Threatened Species Recovery Hub

National Environmental Science Programme

Experimental Ecosystem Accounts for the Central Highlands of Victoria

Appendices

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FENNER SCHOOL OF ENVIRONMENT AND SOCIETY

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Front cover images: (clockwise from top): Dr Dan Harley, Dave Blair, Rail Trails Australia, Ern Mainka, De Bortoli Wines, Dave Blair, Dr Chris Taylor.

Appendices

Appendices are numbered in alignment with the section numbers of the main report.

A1. Introduction

A1.2 System of Environmental Economic Accounting

References providing additional guidance to the SEEA include:

- General guidance – SEEA Implementation Guide (UNSD 2014c)
- Water – SEEA Water (UNSD 2012a) and International Recommendations for Water Statistics (UNSD 2012b), Guidelines for the Compilation of Water Accounts and Statistics (UNSD 2014d)
- Forests (Castañeda 2016)
- SEEA-Agriculture, Forestry and Fisheries (FAO 2015)
- Ecosystem accounting (World Bank 2014)

Examples of application of the SEEA in Australia include:

- Australian Bureau of Statistics (ABS) (ABS 2015a)
- Government of Victoria (Eigenraam *et al.* 2013; Varcoe *et al.* 2015)
- Bureau of Meteorology (BoM) uses a system of water accounting (BoM 2014) that can be related to SEEA (Vardon *et al.* 2012)
- Wentworth Group of Concerned Scientists has developed a process and metrics for producing accounts (Sbrocchi 2015).

A number of accounts for specific assets or services already cover all or part of the Central Highlands region or the economic users of the region, including:

- Land Accounts Victoria, Experimental Estimates (ABS 2013)
- Water Accounts, Australia (ABS 2015)
- National Water Account – Melbourne (BoM 2014)
- State Tourism Satellite Accounts (TRA 2015)
- Value of Tourism to Victoria's Regions (Tourism Victoria 2015)
- Victorian Experimental Ecosystem Accounts (Eigenraam *et al.* 2013)
- Valuing Victoria's Parks (Varcoe *et al.* 2015)
- Melbourne Water Annual Reports
- VicForests Annual Reports.

General outcomes from accounts, both actual and potential, are covered in the documents of the SEEA Applications and Extensions (European Commission *et al.* (2014), Smith (2014) and Vardon *et al.* (2012)).

There is also a growing Australian literature on ecosystem services (Crossman *et al.* 2013; Stoeckl *et al.* 2011; Tovey 2008; Straton and Zander 2009).

A2. Accounting methods

A2.3 Classifications

Definitions of industry classifications according to the Australia New Zealand Standard Industry Classification (ANZSIC 2016) (ABS and SNZ 2006), together with additional notes to assist interpretation of the report.

Division A: Agriculture, Forestry and Fishing

> *"The Agriculture, Forestry and Fishing Division includes units mainly engaged in growing crops, raising animals, growing and harvesting timber, and harvesting fish and other animals from farms or their natural habitats. The division makes a distinction between two basic activities: production and support services to production. Included as production activities are horticulture, livestock production, aquaculture, forestry and logging, and fishing, hunting and trapping.*
>
> *The term 'agriculture' is used broadly to refer to both the growing and cultivation of horticultural and other crops (excluding forestry), and the controlled breeding, raising or farming of animals (excluding aquaculture).*
>
> *Aquacultural activities include the controlled breeding, raising or farming of fish, molluscs and crustaceans.*
>
> *Forestry and logging activities include growing, maintaining and harvesting forests, as well as gathering forest products.*
>
> *Fishing, hunting and trapping includes gathering or catching marine life such as fish or shellfish, or other animals, from their uncontrolled natural environments in water or on land.*
>
> *Also included in the division are units engaged in providing support services to the units engaged in production activities."* (ABS and SNZ 2006, p. 66)"

Within Division A, the Subdivisions of relevance for this report are 01 Agriculture and 03 Forestry and Logging. In particular, VicForests is part of the Subdivision 03 Forestry and Logging.

Division D: Electricity, Gas, Water and Waste Services

> *"The Electricity, Gas, Water and Waste Services Division comprises units engaged in the provision of electricity; gas through mains systems; water; drainage; and sewage services. This division also includes units mainly engaged in the collection, treatment and disposal of waste materials; remediation of contaminated materials (including land); and materials recovery activities.*
>
> *Electricity supply activities include the generation, transmission and distribution of electricity and the on-selling of electricity via power distribution systems operated by others.*
>
> *Gas supply includes the distribution of gas, such as natural gas or liquefied petroleum gas, through mains systems.*
>
> *Water supply includes the storage, treatment and distribution of water; drainage services include the operation of drainage systems; and sewage services include the collection, treatment and disposal of waste through sewer systems and sewage treatment facilities."* (ABS and SNZ 2006, p. 68)

Within Division D, the Subdivision Water Supply, Sewerage and Drainage Services is the area of interest, with Melbourne Water coded to this Subdivision.

Other ANZIC industries

Other Divisions to note are: *Division C: Manufacturing,* which includes Food Product Manufacturing (Subdivision 11), Beverage and Tobacco Product Manufacturing (Subdivision 12), Wood Product Manufacturing (Subdivision 14), and Pulp, Paper and Converted Paper Product Manufacturing (Subdivision 15); and *Division R: Arts and Recreation Services* which includes the operation of National Parks (Subdivision 892 Parks and Garden Operations).

Division C: Manufacturing will use inputs from *Division A: Agricultural, Forest and Fishing*. The distinction is important as in other contexts the Agriculture Industry or the Forest Industry are defined to include the transformation of the primary products into manufactured goods (e.g. grapes processed into wine, or woodchips into paper). This report does not take this approach and uses the ANZSIC definition of Agriculture and Forestry.

Tourism

Tourism is not defined in ANZSIC but in a satellite accounting framework of the System of National Accounts (ABS 2016d), and additional information on the definition of tourism is found in the Explanatory Notes of the ABS (2016d) Tourism Satellite Account.

A3. Land

A3.1 Spatial data sources

LAND COVER

'Land Cover' classes were initially allocated on uncleared land by grouping the 2005 version of extant Ecological Vegetation Class (EVC) types in 'NV2005_EVCBCS' (https://www.data.vic.gov.au/data/dataset/native-vegetation-modelled-quality-site-condition-and-landscape-context-2005).

These were subsequently modified on public land by the more detailed forest type information in the 2013 version of State-wide Forest Resource Inventory (SFRI) data, 'SFRITrev2013' (http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002820&publicId=guest&extractionProviderId=1), where available, and by plantation information in the 2015 version of Forest Management Zone (FMZ) data, 'FMZ100' (http://www.giconnections.vic.gov.au/content/vicgdd/record/ANZVI0803002608.htm).

Then, 'Land Cover' classes on private land were adjusted using land cover and land use classes in several versions of the Victorian Land Use Information System
https://www.data.vic.gov.au/data/dataset/victorian-land-use-information-system-2006-2007
https://www.data.vic.gov.au/data/dataset/victorian-land-use-information-system-2010-2011
https://www.data.vic.gov.au/data/dataset/victorian-land-use-information-system-2014-2015

Finally, water, road and structure classes in these data, overwrote any previous allocations on all land.

LAND USE

'Land Use' classes were allocated on public land by grouping classes in the 2015 version of Forest Management Zone (FMZ) data, 'FMZ100'
http://www.giconnections.vic.gov.au/content/vicgdd/record/ANZVI0803002608.htm

Private land was grouped by classes in the 2014/2015 version of Victorian Land Use Information System.
https://www.data.vic.gov.au/data/dataset/victorian-land-use-information-system-2014-2015).

LAND MANAGEMENT

We used the 2015 version of 'PLM25'
(https://www.data.vic.gov.au/data/dataset/public-land-management-plm25),
which describes public land management, where Public Land is defined as land held by/vested in/or owned by DELWP and other government departments, public authorities, Commonwealth government and municipalities.

FIRE HISTORY

We used the 2015 version of 'FIRE_HISTORY'
(https://www.data.vic.gov.au/data/dataset/fire-history-records-of-fires-primarily-on-public-land)
which represents the spatial extent of fires recorded since 1903 primarily on public land, and is attributed for wildfire and prescribed burn. The assumption was made that wildfires result in regeneration of ash forests and rainforest. However, additional fire severity information was available for the 2009 wildfires.
https://www.data.vic.gov.au/data/dataset/victorian-bushfires-severity-map-2009-polygons
For these fires, regeneration was only assumed for the two most severe classes – Crown Burn and Crown Scorch.

LOGGING HISTORY

We used the 2015 version of 'LASTLOG25'
http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002521&publicId=guest&extractionProviderId=1
A coupe-based logging history overlay of most recent harvesting activities, attributed by time period and silvicultural method. Harvesting, other than 'Thinning from Below' and 'Single Tree Selection' was assumed to result in forest regeneration.

OLD GROWTH FOREST

We assessed the 2009, post-fire, version of Modelled Old Growth Forest 'MOG2009'
https://www.data.vic.gov.au/data/dataset/modelled-old-growth-boundaires

A3.5 Anomalies in land classification

Examples of anomalies in the land classification systems.

Example 1. Incorrect coding in one year.

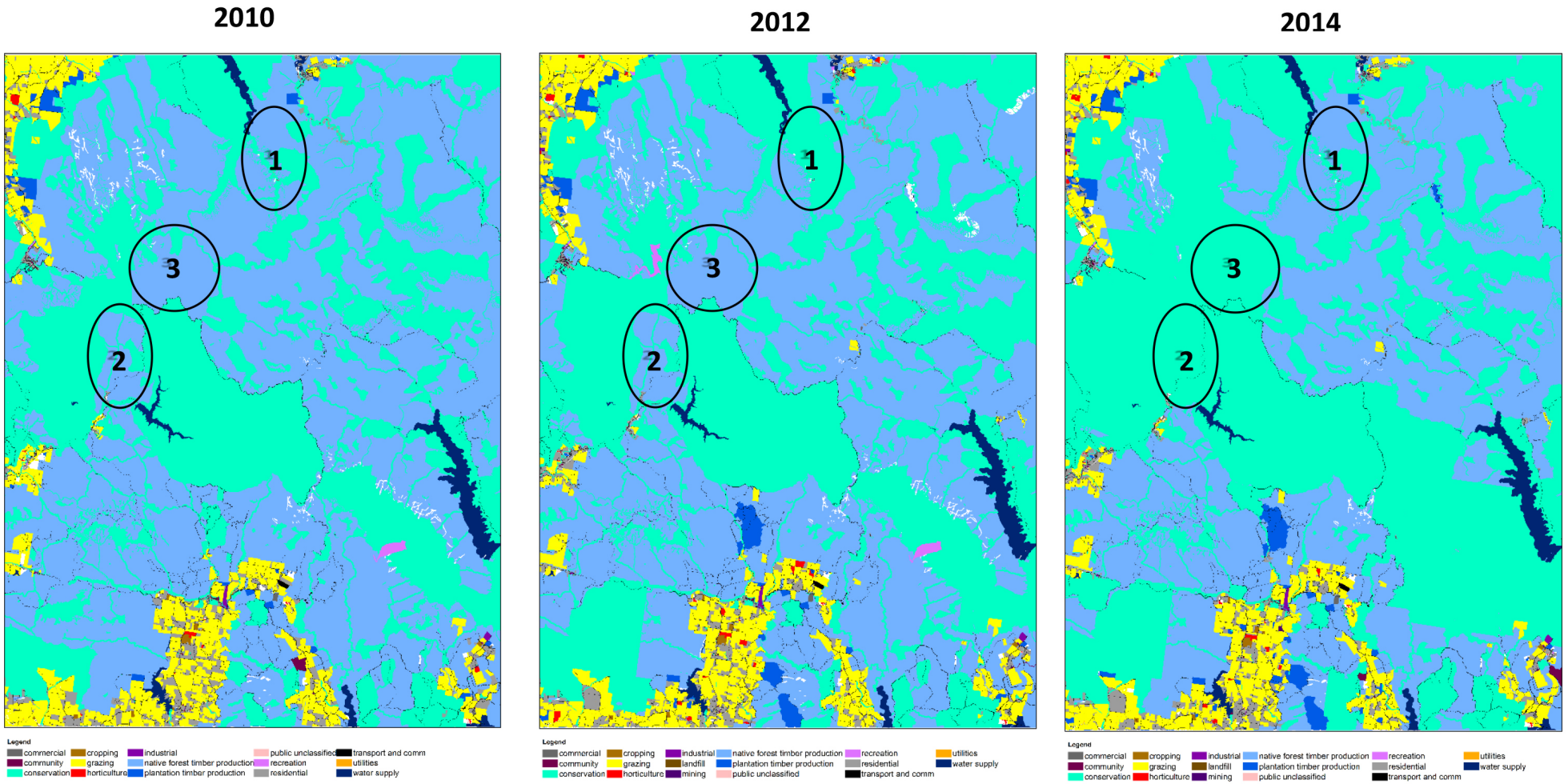

Figure A3.1. Land use classification showing three anomalies in the coding for areas of 'conservation'.

The areas marked as 'conservation' in only one year (1. in 2012, 2. and 3. in 2014) had not changed the land use category in reality, but had been coded incorrectly.

Example 2. Change in definition of the classification criteria in one year.

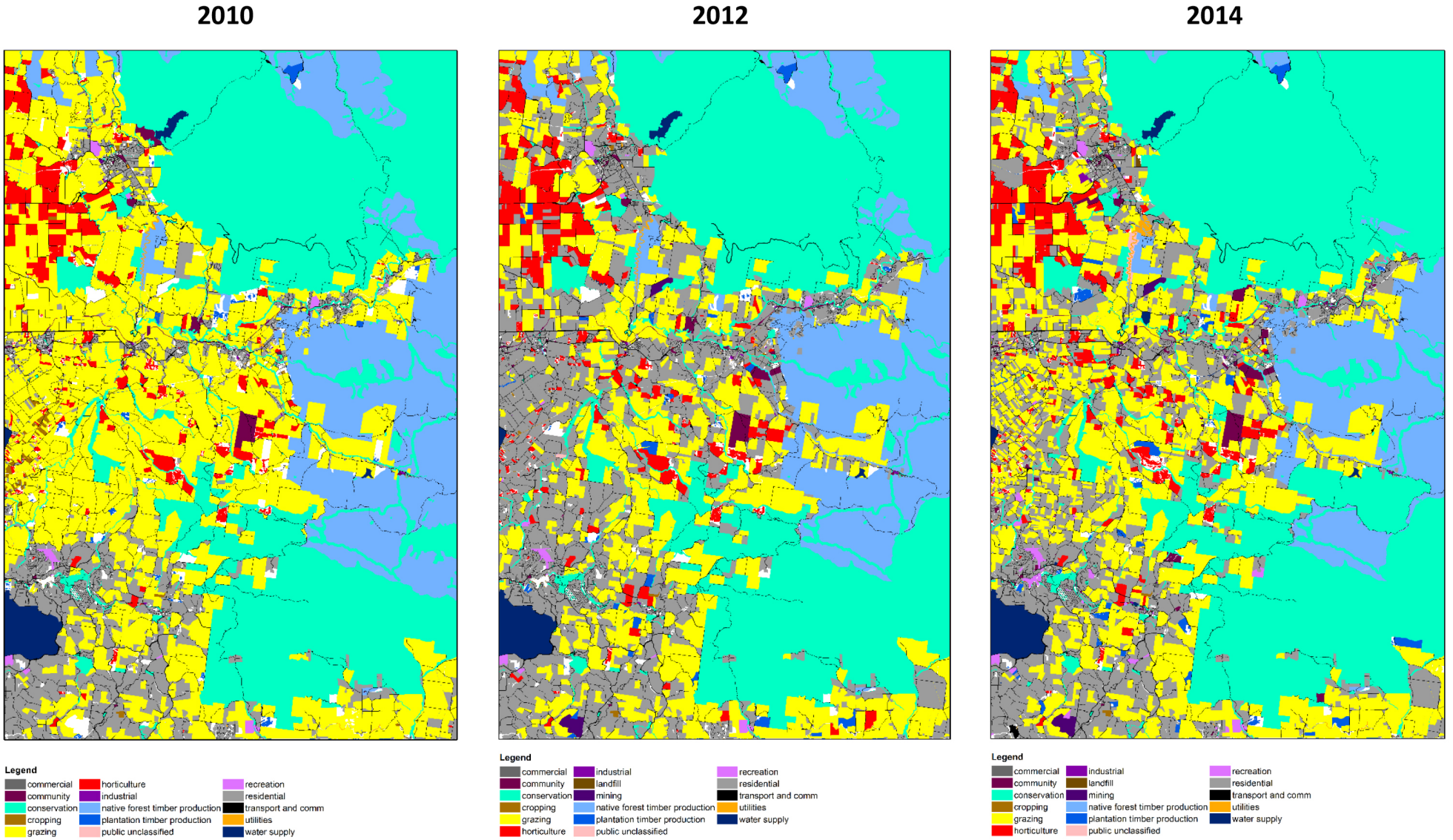

Figure A3.2. Land use classification showing an anomaly in the criteria for 'residential'.
In 2012 there was a larger area of 'residential' than in 2010 or 2014, which would not have occurred in reality.

Example 3. Inconsistency in boundaries between different spatial layers of land cover.

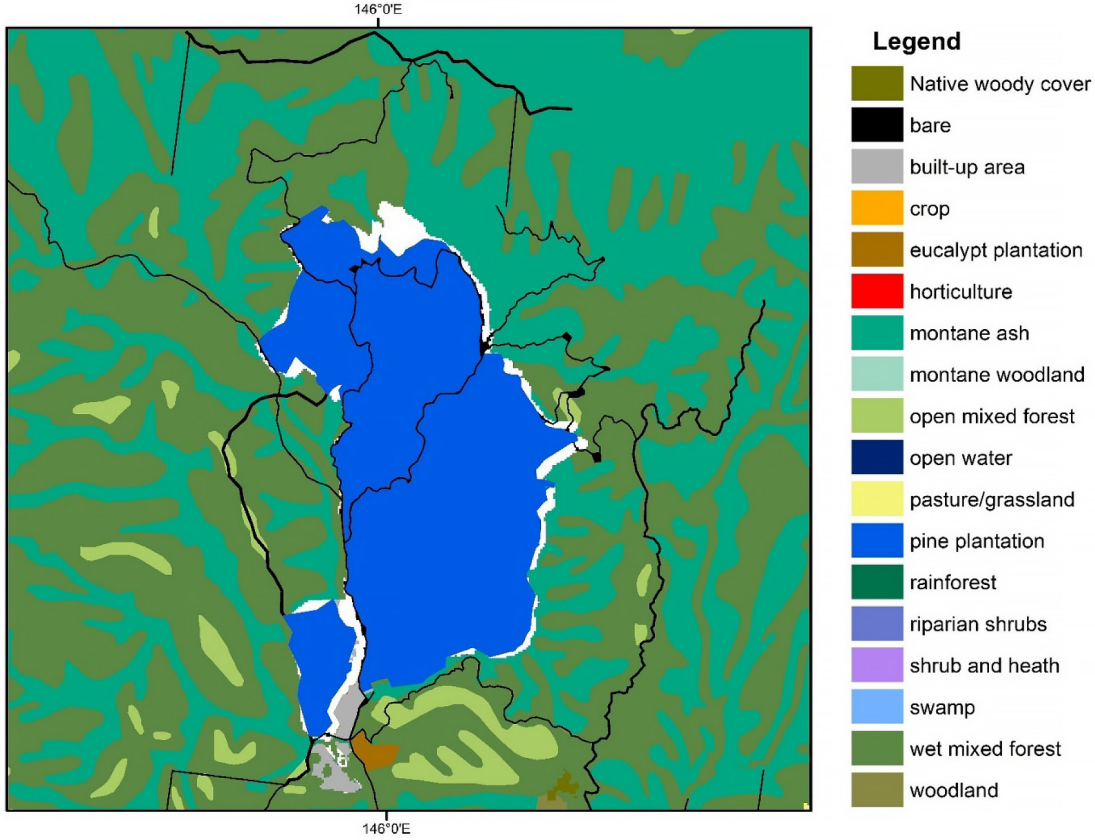

Figure A3.3. Native vegetation and managed vegetation area based on different spatial layers, and in this case the boundaries of the pine plantation do not match that of the native vegetation.

Example 4. Different sources of spatial data cause problems due to scale and aggregation.

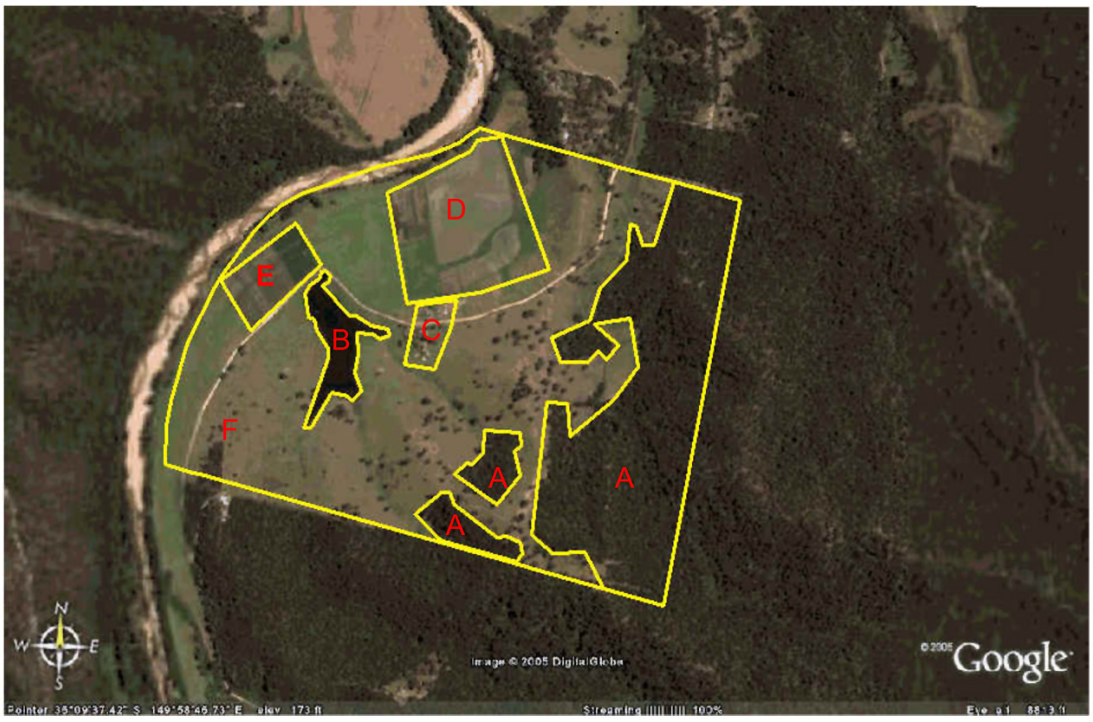

Figure A3.4. Land cover is assessed from satellite images whereas land use is mapped using administrative data.

Areas calculated for land cover and land use include:
Land cover: A: forest – 39.0 ha, B: water – 3.5 ha, C: residence – 1.8 ha, D: irrigated crop – 13.5 ha,
E: other crop – 3.8 ha, F: grassland – 68.0 ha.
Land use: Agriculture (grazing) – 129.6 ha

Example 5. Anomalies between land cover and land use classifications.

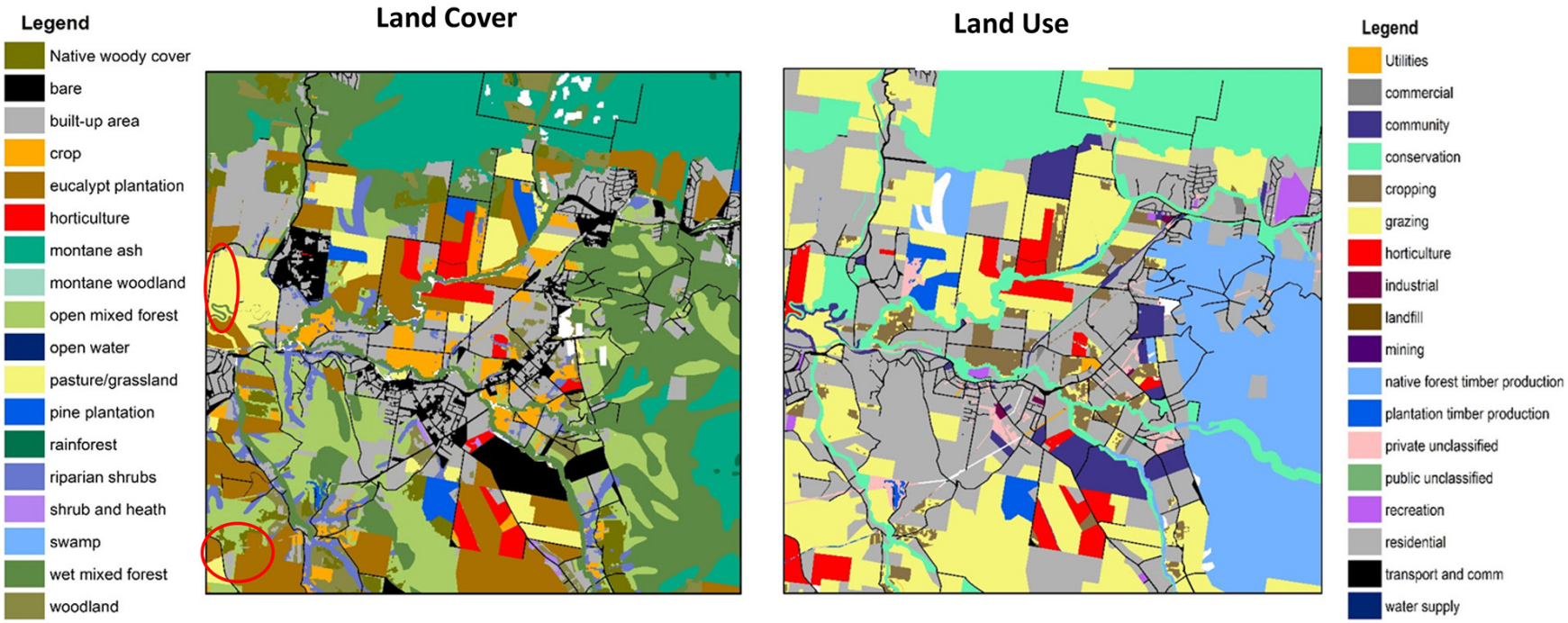

Figure A3.5. Classes that should be the same in both the land cover and land use classification systems sometimes do not correspond.
'Horticulture' is the same class but there are two areas on the west boundary that show a 'horticulture' land use but not land cover (circled in red). 'Built-up area' land cover should correspond to 'residential' and 'commercial' land use, all shown in shades of grey. However, there is more grey area for land use than for land cover, particularly in the central section of the map.

A4. Water

A4.2 Water asset account

Table A4.1. Central Highlands water asset account for the reservoirs from 1990 – 2015.

Stocks are the water storage within the 10 reservoirs managed by Melbourne Water and sourced from runoff within the study area. Precipitation and evaporation refer to the transfers from the surface water of the reservoirs. Data are not available for all components of a full water asset account and these amounts are included in the unaccounted changes. See table on next page.

Volume of water (GL)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Opening stock of reservoir water	1539	1599	1619	1577	1526	1502	1625	1470	1149	1089	981	980	969	854	969	1028	878	641	603	564	717	1045	1300	1372	1389	1300
Additions to stock																										
Returns																										
Inflows	698	628	760	712	527	667	826	232	433	317	560	426	324	509	508	389	163	374	287	369	559	634	658	416	421	306
Precipitation	61	62	67	67	45	62	68	37	54	49	56	51	41	53	54	52	35	51	47	45	65	65	58			
Inflows from other territories																										
Inflows from other water resources																										
Total additions	758	690	827	778	571	729	894	269	487	366	616	477	365	562	562	441	198	425	335	414	625	699	716	416	421	306
Reductions to stock																										
Abstraction	465	465	476	447	453	482	459	512	520	490	502	500	462	476	433	431	435	401	370	360	349	343	360	393	395	401
Evaporation	43	44	37	38	42	39	39	46	44	42	42	41	46	45	44	44	48	48	44	47	40	38	42			
Outflows to other territories																										
Outflows to sea																										
Outflows to other water resources																										
Total reductions	508	509	513	485	495	521	498	558	564	532	544	541	508	521	477	475	483	449	414	407	389	381	402	393	395	401
Net additions and reductions	250	181	314	293	77	208	396	-289	-77	-166	72	-63	-143	41	86	-34	-285	-24	-79	7	236	318	314	23	26	NA
Unaccounted changes	-191	-161	-356	-345	-101	-84	-551	-32	17	58	-73	52	28	74	-27	-116	49	-14	39	146	93	-64	-242	-6	-115	NA
Closing stock of reservoir water	1599	1619	1577	1526	1502	1625	1470	1149	1089	981	980	969	854	969	1028	878	641	603	564	717	1045	1300	1372	1389	1300	NA

A4.3 Water Yield

A4.3. Background

The response of water yield to forest age was derived from a synthesis of information from the literature. Disturbance within a forested catchment results in increased runoff due to loss of leaf area in the short-term of up to 1 to 5 years, until leaf area is restored. Reported increases in runoff after a range of disturbance events range from 25 to 100% (Jayasuriya *et al.* 1993; Vertessy *et al.* 1996, 2001; Watson et al. 1999a, 2001; Lane *et al.* 2006, 2010; Feikema *et al.* 2006, 2013). The water yield response immediately post-disturbance is highly dependent on the soil moisture conditions pre- and post-disturbance. Increased runoff post-fire is diminished if initial soil moisture stores are low and if subsequent rainfall is low. Such dry conditions typically occur prior to major fires and were particularly the case in 2009, where there was no clear evidence of an increase in post-fire runoff (Tan *et al.* 2011). This is also likely the reason that Kuczera (1987) did not report an increase in flow after the 1939 fire, which occurred during a prolonged dry period. A post-disturbance increase in streamflow is more likely after harvesting and if rainfall conditions and soil moisture storage are average or above average.

In many ecosystems, there is a gradual return of runoff to pre-disturbance levels as leaf area is restored. However, in the montane ash forest there is an additional factor: the regenerating forest with dense leaf growth results in high water use by transpiration and hence reduced runoff. The pattern of response of water yield is well established, but the parameters describing magnitude and timing are variable (Langford 1976; Kuczera 1985, 1987; Vertessy *et al.* 2001; Buckley et al. 2012). The hydrological effects of forest age have been related to the hydraulic and structural characteristics of ash stands, such as age-dependent trends in leaf area index, leaf conductance, interception and sapwood area index. Kuczera (1987) developed a model of the catchment level response of water yield to large-scale disturbance in ash forest, that is, a stand-replacing event. Reductions in water yield were projected to commence about 3 years post-disturbance, reach a maximum in 20 - 30-year-old stands, and then decline as the forest aged and transpiration and interception declined. The gradual recovery of water yield may take about 150 to 200 years (Vertessy *et al.* 1998, 2001). The Kuczera model provides a general response of water yield to disturbance over time that is appropriate to apply at the regional scale. The general relationship and the magnitude of the parameters have been verified by studies of smaller paired catchment silvicultural treatment experiments and re-analysis of longer time periods of the streamflow data (Vertessy *et al.* 1998; Watson et al. 1999b; Brookhouse *et al.* 2013), and in other eucalypt forest types (Cornish and Vertessy 2001). At smaller scales, there are large variations in water yield between catchments with different site and forest characteristics and high levels of uncertainty in predictions of the recovery of water yield (Vertessy *et al.* 1998). Detailed prediction of impacts on water yield at the small catchment scale can be made using physically-based models that predict forest regrowth and its interactions with the water and energy balances given local site characteristics (Vertessy *et al.* 1996; Watson *et al.* 1999a, b).

A4.3.2 Calculations

Water yield with and without disturbance, and the resulting changes in forest age, was calculated for each grid cell in the study area. Alpine Ash, Mountain Ash and rainforest forest types that were clearfell logged or burnt (fire severity class 1 or 2 assessed in 2009) had an initial increase in runoff followed by a decrease related to forest age. Mixed species forest types that were clearfell logged had an initial increase in runoff, but then, were assumed to have constant leaf area (Feikema *et al.* 2006; Lane *et al.* 2010). Percent changes in water yield in relation to forest age of ash were applied to the annual runoff calculated from the water balance model. Two equations were used to describe the relationship between reduction in water yield and forest age, depending on the assumed initial or pre-disturbance forest age of either old growth or regrowth. The Kuczera (1987) model assumed the initial forest was old growth and was calibrated before the 1939 fire. Whereas, the current forest is mostly regrowth since the 1939 fire, and hence, is assumed to be experiencing reduced water yield. The water balance model was calibrated for the current forest, which meant that at the time of each disturbance event in the current calculations, the modelled water yield would have been less than maximum, and hence the corresponding reduction in the regenerating forest would be less than that modelled.

The following functions were used in the calculation of water yield (shown in Figure A4.1):

Initial increase in water yield following disturbance as a proportion of the baseline calculation for constant age:
Year 1 = +0.5; Year 2 = + 0.25; Year 3 = 0.

Reduction in water yield as a proportion of the baseline calculation for constant age:

Pre-disturbance forest of old growth:

reduction proportion = 0.48 * 0.04167 * (t -3) * exp(1 - 0.04167 * (t - 3))

Pre-disturbance forest of regrowth:

reduction proportion = 0.48 * 0.03667 * (t - 3 + 4.82) * exp(1 - 0.03665 * (t - 3 + 4.82)) + 0.1949

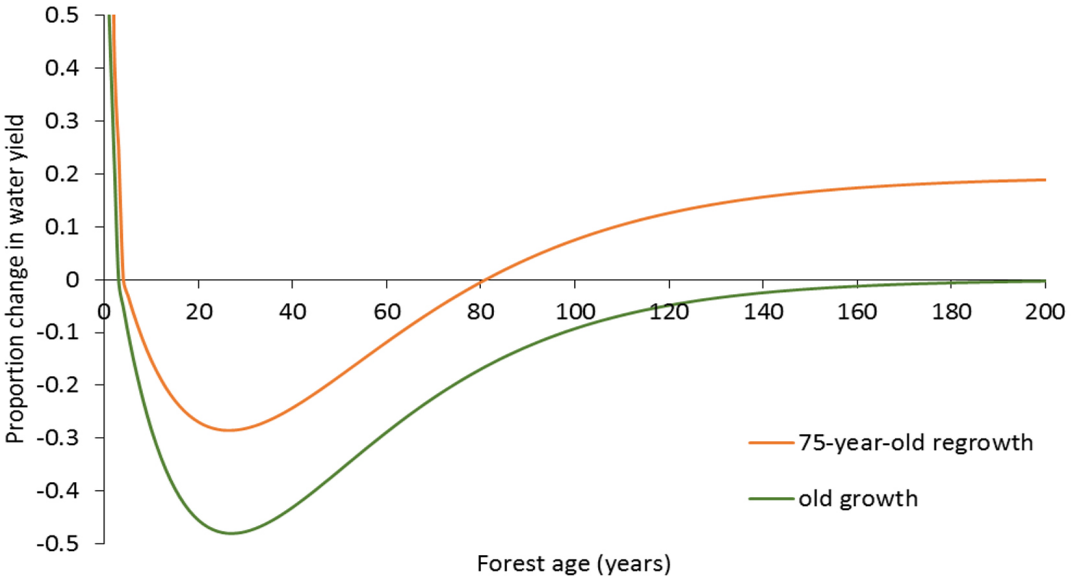

Figure A4.1. Change in water yield following stand-replacing disturbance in montane ash forest calculated for old growth forest and 75-year-old regrowth.

Source: Kuczera (1987) for old growth model

An initial increase in water yield occurs and then a decrease over time under the regrowing forest. Pre-disturbance conditions of 75-year-old regrowth and old growth forest are compared.

A4.3.3 Results

The water yield for the combined catchments within in the study area is shown in Figure A4.2, together with the difference in yield due to the reduction resulting from forest age using conditions of the initial forest being old growth or regrowth. Using a pre-disturbance vegetation condition of the 75-year old regrowth is probably the most realistic scenario for this region because the majority of the forest was burnt in 1939. Pre-disturbance condition of regrowth produces a lesser reduction because the catchment was not at maximum water yield at the time that the disturbances occurred. The difference between constant forest age and the regrowth and old growth conditions are reduced over time as the forest increases in age.

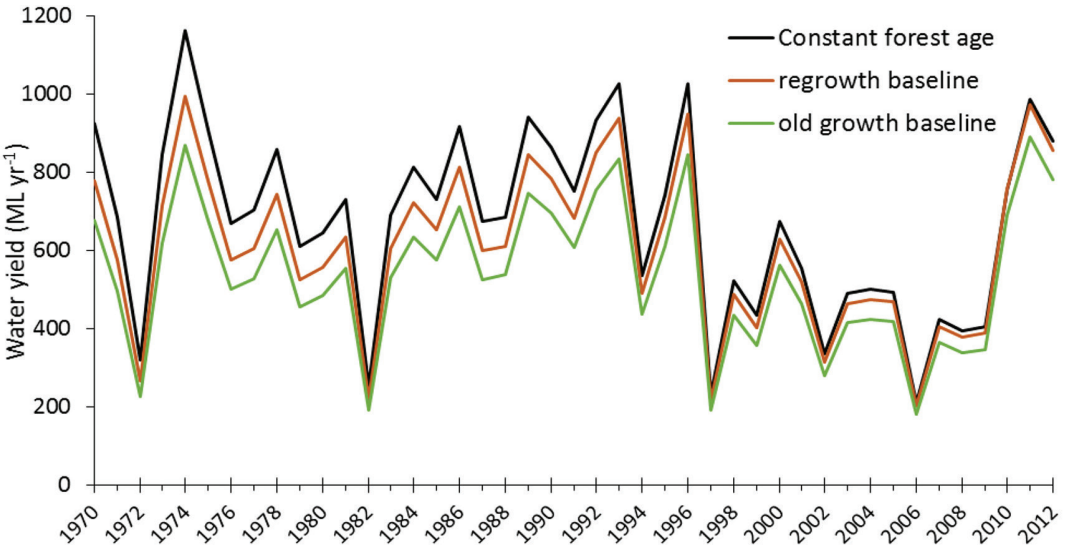

Figure A4.2. Total annual water yield for the reservoirs in the Central Highlands showing the difference in yield resulting from different initial conditions of forest age, being either constant, old growth or regrowth.

Water yield reflects the area of the catchment, but also the water balance between precipitation and evaporation, and the effect of vegetation type and slope on runoff. For example, the O'Shannassy, Maroondah and Tarago catchments are similar sizes (Table A4.2), but the water yield is greatest in the O'Shannassy and least in the Tarago. The catchments differ greatly in their proportions of different land cover types (Table A4.2 and Figure A4.2), and this influences the response of water yield because the reduction due to forest age is applied to the Mountain Ash, Alpine Ash and rainforest land cover types, but not to the mixed forest and woodland types. The proportion of each catchment that has regenerating forest following disturbance by wildfire or logging over the period 1970 – 2012 is shown in Figure A4.3. The largest catchment, the Thomson, had 9% of the area logged in ash forest representing 4300 ha, which was a similar area to that burnt in 2009 in the O'Shannassy catchment.

Table A4.2. Area (ha) of each land cover class in the catchments

	Land Cover Class						
Reservoir catchment	Mountain & Alpine Ash, Rainforest		Open & wet mixed forest, woodland, montane woodland		Other		Total
	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)
Upper Yarra	16,271	48	16,853	50	910	3	34,034
Maroondah	7,473	73	2,461	24	250	2	10,184
O'Shannassy	11,394	96	444	4	43	0	11,881
Thomson	16,781	35	27,380	58	3 386	7	47,548
Tarago	4,949	43	3,798	33	2755	24	11,502
Total							115,149

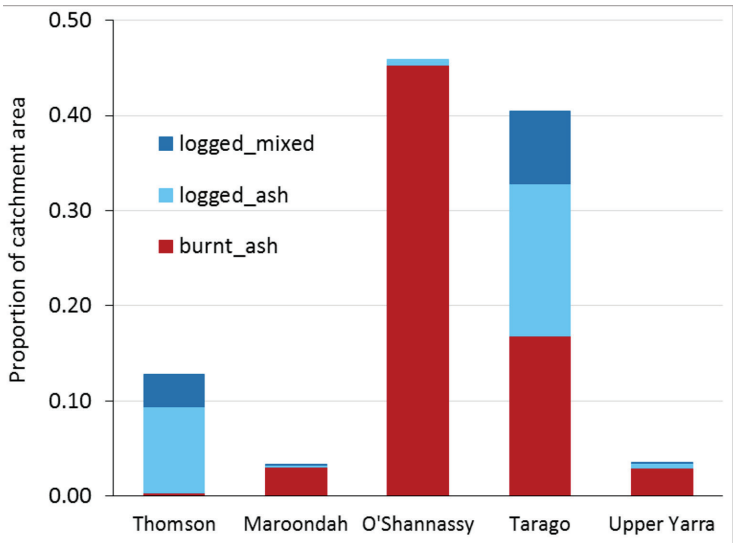

Figure A4.3. Proportion of the catchment area that is regenerating forest following wildfire or logging in ash forest, and logging in mixed species forest, over the period 1970 to 2012.

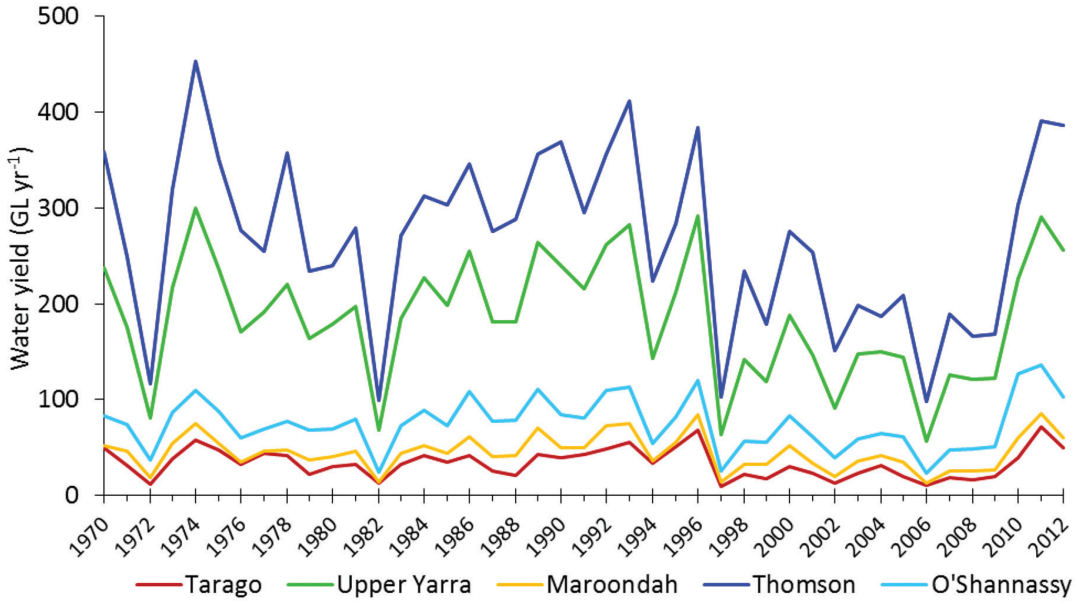

Figure A4.4. Annual water yield in the five catchments of the Central Highlands study area over the period 1970 to 2012, using a baseline of regrowth forest

The effect of the water yield reduction depends on the age of the montane ash forest and rainforest, and the area of these forest types within each catchment. The shift in age categories over time due to fire or logging is shown in the following graphs and maps. The age categories were selected to coincide with similar proportions of water yield reduction, with the greatest reduction occurring between ages of 13 – 49 years and peaking at 25 years. Forest age is determined from the last stand-replacing event, which refers to fire or clearfell logging for ash, and clearfell logging for mixed species forest.

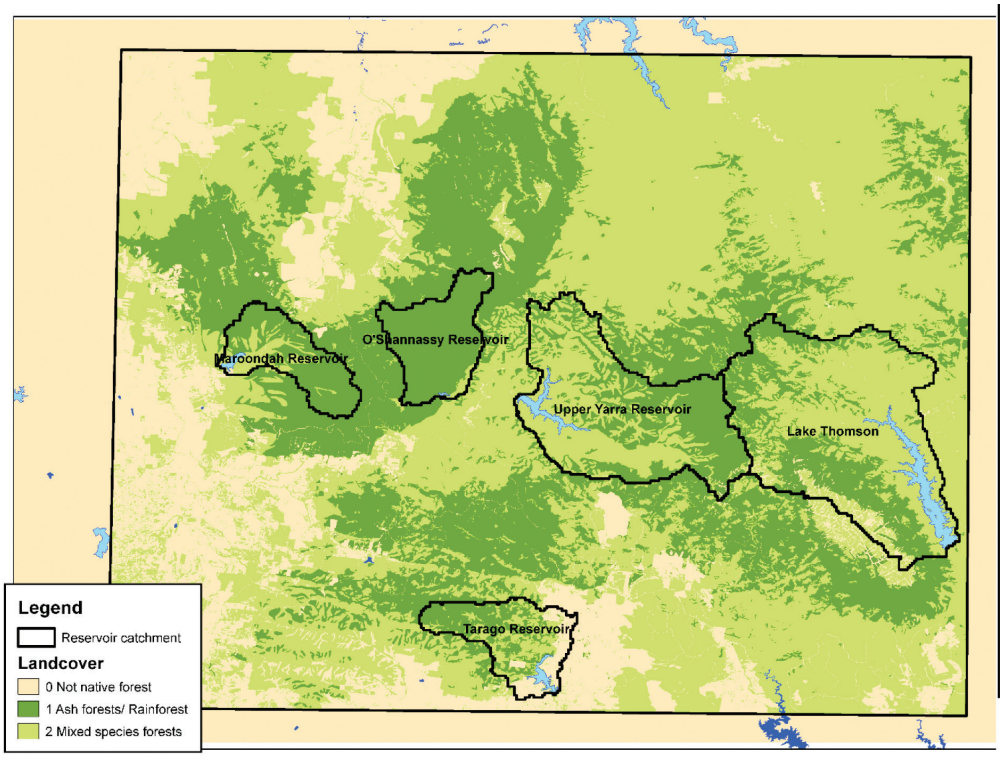

Figure A4.5. Distribution of forest types across the catchments, where montane ash type forest and rainforest are affected by reduction in water yield and mixed forest is not affected

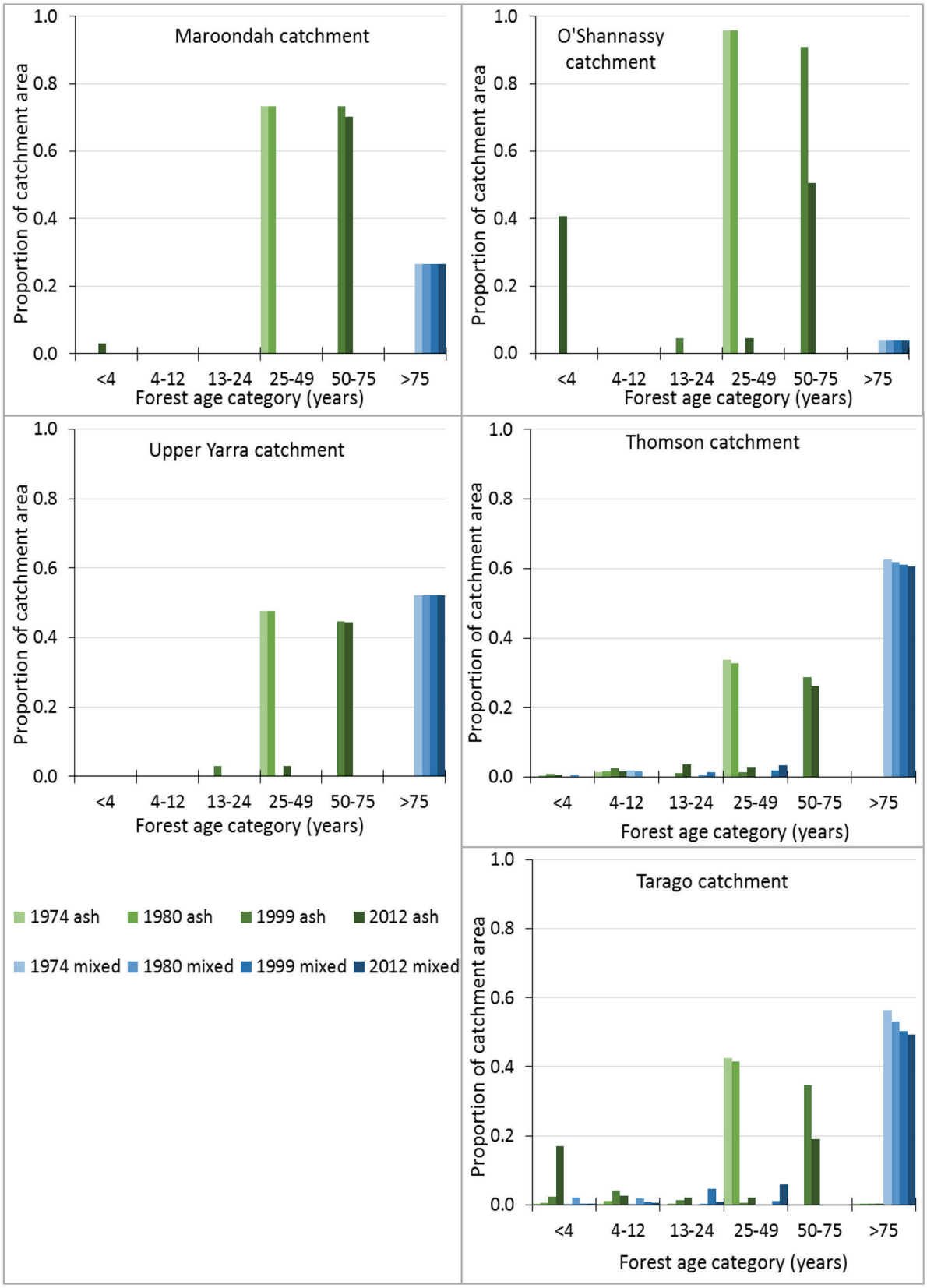

Figure A4.6. The proportion of catchment area in each forest type and age category, which determine the reduction in the water yield function. Shown at time intervals of 1974, 1980, 1999 and 2012 to provide an estimate of change over time.

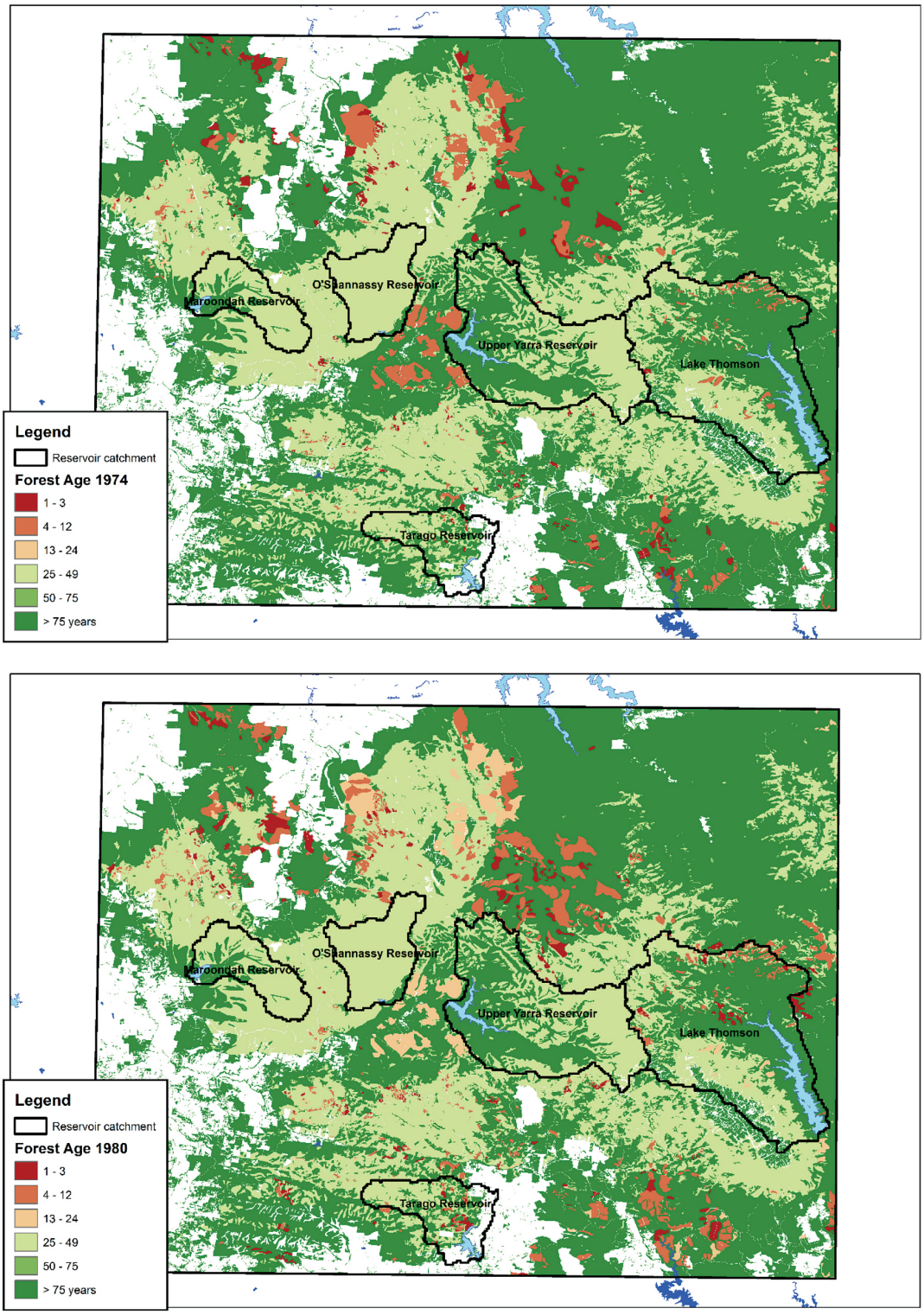

Figure A4.7. Spatial distribution of forest age categories shown for a selection of years to illustrate the change over time, both as forests increase in age and disturbance results in regeneration of young forest.

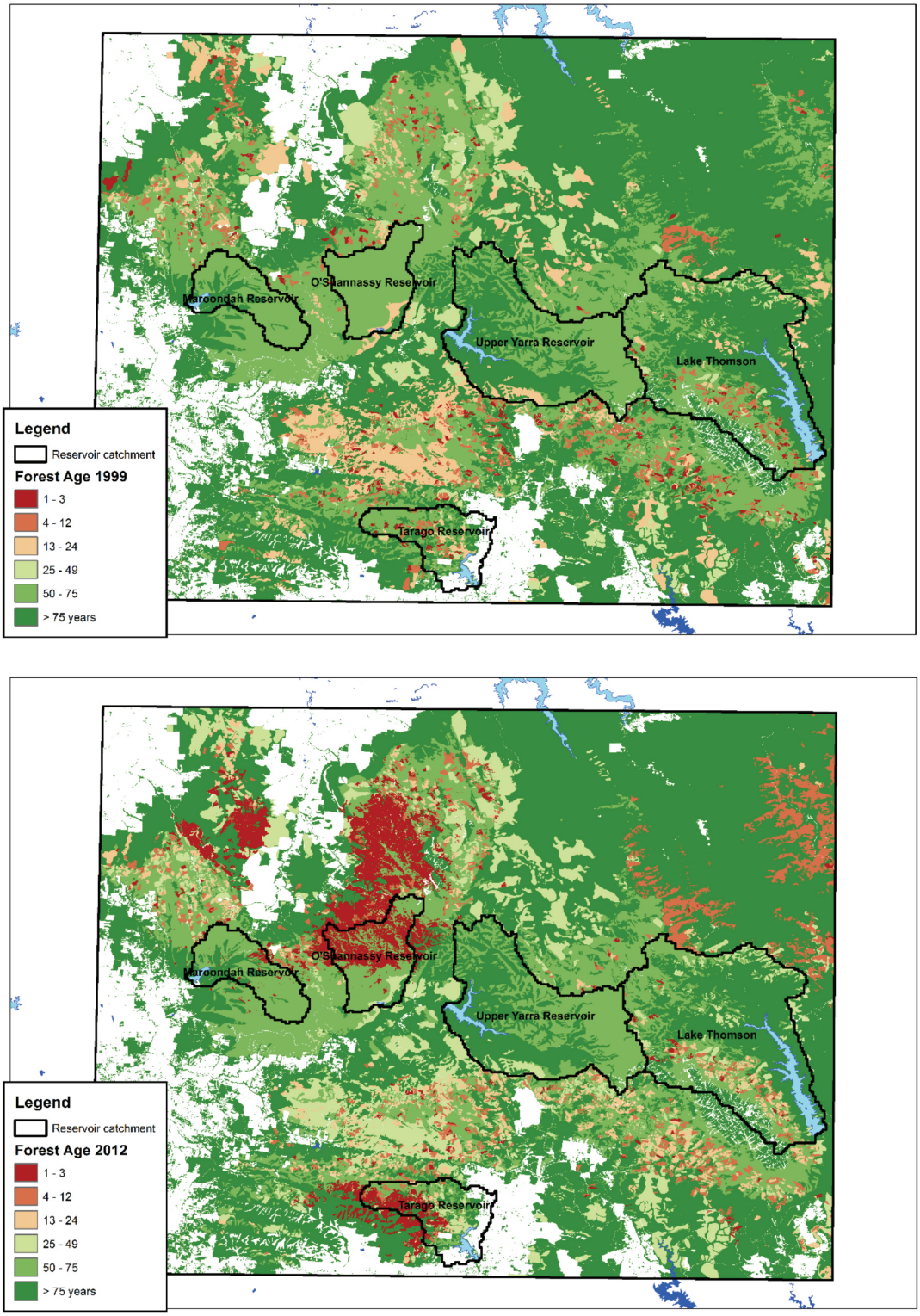

Figure A4.7. (continued) Spatial distribution of forest age categories shown for a selection of years to illustrate the change over time, both as forests increase in age and disturbance results in regeneration of young forest.

The reduction in water yield due to forest age is declining in all catchments over the period 1970 to 2012, because the majority of the forest is 1939 regeneration, which is increasing in age (Figure A4.8). Differences between the catchments in their rate of change reflect the factors that reduce water yield. The greatest rate of decline in the reduction of water yield, that is, the greatest rate of return of water yield to pre-disturbance levels, occurs in the O'Shannassy catchment. This catchment has the highest proportion of montane ash forest and had no stand-replacing disturbances, until the 2009 fire. The Maroondah catchment is similar but with a lower proportion of ash forest.

The Tarago and Thomson catchments have a smaller proportional reduction in water yield than other catchments, because they have more mixed species forest where the regrowth does not cause the reduction in water yield. These two catchments have more logged areas and hence younger forest, but less of this forest is ash, than in the other catchments. The Tarago catchment does not show a decline from 2004 to 2009, which may indicate reductions in yield due to younger forest regenerating from logging.

The increases in water yield in 2010 and 2011 in the O'Shannassy and Tarago catchments reflect the large areas burnt in 2009 and the short-term increase in runoff after fire. This result may be an over-estimate of the increase in runoff after disturbance, because the increase may not have be as large as that described by the standard function due to the dry conditions before and after this fire.

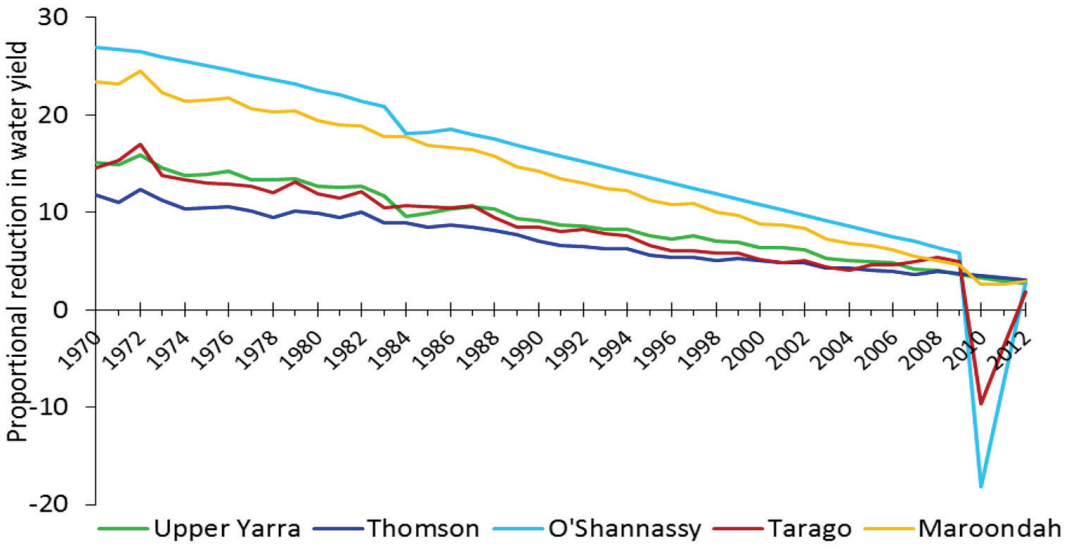

Figure A4.8. Reduction in water yield from constant forest age assuming regrowth forest baseline

The difference in water yield for the counterfactural case with no logging in the catchments was calculated using the response function of water yield in regenerating forest. The assumption about an initial increase in runoff following disturbance until leaf area is restored depends on the antecedent soil water content and post-disturbance weather conditions, which influence the proportion of rainfall that infiltrates the soil. The effect of this assumption on water yield is shown in Figure A4.9.

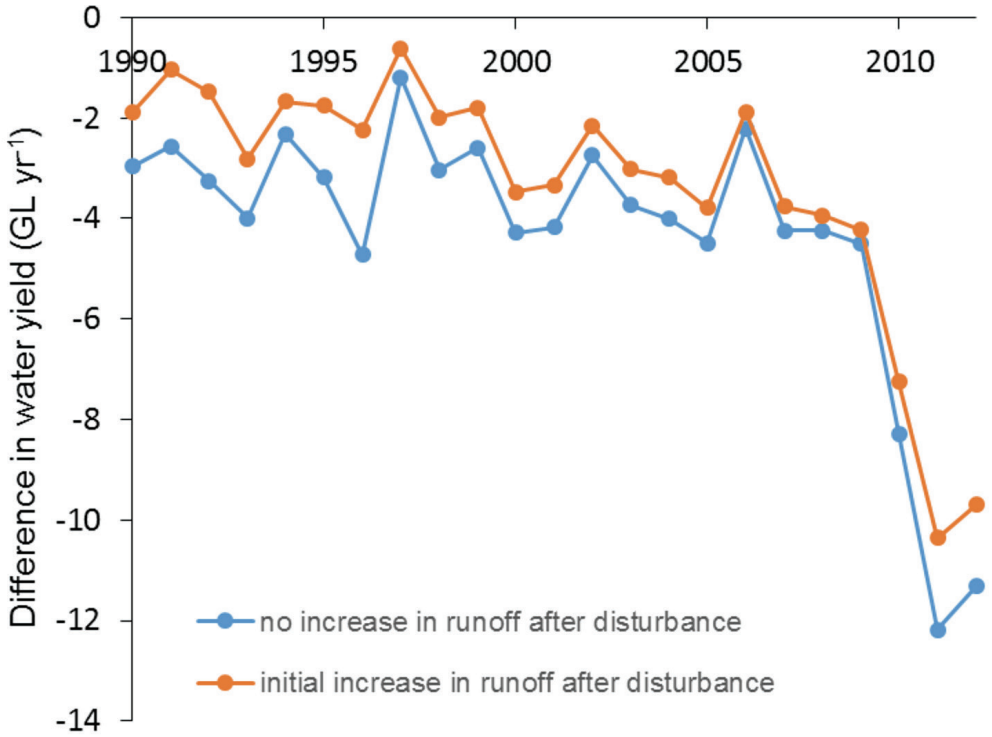

Figure A4.9. Difference in water yield for the counterfactual case with no logging in the catchments, showing the effect of the assumption about an initial increase in runoff post-disturbance

A5.2 Carbon stock assets

A5.2.1.1 Carbon stocks in land cover types

The biomass carbon stock model was derived for montane ash forest, but the carbon stock in mixed species wet temperate forest is less than for the ash forest. This adjustment in the modelled carbon stock was estimated using existing allometric volume equations and wood density for the other species compared with the ash species (Keith *et al.* 1997, 2000; Bi *et al.* 2004; Illic *et al.* 2000). Estimates of biomass carbon stock density for other land cover types were derived from the best available information in the literature, and were applied as constant values. Carbon stocks in eucalypt and pine plantations were calculated using the FullCAM model with standard plot values for the region (DotE 2015).

Table A5.1 Estimates of biomass carbon stock density for all land cover types in the study area

Land cover	Average carbon stock (tC ha^{-1})	Proportion of modelled ash	Source
Rocky / bare	0		1
Riparian shrubs	40		1
Rainforest	325		2
Wet mixed forest		0.6	3, 4, 5, 6, 7
Montane ash forest		1.0	8
Open mixed forest		0.5	5, 6, 7
Woodlands	150		9
Shrub and heath	30		1
Swamp	20		1
Montane woodland	150		10
Grazing	4		1
Cropping	4		1
Horticulture	8		1
Plantation softwood	56		7
Plantation hardwood	152		7
Residential	15		1
Reservoirs	0		1

1. Ajani and Comisari (2014); 2. May *et al.* (2012); 3. Keith unpubl.; 4. West and Mattay (1996); 5. Grierson *et al.* (1992); 6. Borough (1984); 7. DotE (2015a); 8. Keith *et al.* (2014a); 9. Berry *et al.* (2010); 10. Keith *et al.* (1997)

A5.2.1.2 Carbon accumulation functions

Table A4.2. Carbon accumulation functions based on forest growth for each forest type
t is the time since the last stand-replacing disturbance event

Forest type	Carbon accumulation function	Reference
Montane ash	$1200 \times (1-\exp(-0.0045\ t)^{0.7}$	1
Wet mixed species	$450 \times (1-\exp(-0.015\ t)^{1.05}$	3, 4, 5, 6, 7
Open mixed species	$310 \times (1-\exp(-0.025\ t)^{1.1}$	5, 6, 7
Rainforest	$800 \times (1 - \exp(-0.002\ t)^{1.2}$	11, 12
Pine plantation	$130 \times (1 - \exp(-0.15\ t)^{6}$	7
Eucalypt plantation	$500 \times (1-\exp(-0.35\ t)^{1.25}$	7
Woodland	$C_{t-1} + 0.23$	11

1. Keith *et al.* (2014a); 3. Keith unpubl.; 4. West and Mattay (1996), 5. Grierson *et al.* (1992); 6. Borough (1984); 7. DotE (2015a); 11. DotE (2015b); 12. Wood *et al.* (2010).

A5.2.1.3 Change in carbon stock due to logging

Equations describing the reduction in carbon stock due to logging of the majority of biomass, based on Keith *et al.* (2014a).

Amount of biomass remaining on-site after product removal from logging:

$$C_{slash} = 0.6 \times C_{initial}$$

Amount of biomass remaining on-site after slash burning:

$$C_{residual(}0) = 0.5 \times C_{slash}$$

Decomposition of the residual biomass remaining after harvesting and slash burning:

$$Cr_{esidual}(t) = C_{residual(}0) \times \exp(-0.07\ t)$$

Reduction in carbon stock due to selective logging, including single tree selection and thinning, were based on information about silvicultural systems and proportion of basal area removed (Florence 1996, Lutze *et al.* 1999, Flinn *et al.* 2007). Single-tree selection and thinning from above were estimated as a reduction by 50%, and thinning from below as a reduction by 30%. Selective harvesting and single-tree selection are described as the removal of mature trees only and leaving immature trees for harvesting in the future (VAGO 2013). Thinning removes some trees to increase the health and growth rate of the remaining trees or to access timber from trees before they die (VAGO 2013). Stems removed can be mature trees and merchantable species for timber, over-mature trees to provide space for growing stock, or small trees or non-merchantable species to reduce competition with growing stock. Hence, these silvicultural systems are highly variable in terms of biomass removed and effect on forest age structure.

A5.2.1.4 Change in carbon stock due to fire

Equations describing the change over time in dead biomass components after fire, based on Keith *et al.* (2014b).

Dead standing trees remain after fire, but slowly collapse and fall to the ground.

$$C_{dead\_standing\ (t+1)} = C_{dead\_standing\ (t0)} / (1 + \exp(0.1\ t - 5))$$

Fallen trees become input to the coarse woody debris (CWD).

$$C_{dead\_standing\ (t)} - C_{dead\_standing\ (t+1)} = C_{CWD\_input}$$

Coarse woody debris on the ground decomposes over time.

$$C_{CWD\ (t) = CCWD\ (0)} \times \exp(-0.07\ t) + C_{CWD\_input}$$

Table A4.3. Loss in biomass carbon stock (%) due to emissions under different fire severities

Forest age (yrs)	Fire severity	
	Low (classes 3 ,4 ,5)	High (classes 1, 2)
0 - 30	6	14
31 – 72	7	11
> 72	7	9

If fire severity was not known, an average of 10% carbon stock loss due to emissions was used. (Keith *et al.* 2014b).

A6. Plantation Timber

Table A6.1. Australian forestry and logging industry, estimated resource rent, 2006-07 to 2013-14 ($m current prices)

SUBDIVISION 03 Forestry and logging									
		2006-07 $m	2007-08 $m	2008-09 $m	2009-10 $m	2010-11 $m	2011-12 $m	2012-13 $m	2013-14 $m
	Total industry output (Australian production)	**3,075**	**3,406**	**3,363**	**3,732**	**3,354**	**3,262**	**3,043**	**3,632**
less	Intermediate consumption	2,264	2,542	2,417	2,477	1,647	1,907	1,681	1,937
	Compensation of employees	555	524	648	618	595	516	491	557
	Net taxes on production	21	30	21	16	34	20	-8	-47
equals	Gross operating surplus & mixed income	235	310	278	621	1,078	819	879	1,185
less	Consumption of fixed capital	122	150	121	281	429	321	320	465
	Return to fixed capital	83	101	73	154	252	112	146	207
equals	**Resource rent**	**30**	**59**	**84**	**186**	**397**	**386**	**413**	**514**
	Resource rent % of total industry output	1.0%	1.7%	2.5%	5.0%	11.8%	11.8%	13.6%	14.2%
	Net Present Value								
	Net Capital Stock at beginning of year	1,320	1,570	1,319	3,010	4,835	3,698	3,884	5,836
	Rate of Return on capital (RBA 10yr Bond-Rate)	6.26%	6.45%	5.52%	5.10%	5.21%	3.04%	3.76%	3.54%
	Discount Rate	6.26%	6.45%	5.52%	5.10%	5.21%	3.04%	3.76%	3.54%

Table A6.2. Central Highlands forestry and logging industry, estimated resource rent, 2006-07 to 2013-14 ($m current prices)

SUBDIVISION 03 Forestry and logging									
		2006-07 $m	2007-08 $m	2008-09 $m	2009-10 $m	2010-11 $m	2011-12 $m	2012-13 $m	2013-14 $m
	Total industry output (Central Highlands)	**16.76**	**16.05**	**17.94**	**18.69**	**27.54**	**39.61**	**52.04**	**64.07**
less	Intermediate consumption	12.33	11.98	12.89	12.41	13.53	23.16	28.75	34.17
	Compensation of employees	3.02	2.47	3.46	3.10	4.89	6.27	8.40	9.83
	Net taxes on production	0.11	0.14	0.11	0.08	0.28	0.24	-0.14	-0.83
equals	Gross operating surplus & mixed income	1.28	1.46	1.48	3.11	8.85	9.95	15.03	20.90
less	Consumption of fixed capital	0.67	0.71	0.65	1.41	3.52	3.90	5.48	8.19
	Return to fixed capital	0.45	0.48	0.39	0.77	2.07	1.37	2.50	3.64
equals	**Resource rent**	**0.17**	**0.28**	**0.45**	**0.93**	**3.26**	**4.68**	**7.06**	**9.07**
	IVA	4.42	4.07	5.05	6.28	14.01	16.46	23.29	29.90

A7. Agriculture

Table A7.1. Australian agriculture, estimated resource rent, 2006-07 to 2014-15 ($m current prices)

SUBDIVISION 01 Agriculture								
		2008-09 $m	2009-10 $m	2010-11 $m	2011-12 $m	2012-13 $m	2013-14 $m	2014-15 $m
	Total industry output (Australian production)*	**57,293**	**58,109**	**54,033**	**62,732**	**66,887**	**70,665**	**71,895**
less	Intermediate consumption	33,253	32,187	28,505	33,401	36,242	37,197	39,665
	Compensation of employees	5,034	4,967	4,570	4,887	5,093	5,249	5,634
	Net taxes on production	394	484	421	512	646	680	713
equals	Gross operating surplus & mixed income	18,612	20,471	20,537	23,932	24,906	27,539	25,883
less	Consumption of fixed capital	9,013	8,941	9,287	9,532	9,762	10,039	10,145
	Return to fixed capital	6,080	5,370	5,081	5,593	3,417	4,575	4,512
equals	**Resource rent**	**3,519**	**6,160**	**6,169**	**8,808**	**11,727**	**12,924**	**11,226**
	Resource rent % of total industry output	6.1%	10.6%	11.4%	14.0%	17.5%	18.3%	15.6%
	Net Present Value							
	Net Capital Stock at beginning of year	94,265	97,290	99,631	107,343	112,406	121,678	127,452
	Rate of Return on capital (RBA 10yr Bond-Rate)	6.45%	5.52%	5.10%	5.21%	3.04%	3.76%	3.54%

* Total industry output (Australian production) is more than Gross value of agricultural production in Australia (Table 7.2) as it also includes services to agriculture plus household own-account production of agricultural products.

A9. Biodiversity

Table A9.1. List of threatened species in the Central Highlands study area classified under IUCN, EPBC, FFG and Victorian Advisory lists

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Mammals					
Antechinus minimus maritimus	Swamp Antechinus			Listed	Near Threatened
Bettongia gaimardi	Eastern Bettong	Near Threatened 2008; Lower Risk 1996	Extinct on mainland	Listed	Regionally Extinct
Burramys parvus	Mountain Pygmy-possum	Critically Endangered 2000; Endangered 1994	Endangered 2000	Listed	Critically Endangered
Dasyurus maculatus maculatus	Spotted-tailed Quoll	Near Threatened 2008; Vulnerable 1996	Endangered 2004	Listed	Endangered
Dasyurus viverrinus	Eastern Quoll	Near Threatened 2008; Lower Risk 1996	Extinct on mainland. Not endangered in Tasmania	Listed	Regionally Extinct
Gymnobelideus leadbeateri	Leadbeater's Possum	Endangered 2008, 1994; Vulnerable 1990	Critically Endangered 2015	Listed	Endangered
Isoodon obesulus obesulus	Southern Brown Bandicoot		Endangered 2001	Listed	Near Threatened
Miniopterus schreibersii	Common Bent-wing Bat	Near Threatened 2008; Least Concern 2004; Lower Risk 1996		Listed	
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat			Listed	Vulnerable
Perameles gunnii	Eastern Barred Bandicoot (mainland form)	Near Threatened 2008; Vulnerable 1996	Endangered 2000	Listed	Regionally Extinct
Petaurus norfolcensis	Squirrel Glider	Least concern 1996, 2008		Listed	Endangered
Petaurus volans	Greater Glider				Vulnerable
Phascogale tapoatafa	Brush-tailed Phascogale	Near Threatened 1996, 2008		Listed	Vulnerable
Pseudomys fumeus	Smoky Mouse	Endangered 2008; Vulnerable 1996; Rare 1990	Endangered 2000	Listed	Endangered
Rhinolophus megaphyllus megaphyllus	Eastern Horseshoe Bat			Listed	Vulnerable
Sminthopsis leucopus	White-footed Dunnart	Vulnerable 2008; Data Deficient 1996		Listed	Near Threatened
Reptiles					
Delma impar	Striped Legless Lizard	Vulnerable 1996, 1994	Vulnerable 2007	Listed	Endangered
Lissolepis (Egernia) coventryi	Eastern Mourning Skink			Listed	Vulnerable
Pseudemoia cryodroma	Alpine Bog Skink			Listed	Endangered
Pseudemoia rawlinsoni	Glossy Grass Skink				Vulnerable
Vermicella annulata	Bandy-bandy Snake			Listed	Vulnerable

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Amphibians					
Litoria raniformis	Southern Bell Frog	Endangered 1996, 2002, 2004; Insufficiently Known 1994	Vulnerable 2000	Listed	Endangered
Litoria spenceri	Spotted Tree Frog	Critically Endangered 2002; Vulnerable 1996; Endangered 1994	Endangered 2000	Listed	Critically Endangered
Litoria verreauxii alpina	Alpine Tree Frog		Vulnerable 2000	Listed	Critically Endangered
Philoria frosti	Baw Baw Frog	Critically Endangered 2002, Endangered 1996, Vulnerable 1994, Rare 1986	Endangered 2000	Listed	Critically Endangered
Pseudophryne bibronii	Brown Toadlet	Near Threatened 2004, Data Deficient 2002, Lower Risk 1996, Insufficiently Known 1994		Listed	Endangered
Pseudophryne semimarmorata	Southern Toadlet				Vulnerable
Fish					
Gadopsis marmoratus	River Blackfish				Critically Endangered
Galaxias fuscus	Barred Galaxia	Critically Endangered 1996, Endangered 1994	Endangered 2000	Listed	Critically Endangered
Galaxias rostratus	Flathead Galaxias	Vulnerable 1996, Rare 1994			Vulnerable
Galaxiella pusilla	Dwarf Galaxias	Vulnerable 1996, 1994	Vulnerable 2000	Listed	Endangered
Nannoperca (Edelia) obscura	Yarra Pygmy Perch	Vulnerable 1996, 1994	Vulnerable 2010	Listed	Vulnerable
Prototroctes maraena	Australian Grayling	Near Threatened 2009, Vulnerable 1996, 1990	Vulnerable 2000	Listed	Vulnerable
Birds					
Actitis hypoleucos	Common Sandpiper				Vulnerable
Anas (Spatula) rhynchotis rhynchotis	Australasian Shoveler				Vulnerable
Anseranas semipalmata	Magpie Goose			Listed	Near Threatened
Anthochaera (Xanthomyza) phrygia	Regent Honeyeater	Critically Endangered 2013, 2012; Endangered 2008, 1994; Threatened 1988	Critically Endangered 2015	Listed	Critically Endangered
Ardea (Casmerodius) modesta	Eastern Great Egret				Vulnerable
Ardea (Mesophoyx) intermedia	Intermediate Egret	Least Concern 2014		Listed	Endangered
Aythya (Nyroca) australis	Hardhead Duck				Vulnerable
Biziura lobata	Musk Duck				Vulnerable
Botaurus poiciloptilus	Australasian Bittern	Endangered 2014, 2004; Vulnerable 2000; Endangered 1996, 1994; Lower Risk 1988	Endangered 2011	Listed	Endangered

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Burhinus (Burhinus) grallarius	Bush Stone Curlew	Least Concern 2012; Near Threatened 2008, 2004; Lower Risk 2000, 1988		Listed	Endangered
Calamanthus pyrrhopygius	Chestnut-rumped Heathwren			Listed	Vulnerable
Chthonicola sagittata	Speckeld Warbler			Listed	Vulnerable
Egretta garzetta nigripes	Little Egret			Listed	Endangered
Excalfactoria (Coturnix) chinensis victoriae	King Quail			Listed	Endangered
Falco (Hierofalco) subniger	Black Falcon				Vulnerable
Geopelia cuneata	Diamond Dove			Listed	Near Threatened
Grantiella picta	Painted Honeyeater	Vulnerable 2012, 2009; Near Threatened 2008, 2004; Lower Risk 2000; Vulnerable 1996, 1994; Lower Risk 1988		Listed	Vulnerable
Grus (Mathewsia) rubicunda	Brolga	Least Concern 2012, 2004; Lower Risk 2000, 1988		Listed	Vulnerable
Ixobrychus dubius	Little Bittern			Listed	Endangered
Lewinia (Rallus Dryolimnas) pectoralis	Lewin's Rail			Listed	Vulnerable
Lichenostomus melanops cassidix	Yellow-tufted (Helmeted) Honeyeater		Critically Endangered 2014	Listed	Critically Endangered
Lophoictinia isura	Square-tailed Kite	Least Concern 2012, 2004; Lower Risk 2000; Vulnerable 1996, 1994; Lower risk 1988		Listed	Vulnerable
Melanodryas (Melanodryas) cucullata cucullata	Hooded Robin			Listed	Near Threatened
Neophema pulchella	Turquoise Parrot	Least Concern 2012, 2004; Lower Risk 2000, 1994, 1988		Listed	Near Threatened
Ninox (Hieracoglaux) connivens connivens	Barking Owl			Listed	Endangered
Ninox strenua	Powerful Owl	Least Concern 2012, 2004; Lower Risk 2000; Vulnerable 1996, 1994; Lower Risk 1988		Listed	Vulnerable
Oxyura australis	Blue-billed Duck	Near Threatened 2012, 2004; Lower risk 2000, 1988		Listed	Endangered
Porzana pusilla palustris	Baillon's Crane			Listed	Vulnerable
Rostratula (benghalensis) australis	Australian Painted Snipe	Endangered 2012, 2010; Not Recognised 2008, 1988	Endangered 2013; Vulnerable 2003	Listed	Critically Endangered

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Stagonopleura guttata	Diamond Firetail Finch	Least Concern 2012; Near Threatened 2008, 2004; Lower Risk 2000, 1988		Listed	Near Threatened
Stictonetta naevosa	Freckled Duck	Least Concern 2012, 2004; Lower Risk 2000; Vulnerable 1996, 1994; Threatened 1988		Listed	Endangered
Turnix pyrrhothorax	Red-chested Button Quail	Least Concern 2012, 2004; Lower Risk 2000, 1994, 1988		Listed	Vulnerable
Tyto (Megastrix) novaehollandiae novaehollandiae	Masked Owl			Listed	Endangered
Invertebrates					
Acrodipsas myrmecophila	Small Ant-blue Butterfly			Listed	Critically Endangered
Archaeophylax canarus	Caddisfly			Listed	
Austroaeschna flavomaculata	Alpine Darner				Vulnerable
Austrogammarus australis	Dandenong Freshwater Amphipod	Critically Endangered 2014; Extinct 1994		Listed	Endangered
Austrogammarus haasei	Sherbrooke Amphipod			Listed	Vulnerable
Austropyrgus grampianensis	Dairy Creek Austropyrgus Snail			Listed	Critically Endangered
Caliagrion billinghursti	Large River Damsel				Endangered
Canthocamptus dedeckkeri	Harpactacoid Copepod	Vulnerable 1996; Insufficiently Known 1994			Vulnerable
Canthocamptus mammillifurca	Harpactacoid Copepod	Vulnerable 1996; Insufficiently Known 1994			
Colubotelson searlei	Phreatoicid Isopod				Vulnerable
Ecnomus nibbor	Caddisfly				Vulnerable
Engaeus curvisuturus	Curve-tail Burrowing Cray	Data Deficient 2010; Endangered 1996		Listed	Endangered
Engaeus hemicirratulus	Gippsland Burrowing Cray	Least Concern 2010			Endangered
Engaeus sternalis	Warragul Burrowing Cray	Critically Endangered 2010; Endangered 1996; Vulnerable 1994		Listed	Critically Endangered
Engaeus tuberculatus	Tubercle Burrowing Cray				Endangered
Engaeus urostrictus	Dandenong Burrowing Cray	Vulnerable 2010; Endangered 1996		Listed	Critically Endangered
Engaeus victoriensis	Foothill Burrowing Cray				Endangered
Euastacus armatus	Murray Cray	Data Deficient 2010; Vulnerable 1996; Indeterminate 1994		Listed	Near Threatened
Hemiphlebia mirabilis	Ancient Greenling Damselfly	Endangered 2008; Vulnerable 1996; Rare 1994; Endangered 1990		Listed	Endangered
Leptocerus souta	Caddisfly				Vulnerable

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Pasma tasmanica	Tasmanica Skipper Butterfly				Vulnerable
Plectrotarsus gravenhorstii	Caddisfly				Vulnerable
Pseudalmenus chlorinda zephyrus	Silky Hairstreak Butterfly				Vulnerable
Riekoperla darlingtoni	Mount Donna Buang Wingless Stonefly	Critically Endangered 2014; Vulnerable 1996; Rare 1994, 1990		Listed	Critically Endangered
Riekoperla intermedia	Stonefly			Listed	Endangered
Riekoperla isosceles	Stonefly			Listed	Critically Endangered
Synemon plana	Golden Sun Moth		Critically Endangered 2002	Listed	Critically Endangered
Tanjistomella verna	Caddisfly				Critically Endangered
Themognatha sanguinipennis	Jewel Beetle				Vulnerable
Vascular plants					
Acacia daviesii	Timbertop wattle			Listed	Vulnerable
Acacia sporadica	Pale Hickory-wattle				Vulnerable
Acacia verniciflua	Stinkwood Bush				Vulnerable
Actinotus bellidioides	Tiny Flannel-flower				Regionally Extinct
Adiantum capillus-veneris	Dainty-Maiden-hair Fern	Least Concern 2013		Listed	Endangered
Adiantum diaphanum	Filmy Maidenhair			Listed	Endangered
Astelia australiana	Tall Astelia		Vulnerable 2000	Listed	Vulnerable
Asterolasia asteriscophora subsp. albiflora	White Star-bush			Listed	Endangered
Boronia citrata	Lemon Boronia				Vulnerable
Botrychium australe	Austral Moonwort			Listed	Vulnerable
Caladenia concolor	Crimson Spider Orchid			Listed	Endangered
Caladenia maritima	Angahook Pink-fingers			Listed	Endangered
Caladenia oenochila	Wine-lipped Spider-orchid				Vulnerable
Caladenia ornata	Ornate Pink Finger Orchid		Vulnerable 2008	Listed	Vulnerable
Caladenia reticulata	Veined Caladenia				Vulnerable
Caladenia versicolor	Candy Spider-orchid		Vulnerable 2000	Listed	Endangered
Callistemon nyallingensis	Boggy Creek Bottlebrush			Listed	Vulnerable
Callitriche umbonata (cyclocarpa)	Water Starwort				Rare
Cardamine astoniae	Spreading Bitter-cress				Vulnerable
Cardamine gunnii	Spade-leaf Bitter-cress			Listed	Regionally Extinct
Cardamine lilacina	Lilac Bitter-cress				Vulnerable
Cassinia ozothamnoides	Cottony Haeckeria				Vulnerable

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Correa reflexa var. lobata	Powelltown Correa				Rare
Craspedia lamicola	Bog Billy-buttons				Vulnerable
Cullen parvum	Small Scurf-pea			Listed	Endangered
Cyathea cunninghamii	Slender Tree Fern			Listed	Vulnerable
Cyathea x marcescens	Skirted Tree-fern				Vulnerable
Dianella amoena	Grassland Flaxlily		Endangered 2000	Listed	Endangered
Dianella revoluta	Black-anthered Flaxlily				Vulnerable
Discaria pubescens	Australian Anchor Plant			Listed	Rare
Diuris behrii	Golden cowslip				Vulnerable
Diuris palustris	Swamp Diuris			Listed	Vulnerable
Erigeron tasmanicus	Tasmanian Fleabane				Vulnerable
Eucalyptus crenulata	Buxton Gum		Endangered 2015	Listed	Endangered
Eucalyptus splendens	Apple Jack				Endangered
Eucalyptus strzeleckii	Strzeleckii Gum		Vulnerable 2000	Listed	Vulnerable
Euphrasia collina ssp. muelleri	Purple Eyebright		Endangered 2000	Listed	Endangered
Euphrasia scabra	Rough Eyebright			Listed	Endangered
Ficus coronata	Sandpaper Fig			Listed	Vulnerable
Gahnia grandis	Brickmakers Sedge				Vulnerable
Gaultheria hispida	Snow Berry			Listed	Endangered
Glycine latrobeana	Clover Glycine		Vulnerable 2000	Listed	Vulnerable
Grammitis magellanica subsp. nothofageti	Beech Finger-fern				Vulnerable
Grevillea barklyana ssp barklyana	Gully Grevillea			Listed	Vulnerable
Grevillea parvula	Genoa Grevillea				Vulnerable
Grevillea polychroma	Royal Grevillea				Vulnerable
Hovea asperifolia	Rosemary Hovea				Rare
Huperzia varia	Long Clubmoss				Vulnerable
Isolepis gaudichaudiana	Benambra Club-sedge				Vulnerable
Lastreopsis decomposita	Trim Shield-fern				Vulnerable
Leptorhynchos elongatus	Lanky Buttons				Endangered
Nematolepis squamea	Harsh Nematolepis		Vulnerable 2000	Listed	Vulnerable
Nematolepis wilsonii	Shiny Nematolepis		Vulnerable 2000	Listed	Vulnerable
Olearia pannosa subsp. cardiophylla	Velvet Daisy-bush			Listed	Vulnerable
Olearia rugosa	Wrinkled Diasy-bush				Vulnerable

Species	Common name	IUCN Red List	EPBC category	FFG Act	Vic Advisory List
Persoonia arborea	Tree Geebung				Vulnerable
Plantago muelleri	Star Plantain				Vulnerable
Pomaderris vacciniifolia	Round-leaf Pomaderis		Critically Endangered 2014	Listed	Endangered
Prasophyllum frenchii	French's Leek Orchid		Endangered 2015	Listed	Endangered
Prasophyllum lindleyanum	Green Leek Orchid				Vulnerable
Prasophyllum pyriforme	Graceful Leek Orchid				Endangered
Pterostylis chlorogramma	Green-striped Greenhood		Vulnerable 2000	Listed	Vulnerable
Pterostylis cucullata	Leafy Greenhood		Vulnerable 2000	Listed	Endangered
Pterostylis lustra	Forked Greenhood			Listed	Endangered
Pterostylis truncata	Brittle Greenhood			Listed	Endangered
Pultenaea blakelyi	Blakely's Bush-pea				Endangered
Senecio psilocarpus	Smooth-fruited Groundsel		Vulnerable 2000		Vulnerable
Thelymitra circumsepta	Naked Sun Orchid				Vulnerable
Thelymitra gregaria	Basalt Sun-orchid			Listed	Endangered
Thelymitra hiemalis	Winter Sun-orchid			Listed	Endangered
Thelymitra longiloba	Marsh Sun-orchid				Endangered
Thismia rodwayi	Fairy Lantern			Listed	Vulnerable
Tmesipteris elongata	Elongate Fork-Fern				Vulnerable
Uncinia compacta	Compact Hook-sedge				Vulnerable
Zieria cytisoides	Downy Zieria				Rare
Non-vascular plants					
Acrobolbus cinerascens	Grey Pouchwort				Vulnerable
Anoectangium bellii	Kiwi Cave-moss			Listed	Vulnerable
Braithwaitea sulcata	Giant Fern-moss				Regionally Extinct
Dinckleria (Plagiochila) pleurata	Delicate Featherwort			Listed	Endangered
Distichium capillaceum	Fine Fringe-moss				Vulnerable
Orthotrichum hortense	Gardner's Bristle-moss			Listed	Endangered
Pedinophyllum monoicum	Southern Pedinophyllum			Listed	Vulnerable
Pseudocephalozia paludicola	Alpine Leafy Liverwort		Vulnerable 2000	Listed	Vulnerable
Tetraphidopsis pusilla	Arc Moss				Vulnerable
Thuidium laeviusculum	Forest Weft-moss				Vulnerable
Triandrophyllum subtrifidum	Variable Gondwanawort			Listed	Endangered
Treubia tasmanica	Treubia			Listed	Endangered
Xanthoparmelia suberadicata	Foliose Lichen			Listed	Endangered

A10. Ecosystem accounts

Table A10.1 Ecosystem services – physical supply. Average values over 5-year time periods

2011-2015		Land cover																			
Ecosystem services	Units	unclass-ified	bare	open water	swamp	built-up area	crop	crop/ pasture	pasture grass	horticul-ture	pine plantation	eucalypt plantation	shrub / heath	riparian shrubs	woodland	montane woodland	open mixed forest	wet mixed forest	alpine ash	mountain ash	rain-forest	total
Area	Ha	2,918	11,821	4,361	4	16,885	1,131	8,407	44,399	4,056	11,010	25,305	4,397	4,812	6,577	13,835	151,951	213,081	64,476	140,583	5,646	735,655
Provisioning services																						
Water	ML yr^{-1}	4,454	42,066	13,827	61	52,559	2,321	25,711	97,546	11,271	37,258	79,598	26,668	28,507	17,273	144,984	675,159	1,062,748	624,202	969,954	54,648	3,970,818
Timber - sawlogs	m^3 yr^{-1}										122,500	7,300					6,079	25,808	139,907	133,126		507,018
pulplogs	m^3 yr^{-1}										68,900	340,900					15,151	64,327	227,803	216,764		600,245
Regulating services																						
Water storage	GL			1,281																		1,281
Carbon sequestration	Mt yr^{-1}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.00	0.00	0.00	0.00	0.17	0.43	0.22	0.69	0.00	1.64
Carbon storage	Mt		0.00	0.00	0.00	0.25	0.01	0.03	0.18	0.03	0.58	4.26	0.13	0.19	0.95	2.06	10.58	28.99	39.42	56.54	1.82	146.02

2006-2010		Land cover																			
Ecosystem services	Units	unclass-ified	bare	open water	swamp	built-up area	crop	crop/ pasture	pasture grass	horticul-ture	pine plantation	eucalypt plantation	shrub / heath	riparian shrubs	woodland	montane woodland	open mixed forest	wet mixed forest	alpine ash	mountain ash	rain-forest	total
Area	Ha	2,918	11,821	4,361	4	16,885	1,131	8,407	44,399	4,056	11,010	25,305	4,397	4,812	6,577	13,835	151,951	213,081	64,476	140,583	5,646	735,655
Provisioning services																						
Water	ML yr^{-1}	1,412	13,019	4,391	38	14,052	510	6,822	24,376	2,752	11,129	21,848	13,077	13,079	4,357	72,876	228,955	387,057	268,102	377,444	22,159	1,487,455
Timber - sawlogs	m^3 yr^{-1}										90,000	200					6,012	9,458	78,555	206,247		390,472
pulplogs	m^3 yr^{-1}										44,000	7,000					21,786	34,272	145,218	381,270		633,546
Regulating services																						
Water storage	GL			680																		680
Carbon sequestration	Mt yr^{-1}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.03	0.00	0.00	0.00	0.00	0.11	0.31	0.00	0.19	0.00	0.56
Carbon storage	Mt		0.00	0.00	0.00	0.25	0.01	0.03	0.18	0.03	0.54	3.68	0.12	0.18	0.95	2.06	9.73	26.83	38.33	53.10	1.80	137.82

2001-2005		Land Cover																			
Ecosystem services	Units	unclass-ified	bare	open water	swamp	built-up area	crop	crop/ pasture	pasture grass	horticul-ture	pine plantation	eucalypt plantation	shrub / heath	riparian shrubs	woodland	montane woodland	open mixed forest	wet mixed forest	alpine ash	mountain ash	rain-forest	total
Area	Ha	2,918	11,821	4,361	4	16,885	1,131	8,407	44,399	4,056	11,010	25,305	4,397	4,812	6,577	13,835	151,951	213,081	64,476	140,583	5,646	735,655
Provisioning services																						
Water	ML yr^{-1}	2,362	21,435	6,493	47	25,923	1,142	12,635	48,903	5,506	18,987	38,892	17,505	18,250	8,184	96,688	353,956	550,497	349,860	511,585	29,381	2,118,232
Timber - sawlogs	m^3 yr^{-1}										101,600	2,400					9,833	15,338	66,184	272,762		299,794
pulplogs	m^3 yr^{-1}										55,800	3,600					50,950	79,476	106,912	440,615		781,551
Regulating services																						
Water storage	GL			960																		1,564
Carbon sequestration	Mt yr^{-1}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.43	0.18	0.26	0.01	1.05
Carbon storage	Mt		0.00	0.00	0.00	0.25	0.01	0.03	0.18	0.03	0.63	3.85	0.13	0.19	0.96	2.07	9.18	25.29	38.36	52.12	1.81	135.09

1996-2000		Land cover																			
Ecosystem services	Units	unclass-ified	bare	open water	swamp	built-up area	crop	crop/ pasture	pasture grass	horticul-ture	pine plantation	eucalypt plantation	shrub / heath	riparian shrubs	woodland	montane woodland	open mixed forest	wet mixed forest	alpine ash	mountain ash	rain-forest	total
Area	Ha	2,918	11,821	4,361	4	16,885	1,131	8,407	44,399	4,056	11,010	25,305	4,397	4,812	6,577	13,835	151,951	213,081	64,476	140,583	5,646	735,655
Provisioning services																						
Water	ML yr^{-1}	3,047	28,870	8,699	48	36,572	1,497	17,973	67,224	7,946	25,282	54,654	19,669	20,912	11,949	103,426	440,591	708,858	378,299	606,153	32,632	2,574,300
Timber - sawlogs	m^3 yr^{-1}																8,342	12,235	69,407	290,687		290,276
pulplogs	m^3 yr^{-1}																66,600	97,684	153,122	641,297		789,155
Regulating services																						
Water storage	GL			1,263																		1,275
Carbon sequestration	Mt yr^{-1}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.43	0.17	0.30	0.01	1.07
Carbon storage	Mt		0.00	0.00	0.00	0.25	0.01	0.03	0.18	0.03	0.63	3.85	0.13	0.19	0.95	2.05	8.32	23.12	37.48	50.82	1.78	129.82

1991-1995		Land cover																			
Ecosystem services	Units	unclass-ified	bare	open water	swamp	built-up area	crop	crop/ pasture	pasture grass	horticul-ture	pine plantation	eucalypt plantation	shrub / heath	riparian shrubs	woodland	montane woodland	open mixed forest	wet mixed forest	alpine ash	mountain ash	rain-forest	total
Area	Ha	2,918	11,821	4,361	4	16,885	1,131	8,407	44,399	4,056	11,010	25,305	4,397	4,812	6,577	13,835	151,951	213,081	64,476	140,583	5,646	735,655
Provisioning services																						
Water	ML yr^{-1}	4,294	38,820	13,413	59	47,497	1,945	23,408	88,391	10,289	34,382	72,314	25,108	26,687	15,260	137,990	643,267	1,000,743	502,009	807,288	42,162	3,535,325
Timber - sawlogs	m^3 yr^{-1}																5,723	8,176	49,835	236,060		468,117
pulplogs	m^3 yr^{-1}																47,132	67,331	116,281	550,807		737,353
Regulating services																						
Water storage	GL			1,564																		960
Carbon sequestration	Mt yr^{-1}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.39	0.20	0.33	0.01	1.08
Carbon storage	Mt		0.00	0.00	0.00	0.25	0.01	0.03	0.18	0.03	0.63	3.85	0.13	0.19	0.95	2.03	7.53	20.97	36.64	49.30	1.75	124.47

1990		Land cover																			
Ecosystem services	Units	unclass-ified	bare	open water	swamp	built-up area	crop	crop/ pasture	pasture grass	horticul-ture	pine plantation	eucalypt plantation	shrub / heath	riparian shrubs	woodland	montane woodland	open mixed forest	wet mixed forest	alpine ash	mountain ash	rain-forest	total
Area	Ha	2,918	11,821	4,361	4	16,885	1,131	8,407	44,399	4,056	11,010	25,305	4,397	4,812	6,577	13,835	151,951	213,081	64,476	140,583	5,646	735,655
Provisioning services																						
Water	ML yr^{-1}	3,914	33,522	11,210	61	40,237	1,964	19,729	81,576	8,755	30,794	61,455	24,470	26,189	12,712	140,066	594,173	904,808	500,190	750,495	41,651	3,287,971
Timber - sawlogs	m^3 yr^{-1}																2,226	16,723	47,406	223,921		380,671
pulplogs	m^3 yr^{-1}																18,336	137,722	110,615	522,482		958,703
Regulating services																						
Water storage	GL			1,275																		1,263
Carbon sequestration	Mt yr^{-1}																					
Carbon storage	Mt		0.00	0.00	0.00	0.25	0.01	0.03	0.18	0.03	0.63	3.85	0.13	0.19	0.94	2.02	6.76	19.00	35.66	47.65	1.72	119.05

Further information:
http://www.nespthreatenedspecies.edu.au/

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