natural resource planning

Summary of the Regional Ecosystem Model of Tasmanian biodiversity

The Regional Ecosystem Model (REM) is a comprehensive spatial modelling system of Tasmanian biodiversity. It:

- Integrates spatial data on the distribution of the major components of biodiversity, and the factors affecting them;
- Models key biodiversity attributes that derive from multiple inputs;
- Analyses the relationships among the components of biodiversity and the environment; and
- Spatially identifies areas which have immediate or potential conservation concerns, and provides indicators of their relative importance, to inform approaches and priorities for management.

The REM was developed by Natural Resource Planning Pty Ltd using funds from the Australian Government's Caring for Our Country program. The following briefly summarises the REM, which is described in more detail in Knight and Cullen 2009[1], 2010[2].

The REM is based on a comprehensive 'Strategy Review' of both the strategic framework for biodiversity management in Tasmania and of the major themes in the relevant scientific literature. Issues identified from the Strategy Review are examined against a range of criteria to determine their suitability for incorporation into the REM, including:

- The ability of each Issue to be stored spatially and analysed in a GIS;
- Whether Issues are confounded, i.e. in combining multiple Issues into one and thus compromising objective assessment of more fundamental Issues; and
- Whether Issues are logically consistent and supported by scientific opinion.

[1] Knight, R.I. & Cullen, P.J. (2009). A review of strategies for planning & management of the natural resources of biodiversity, freshwater, land & soils in the Tasmanian midlands. A report of the Caring for Our Country project 'Using landscape ecology to prioritise property management actions in Tasmania'. Natural Resource Planning, Hobart, Tasmania.

[2] Knight, R.I. & Cullen, P.J. (2010). Specifications for a Regional Ecosystem Model of natural resources in the Tasmanian Midlands. A report of the Caring for Our Country Project 'Using landscape ecology to prioritise property management actions in Tasmania'. Natural Resource Planning, Hobart, Tasmania.

The resulting list of biodiversity Issues are placed in a conceptual framework which separately considers the biological significance of the components of biodiversity and their landscape-scale ecological context. Figure 1 shows this conceptual structure.

Issues identified as appropriate for inclusion in the REM are assessed to identify:

- Indicators that represent important ways of viewing each Issue;
- Classes within each Issue that indicate relevant ranges of variation and suitable thresholds for categories; and
- A 'Level of Concern' to be assigned to each class to be used as a guide in determining management priorities.

'Level of Concern' is considered to vary according to the management context and is defined in two ways:

- Immediate – an estimate of the relative priority for immediate management action to address current risk to the natural resource; and
- Potential – an estimate of the relative priority to protect and manage the natural resource from risks which may arise in the future.

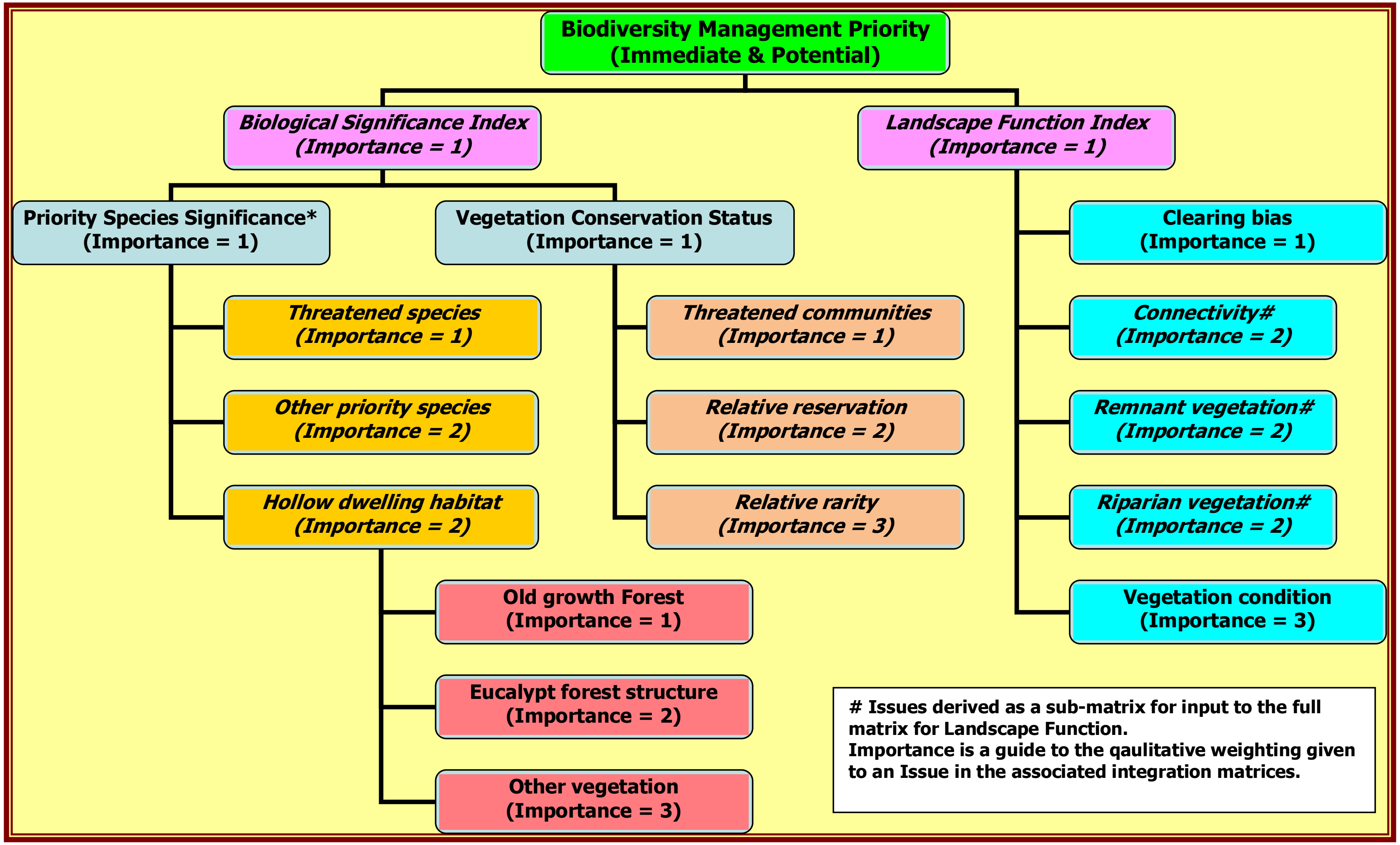
The two types of Level of Concern are designed to be consistent with the definitions of Conservation Management Priority in the Conservation of Freshwater Ecosystems Values project (DPIWE 2008[3]), which also uses the Immediate and Potential perspectives.

Use of Immediate Level of Concern is generally most appropriate where past management may have created a need to improve the condition of an Issue, or where there is continuing landuse which may place the resource at risk if not managed appropriately. For example, native vegetation whose condition has been degraded may need to be improved to help address biodiversity conservation needs.

Potential Level of Concern is generally appropriate in circumstances where a change in management could be detrimental. An example for native vegetation might be an area where its condition is considered important to maintain to address biodiversity needs, or whose loss would compromise those needs.

[3] Department of Primary Industries & Water (2008). Conservation of Freshwater Ecosystems Values (CFEV) project technical report. CFEV program, Department of Primary Industries & Water, Hobart.

Figure 1. Assets and Issues in the Biodiversity Asset Class



Where possible, classes in each Issue were chosen to reflect thresholds which have been applied elsewhere or identified in the scientific literature. An example of classes within an Issue, and their associated Level of Concern, is shown below.

Example classification: Remnant vegetation (patch size)

Native vegetation patch size (ha)	Concern – Immediate	Concern – Potential
<2ha	M	L
2-20ha	VH	VH
20-200ha	H	VH
>200ha	L	M

The ranges of patch size classes within the indicator reflect first the range of 2-200ha for remnants nominated by Kirkpatrick *et al.* (2007), with patches >2ha generally retaining much higher conservation values than smaller patches. Remnant <2ha are considered to be of little importance to landscape function, while those >200ha are subject to the processes which affect remnants at a significantly diminished intensity and effect. The split in the middle size class in the indicator is based on the RFA assessment of remnant vegetation, which considered patches <20ha, though potentially locally important, as below the threshold for importance in maintaining existing processes or natural systems at the regional scale (Tasmanian Public Land Use Commission 1997).

Source: Knight and Cullen (2010), p14.

Not all Issues have Level of Concern which diverges according to whether they are Immediate or Potential. Threatened species, for example, have statutory recognition that they are likely to become extinct. Thus both Immediate and Potential Level of Concern are considered identical, as the species status applies to the entire taxon. However, for any given species the management response at a given site may be different to that elsewhere.

Each Issue in the REM has Level of Concern classes assigned in a classification matrix (see remnant vegetation example above). Each matrix is designed to transparently illustrate how the Issue is treated in the REM, to assist interpretation, and to provide a simple method by which the REM parameters can be altered if required (e.g. where new research indicates thresholds in a matrix may need alteration).

The REM separately assesses each Issue within the Biodiversity Asset Class, but also places them in a hierarchically structured matrix that integrates related issues. This provides an overall indicator of Biodiversity Management Priority, but also means that the important issues for managing biodiversity at any one location can be readily identified. Attachment 1 summaries the terms used in the REM. Attachment 2 provides a full illustration of the prioritisation process and relationships in the REM.

The highest level in the REM classification is Biodiversity Management Priority. It is derived through integrating the prioritisation matrices of two contributing themes in biodiversity conservation:

- Biological Significance - the relative importance of the elements of biodiversity and hence their priority to be protected through appropriate management regimes; and
- Landscape Ecological Function - an assessment at multiple scales of the characteristics of the landscape and its ability to maintain the elements of biodiversity it contains.

The matrix which integrates Biological Significance and Landscape Ecological Function is shown below. An important feature of the matrix structure is that it does not dilute a high level of concern for one if the other is low. This approach addresses a known limitation that arises when using additive or averaging indices for conservation purposes and has the further advantage of being simple, transparent and flexible for use in testing different approaches.

Integration matrix for Biodiversity Management Priority

	Landscape Function Index			
Biological Significance Index	**VH**	**H**	**M**	**L**
VH	VH	VH	VH	VH
H	VH	VH	H	H
M	VH	H	M	M
L	VH	H	M	L

Similar forms of integration matrices are used at each level of the REM, with some variation according to the issues being addressed and the relative importance of each Issue to the overall index being derived. The full set of REM matrices is shown in Attachment 2.

Within the Biological Significance component of the REM are two Assets (see Figure 1) towards which management goals are likely to be directed:

- Native vegetation - composed of vegetation communities with Level of Concern a function of each community's conservation status, bioregional extent and percentage level of reservation; and
- Priority species - the subset of species and species groups identified as requiring consideration in management as a result of them being listed as threatened,

otherwise identified as priorities (e.g. Regional Forest Agreement priorities, poorly reserved flora species), or as the habitat for the group of 29 species identified in Tasmania as hollow dwelling (Koch et al. 2009[4]).

A unique feature of the REM is its system for generating spatial habitat modelling for all threatened and priority species. This is based on a two stage process that:

- Models habitat of all species from known locations, based on a simple model that considers factors such record accuracy and data, the distributional characteristics of each species (e.g. do they occur in highly restricted locations or more generally in an area), and the types of vegetation they occur in; and
- More detailed models of about 100 threatened fauna species, whose habitat is generated from within the REM data based on a model developed for the particular species (see Knight 2014[5] for details).

The Landscape Ecological Function component of the REM is designed to account for the factors that can affect biodiversity through the presence/absence of critical characteristics of the environment at multiple scales. The REM addresses Landscape Ecological Function by considering Issues at three scales:

- Broad scale habitat loss is a major threat to biodiversity and cause of biodiversity decline, which can continue after habitat loss has ceased due to ecological inertia associated with extinction debt. Habitat loss is characterised by patterns in the types of land from which habitat has been removed. The Issue of Clearing Bias measures these patterns at the landscape scale by assessing the percentage of each land component (land facet is also sometimes used) within Tasmania land systems that exist as native and cleared vegetation. More heavily cleared land components have higher Clearing Bias.
- Medium scale landscape patterns are addressed through the examination of the configuration of three landscape variables. Connectivity characteristics of the landscape are assessed by measuring the relative of isolation of remnants and the permeability of cleared land to species movements. The size of patches of native vegetation is assessed against thresholds for identifying Remnant Vegetation. The proportion of native Riparian Vegetation within each river section catchment provides an indicator of the health of the aquatic environment within each catchment, and its distal effects on biodiversity.

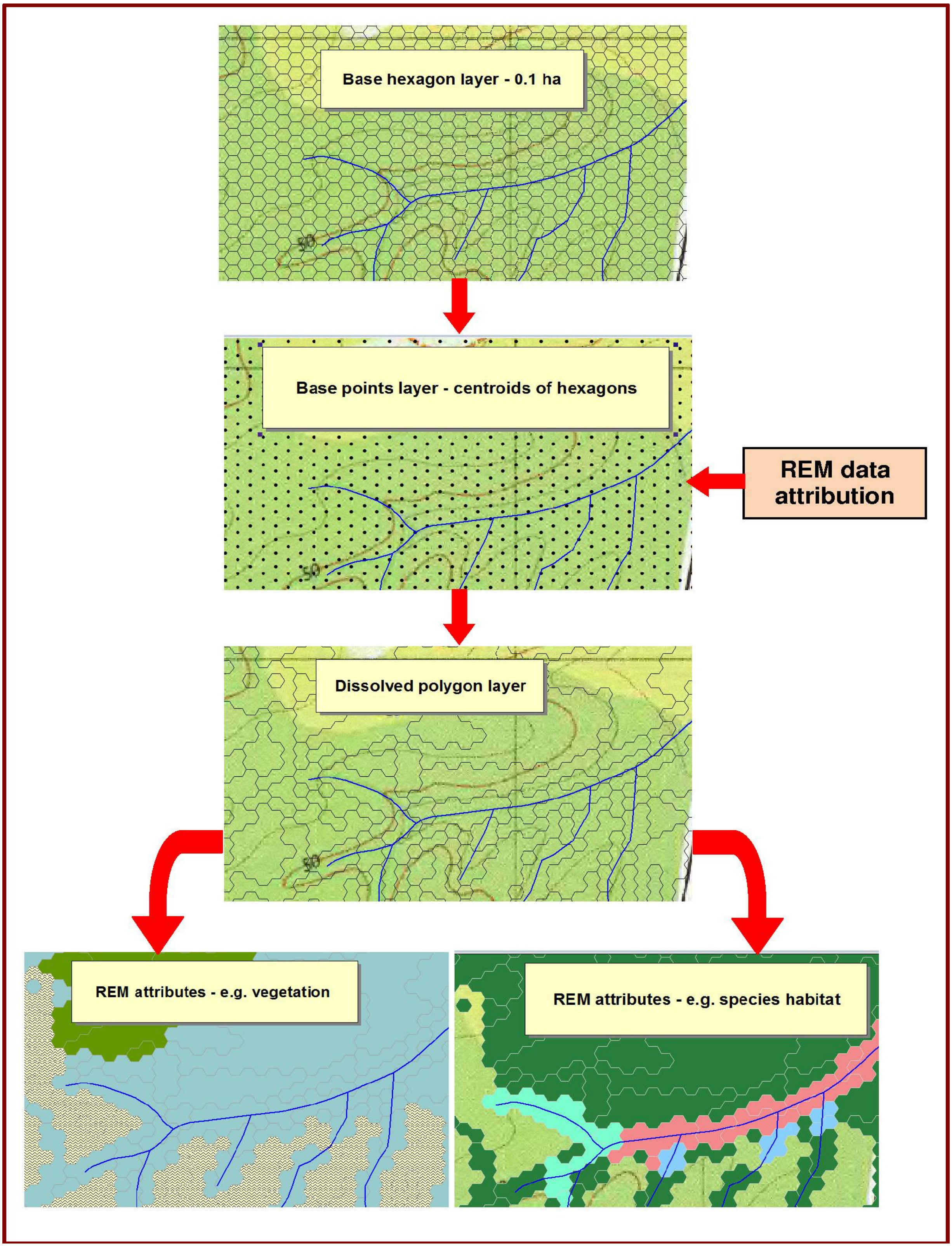
[4] Koch, A.J., Munks, S.A. & Woehler, E.J. (2009). Hollow-using vertebrate fauna of Tasmania: distribution, hollow requirements & conservation status. Australian Journal of Zoology, 56(5):323-349.
[5] Attachment 7 in Knight, R.I. (2014). Biodiversity data, models & indicators for Forestry Tasmania's Forest Management Unit. A report to Forestry Tasmania, March 2014. Natural Resource Planning, Hobart, Tasmania.

- Local scale landscape processes are assessed through assessing vegetation condition, which is expressed in the REM as Biophysical Naturalness. This assesses the characteristics of native vegetation for perturbation in structure and composition within each patch of native vegetation.

Each element of the REM is underpinned by Statewide spatial data layers. Each data layer has clear rule sets for its use in building the REM. The integrated REM spatial layers contain all the input data from the base layers, including multiple inputs for the same Issue where available (e.g. desktop and field vegetation mapping), and all the derived Level of Concern indicators.

The REM is built on a novel spatial architecture designed to store and process large amounts of spatial data efficiently and at fine scales. It is based on a non-overlapping layer of hexagonal polygons of 0.1 ha size, which approximates to a spacing of about 30 m. The centroids of the polygons are extracted and are used to process the REM and its data. The point format significantly reduces complexity of the spatial geometry and hence increases processing speed. The REM generated in the points layer is then re-attributed to the parent hexagons. A subset of the combination of primary inputs to the REM is then used to dissolve the hexagon layer to a more manageable number of polygons. Derived attributes are then re-attached to the data and the polygon layer used for multiple purposes. Figure 2 summarises the REM architecture.

Figure 2. Simplified REM spatial architecture and process



The core components of the REM described above are common to all applications. A spreadsheet version of the REM is also available[6] which can be used in the absence of spatial data to generate the full range of REM indicators. This can be used, for example, to determine REM indicators where the input data is wrong or to model the changes in indicators resulting from management actions . A standard output is also a summary REM profile, which display all the indicators as a percentage of the area of interest, as shown in Figures 3 and 4. These tools can also serve as a useful tool for modelling change, whether planned or actual, arising from conservation investments and from development.

Attachment 3 provides a simple guide giving examples of how to interpret REM indicators for particular issues and circumstances.

The REM can further customised for each project and users to deliver outputs and tools that assist meeting their specific needs. Customised add-ons that have been developed include tools to cross tabulate priority species with vegetation types, generate REM summary tables of the characteristics of multiple areas, and additional layers to assist in use of the REM. For example, a urban threat index spatial layer has been developed to assist in local government application, and for property planning the REM can be linked to data on issues such as salinity and erosion risk.

Use of the REM is licensed by NRP to clients for approved purposes, in accordance with the commercialisation provisions of the Australian Government's funding for its development. NRP wishes to establish ongoing partnerships with a wide range of potential users of the REM. Access to the REM is provided under a data license agreement and subject to a license fee negotiated on a case by case basis. License fees are designed to be cost effective – to encourage use – while also reflecting the reasonable costs to NRP of development, maintenance and support.

Clients who have used the REM or its components since completion of the original project include:

- Australian Government Biodiversity Fund;
- Clarence Council;
- Forestry Tasmania;
- Gunns Limited;
- Kingborough Council;
- NRM South;
- Norske-Skog;
- PF Olsen Pty Ltd;
- Southern Midlands Council and
- The Understorey Network.

[6] http://www.naturalresourceplanning.com.au/landscape-ecology-tools/

Figure 3. Sample REM profile – Immediate Level of Concern

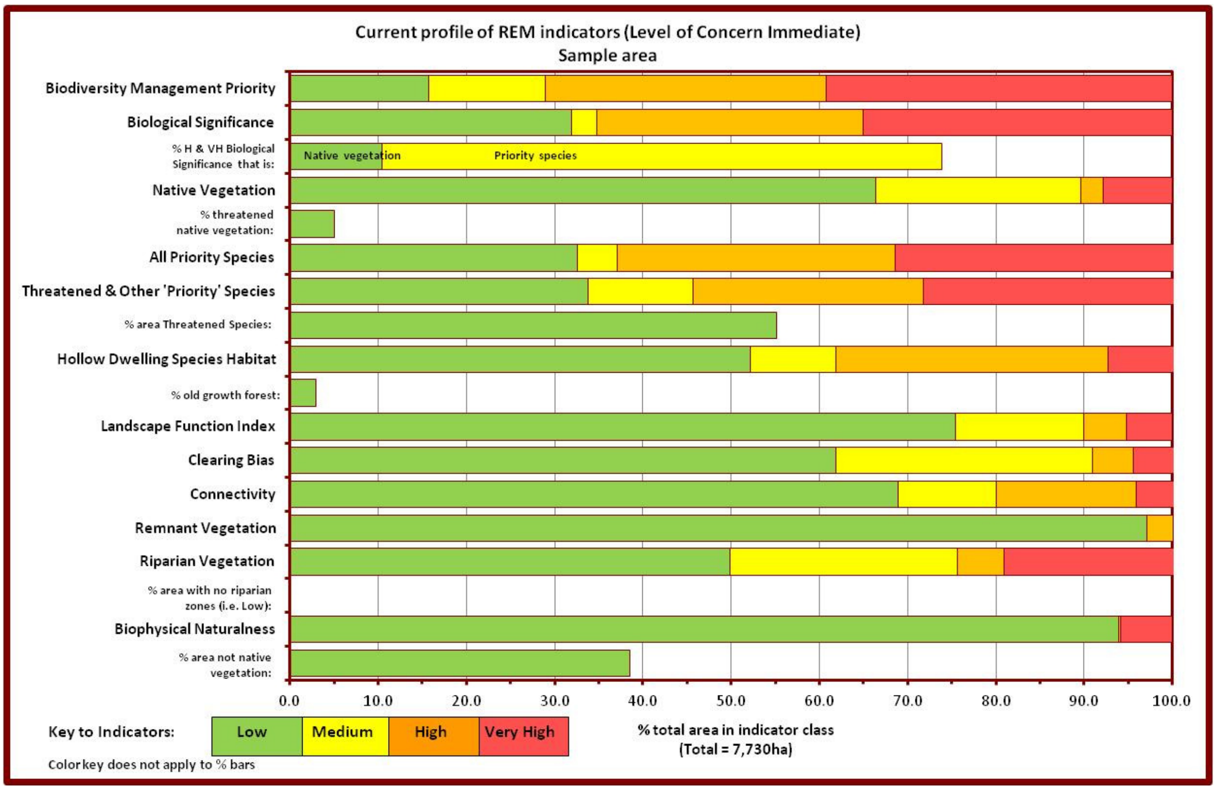
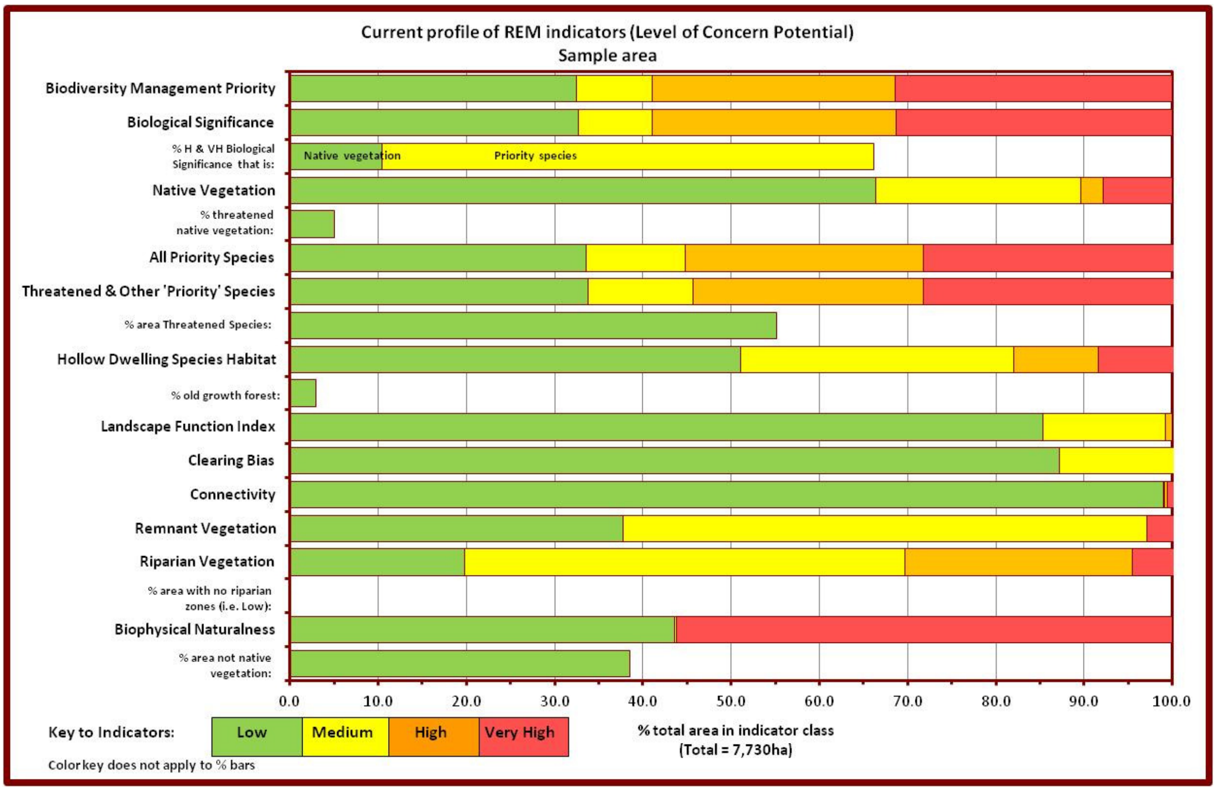


Figure 4. Sample REM profile – Potential Level of Concern



Attachment 1. Summary of REM assets, indicators and Issues

Issue	Definition	Summary	Indicator
Biological Significance	Biological significance measures the relative priority for management of the elements of biodiversity contained within a given area.	Biological significance is one of two arms of the REM and represents a structured classification of biodiversity. It is comprise of Native Vegetation and priority species (see below).	Classes ranked from Low-Very high derived from a matrix of Level of Concern classes for Native Vegetation and Priority Species.
Native Vegetation	Native vegetation communities based on the classification used in Tasveg.	Native vegetation comprises all areas mapped to the Tasveg classification, except for cleared land types (“F” codes), water, (OAQ”), sand and mud (OSM) and rock (ORO). An additional native vegetation mapping unit has been introduced to the REM for areas comprised of native vegetation plantings (DEP).	The REM contains a grouped classification for native vegetation which is used in various parts of its application.
Vegetation conservation status	Native vegetation communities with legislative recognition of being threatened.	na	Vegetation communities listed as threatened under the Tasmanian Nature Conservation Act 2002 or Commonwealth Environment Protection and Biodiversity Conservation Act 1999.
Relative reservation	Reservation status is a measure of the degree to which vegetation communities are included in the Comprehensive, Adequate and Representative (CAR) reserve system	Higher levels of reservation give greater confidence that the species for which vegetation communities are surrogates are likely to be protected, subject to appropriate geographic and biophysical distribution in the landscape.	Percentage bands of reservation of the vegetation communities, utilising the lesser of the Statewide or relevant bioregional reservation level.
Relative rarity	The extent of a native vegetation community in the bioregion being assessed.	Relative rarity is scale to reflect increased importance for vegetation types which are more restricted, and less importance for those which are relatively extensive.	The REM stratifies the extent of each community in each bioregion into bands, which are then form part of the matrix for deriving Level of Concern for native vegetation.
Priority species	Priority species are those that are recognised as threatened and certain classes of other species that are identified as priorities for conservation.	Classification within the group is structured around species listed as threatened and other priority species.	Level of Concern for priority species is classified from Low-Very High through a matrix combining threatened species status, number of threatened species, other priority species and hollow dwelling species habitat.

Issue	Definition	Summary	Indicator
Listed threatened species	Species listed as threatened under the Tasmanian Threatened Species Protection Act (1975) or Commonwealth Environment Protection and Biodiversity Conservation Act (1999)	na	Threat status and number of co-occurring threatened species in an area.
Other priority species	Non-threatened species identified as priorities for attention to conservation and management.	Other priority species comprises non-threatened species identified in the Regional Forest Agreement as Priority Species, including species groups such as hollow dwelling species, and flora species identified as inadequately reserved at the State or bioregional level.	The presence of other priority species (excluding hollow dwelling species habitat) is assigned a single ranking the REM (Medium), above that for no priority species and below that for threatened species.
Hollow dwelling species	Habitat for hollow dwelling species.	Hollow dwelling species comprise a group of 29 species listed in the Regional Forest Agreement as a priority species group.	Hollow dwelling species habitat is classed from Low-Very High depending on the type of vegetation present, eucalypt forest structure, predicted hollow abundance and presence/absence of old growth forest.
Old growth forest	Old growth forest is ecologically mature forest demonstrating the characteristics found in older and/or minimally disturbed forests	na	Old growth forest is classed as Very High Level of Concern (Potential) and as low Level of Concern (Immediate) in the Hollow Dwelling Species component of the REM.
Eucalypt forest structure	Forest structure classes derived from air-photo interpreted vegetation mapping.	Eucalypt forest structure is derived from the published RFA map depicting standard classes as Silviculturally Regeneration, Regrowth, Predominantly Regrowth/Some Mature, Predominantly Mature/Some Regrowth and Mature. This is supplemented with more up to date data where available.	Classes ranked from Low-Very High reflecting higher Immediate Level of Concern where structure is likely to contain fewer hollows and higher Potential Level of Concern where hollows are likely to be more abundant.
Non-eucalypt vegetation.	Vegetation communities in the Tasveg classification that are not recognised as eucalypt forest.	Eucalypt forest classes are identified in Tasveg by the prefixes “W” and “D”.	Non-eucalypt vegetation is ranked Low in the schema for hollow dwelling species habitat due to the absence of eucalypts.

Issue	Definition	Summary	Indicator
Landscape Function	The ability of the landscape to sustain the elements of biodiversity it contains.	Landscape function integrates five indicators representing successively finer partitioning of the landscape.	Classes ranked from Low-Very High using a 3 way matrix combining the same classes of Clearing Bias, a submatrix combining Connectivity, Remnant Vegetation and Riparian Vegetation, and Biophysical Naturalness.
Clearing bias	Clearing bias is a measure of the patterns of habitat loss in a region.	There is potential for ecological collapse at a regional level where >70% of a region has been cleared, and potential localised collapse and stress within the region where lower levels of clearing have occurred due to preferential clearing of certain land types.	The percentage of each land component that has been cleared, stratified spatially into areas now cleared or with extant native vegetation.
Connectivity	Connectivity is the degree to which patches of native vegetation are inter-connected and the extent to which species can move between patches,	Remnant vegetation may suffer loss of species in some taxonomic groups, and loss of ecosystem function, if the distance between remnants and the impermeability of the interstice (e.g. through absence of paddock trees) exceeds that which each organism is capable of crossing.	For remnant vegetation patches, the distance to the nearest non-remnant patch. For cleared land, the distance to the nearest patch of native vegetation.
Remnant vegetation	Remnant vegetation is defined as islands of native vegetation, below a specified size, that are surrounded by cleared land.	In heavily cleared landscapes, patches of remnant vegetation can contribute significantly to the maintenance of ecosystem function, while their loss and decline is a major factor in ecosystem collapse. Their smaller size makes them vulnerable to ongoing degradation through various combinations of anthropogenic and natural ecological processes	The indicator for remnant vegetation is the contiguous extent of each patch of native vegetation communities, stratified into size classes.
Riparian vegetation	Riparian vegetation is the vegetation that adjoins freshwater features (e.g. rivers wetlands) and has ecological characteristics which are influenced by the freshwater environment.	Riparian vegetation has been found to have consistently high biodiversity values relative to its extent and therefore contribute disproportionately to landscape function. Its values are also multi-faceted, providing protection for terrestrial biodiversity, land and soils resources, and freshwater ecosystems, and multi-scale in extending beyond the immediate riparian zone.	The percentage of the local catchment of each of river section and wetland which is under native riparian vegetation, stratified into bands as described for the CFEV project. The indicator applies equally to both the cleared and native vegetation components of the catchment.

Issue	Definition	Summary	Indicator
Vegetation condition	Vegetation condition is the composition and structure of native vegetation relative to a reference framework for the particular type of vegetation.	Vegetation condition is an indicator of the ability of native vegetation at the local physical and near-temporal scale to maintain and sustain the elements of biodiversity it contains.	Modified biophysical naturalness classes derived from RFA mapping and application of logical consistency rules to Tasveg community attributions and limited condition descriptors.

Attachment 2. Tasmanian Regional Ecosystem Model - Indicators, Content & Prioritisation Matrices

Native Vegetation Index	Priority Species Index VH	H	M	L
VH	VH	VH	VH	VH
H	VH	VH	H	H
M	VH	H	M	M
L	VH	H	M	L

Biological Significance Index	Landscape Function Index VH	H	M	L
VH	VH	VH	VH	VH
H	VH	VH	H	H
M	VH	H	M	M
L	VH	H	M	L

Threatened & Other Priority Species		Hollow Dwelling Species Habitat VH	H	M	L
Two or more listed species	**VH**	VH	VH	VH	VH
Endangered, Critically Endangered	**VH**	VH	VH	VH	VH
Vulnerable, Rare	**H**	VH	H	H	H
Other Priority Species	**M**	H	H	M	M
None	**L**	H	M	L	L

Biodiversity Management Priority

See next page

Biological Significance Index (Importance = 1)

Landscape Function Index (Importance = 1)

Component Cleared (%)	Concern – Immediate	Concern – Potential
Cleared		
>90%	VH	L
70-90%	H	L
30-70%	M	L
<30%	L	L
Native veg.		
>90%	VH	VH
70-90%	H	H
30-70%	M	M
<30%	L	L

Priority Species Significance* (Importance = 1)

Vegetation Conservation Status (Importance = 1)

Clearing bias (Importance = 1)

Connectivity# (Importance = 2)

Remnant vegetation# (Importance = 2)

Riparian vegetation# (Importance = 2)

Vegetation condition (Importance = 3)

Species category/ attribute	Concern – Immediate	Concern – Potential
Two or more listed species	VH	VH
Endangered, Critically Endangered	VH	VH
Vulnerable, Rare	H	H
Other priority species	M	M
None	L	L

Threatened species (Importance = 1)

Other priority species (Importance = 2)

Hollow dwelling habitat (Importance = 2)

Threatened communities (Importance = 1)

Relative reservation (Importance = 2)

Relative rarity (Importance = 3)

Old growth Forest (Importance = 1)

Eucalypt forest structure (Importance = 2)

Other vegetation (Importance = 3)

Distance of:	Concern – Immediate	Concern – Potential
Cleared land to native veg.		
<50m	L	L
50-250m	M	L
250-1,000m	H	L
>1,000m	VH	L
Native remnant to non-remnant		
<50m	L	VH
50-250m	M	H
250-1,000m	H	M
>1,000m	VH	L
Non-remnant		
Any	L	L

Status and bioreg. extent	Concern – Immediate & Potential Reservation level (Min. % State/bioreigon) <10%	10-30%	30-60%	>60%
Threatened				
Any	VH	VH	H	H
Not threatened *Bioregional extent*				
<2,000ha	VH	VH	H	M
2,000-5,500ha	VH	VH	H	M
5,500-15,000ha	VH	H	M	L
15,000-55,000ha	H	M	M	L
>55,000ha	M	M	L	L

Biophysical naturalness category	Concern – Immediate	Concern – Potential
5 (highest)	L	VH
4	L	VH
3	M	H
2	H	M
1 (lowest)	VH	M
0 (non-native)	L	L
-1 (water, sand, mud)	na	na

Descriptor of hollow probability (eucalypt forest only)	Concern – Immediate	Concern – Potential
Old growth forest	L	VH
Mature; Predominantly Mature, Some Regrowth	M	H
Predominantly Regrowth, Some Mature	H	M
Regrowth, Silvicultural Regeneration	VH	L
All other vegetation	L	L

Forest Practices Authority - predicted hollow abundance	Concern – Immediate	Concern – Potential
High	L	VH
Medium	M	H
Low	H	M
Not rated	L	L

Native vegetation patch size (ha)	Concern – Immediate	Concern – Potential
<2ha	M	L
2-20ha	VH	VH
20-200ha	H	VH
>200ha	L	M

River section catchment or wetland riparian vegetation (%)	Concern – Immediate	Concern – Potential
<1	VH	L
1-20%	H	VH
20-80%	M	H
>80%	L	M

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Attachment 2 (cont). Derivation of Landscape Function Index

Sub-matrix of Connectivity, Remnant Vegetation & Riparian Vegetation (CRR)

Connectivity	Remnant Vegetation	Riparian Vegetation	CRR Index	Rank (1 = highest)
VH	VH	VH	VH	1
H	VH	VH	VH	2
VH	VH	H	VH	3
VH	H	VH	VH	4
M	VH	VH	VH	5
H	VH	H	VH	6
VH	VH	M	VH	7
H	H	VH	VH	8
VH	H	H	VH	9
VH	M	VH	VH	10
L	VH	VH	H	11
M	VH	H	H	12
H	VH	M	H	13
VH	VH	L	H	14
M	H	VH	H	15
VH	H	M	H	16
H	M	VH	H	17
VH	M	H	H	18
VH	L	VH	H	19
L	VH	H	H	20
M	VH	M	H	21
H	VH	L	H	22
L	H	VH	H	23
VH	H	L	H	24
M	M	VH	H	25
VH	M	M	H	26
H	L	VH	H	27
VH	L	H	H	28
L	VH	M	H	29
M	VH	L	H	30
L	M	VH	H	31
VH	M	L	H	32
M	L	VH	H	33

Connectivity	Remnant Vegetation	Riparian Vegetation	CRR Index	Rank (1 = highest)
VH	L	M	H	34
H	H	H	H	35
M	H	H	M	36
H	H	M	M	37
H	M	H	M	38
L	VH	L	M	39
L	L	VH	M	40
VH	L	L	M	41
L	H	H	M	42
M	H	M	M	43
H	H	L	M	44
M	M	H	M	45
H	M	M	M	46
H	L	H	M	47
L	H	M	M	48
M	H	L	M	49
L	M	H	M	50
H	M	L	M	51
M	L	H	M	52
H	L	M	M	53
L	H	L	M	54
L	L	H	M	55
H	L	L	M	56
M	M	M	L	57
L	M	M	L	58
M	M	L	L	59
M	L	M	L	60
L	M	L	L	61
L	L	M	L	62
M	L	L	L	63
L	L	L	L	64

Full Landscape Function Index matrix

Clearing Bias	CRR sub-matrix	Condition	Landscape Function Index	Rank (1 = highest)
VH	VH	VH	VH	1
VH	VH	H	VH	2
VH	H	VH	VH	3
VH	VH	M	VH	4
VH	H	H	VH	5
VH	VH	L	VH	6
H	VH	VH	VH	7
VH	M	VH	VH	8
VH	H	M	VH	9
H	VH	H	VH	10
VH	M	H	VH	11
VH	H	L	VH	12
H	H	VH	VH	13
H	VH	M	VH	14
VH	L	VH	VH	15
VH	M	M	VH	16
H	H	H	H	17
H	VH	L	H	18
M	VH	VH	H	19
VH	L	H	H	20
VH	M	L	H	21
H	M	VH	H	22
H	H	M	H	23
M	VH	H	H	24
VH	L	M	H	25
H	M	H	H	26
H	H	L	H	27
M	H	VH	H	28
M	VH	M	H	29
VH	L	L	M	30
H	L	VH	H	31
H	M	M	H	32
M	H	H	M	33

Clearing Bias	CRR sub-matrix	Condition	Landscape Function Index	Rank (1 = highest)
L	VH	VH	M	34
M	VH	L	M	35
H	L	H	M	36
H	M	L	M	37
M	M	VH	M	38
M	H	M	M	39
L	VH	H	M	40
H	L	M	M	41
M	M	H	M	42
M	H	L	M	43
L	H	VH	M	44
L	VH	M	M	45
H	L	L	M	46
M	L	VH	M	47
M	M	M	M	48
L	H	H	L	49
L	VH	L	M	50
M	L	H	L	51
M	M	L	M	52
L	M	VH	L	53
L	H	M	L	54
M	L	M	L	55
L	M	H	L	56
L	H	L	L	57
M	L	L	L	58
L	L	VH	L	59
L	M	M	L	60
L	L	H	L	61
L	M	L	L	62
L	L	M	L	63
L	L	L	L	64

Attachment 3:
A simple guide to using the Regional Ecosystem Model for biodiversity planning

The REM contains assessments of four attributes of biodiversity that may need to be considered for conservation:

- Native vegetation (Tasveg-based units assessed Statewide and bioregionally);
- Priority species (threatened and other important species);
- Hollow dwelling species habitat; and
- Landscape ecological function – the ability of the landscape to maintain the elements of biodiversity it contains.

Actions may range from retention in an existing state, rehabilitation to a better state or restoration of native vegetation. Actions can be guided by the REM classification of attributes from two prioritisation perspectives:

- Immediate – importance for intervention to restore or rehabilitate; and
- Potential – important to protect from further loss or degradation.

In the REM these are termed 'Level of Concern'. All REM Level of Concern attributes are rated on a scale of Low, Medium, High or Very High. Immediate and Potential priorities are identical for native vegetation and priority species, but are different for hollow dwelling species habitat and landscape ecological function.

Priorities to be assigned to any of the REM attributes will be heavily influence by the purpose and objectives being considered and the adequacy of resources to effect desired outcomes. REM priorities can also be considered on an entirely objective basis, and used to judge whether objectives and resources are appropriately targeted, adequate to achieve outcomes. Monitoring over time can also be facilitated by the REM.

Prioritising areas or actions may require consideration of any of the four key attributes either singly or in combination. The potential range of combinations is large. However, for regions which are relatively intensively developed a fairly consistent set of combinations can be identified, particularly through focusing on priorities classified as either High or Very High. These are identified in the table that follows.

REM attribute (High or Very High)	Co-occurring attributes	Key considerations
Native vegetation	Priority species	Actions will depend on individual species' conservation needs.
	Landscape function – Potential	Landscape has some sensitivity to further loss or degradation. Action to protect the vegetation should be considered.
	Landscape function – Immediate	Landscape function is degraded. Consider whether actions to protect or enhance the native vegetation can make a difference.
	None	Consider if there are potential threats or other benefits that would arise from intervention. Also consider if there is a residual reservation target for the vegetation community and whether a good example of the community would be secured.
Priority species	None	Consider the conservation needs of each individual species individually.
	Landscape function – Potential	Landscape is sensitive to further loss or degradation. Consider whether this might have negative effects on each species.
	Landscape function – Immediate	Landscape function is degraded. Consider if landscape characteristics are contributing to the species status or likely persistence.
Hollow dwelling species habitat – Immediate	None	Vegetation is lacking in hollows. Look at the landscape context to determine if there is a likely benefit from taking actions which would improve long term prospects to have adequate mature eucalypt abundance, e.g. is the area a gap in distribution. The primary attribute field [Vstr_clasZ] should be used for this.
Hollow dwelling species habitat – Potential	None	Mature eucalypt abundance is likely to be relatively high. Act to protect and enhance, especially if either Immediate or Potential landscape ecological function classes are high.
Landscape function – Immediate	None	Landscape function is degraded. Consider what aspects of can be improved – condition, patch size, riparian vegetation or connectivity – within the available resources. The spreadsheet version of the REM can be used to explore scenarios.
Landscape function - Potential	None	Landscape function is sensitive to further loss or degradation. Consider what action can be take to secure landscape attributes.
Landscape function – Immediate	Landscape function - Potential	These are generally more important remnants. Consider whether resources are sufficient to both secure and improve landscape attributes.

Two part process for spatial modeling of species habitat in the Regional Ecosystems Model

Rod Knight, November 2014

Natural Resource Planning's Regional Ecosystem Model is a comprehensive system for:

- Integrating spatial data on the distribution of the major components of biodiversity, and the factors affecting them;
- Analysing the relationships among the components of biodiversity and the environment; and
- Spatially identifying areas which have immediate or potential conservation concerns, and providing indicators of their relative importance, to inform approaches and priorities for management.

The REM was originally developed with funding from the Australian Government's Caring for Our Country program. It has since been applied in a variety of contexts, including forest management and certification, local government planning, property management, and as a decision support tool for ecological restoration and rehabilitation projects.

The REM is built on:

- A systematic, hierarchical model of biodiversity attributes (vegetation and priority species) and indicators of landscape scale ecological function (e.g. condition, patch size, connectivity). Attachment 1 shows the structure of the model.
- A spatial architecture designed to capture and analyse data on all components of the model at high resolution (0.1 ha).

A key factor in the REM having sufficient utility for its intended purposes is the ability to spatially model habitat of as many species of 'priority' flora and fauna as possible. Priority species in this context are those whose conservation needs may not be adequately met simply by managing native vegetation communities (a surrogate for species assemblages) or of the landscape generally. The priority species modeled in the REM are all listed threatened species in Tasmania, flora species identified as poorly reserved either Statewide or in some of their bioregions, and some non-listed fauna species considered to be of particular concern, priority or importance for other reasons (e.g. Eastern Quoll, Tasmanian Betting).

Detailed spatial habitat models exist for only some of the Tasmanian priority species. To address this limitation, a two part modeling process is used in the REM to ensure that all species are addressed:

- A generic model incorporating relatively few habitat variables to model habitat of all priority species from known locations in the Natural Values Atlas; and
- More detailed models developed for individual species using a broader range of habitat variables identified as having strong associations with the species concerned.

Both types of models are maintained on a continuous improvement basis. They are updated regularly to reflect changes in species data, understanding of species habitats, new models and also feedback from users of the modeled outputs.

Generic species models

The generic species models in the REM are based on each priority species being classified according to a small number of habitat variables that are contained within Natural Values Atlas data or the standard data captured by the REM (Table 1). Table 2 provides some examples of the range of generic species modeling rules. Figure 1 shows some examples of modeled species habitat generated using this method.

Table 1. Habitat attributes used in generic modeling process

Habitat attribute	**Description**
Record accuracy.	The minimum accuracy for an NVA record to be used for modeling the species. Tighter accuracy limits are used for species that tend to occur in fixed, localised situations (e.g. many threatened flora), with more relaxed limits used for species which occur generally around their locations or are relatively mobile.
Record distance	The maximum distance from an NVA record in which habitat can be attributed. As with record accuracy, model distances are tighter for localised and immobile species and more relaxed for species with more general distributions or higher mobility.
Year	The earliest year for an NVA record to be included in a species model. This variable is designed to account for species whose distributions are known or reported to have changed (e.g. Eastern Barred Bandicoot, Tasmanian Devil).
Riparian	Where species are known to have strong riparian associations, the modeling process restricts the attribution of habitat around records to the riparian zones around streams, waterbodies and wetlands. Note: where records of such species are not in riparian zones, a standard point based model based on the other habitat variables is applied.
Water	This habitat variable allows the habitat of certain species to be modeled in water (e.g. waterbodies and larger streams). It applies to species such as fish and crayfish.

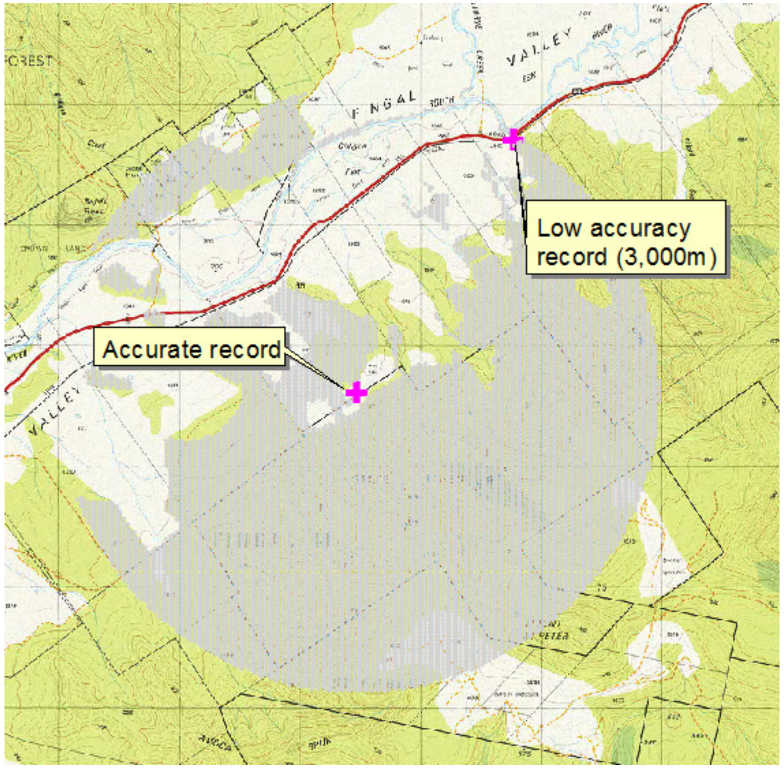
Habitat attribute	Description
Native	This habitat variable restricts the attribution of species habitat to areas of native vegetation only. The attribute is applied particularly to mobile fauna species with large proportions of their recorded locations from road kill. The model attempts to capture native vegetation which may be used for denning and shelter (and is usually accompanied by a larger value for the record distance variable).
Plantation	This habitat variable relaxes the modeling of habitat so that it can be attributed in plantations. Application of the variable is currently restricted to the zones around raptor nests, which may be sensitive to disturbance.
Bioregions	The habitat variable contains a list of bioregions in which flora species are identified as poorly reserved (<2 locations in reserves in the bioregion). The modeling process restricts the attribution of habitat to only those bioregions in the list.

Table 2. Examples of generic species modeling rules

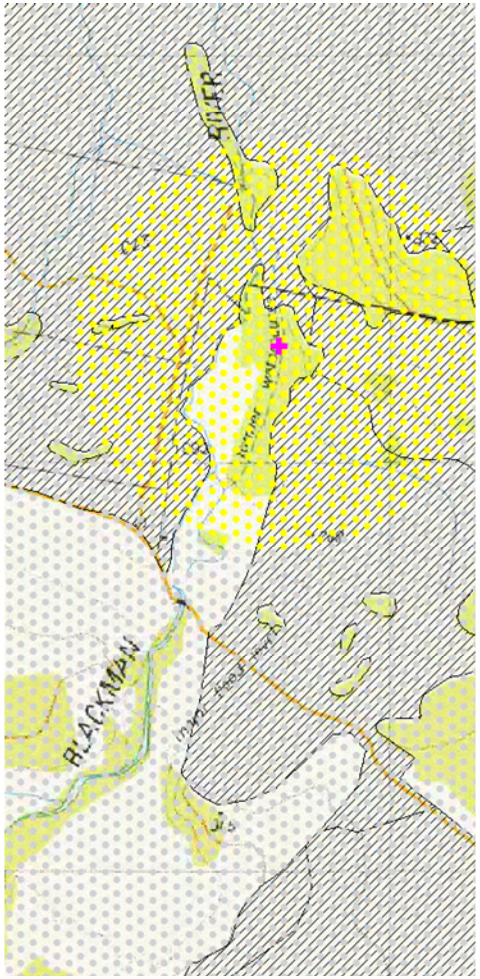
Species	Accuracy	Distance	Year (earliest)	Riparian	Plantation	Water	Native only	IBRA regions	Notes
Acacia axillaris	200	500	0	Y					Models riparian zones within 500m of NVA record
Aquila audax subsp. *fleayi*	200	500	0		Y				Models 500m around known nest sites, including in plantations
Caladenia anthracina	200	100	0						Models everything within 100m or record
Caladenia atrata	200	100	0					FL;NS;	Non-threatened species, poorly reserved in Flinders and Northern Slopes bioregions.
Perameles gunnii	500	2000	1980				Y		Models native vegetation within 2,000m of post-1980 records
Prototroctes maraena	200	500	0	Y		Y			Models riparian zones and water within 500m of records
Sarcophilus harrisii (post 2005)	200	2000	2005				Y		Model native vegetation within 2,000m of post-2005 records

Figure 1. Example of generic species habitat model outputs

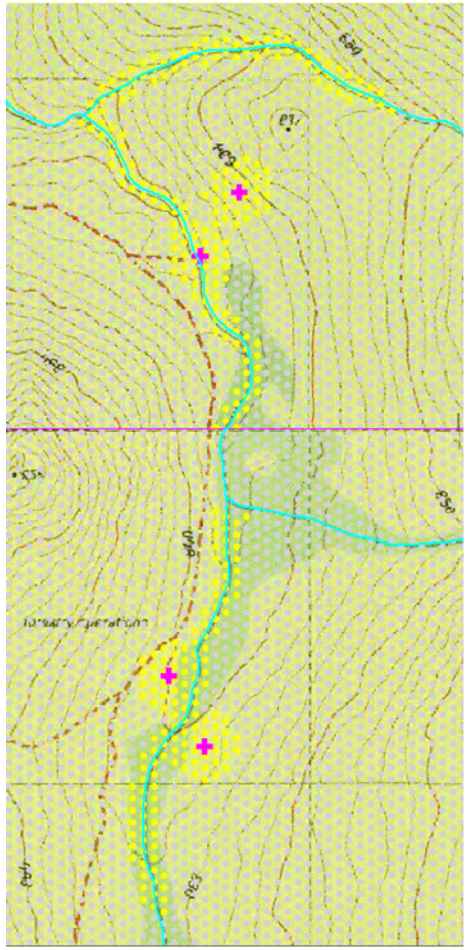
Eastern Quoll (native veg. within 2.5 km of 500m accuracy records)



Wedgie – nests



Acacia axillaris



Detailed species habitat models

The focus for developing detailed spatial habitat models is those species less likely to be accurately modeled from known location records. It is particularly important for a number of fauna species. Detailed species habitat models are developed for the REM using an expert-based rules system in which the characteristics of each species are described from current knowledge and available data, which are in turn converted to GIS-based rules to achieve spatial outputs.

The current basis for both the list of species to be modeled and, as far as possible, the characteristics of the model to be produced, is descriptions of species range, habitat and significant habitat developed by the Forest Practices Authority[1]. The species being considered in that process have been described in terms of their:

- core range;
- potential range;
- known range;
- potential habitat;
- significant habitat; and
- other habitat definitions used in management.

The process of developing each detailed species model involves reviewing the standard FPA descriptors and other relevant information (e.g. other models, communications with researchers). Some species models can be developed relatively simply from this information.

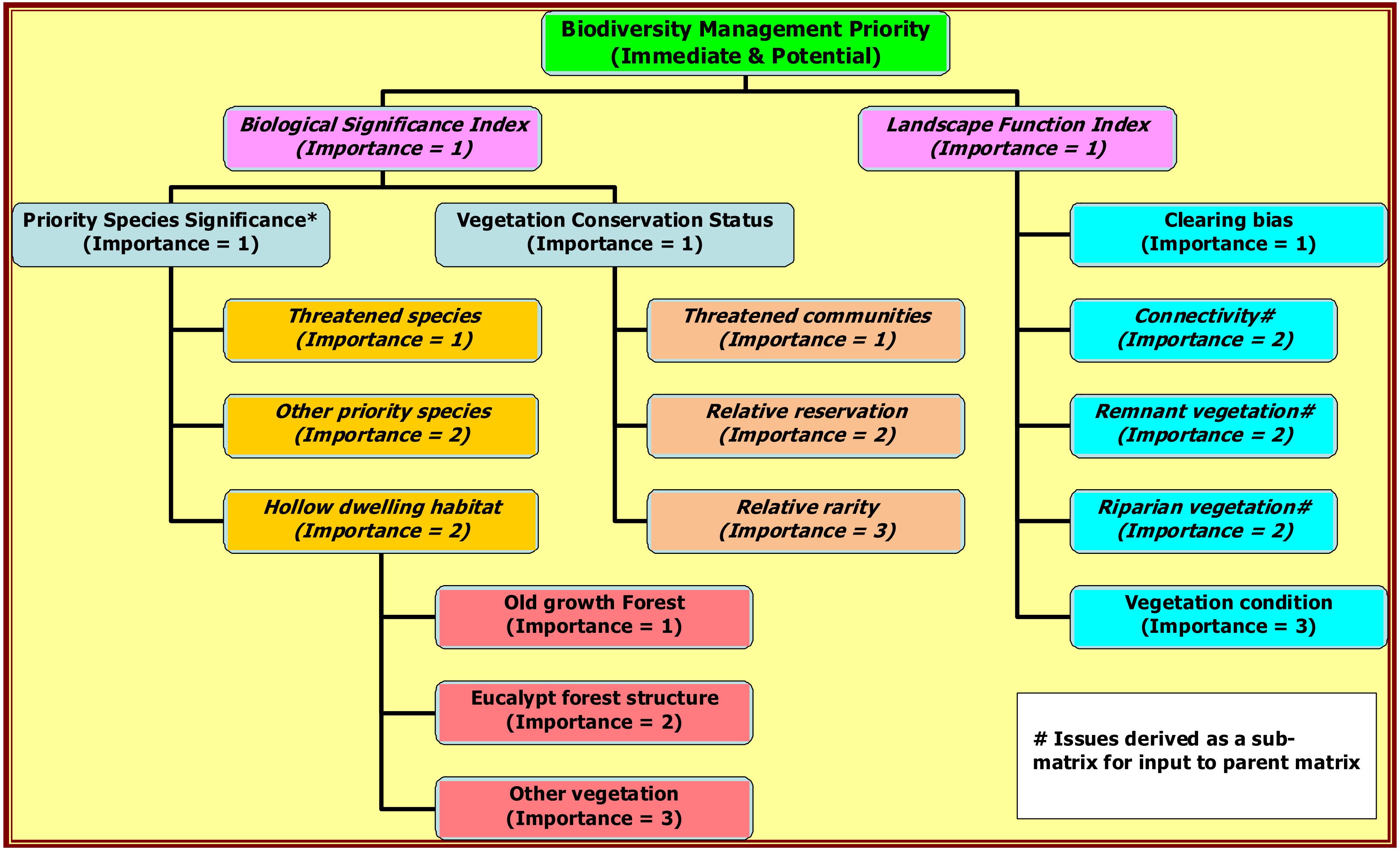
For other species the modeling process involves reviewing a range of GIS data to determine if there are strong associations between described species habitat and attributes recorded in GIS data available for use in the REM. Once strong associations are identified a revised set of descriptors of the model is described (called the "REM habitat model" to avoid confusion), and GIS processes are developed to produce a spatial model that reflects the descriptors. The outputs from this process are then reviewed to determine if the spatial model is consistent with the description.

Approximately 100 fauna species have detailed spatial habitat models developed through the above process. Coverage of the model of each species varies, as the habitat model is only developed for areas covered by the REM. This is typically on a project-by-project basis but is being transformed to a regularly maintained and complete Statewide coverage.

Some examples of REM habitat model descriptions are shown in Attachment 2. A full list of the current model descriptions is available on request. Spatial characteristics and patterns in these models vary considerably depending on model formulation, so no examples are provided.

[1] Forest Practices Authority (2014). Summary of threatened fauna species range boundaries and habitat descriptions. v1.7 August 2013, Forest Practices Authority, Hobart. Table is an updated summary of information in Forest Practices Authority and Threatened Species Section (2012). Review of Threatened Fauna Adviser: background report 2: Review of information on species & management approach. Forest Practices Authority, Hobart.

Attachment 1. Conceptual structure of biodiversity in the Regional Ecosystem Model



Attachment 2. Examples of REM habitat models

Species: Orange-bellied Parrot
Neophema chrysogaster

Species attribute	Definition
FPA attributes	
Core range	N/A
Potential range	The potential range of the orange-bellied parrot comprises the potential foraging range and the potential breeding range. [still to be developed]
Known range	N/A
Potential habitat	Potential habitat for the orange-bellied parrot comprises potential breeding habitat and potential foraging habitat. Potential breeding habitat is mature eucalypt forest and woodland, including copses amongst plains, with obvious hollows present. Potential foraging habitat is dunes, heathlands, coastal grasslands and saltmarshes.
Significant habitat	N/A
Other habitat definitions	N/A
CARSAG habitat model	N/A
Other information	Additional information on the species is contained in the Orange-bellied Parrot recovery plan (2006[2]), which includes a map of the Breeding Range and Non-breeding Range in Tasmania: "Eucalypt forest (in the breeding range) saltmarshes, coastal dunes, pastures, shrublands, estuaries, islands, beaches and moorlands, usually within ten kilometres of the coast, make up the diverse habitats used by Orange-bellied Parrots. Breeding habitat is a mosaic of eucalypt forest, rainforest, and extensive fire dependant moorland and sedgeland plains, intersected by wooded creeks, rivers and estuaries within the Tasmanian Wilderness World Heritage Area (Brown and Wilson 1982, 1984; Stephenson 1991). Nesting occurs predominantly in the hollows of live Smithton Peppermint *Eucalyptus nitida* in patches of forest throughout coastal southwest Tasmania, but focused within 20 km of Melaleuca and 5km of Birch's Inlet (Brown and Wilson 1984; Higgins 1999). The entire known breeding population is contained within the Tasmanian Wilderness World Heritage Area (in particular the Southwest National Park) and Southwest Conservation Area.

[2] Orange-belled Parrot Recovery Team (2006). National recovery plan for the Orange-bellied Parrot (*Neophema chrysogaster*). Threatened Species Section, Department of Primary Industries & Water, Hobart.
http://www.environment.gov.au/system/files/resources/f493ebf4-a19b-412c-ac15-413b7d413a69/files/orange-bellied-parrot-recovery.pdf

Species attribute	Definition
	On passage in western and northwestern Tasmania (including offshore islands) the species occurs in dunes, heathland, coastal grasslands, saltmarsh and pasture. On King Island, they mostly occur in saltmarsh dominated by Beaded Glasswort *Sarcocornia quinqueflora*, flanked by tall dense Swamp Paperbark *Melaleuca ericifolia* forest (Higgins 1999)." p3 of Recovery Plan
REM habitat model	1. Breeding habitat for the species is native vegetation containing mature forest elements (any density) in the breeding range, as defined in the 2006 Recovery Plan. 2. Foraging habitat is vegetation communities in the species inclusion list (see below) within either the breeding range or the foraging range, based on the map and description in the 2006 Recovery Plan.
Notes	The inclusions list for the species is the Tasveg communities in which the species has been recorded in the NVA since 1983 at accuracy <=500 mm and that are consistent with the descriptions of the foraging habitat: ARS ASS, AUS, AWU, GHC, MBS, SCA, SSC and SSK.
Data	Breeding range polygon generated from map in 2006 Recovery Plan. Foraging range polygon (outside of the breeding range) generated from the map and descriptions in the 2006 Recovery Plan, comprising the Breeding range, 10km inland of the coast from Veridian Point (SW Tas) to Sisters Beach (NW Tas), and King, Hunter, Three Hummock, Walker, Robbins and Perkins Islands. Vegetation mapping from Tasveg and/or NRP Atomic Planning Units data.
Model status	Model tested and used in the REM.

Species: Dwarf Galaxias
Galaxiella pusilla

Species attribute	Definition
FPA attributes	
Core range	The core range of the dwarf galaxiid incorporates known sites and the catchments above known sites.
Potential range	The potential range of the dwarf galaxiid is the broader catchments defined by specialists where the species may occur and where surveys have not been conducted.
Known range	N/A
Potential habitat	Potential habitat for the dwarf galaxiid is slow-flowing waters such as swamps, lagoons, drains or backwaters of streams, often with aquatic vegetation. It may also be found in temporary waters that dry up in summer for as long as 6-7 months, especially if burrowing crayfish burrows are present (although these will usually be connected to permanent water). Habitat may include forested swampy areas. Juveniles congregate in groups at the water surface in pools free of vegetation.
Significant habitat	Significant habitat for the dwarf galaxiid is all potential habitat and a 30 m stream-side reserve within the core range.
Other habitat definitions	N/A
CARSAG habitat model	APUs of riverine, wetland or water vegetation within 500 m of known locations, plus some areas individually tagged.
Other information	N/A
REM habitat model	1. LIST wetlands and 2D watercourses, and Tasveg wetlands, within the Core Range that are <50 m altitude. 2. Native riparian vegetation on Class 1, 2 streams in the Core Range that are <50 m altitude. 3. Native riparian vegetation on Class 3 and 4 streams in the Core Range that are <50 m altitude AND have a streambed slope (CFEV data) of <2 degrees.
Notes	82% of record locations that intersect stream buffers are on Class 2 streams. All NVA records with an accuracy <=200 m are on CFEV river sections with a slope of <2 degrees (CFEV data), and are also at <50 m altitude.
Data	Vegetation data from NRP Atomic Planning Units. LIST Hydarea layer. CFEV river sections data (contains bed slope data).
Model status	Model tested and used in the REM.
Known issues	DPIPWE advised on 30 January 2014 that it needs to develop a new range boundary for the species to correct erroneous TMAG data points. This occurred after the model had been developed and may need to be incorporated into a future revision.

Species: Glossy Grass Skink
Pseudemoia rawlinsoni

Species attribute	Definition
FPA attributes	
Core range	N/A
Potential range	The potential range of the glossy grass skink is a 5 km (radius) buffer centred on known sites.
Known range	N/A
Potential habitat	Potential habitat for the glossy grass skink is wetlands and swampy sites (including grassy wetlands, tea tree swamps and grassy sedgelands), and margins of such habitats.
Significant habitat	N/A
Other habitat definitions	N/A
CARSAG habitat model	N/A
Other information	N/A
REM habitat model	1. The Core Range (500 m buffer of known locations), excluding urban areas (Tasveg FUR, FUM). 2. Parts of the land system polygons that are within one kilometre of the Core Range and have any of the following characteristics: (i) are LIST freshwater features classified as wetlands, wet areas or floodplains; or (ii) are land components that are gentle lower slopes or lower plains with the Tasveg communities for wetlands ("A" codes), grasslands, (GSL, GCL) swamp forests (NLM, NME), forests known to occur on wet areas (DOV, DOW, DVS) or wet scrubs (SRI, SSC).
Notes	The Core Range data on the NVA is a 500 m buffer, not 5km. Some recorded locations are on the edge of urban areas, with the Core Range buffer extending into them. 78% of NVA records with accuracy <=500 m are on land components that are gentle lower slopes or lower plains.
Data	NRP Land systems components data. LIST Hydarea layer. Vegetation from NRP Atomic Planning Units. Additional data generated by a script embedded in the REM.
Model status	Model tested and used in the REM.
Known issues	DPIPWE advised on 30 January 2014 that the revised boundary developed by the FPA needs to be included in the repository on the NVA. This occurred after the model had been developed and may need to be incorporated into a future revision.

Species: Chaostola Skipper
Antipodia chaostola

Species attribute	Definition
FPA attributes	
Core range	The core range of the chaostola skipper is a 2 km (radius) buffer centred on the known sites.
Potential range	The potential range of the chaostola skipper is the distribution of *Gahnia radula* and *G. microstachya*.
Known range	N/A
Potential habitat	Potential habitat for the chaostola skipper is dry forest and woodland supporting *Gahnia radula* (usually on sandstone and other sedimentary rock types) or *Gahnia microstachya* (usually on granite-based substrates).
Significant habitat	N/A
Other habitat definitions	N/A
CARSAG habitat model	Sites identified by Neyland (1994[3]) as having good stands of *Gahnia radula* which provide suitable habitat for the species.
Other information	N/A
REM habitat model	1. Areas within 200 m of known locations. 2. Native vegetation in the Core Range that is dry eucalypt forest (Tasveg "D"), native grassland (Tasveg "G") or dry scrub types (SCH, SHL, SHU). 3. Native vegetation that is dry eucalypt forest (Tasveg "D"), native grassland (Tasveg "G") or dry scrub types (SCH, SHL, SHU) on land system polygons within 5km of the Core Range which are sedimentary or acid igneous (granitic) rock types, <300 m altitude and <750 mm rainfall
Notes	The use of *G. radula* and *G. microstachya* as a predictor of potential habitat on its own is not supported by data on environmental characteristics of the species recorded locations. 91% of Chaostola Skipper records occur on sediments (though the number of known sites is small so this figure may not be reliable). In comparison, only 42% of the *Gahnia* species records occur on sediments. There are additional strong associations with rainfall, with 82% of Chaostola Skipper locations in areas with <750 mm rainfall, and altitude, with 93% of locations on areas <300 m ASL. The species also has a strong association with distance from the coast, with no records locations more than 21km inland.
Data	
Model status	Model developed and tested.

[3] Neyland, M. (1994). The ecology & conservation status of three rare hesperiid butterflies in Tasmania. Wildlife Report 94/3, Parks & Wildlife Service, Hobart.

Species attribute	Definition
Known issues	DPIPWE advised on 30 January 2014 that it needs to update the range boundary for the species to include new populations at Grasstree Hill and Buckland. This occurred after the species model had been developed and may need to be incorporated into a future revision.