shows the landscape-scale themes and design principles from Salt et al. (2004) mapped against the relevant landscape-scale components of the 'Habitat Hectares' Method and the Plantation Biodiversity Score Method.

Table 39 The juxtaposition of the landscape-scale themes and design principles from Salt et al. (2004) with the landscape context components of Parks et al. (2003).

<table>
<tr><th colspan="2">Salt et al. (2004)</th><th>Parkes et al. (2003)</th><th>Plantation Biodiversity Score</th></tr>
<tr><th>Theme</th><th>Design Principle</th><th colspan="2">Landscape Context Component</th></tr>
<tr><td rowspan="4">Location</td><td>Adjacency</td><td rowspan="3">Neighbourhood</td><td rowspan="3">Landscape Connectivity</td></tr>
<tr><td>Connectivity</td></tr>
<tr><td>Landscape context</td></tr>
<tr><td>Protection of waterways[a]</td><td>-</td><td>(covered at the site scale)</td></tr>
<tr><td rowspan="2">Configuration</td><td>Size of plantings</td><td>Patch size</td><td>Planting Area Weighting</td></tr>
<tr><td>Shape of plantings</td><td>-</td><td>Plantation Width</td></tr>
</table>

[a] This design principle has been dealt with under the site-scale Site Preparation Score.

The next sections describe the methods for assessing the landscape-scale portion of the Plantation Biodiversity Score.

1. Landscape connectivity

The Landscape Connectivity Score is calculated using 2 separate scores, the Landscape Cover Score and the New Planting Area Weighting.

The Landscape Cover Score has 3 components; the Neighbourhood100 Score, the Neighbourhood1k Score and the Neighbourhood5k Score. The values for the component scores are summed to give the final Landscape Cover Score. The method for determining the Landscape Cover Score is shown in Table 40. The calculation of the score is more accurately done within a GIS, but could be approximated by eye.

Table 40 Neighbourhood sizes, criteria and scores for the Landscape Cover Score.

Neighbourhood Size	**Criteria**	**Neighbourhood100 Score**
100 metres	existing vegetation cover < 10%	0
	existing vegetation cover between 10 and 30%	3
	existing vegetation cover ≥ 30%	5
		Neighbourhood1k Score
1 kilometre	existing vegetation cover ≥ 30%	0
	existing vegetation cover < 10%	3
	existing vegetation cover between 10 and 30%	5
		Neighbourhood5k Score
5 kilometres	existing vegetation cover ≥ 30%	0
	existing vegetation cover < 10%	3
	existing vegetation cover between 10 and 30%	5
Landscape Cover Score = Σ(Score Values for the 3 neighbourhood sizes)		

Table 41 shows how to determine the Planting Area Weighting and the final Landscape Connectivity Score.

Table 41 Criteria and scores for the Planting Area Weighting of the Plantation Biodiversity Score and calculation of the final Landscape Connectivity Score.

Criteria	**Planting Area Weighting**
Combined area of new plantings in the commercial environmental forestry proposal ≤ 10ha	0.6
Combined area of new plantings in the commercial environmental forestry proposal between 10 – 50	0.8
Combined area of new plantings in the commercial environmental forestry proposal ≥ 50ha	1
Landscape Connectivity Score = Landscape Cover Score x Planting Area Weighting	

The Landscape Connectivity Score for the Plantation Biodiversity Score is based loosely upon the Neighbourhood Score in the 'Habitat Hectares' Method. The description of the Neighbourhood Score has been taken from Chapter 8 of Department and Sustainability and Environment (2004).

For the 'Habitat Hectares' method, '*The neighbourhood score represents the amount and configuration of native vegetation within the proximity of the habitat zone being assessed*'. The approach estimates the amount of native vegetation present within three neighbourhood radii (i.e. neighbourhood sizes) as shown in Figure 3 and Table 40.

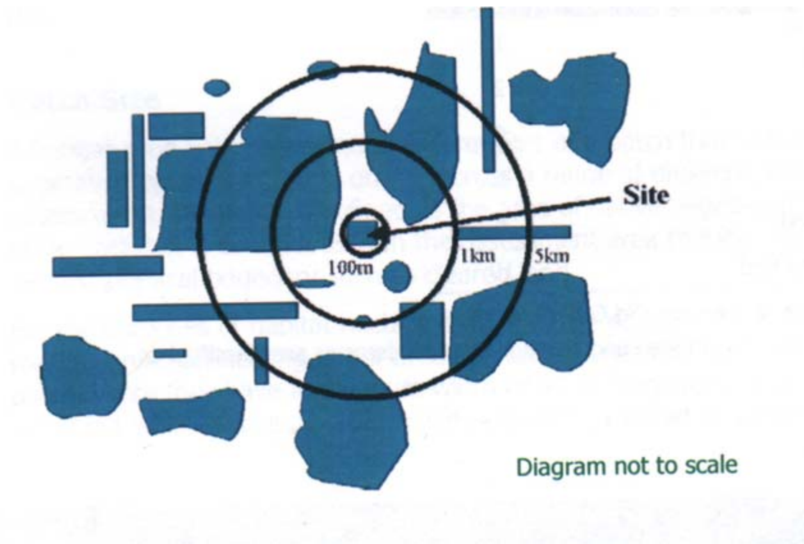

Figure 3 The principle of neighbourhood analysis for habitat hectares assessment (from Parkes et al. 2003 and Department of sustainability and Environment 2004)

The philosophy behind the Neighbourhood Score in the 'Habitat Hectares' Method is to encourage native plantings and enhancements in areas of high landscape connectivity. The higher the Neighbourhood Score, the higher the landscape connectivity. A landscape with high connectivity is one in which many species can move readily between patches of suitable native habitat (Salt et al. 2004).

The Neighbourhood Score also incorporates the concept of adjacency. A planting established in a 100 metre radius zone with 70 % cover is highly likely to be adjacent to existing native vegetation then one established in a zone with 10 % cover. Analysis of cover in the three zones can give a high score for a planting in a 100 metre radius zone with 80 % cover, but much lower scores if the 1 km and 5 km zones around this plantation only have 10 % cover.

The amount of native vegetation is assessed by rounding the percent vegetation cover to the nearest 20% for each radius, multiplying the value for each radius by the radius weighting (fixed) and summing the resulting value for the three radii. This can be done more accurately by using a GIS, but can also be approximated by eye. For the 'Habitat Hectares' method, the final score is adapted by disturbance.

Discussions with the Department of Sustainability and Environment, Victoria, and the Goulburn-Broken Catchment Management Authority have highlighted the fact that the aims of the 'Habitat Hectares' Method and those of the Plantation Biodiversity Score are philosophically very different.

The Neighbourhood Score of the 'Habitat Hectares' method is weighted heavily in favour of placing **native** plantings in a landscape which is already highly connected. In highly connected landscapes, the placing of plantations is more likely to be viewed as a biodiversity disbenefit, because a plantation would preclude the immediate possibility for that part of the landscape to be planted to native vegetation and, as the landscape is already well connected, any additional connectivity benefit from the non-native vegetation will be concomitantly low. For this reason, it would be preferable to score the placement of plantations in the landscape almost as an inverse to the Neighbourhood Score, with high scores given to plantations which do not pre-empt native vegetation.

Research has shown that landscapes require a minimum 30% native vegetation cover to maintain ecological sustainability and connectivity (e.g. Andren 1995, Reid 1999 and 2000, McIntyre et al. 2000). On this basis we have classified landscapes with ≥ 30% vegetation cover as ‘connected’ landscapes.

Although a plantation cannot be considered the equivalent of native vegetation cover, the use of plantations to increase vegetation cover and connectivity in a highly cleared agricultural landscape will provide woody vegetation cover which may not otherwise be available. This gain in cover could add value to any future native vegetation plantings which might be placed into these landscapes, by providing the opportunity to add to the connectivity of the landscape, thus allowing the gradual building of corridors and stepping-stones to facilitate the movement of wildlife.

The greater the area of planting involved, the more it will contribute to an increase in general vegetation cover and connectivity. Therefore we have used **the total area of proposed re-vegetation** to weight the scores achieved through the assessment of landscape cover (Table 41). The Landscape Connectivity Score therefore is achieved through two sets of criteria, the Land Cover Score and the Planting Area Weighting.

The Landscape Cover Score Method calculates the percent cover of the landscape at the three neighbourhood sizes (i.e. radii) chosen for the Neighbourhood Score in the ‘Habitat Hectares’ Method. The first neighbourhood will extend 100 metres from the plantation edge on all sides. The scoring system for this neighbourhood is designed to encourage the connection of plantations to neighbouring vegetation, by giving highest scores to plantations which will have ≥ 30% vegetation cover in their 100 metre neighbourhood **after** they have been established. Plantations which have a high connectedness to the landscape at this scale will encourage the movement of wildlife from abutting vegetation into and through the plantation vegetation.

The percent cover inside the 100 metre neighbourhood will then be assessed (see hatched area in Figure 4). Note that this assessment **excludes the area which will be covered by the plantation** (see solid grey square in Figure 4). Existing native remnants, paddock trees **and all vegetation cover which will be added to the landscape by any native vegetation plantings associated with the commercial environmental forestry proposal** will contribute to the percent cover assessment, because we are assessing what the connectivity in the 100 metre zone will be **after** the plantation has been established. Thus, all projected vegetation plantings will eventually contribute to the connectivity of the landscape in the 100 metre neighbourhood after the plantation and associated native plantings have been established.

The scoring system for the other neighbourhood sizes is very different, in that for these two neighbourhoods we wish to encourage the establishment of plantations in landscapes which occupy the moderately cleared range **before** any plantings are established. For this reason we give the highest score to landscapes with between 10 and 30% existing cover, because of the larger contribution to landscape connectivity, through the building of stepping-stones and corridors. For example, a 100 ha planting established in an area with < 10% pre-existing tree cover will contribute less to connectivity than a 100 ha planting in an area with existing cover between 10 and 30%.

The 1 kilometre neighbourhood (blue arrow in Figure 4) will extend 1 kilometre from the plantation edge on all sides of the plantation. The 5 kilometre neighbourhood (red arrow in Figure 4) will extend 5 kilometres from the plantation edge on all sides. The percent cover in the 1 kilometre and 5 kilometre neighbourhoods will be assessed **including the area which will be covered by the plantation** (solid grey square in Figure 4).

Existing native remnants and paddock trees will contribute to the percent cover assessment, **but all vegetation cover which will be added to the landscape by the proposed plantation**

and any native vegetation plantings associated with the commercial environmental forestry proposal will be excluded because for these scores we are assessing landscape cover prior to plantation establishment.

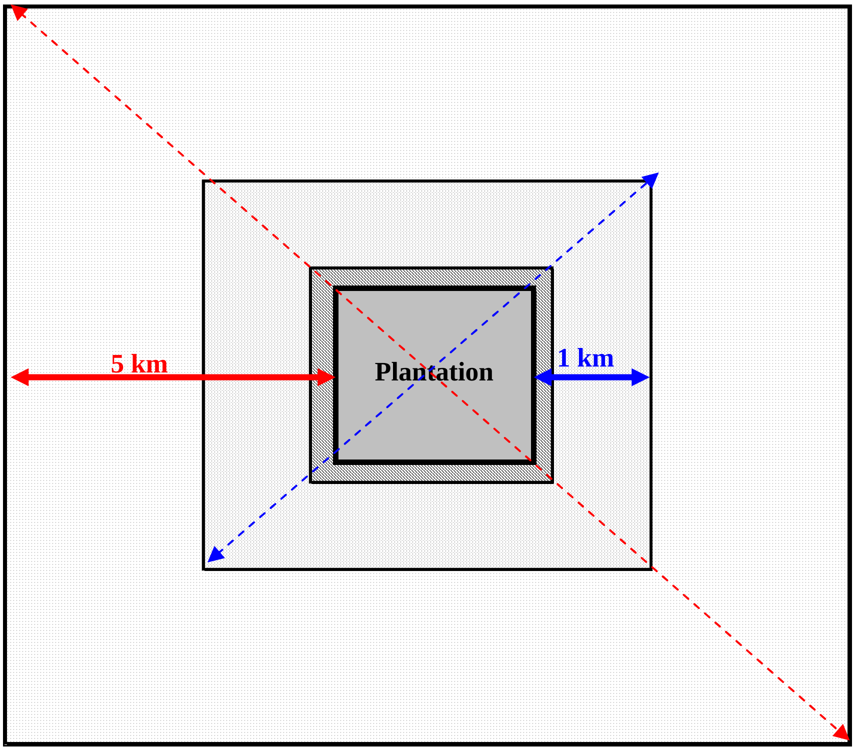

Figure 4 The 100 metre (hatched), 1 kilometre (blue arrow) and 5 kilometre (red arrow) neighbourhoods for calculation of the three components of the Landscape Cover Score. Only the hatched area contributes to the calculation of the Neighbourhood100 Score. All of the area encompassed by the dotted blue arrow contribute to the calculation of the Neighbourhood1k Score. All of the area encompassed by the slanted red arrow contributes to the calculation of the Neighbourhood5k Score.

The value of the Landscape Cover Score is then multiplied by the Plantation Size Weighting, which effectively discounts the value of the Landscape Cover Score for plantation sizes < 50 hectares. The rationale behind this is that, in highly cleared landscapes, plantation size is important. The maximum benefit which can be achieved by the Landscape Connectivity Score is equivalent to the value of the Landscape Cover Score. A plantation in a highly connected landscape will tend to perform poorly on the Landscape Cover Score and the size of the plantation can only reduce the final value of the Landscape Connectivity Score. A plantation in a highly cleared landscape will tend to perform well on the Landscape Cover Score. However, in highly cleared landscapes, a small plantation will do less to contribute to landscape connectivity than a large one, as the Plantation Size Weighting discounts the connectivity effects of small plantations.

The maximum contribution to the Plantation Biodiversity Score from the Landscape Connectivity Score = 15 out of a possible 25.

2. Plantation width

The method for determining the Plantation Width Score is shown in Table 42.

Table 42 Criteria and scores for the Plantation Width Score.

Criteria	Width Score
Width < 50 metres	0
Width between 50 -100 metres	7
Width > 100 metres	10

The wider a plantation the more protection it provides for wildlife by reducing the ‘edge effect’ (Salt et al. 2004). Please note that in the calculations for the criteria, the width is always the smaller dimension of the plantation.

The maximum contribution to the Plantation Biodiversity Score from the Plantation Width Score = 10 out of a possible 25.

Worked example

Figure 5 (same as Figure 1, but reproduced here for convenience) diagrammatically presents the possible vegetation components of a hypothetical commercial environmental forestry proposal.

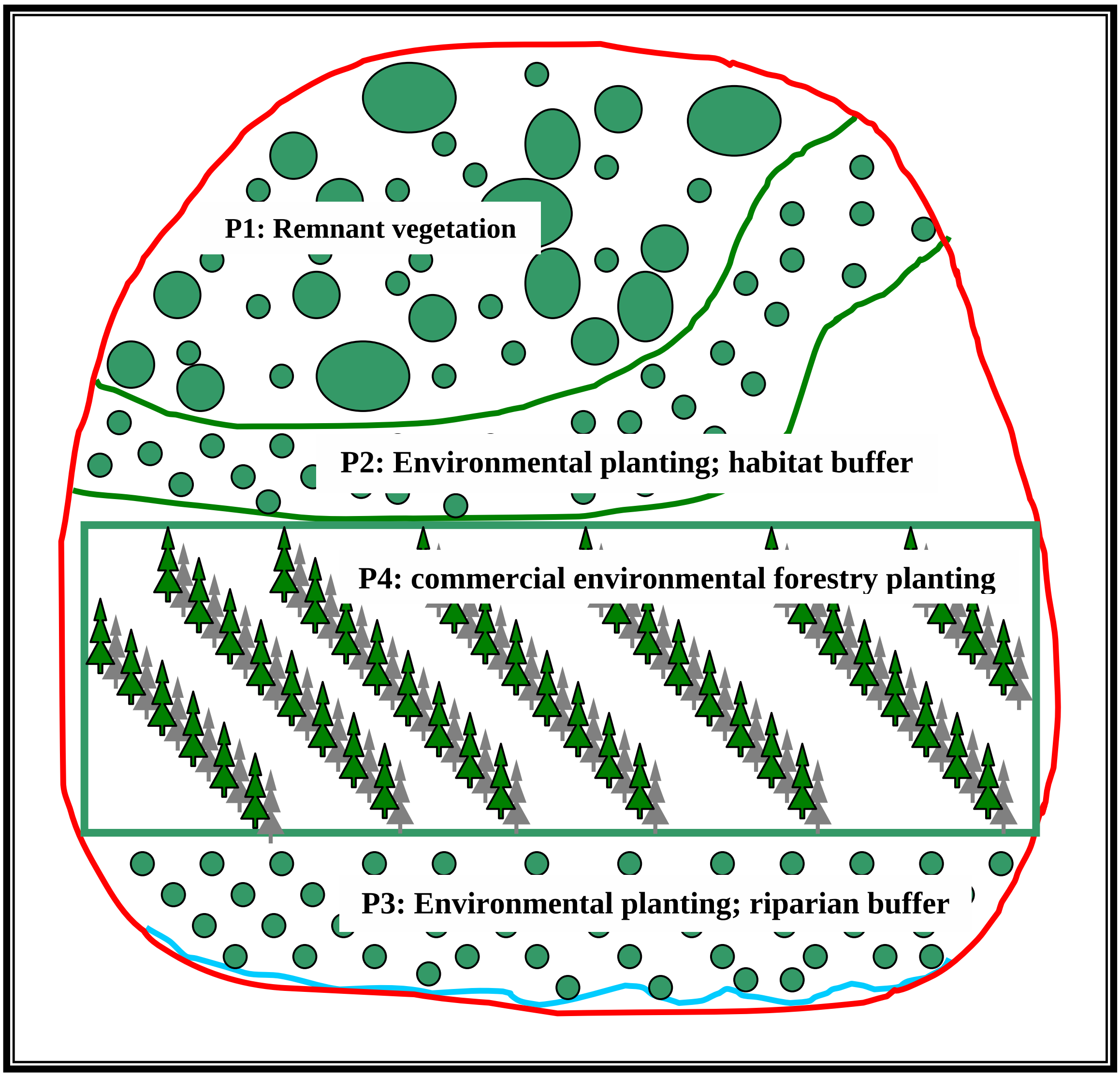

Figure 5 The vegetation components of a hypothetical commercial environmental forestry proposal.

Each patch in Figure 5 represents a different vegetation management unit of the hypothetical commercial environmental forestry proposal. There are four vegetation management units represented in the illustration; P1 (area = 8 hectares), P2 (area = 2 hectares) and P3 (area = 2 hectares) are patches of native vegetation.

The scenario

In Figure 5, P4 represents the actual proposed commercial environmental forestry plantation. This vegetation management unit has an area of 10ha, with a width of 200 metres and a length of 500 metres. The total area of vegetation for the proposal is 27 hectares, including native vegetation management units P1-P3 and the plantation P4. The total area of new plantings, P2-P4, is 19 hectares.

Prior to plantation, the P4 was an exotic pasture with scattered large trees. There was no shrub or tree regrowth and all fallen timber had long since been removed for firewood. Prior to all of the plantings involved in the proposal, P4 is estimated to be surrounded by 0% vegetation cover at the 100 metre radius, 15% cover at the 1 kilometre radius and 40% cover at the 5 kilometre radius.

The intention is to plant this vegetation management unit with a monoculture of non-native species, *Eucalypus globulus* (Tasmanian Blue Gum), with rotation periods of different parts of the stand of between 15 and 25 years.

There are 12 large remnant trees currently standing on this vegetation management unit. These will be retained undamaged during site preparation, which will ensure that disturbance associated with site preparation and plantation establishment will not come closer than 3m from the drip-line edge for each tree. A small rocky outcrop near the centre of the plantation will remain intact.

The waterways will be protected from pollution from the plantation by the planting of a 25 metre wide riparian buffer (vegetation management unit P3) prior to the establishment of the plantation. A native habitat buffer (P2) will also be planted between the plantation and the closest native remnant (P1) with a view to protecting that remnant from genetic pollution.

There will not be any artificial hollows installed as the plantation trees mature.

Standard thinning procedures will be employed at appropriate times in the life of the plantation. Thinnings/prunings smaller than 8 cm in diameter will be left on the ground, with larger pieces pushed into large heaps for drying for firewood for several years before removal. A proportion of deformed trees will be left in the plantation until they reach a diameter of at least 10 cm, when they will be ring-barked and left as standing dead trees.

The native buffer zones around the plantation will be monitored annually for wildlings. Any rabbit warrens in the proposal area will be ripped as part of site preparation and the plantation will be surrounded by a rabbit-proof fence. There will be no fox or cat control carried out.

Herbaceous weeds will be controlled by selective herbicide in the early stages of the plantation and by crash-grazing whenever deemed necessary thereafter. The plantation and buffer zones will be monitored annually for control of woody weeds, with the intention of keeping them at negligible levels.

Harvesting will occur in two stages at the first rotation, one at 15 years and the other at 25 years, with new plantation trees planted after each harvest, giving a mosaic of different aged stands, maintaining some connectivity between each age group and the native buffers. During harvesting, the original remnant trees will remain undamaged, whether they are alive or dead. At harvesting, small fallen logs will be retained, pushed into windrows out of the way of machinery. The rocky outcrop will be retained undamaged.

Table 43 shows a worked example of scoring the site-scale components of the Plantation Biodiversity Score for this plantation. In Table 43, the first column shows the relevant component score. The second column shows the component criteria which apply to the P4 plantation. The third column shows the calculation of the score, where that is relevant and the fourth column gives the final value for the component score over all criteria relevant to the component.

Table 43 A worked example of scoring the site-scale components of the Plantation Biodiversity Score for plantation P4.

Component Score	Criteria	Sub Score	Score Value
Paddock Tree Score	≥ 4 remnant trees/ha retained		10
Site Preparation Score	**Tree Protection Score**; site preparation to leave undisturbed an area 3 m from the drip line of all paddock trees **Waterway Protection Score**; native buffers > 20m wide will be planted in the riparian area	6 + 4	10
Biological Legacy Score	**Paddock Tree Legacy Score**; all paddock trees will be retained at time of harvesting. **Tree Environment Score**; coarse woody debris will be retained and in some cases added to the environment around the retained paddock trees although no actual shrub planting will be carried out. **Dead Wood Score**; there will be some retention of 20% of boulders and fallen logs at time of harvesting	4 + 2 + 1	7
Artificial Hollows Score	no nest boxes installed		0
Thinning and Pruning Score	**Thinning Score**; standard thinning practices **Dead Tree Score**; deformed trees will be ringbarked and left standing dead **Pruning Score**; Small prunings will be left on the ground in perpetuity. Large thinnings will be taken for firewood, however, until dried they will be pushed into habitat heaps for several years.	1 + 1 + 2	4
Rotation Time Score	Rotation time is between 15 and 25 years		3
Mosaic Score	Harvesting will occur to give a mosaic of stands of two different ages		3
Mixed Planting Score	only 1 species to be planted		0
Local Species Score	no local species used		0
Control Escapees Score	**Wildlings Score**; wildlings and weeds will be monitored and eliminated **Non-Hybrid Score**; the plantation species selected is known to hybridise with some natives	2.5 + 0	2.5
Control Weeds Score	All high threat herb/grass weed cover and all woody environmental weeds will be reduced to negligible levels		5
Control Animal Pests	**Feral Herbivore Score**; rabbits will be controlled **Feral Predator Score**; there will be no baiting for cats or foxes.	2 + 0	2
Total of Site-scale Plantation Biodiversity Score (maximum possible = 75)			**46.5**

Table 44 shows a worked example of scoring the landscape-scale components of the Plantation Biodiversity Score for this plantation. In Table 44, the first column shows the relevant component score. The second column shows the component criteria which apply to the P4 plantation. The third column shows the calculation of the score, where that is relevant and the fourth column gives the final value for the component score over all criteria relevant to the component.

Table 44 A worked example of scoring the site-scale components of the Plantation Biodiversity Score for plantation P4.

Component Score	Criteria	Sub Score	Score Value
Landscape Connectivity Score	Neighbourhood100 Score: 0% native veg cover Neighbourhood1k Score: 15% native veg cover Neighbourhood5k Score: 40% native veg cover Planting Area Weighting: total area of new plantings = 19 ha	(3 + 5 + 0) * 0.8	6.4
Plantation Width Score	Plantation Width = 100 metres		10
Total of Landscape-scale Plantation Biodiversity Score (maximum possible = 25)			**16.4**
Total Plantation Biodiversity Score (maximum possible = 100)			**62.9**

In the worked example, the total achieved value of the site-scale components of the Plantation Biodiversity Score is 46.5 points out of a possible 75, i.e. an achievement level of 62% of the possible maximum. The total achieved value of the landscape-scale components of the Plantation Biodiversity Score is 16.4 out of a possible 25, i.e. an achievement level of 65.6% of the possible maximum.

As a consequence, the final Plantation Biodiversity Score for P4 is 62.9, or 62.9% of the possible maximum biodiversity benefits which could feasibly be derived from a plantation with exactly the same attributes as P4, within a commercial environmental forestry proposal with exactly the same area of new plantings as in the worked example, placed within a landscape with exactly the same percent cover values as shown for this worked example.

Chapter 6 Summary

The process of the development of the Plantation Biodiversity Score described in this report has evolved through several phases.

The brief of this project was to adapt an existing method for the assessment of biodiversity benefits of plantations.

Salt et al. (2004) have produced a useful framework of ecological design themes and principles for the design and management of plantations. This framework appeared to provide a suitable platform for the development of a plantation biodiversity benefits score. However, during the first phase (*Review of Existing Biodiversity Assessment Systems; Cawsey and Freudenberger 2004*) we formed the view that it would be useful to have a single metric, capable of assessing the biodiversity of the full range of vegetation, from exotic pasture through to pristine native vegetation.

In Victoria there was already an active biodiversity assessment program, run by the Department of Sustainability and Environment. This system was based upon the 'Habitat Hectares' Method, developed by Parkes et al. (2003). The systems developed in NSW were also based upon the Parkes et al. (2003) method, adapted to the legislative requirements of NSW.

The pilot studies for the Commercial Environmental Forestry Project (CSIRO Forestry and Forest Products) were in the Goulburn-Broken Catchment in Victoria. For this reason we originally decided that it would be a useful starting point to adapt the 'Habitat Hectares' Method for plantations.

This approach turned out to be infeasible. The requirement inherent in the brief for this project that the method we developed should be applicable anywhere in Australia. The data required to apply the 'Habitat Hectares' method exists only for Victoria.

Therefore we returned to Salt et al. (2004) ecological design themes, principles and management guidelines and, with reference to the work of Parkes et al. (2003), constructed a generic approach to the assessment of the biodiversity benefits of plantations, that is, the Plantation Biodiversity Score which is described in this document.

During its development, the Plantation Biodiversity Score underwent critical feedback from selected stakeholders (Appendix 2) and was significantly modified in line with this feedback.

The latest version of the Plantation Biodiversity Score, now called the prototype Plantation Biodiversity Score, follows the Salt et al. (2004) framework closely. It represents the first attempt to construct a set of concrete criteria to assess the potential biodiversity benefits in a manner which would allow the comparison of the relative benefits of one or more commercial environmental forestry designs. The prototype Plantation Biodiversity Score criteria are explicit and should give repeatable results. They should be applicable to any plantation in Australia, regardless of geographic and political environments.

Conclusion

The next step should be a series of field trials of the prototype Plantation Biodiversity Score method, over a range of different plantation types. This will lead to further modification, resulting in a more robust version of the Plantation Biodiversity Score method which will be explicit and repeatable, yet practical and flexible to meet users' needs..

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