Experimental Ecosystem Accounts for the Central Highlands of Victoria

Summary document for discussion

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Version 1.0: 16 June 2016

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Acknowledgements

Research funding from Fujitsu Laboratories Ltd, Japan, and the National Environmental Science Programme of the Australian Department of the Environment is gratefully acknowledged for supporting this project. We thank staff at the Australian Bureau of Statistics and the Victorian Department of Environment, Land, Water and Population for assistance with access to data and with its interpretation. This research was undertaken with the assistance of resources from the National Computational Infrastructure (NCI), which is supported by the Australian Government. We would also like to thank Neil Byron, Brendan Freeman, Rocky Harris, Carl Obst and Stuart Peevor for valuable comments on an earlier draft of this report.

Cover image by David Blair

Introduction

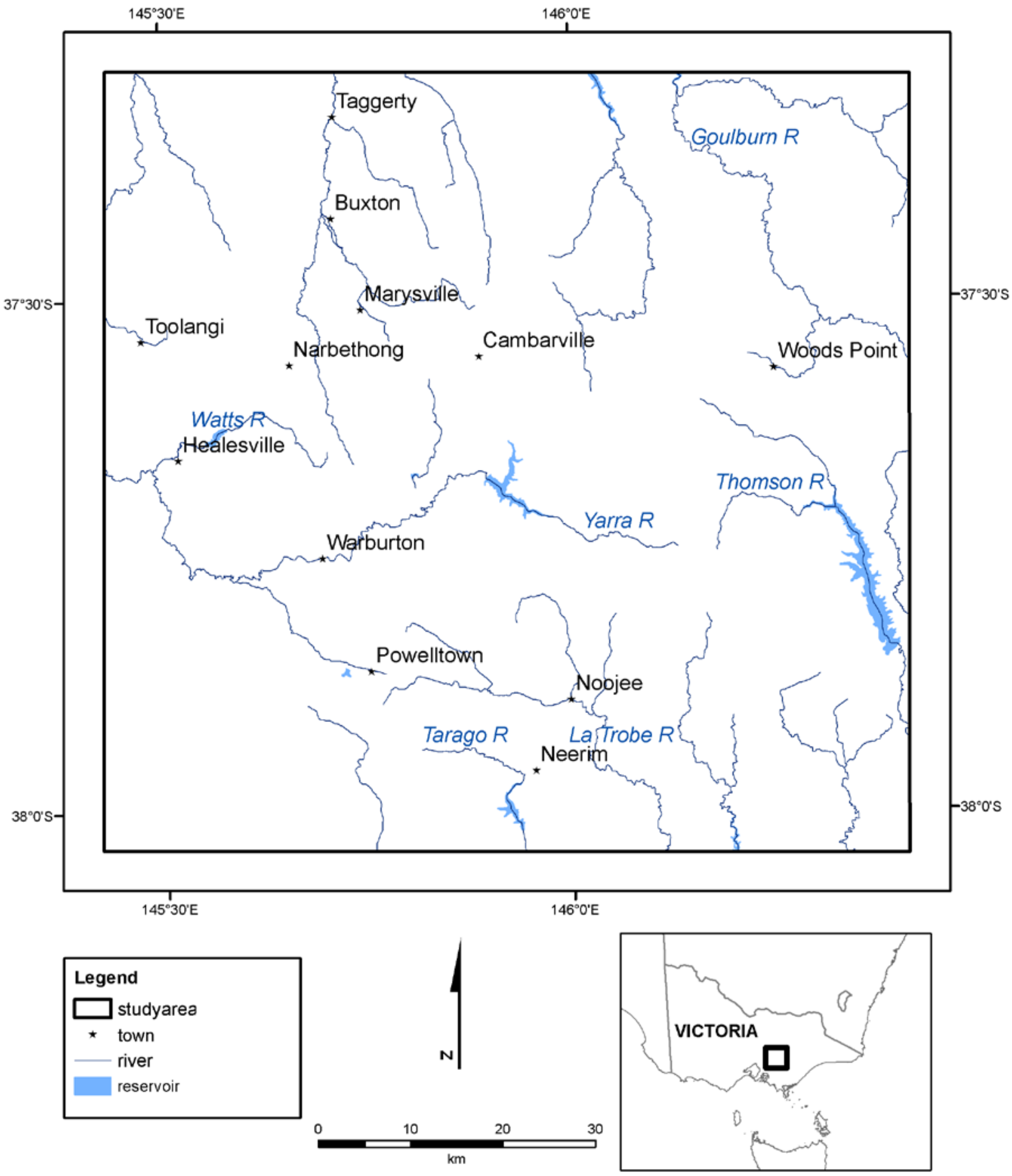
This report presents the Experimental Ecosystem Accounts for the Central Highlands of Victoria. The primary aim of the report is to determine the extent to which the concepts and accounting structures of the System of Environmental-Economic Accounting (SEEA) (UN 2014a, UN 2014b) can be populated with existing data to aid decision-making at a regional level.

Feedback on these accounts is sought, and in particular, about which parts of the accounts are most relevant to decision-making in the Central Highlands and hence would benefit most from improvements to data sources and methods. A discussion document is provided as ecosystem accounting is new and most researchers, analysts and decision-makers are unfamiliar with accounting concepts, structures or applications. Having an experimental suite of accounts provides a clear focus for discussions with potential users of the accounts, as well as researchers and information agencies that could help to improve the quality of the accounts.

The Central Highlands study area (Figure 1) was chosen to include areas with currently controversial land use activities. This area forms part of the Central Highlands Regional Forest Agreement that is due for re-negotiation within 2 years, and areas proposed for addition to the national park network as the Great Forest National Park (GFNP 2016). The study area contains a range of landscapes including human settlements, agricultural land, forests and waterways; and is used for a variety of activities, including timber production, agricultural production, water supply and recreation. It is also home to a range species, including the endemic and critically endangered Leadbeater's Possum. These activities and their use of ecosystems can be either complementary or conflicting. Managing the various activities within the region is therefore complex and requires evaluation of the trade-offs between different land uses and users. The accounts show the current state, but do not show future or potential trade-offs. Additional analysis and interpretation are needed to make future projections.

The Experimental Ecosystem Accounts for the Central Highlands provide a tool for integrating complex biophysical data, tracking changes in the condition and extent of ecosystems, and linking these changes to economic and other human activity, and the benefits they provide to society. The accounts prepared were for land, water, carbon, timber and the production and use of ecosystem services. Information on each of these accounts, along with information in an accounting format for biodiversity, tourism and agricultural production, are found in the main report. Some of these benefits were already known separately, for example, the value of water supplied by Melbourne Water or timber harvested by VicForests, and in these cases the accounts consolidated this information. Other benefits, such as the contribution of ecosystem services to economic production, were unknown and the information presented in the accounts is new.

Figure 1. Location of the Central Highlands study area



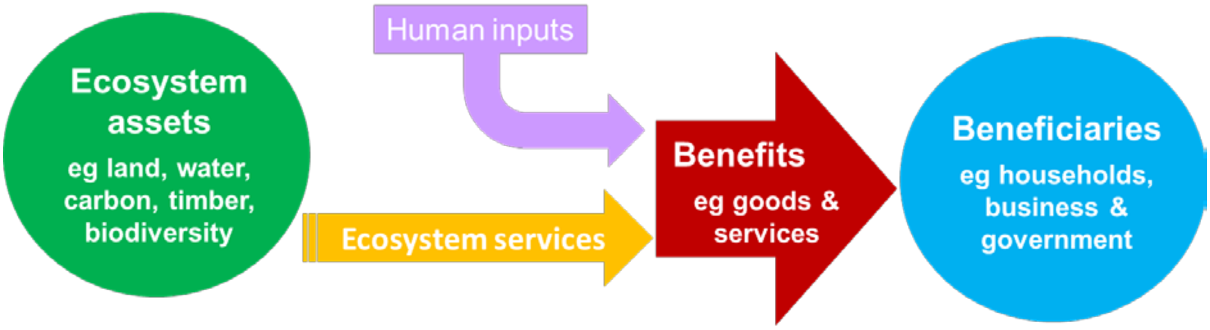
System of Environmental-Economic Accounting (SEEA)

The SEEA provides the basis for the accounts developed for the Central Highlands. The SEEA is contained in two complementary documents of the international community: SEEA Central Framework (UN 2014a) and SEEA Experimental Ecosystem Accounting (UN 2014b). Together they describe an integrated accounting structure covering component accounts (for example, land, water, carbon and biodiversity), as well as accounts for ecosystem extent, condition and services. The SEEA was developed by the international community to compliment the more traditional accounting of the System of National Accounts (SNA) (EC *et al.* 2009) by adding environmental information. The SNA describes the economic state of the nation in terms of monetary transactions between parties in the economy, and is perhaps best known as the source of the aggregate of Gross Domestic Product. The SEEA Central Framework (UN 2014a) extends the SNA, expanding the scope of assets, identifying environmentally related transactions separately (for example, environmental protection expenditures), as well as including physical flows between the environment and the economy (like extraction of natural resources and pollution). The SEEA Experimental Ecosystem Accounting (UN 2014b) goes further, describing the composition and condition of ecosystems as well as the ecosystems services that support human well-being, which are either hidden or missing in the SNA. Environmental – economic accounts are required to provide information to contribute to government policy and management under the internationally adopted Sustainable Development Goals (UNDP 2015).

Accounting records transactions between different agents. Within the economy, the transactions are between people, businesses and government, but exchanges can also be recorded between the economy and the environment or ecosystems. Ecosystem accounting is based on a model of stocks and flows (Figure 2). In this model, ecosystem assets (which are spatially defined areas) provide a flow of services which in combination with human inputs (labour, capital, etc.), produce benefits which can be thought of as goods and services used in the economy, which are then used by a range of beneficiaries (for example, people, businesses or government). In ecosystem accounting, all areas, regardless of level of human modification, are included as ecosystems. For example, crops, pastures and built-up areas are included as ecosystems in the accounts.

A stock is an amount at a particular point in time. Flows are additions to or subtractions from stocks over a period of time. Flows can also be in the form of production, income, consumption, taxes and subsidies. Stocks and flows may be measured in physical terms (for example, litres, hectares, parts per million) or monetary terms (for example, dollars). Stocks are defined by their quantity and condition. Environmental flows are defined as natural inputs (water, timber, minerals) and residuals (for example, pollution), while ecosystem services are classified under the main headings of provisioning, regulating and cultural services.

Figure 2. Model of ecosystem accounting



[Source: Derived from UN 2014b]

The SEEA has been recommended for use by the Australian Government (BoM 2013) and used by a variety of agencies including the Australian Bureau of Statistics (ABS) (ABS 2016) and the Government of Victoria (Eigenraam *et al.* 2013; Varcoe *et al.* 2015). The Bureau of Meteorology (BoM) uses a system of water accounting (BoM 2014) that can be related to SEEA (Vardon *et al.* 2012), while the Wentworth Group of Concerned Scientists has also developed a process and metrics for producing accounts (Sbrocchi 2015). There is also a growing Australian literature on ecosystem services (Crossman *et al.* 2013; Stoeckl *et al.* 2011; Tovey 2008; Straton and Zander 2009).

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. These include: 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; and VicForests Annual Reports.

Data sources and methods

Both economic and ecological data are needed to produce ecosystem accounts and these sources of data must be integrated. Details on the data sources and methods used to compile the accounts are available in the full report. A summary of the main information sources and an indication of the methods are provided below, beginning with the biophysical data in Table 1.

The main economic data used in the report came from various publications of the ABS and summarised at a national level in the Australian System of National Accounts (ABS Cat. No. 5204.0) and other publications (Australian Environmental Economic Accounts Cat. No. 4655.0.001; Tourism Satellite Account ABS Cat. No. 5249.0; and Value of Agricultural Commodities Produced, Australia ABS Cat. No. 7503.0). The Annual Reports and other corporate documents of VicForests and Melbourne Water were also used.

Table 1. Biophysical data sources

Variable	Area covered	Type of information	Reference
Land cover	Native vegetation	Ecological Vegetation classes	DELWP 2005
	Native forest types	State-wide Forest Resource Inventory	DSE 2007
	Non-native vegetation	Victorian Land Use Information System	Vict.Gov. 2015
Land use	All land	Victorian Land Use Information System	Vict.Gov. 2015
Land management	Private land	Land Use Tenure	Vict.Gov. 2015
	Public land	Forest Management Zones	Vict.Gov. 2015
Disturbance history	Public land	Logging events	DELWP 2015
	All land	Wildfire events	DELWP 2015
Water	All land	Water storage	Melb. Water 2016
	All land	Water yield	eMAST 2016, BoM 2016
Carbon	Forest land	Carbon stock	Keith *et al.* 2010
	Forest land	Carbon stock change	Keith *et al.* 2014a,b
	Non-forest land	Carbon stock	Ajani and Comisari 2014
Timber	Public native forest	Timber volume and yield data	DSE 2003-09, VicForests 2007-15
Biodiversity	All land	All species	ALA 2015
	All land	Threatened species	DotE 2016, IUCN 2016
	Montane ash forest	Arboreal marsupials	Lindenmayer 2009

A key challenge for the development of ecosystem accounts is the diverse data sources and methods needed for their compilation. The available biophysical data tends to be small-scale data with clear spatial references, whereas the available economic data are generally aggregated to industries (agriculture, mining, manufacturing, education, etc.) and sectors (public, private, households) for all of Australia. When available, sub-national spatial economic data are usually for large administrative areas (such as, states or local governments) or statistical areas defined by the Australian Bureau of Statistics (ABS). Linking the biophysical and economic data is done spatially and, in general, this means that assumptions and models are needed to scale-up biophysical data and to disaggregate economic data to lower level areas.

A range of different spatial boundaries was considered for defining the study area: local government areas, natural resource management regions, ABS statistical regions, biogeographic regions and watersheds. None approximated closely the areas being considered for addition to the national park network or the available site-based data, and so a simple square encompassing this area was used (Figure 1). The information used in the production of the accounts for the Central Highlands used a range of different classifications and spatial boundaries. All information had to be adapted to the study area of the Central Highlands using a range of assumptions. For the economic data, simple models based on the area within the study area, were used to apportion this information.

The accounts presented in this report relied on data that have already been collected and the suitability for its use in ecosystem accounts varied. A critical task for future work on ecosystem accounts is to examine the range of data needed for comprehensive accounts, compared with the data available, and its suitability for decision-making.

Valuation

Monetary valuation of ecosystem stocks and flows is important for accounting, and methods of valuation are covered in the SNA, SEEA Central Framework and SEEA Experimental Ecosystem Accounting. The accounts for the Central Highlands span environmental and ecosystem accounting. Clearly distinguishing what is being valued is an important issue for accounting. In particular, identifying the value of the benefit, which may be equated with the supply of goods and services within the economy (for example, water and timber), and distinguishing this from the contributions of ecosystems services to that benefit (Figure 2).

The key principle for valuation in accounting is that of exchange value (UN 2014b). In brief, an exchange value represents transactions valued at the price at which they were exchanged (or could have been exchanged) between willing buyers and sellers. Total value is the price multiplied by the quantity sold. An exchange value is distinct from the notion of value used in welfare economics, which is associated with utility.

The contributions of ecosystem services to the goods and services (or benefits) supplied within the economy were calculated using a range of valuation approaches identified for ecosystem accounting in the SEEA Experimental Ecosystem accounting (UN 2014b, Section 5.5.2). The approaches used in the accounts for the Central Highlands are summarised in Table 2.

Table 2. Summary of valuation approaches used to value ecosystem services in the Central Highlands

Approach	Description	Use in this report
Unit resource rent	Estimated as the market price less the unit costs of labour, intermediate inputs and produced capital	Food provisioning* Cultural and recreational services ("tourism")
Stumpage	The value of timber sales less harvest and haulage costs	Timber provisioning
Replacement cost	Based on the cost of replacing the ecosystem services from alternative sources	Water provisioning
Payments for ecosystem services / trading schemes	Use of values from market based systems set up to either minimise or off-set negative environmental impacts or for the provision of particular services	Carbon sequestration

*This is the provision of services for crops and fodder for livestock production (see UN 2014b, pp. 62-63)

Land and ecosystem accounts

The land accounts were based on classifications of land cover, land use and land tenure or management. The land cover classes gave the structure for the accounting, showing the extent of ecosystem types, and the changing areas of these ecosystems over time. Land use is shown by industry: agriculture, forestry, tourism and water supply. Table 3 shows the areas within the Central Highlands aggregated by land cover and land use classes. The area used by a particular industry includes areas owned or operated for different purposes, as well as the primary activity of the industry. For example, the area of total agricultural land use is 96,041 ha, but only 58,213 ha have land cover types of crops, pasture and horticulture. The rest of the area, while owned or operated by agricultural uses, is covered by native vegetation, plantations or residential buildings. Integrating these spatial data about land cover extent and condition means that ecosystem characteristics can be linked to economic agents (or units), which are aggregated to industries. Land cover provides information on the generation of ecosystem services, while land use gives the use of these services.

The condition of native forest was related to forest age, because age is a determinant of the characteristics of water, carbon, timber and biodiversity and the services they provide. Age was calculated from the time since disturbance events of fire and clearfell logging that resulted in stand replacement of different native forest types. Figure 3 shows the change in the forest age class distribution over the 25 year time period. The oldest age classes (<1939 and 1939-1959), which are the forest in the best condition for the provisioning of water and timber as well as carbon and habitat for hollow-dependant animals, declined in the period 1990 to 2015. This was particularly apparent in Mountain Ash forests aged 56-75 years old (the 1939-59 age class) that were reduced from 113,811 ha in 1990 to 78,289 ha in 2015, a 31% reduction in area over 25 years.

Table 3. Area of land in aggregated land cover by land use classes within the study area

2015 Area (ha)			Land cover				
Land Use	built/ bare	open water	crops/ pasture/ horticulture	plantation	native open vegetation	native forest	Total
urban	29,812		4,258	3,714	2,926	15,999	56,709
agriculture	36		53,918	20,659	1,519	19,910	96,041
plantation forestry				11,962			11,962
native forestry	957				4,266	319,158	324,380
conservation	1,690		38		20,497	216,795	239,019
water storage	308	4,361			416	3,876	8,961
Total	32,803	4,361	58,213	36,335	29,624	575,737	737,072

Figure 3. Proportion of the total forest area in each age class for 1990 to 2015

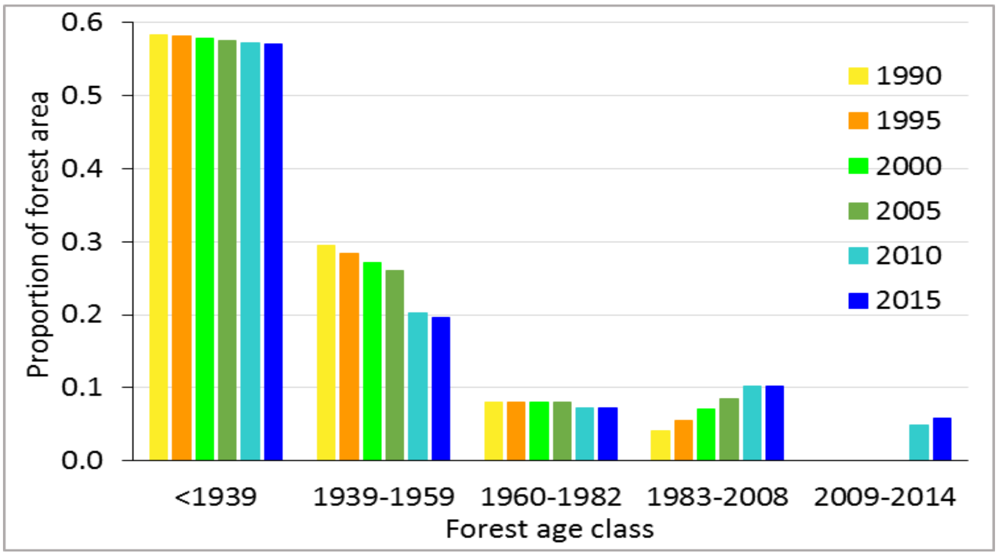


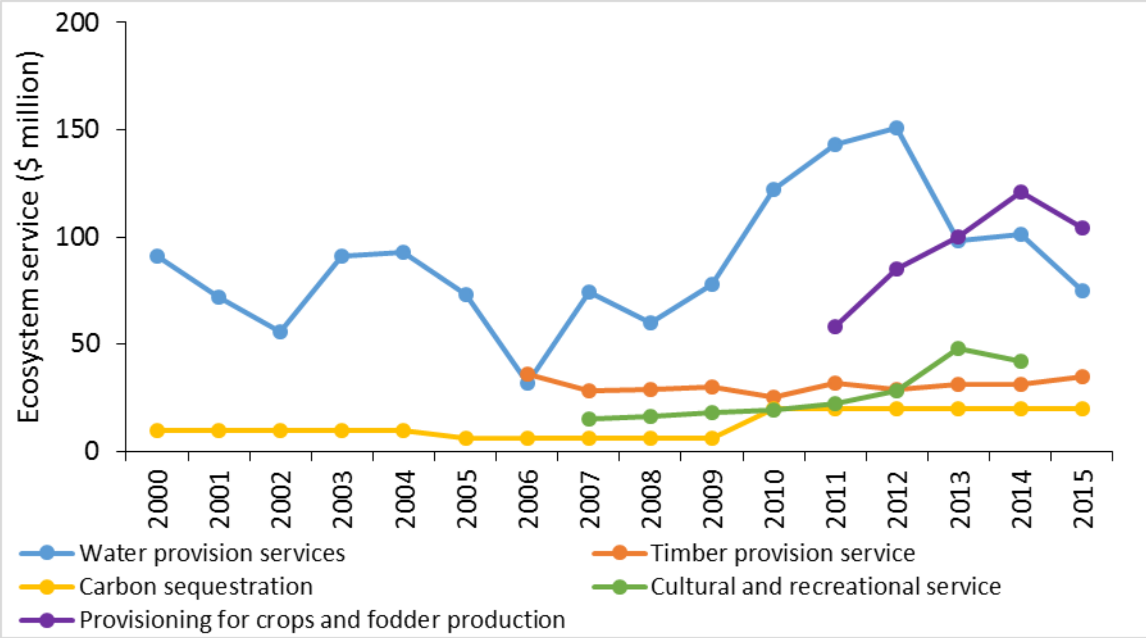
Table 4 summarises the physical quantities of ecosystem services within the study area and spatially disaggregated according to land cover and land use types. The value of ecosystem services over time is shown in Figure 4. For most of the time, water was the most valuable ecosystem service from the study area, but since 2014, the ecosystem services used in food and fodder provisioning have been greater.

Table 4. Physical ecosystem services within land cover types across the study region

2010-15		Land cover						
Ecosystem service	Units	built[a]/ bare	open water	crops/ pastures	plantations	native open vegetation	native forest	total
Area	Ha	32,803	4,361	58,213	36,335	29,624	575,737	737,072
	%	4.5	0.6	7.9	4.9	4.0	78.1	
Provisioning services								
Food [b]	t							
Water	GL yr^{-1}	0.99	0.14	0.14	0.12	0.22	3.39	3.97
Timber sawlogs	m^3 yr^{-1}				257,793		304,920	
Timber residual logs	m^3 yr^{-1}				247,294		524,045	
Regulating services								
Carbon sequestration[c]	MtC yr^{-1}	0.00	0.00	0.00	0.10	0.01	1.58	1.69
Cultural and recreational services [d]								

[a] built includes low-density and semi-rural residential, parks and gardens
[b] the physical volumes of production of different crops, fruit, vegetables and livestock and livestock products are available for ABS statistical areas and can be estimated for the study area, but they have not been presented because the utility of adding these to a single measure in tonnes is doubtful.
[c] carbon sequestration is equated with net carbon stock change because this is the metric that is valued in the Australian government abatement scheme.
[d] physical estimates of the cultural and recreation services were not made but monetary estimates were made.

Figure 4. Value of ecosystem services generated in the Central Highlands



In addition to the calculation of the value of ecosystem services used, economic information for the industries operating within the study area was compiled and is shown in Table 5. In 2013-14, the industry value added (IVA), or the contribution to GDP, was greatest by tourism ($260 million), followed by agriculture ($257 million), water supply ($233 million) and forestry ($9 million). Water supply had the highest value of sales ($911 million). Per hectare of land use, agriculture and water supply were well above tourism and forestry for all measures: sale of products, IVA and ecosystem services. The low per hectare values for tourism are partly explained by the large area used, which was assumed to be the entire study area, thus making the largest denominator.

Table 5. Economic information for industries within the study region in 2013-14

	Industries			
	Agriculture	Native Forestry	Water supply	Tourism
Area of land use (ha)	96,041[a]	324,380[b]	115,149[c]	737,072[d]
Sale of products ($m)	474	49	911	485
Industry valued added ($m)	257	9	233	260
Ecosystem service ($m)	121	15	101	42
Sale of products ($ ha^{-1})	4918	151	7911	659
Industry value added ($ ha^{-1})	2667	29	2023	353
Ecosystem services ($ ha^{-1})	1255	46	877	57

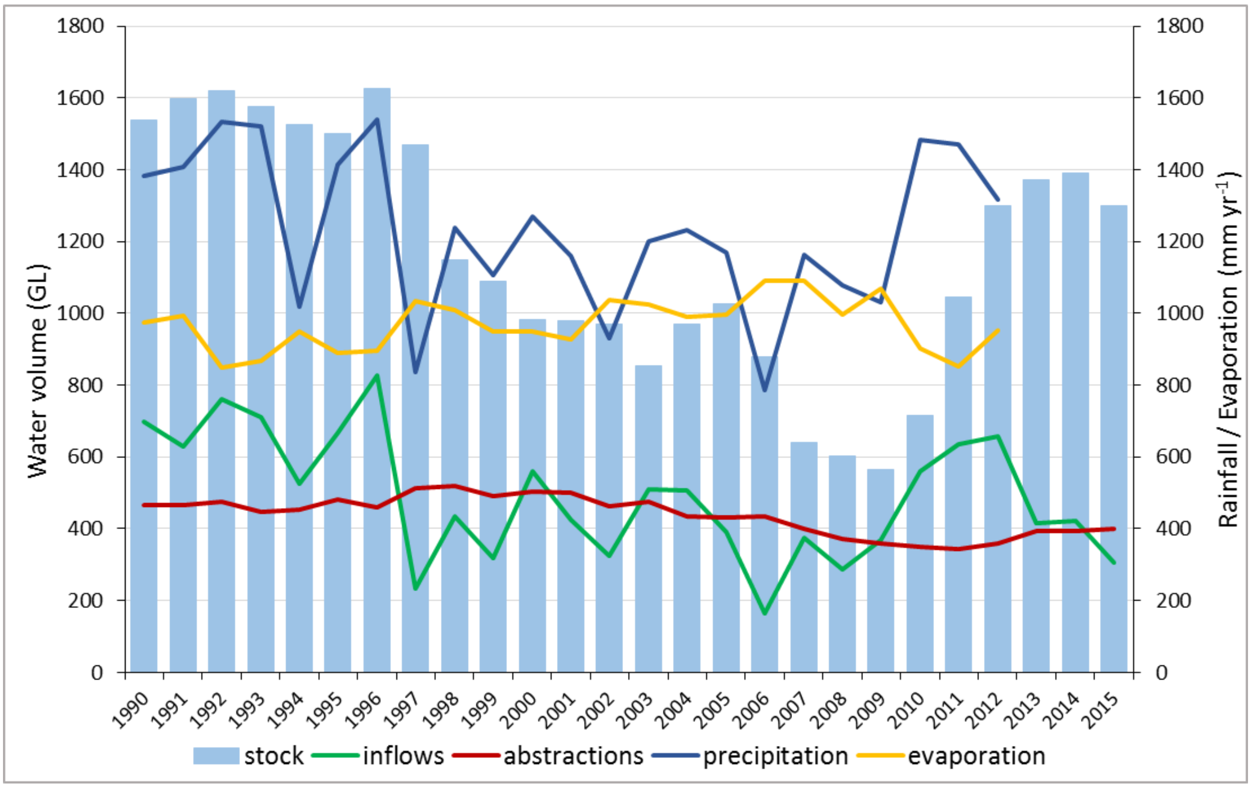
[a] area of agricultural land use
[b] area of native forest timber production
[c] area of water catchments
[d] total area of study region

Water

The study region in the Central Highlands contains the majority of the catchment areas for the ten water storage reservoirs of Melbourne Water that supply water to Melbourne and surrounding regions. The water accounts for the period 1990 – 2015 consist of the asset of water stored in the reservoirs, and the ecosystem service of the provisioning service of water supply. The main sources of data included biophysical data for the study area and Melbourne Water corporation storage and supply data, as well as financial statements.

The water asset account is summarised in Figure 5, showing the annual average water volume stored in reservoirs (stocks), which results from inflows of water from the catchment areas (runoff), precipitation, evaporation, and abstractions of water for supply to consumers, releases for environmental flows and irrigation. Water supply is influenced by human population size and efficiency of water use.

Figure 5. Time series data on precipitation, evaporation, water storage (stock), inflow (runoff), and supply (abstraction) for the Melbourne Water reservoirs and catchments

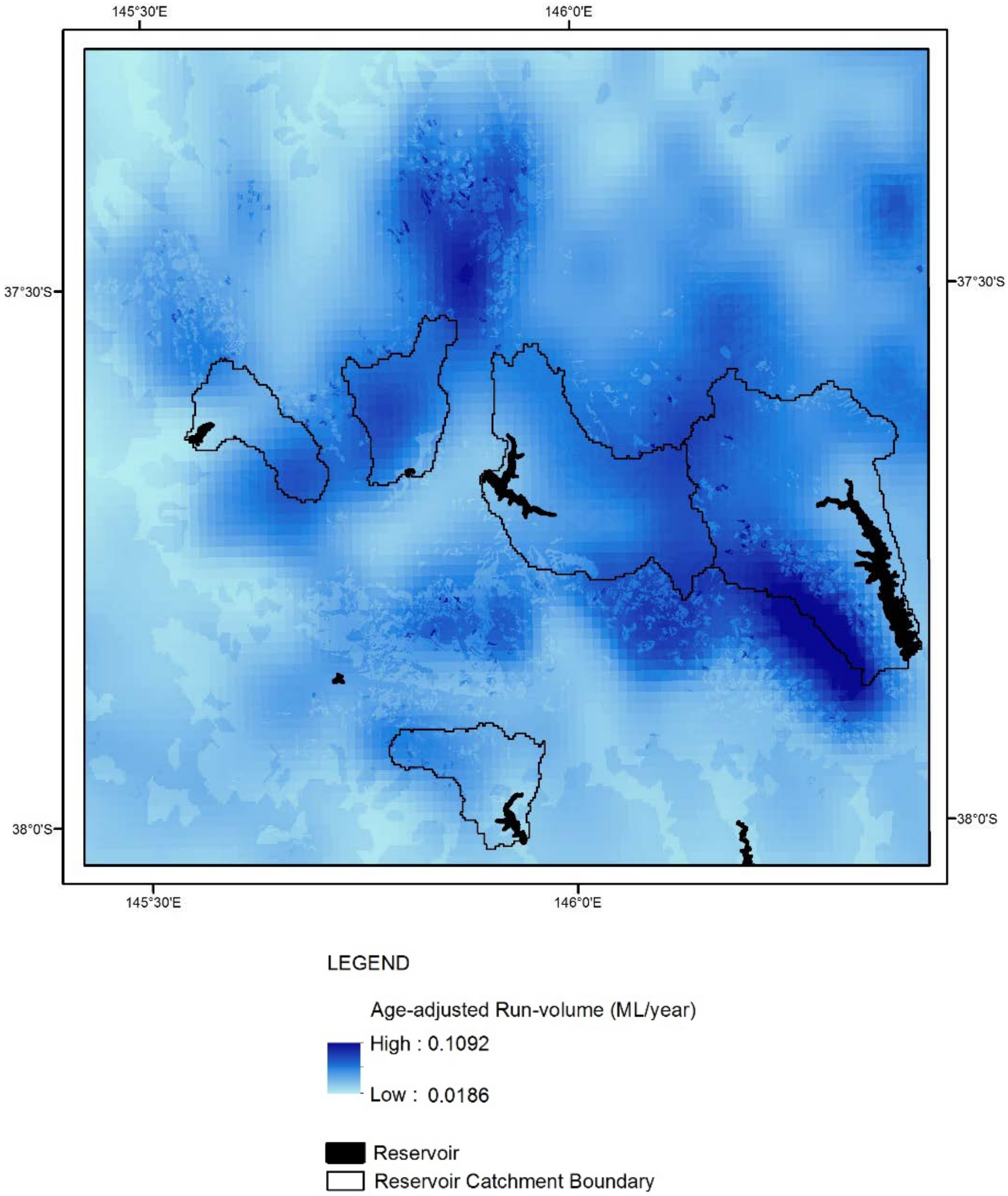


[Data source: Melbourne Water (2000-15) and eMAST (2016)]

The ecosystem service of water provisioning was equated with the runoff calculated spatially across the study area, which provides inflows to the reservoirs. The ecosystem service of water provisioning is taken to be used by Melbourne Water at the time it enters the reservoir, with the supply coming from the land covers of the water catchments that feed the reservoir.

Changes in runoff over time occur in response to climate variability, land cover change, and disturbance history. Runoff is influenced by the condition of the vegetation, and particularly age in montane ash forest. Runoff increases for the first few years after disturbance and then decreases to a reduced proportion of the pre-disturbance forest condition. The greatest reduction occurs between ages of 13 – 49 years, and runoff is not fully restored for at least 80 years if a forest is regrowth at the time it is disturbed, or 200 years if a forest is old growth at the time it is disturbed. Maps of the spatial distribution of runoff across the landscape show reduced runoff in areas that have been disturbed by clearfelling or wildfire, which produced younger forest ages (Figure 6). For example, the mosaic of individual light blue grid cells within patches of dark blue indicate areas of forest that have been clearfelled and are now regrowth, and the subsequent reduction in runoff.

Figure 6. Spatial distribution of runoff in 2012 calculated with changing forest age due to regeneration from wildfire and logging



The volume and value of water supplied by Melbourne Water is shown in Table 6, along with the ecosystem service of water provisioning. The revenue received by Melbourne Water from water supply activities has been increasing since 2008-09 (Melbourne Water 2008). The price of water is regulated by the Essential Services Commission and so the value of sales is not a true market value. This is reflected in the value estimated for the water provisioning service, which was based on replacement cost. That is, if the water were not available from the catchments, the next cheapest alternative would be transfer of water from other regions. However, in practice, a different, more expensive, alternative water source from desalination, was chosen by the Victorian Government.

The industry value added (or contribution to GDP) of Melbourne Water was $267 million in 2014-15. However, not all of this was due to the activity of water supply as Melbourne Water also supplies sewage services. As a first approximation, if industry value added of water supply is proportional to the revenue of water supply compared to total revenue, **the industry value added of water supply by Melbourne Water was $267 million in 2014-15, or $2319 ha^{-1}** (based on the catchment area within the study region of 115,149 ha).

Table 6. Volume and value of water supplied by Melbourne Water for individual years at 5-year time periods

	2000	2005	2010	2015
Water provisioning service				
Volume used (GL)	560	389	559	306
Value used ($m)	91	73	122	75
Water supply				
Volume supplied (GL)	502	441	361	402
Revenue from supply ($m)	155	164	326	876

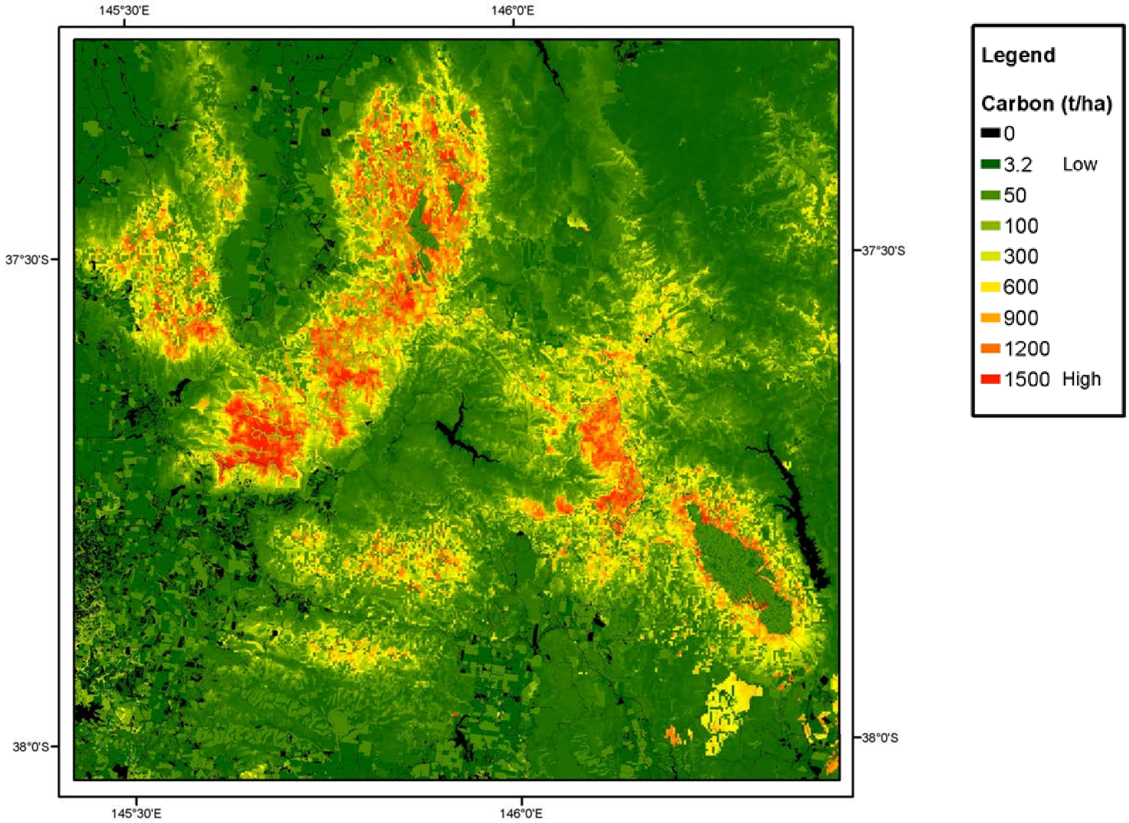
[Source: Melbourne Water Annual Reports]

Carbon

The Central Highlands region contains wet temperate, evergreen forests that are some of the most biomass carbon-dense in the world (Keith *et al.* 2009). Maintaining ecosystem carbon stocks, by reducing carbon losses from degradation and deforestation, is a critical component of climate change mitigation (UNFCCC 2015).

Spatial distribution of biomass carbon stocks across the region was derived from biomass density modelled in relation to environmental conditions, forest type and disturbance history, and calibrated with site data (Figure 7). Change in carbon stocks was calculated in relation to forest age, based on the disturbance history of stand-replacing events of logging and fire. Annual increments in carbon stocks were calculated from forest type-specific growth functions. Losses of carbon were calculated due to logging and fire events and decomposition. Constant, average carbon stock densities were applied to non-forest land cover types.

Figure 7. Spatial distribution of the carbon stock density across the study area in 2015



The total carbon stock within the study area in 2015 was estimated to be 146 Mt C, with a net annual increment of 1.7 Mt C yr^{-1}. Net annual increment in carbon stock was taken to represent the physical ecosystem service of carbon sequestration, which has a value for climate change mitigation. Based on the national carbon price for abatement of $12.25 (second auction of the Emissions Reduction Fund in 2015), annual sequestration from all land cover types within the study area has a value of $20 million.

The effect of land use on carbon stocks was considered as two components: (1) carbon sequestration as a net change in carbon stock per year, and (2) the difference between land use types in their carbon stocks. The carbon stock and rate of net change differ among land cover types, land use activities, and disturbance events. All forest areas have sequestered carbon in each time period, except the area that has been logged, and the area that was burnt in 2009. Net reduction in carbon stock (gain from growth minus loss from logging due to combustion and decomposition of waste and product removal) from the area logged averaged -0.04 Mt C yr^{-1} over the 25 years. In comparison, net gain in carbon stock or sequestration in the area that was unlogged was 0.58 Mt C yr^{-1}. **On a per hectare basis, the difference in carbon sequestration between the areas logged and unlogged was 3.13 tC ha^{-1} yr^{-1} over 1990 to 2015. At a carbon price of $12.25, this is equivalent to $38.36 ha^{-1}**.

The difference in carbon stock density of montane ash forest between areas unlogged and logged in 2015 was an average of 143 tC ha^{-1}. **This represents the carbon stock loss due to logging. At a carbon price of $12.25, this stock loss is equivalent to $1755 ha^{-1}**. Over the area of montane ash forest that has been logged, this difference represents a loss of 7.83 Mt C, which is equivalent to $95.89 million.

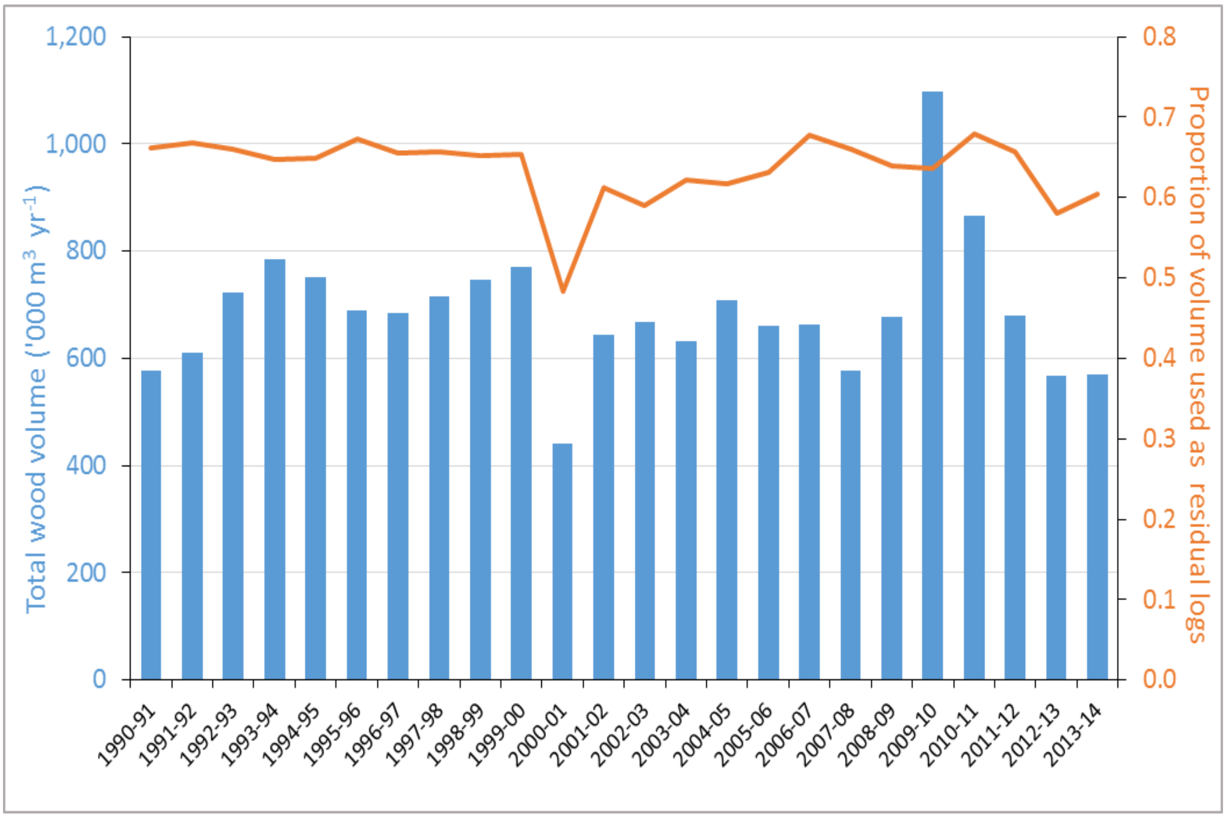
In comparison with the gross carbon stock loss from logging of -14 Mt C over the 25 years, the stock loss from the 2009 fire was -2.4 Mt C. Carbon stock lost during the 2009 fire was re-gained by sequestration within the area burnt over the subsequent five years of regeneration.

Timber

The Central Highlands is an important region in Victoria for the supply of native hardwood for both timber and fibre. The ash species in particular provide high value products. Harvesting is mostly by clearfelling and slash-burning. Most of the old growth montane ash forest available in State Forests, which was not been burnt in 1939, had been logged by about 1990. Logging of the 1939 regrowth commenced in the mid-1980s and is currently continuing.

Data were collated for the area, volume and yield of sawlogs and residual logs harvested from 1990 to 2014, based on Victorian government department reports and spatial data. Spatial data showed larger areas harvested each year than the reported data. As an example of the data, the annual wood volume harvested is shown in Figure 8. More than half the wood volume is used as residual logs for woodchips. The highest volume harvested was after the 2009 fire as salvage logging.

Figure 8. Annual volume of wood harvested ('000 m^3 yr^{-1}) from ash and mixed species forest types, within the study area, and the proportion used as residual logs



[Source: DSE (2003-09) and VicForests (2007-15).]

The ecosystem service of provisioning of timber for supply to market by VicForests was taken as the volume of timber harvested each year. The value of the ecosystem service was based on the reported stumpage value, which is the revenue from forest products less harvesting and haulage costs, and scaled for the volume harvested within the study area. The value of timber production (total sales) from the Central Highlands and industry value added were calculated based on annual reports of VicForests, again scaled to the volume harvested from the study area. In 2013-14, the value of the ecosystem service used in production by VicForests was \$14.8 million or \$46 ha^{-1}. In the same year, **the industry value added from the Central Highlands was \$9.4 million or \$29 ha^{-1}, while timber sales were \$49.0 million**.

Agriculture

Agricultural production relies on a range of ecosystem services, including pollination, abstraction of soil water, soil nutrient uptake, and nitrogen fixation. Some of these services would have been generated on the land used for agricultural production, such as soil water and nutrient uptake, whereas other services may have been generated elsewhere, such as pollination. For this account, all ecosystem services produced (supplied) were allocated to the agricultural land cover.

Agricultural production and costs were obtained for ABS statistical areas, which were mapped against the study area. The resource rent approach was used for calculating the combined value of the ecosystem services of provisioning services for crop production and fodder for livestock. The value of agricultural production in the study area in 2014-15 was \$495 million, and the provisioning services for crop and fodder production used by agriculture were \$103.5 million. **The industry value added was \$238.7 million, which represents \$2477 ha^{-1}**.

Tourism

The Central Highlands region is used for a variety recreational purposes that in ecosystem accounting terms are classed as cultural services. The region includes national parks and other reserves as well as wineries and other tourist attractions. The use of these ecosystem services by people can be valued as part of the value of the consumption by tourists in the area. This consumption relies not just on the ecosystem services but also capital, labour and other inputs from the industries supporting tourists, for example, accommodation and restaurants.

Tourism Victoria produces accounts including details of total outputs, industry value added and employment within regions of the state. Data from these accounts were used based on the weighted average for the area of the regions that occurred within the study area. The cultural and recreational ecosystem services were estimated using the resource rent approach, which has been used by the Australian Bureau of Statistics. **The contribution of tourism to industry value added was \$260 m in 2013-14, accounted for 3,500 jobs, and the value of tourism industry value added per hectare was \$354 ha^{-1}**.

Biodiversity

Biodiversity accounts can be used to identify change in the size and condition of populations and their habitat, threatening processes, and extinction risk. These accounts provide some of the information required to achieve the Aichi Biodiversity Targets, and especially Target 2, of the Convention on Biological Diversity (CBD 2014), which aims to place biodiversity values into mainstream decision-making frameworks of policy-makers.

In an initial assessment of biodiversity accounts, two main types of data were used: threatened species, and abundance and richness of a selected group of species (arboreal marsupials). Condition of the biodiversity was assessed in terms of the number of species classified as threatened, the threat categories, and the change in categories over time. The change in threat category of a species represents change in the extinction risk of that species and should be indicative of changes in size and condition of all biodiversity of the study area. There has been an increase in the number of critically endangered species in the last 5 years, with the addition of Leadbeater's Possum, Regent Honeyeater, Yellow-tufted Honeyeater, Round-leaf Pomaderis, and Mount Donna Buang Wingless Stonefly (Table 5).

Table 7. Change over time in the numbers of species in the study area listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) (ALA 2015)

	Regionally Extinct	Critically Endangered	Endangered	Vulnerable	Total
2000	2	0	12	14	28
2005	2	1	13	15	31
2010	2	1	13	18	34
2015	2	5	14	17	38
Net change	0	5	2	3	10

[Source: EPBC Act list of Threatened Fauna (2016), EPBC list of Threatened Flora (2016), and ALA 2015.]

Arboreal marsupials were selected for initial assessment of biodiversity and compilation of accounts because long-term monitoring data exist and occurrence of these species is well related to habitat variables that are influenced by disturbance events and forest age. The key habitat requirement for these animals is the presence of hollow-bearing trees.

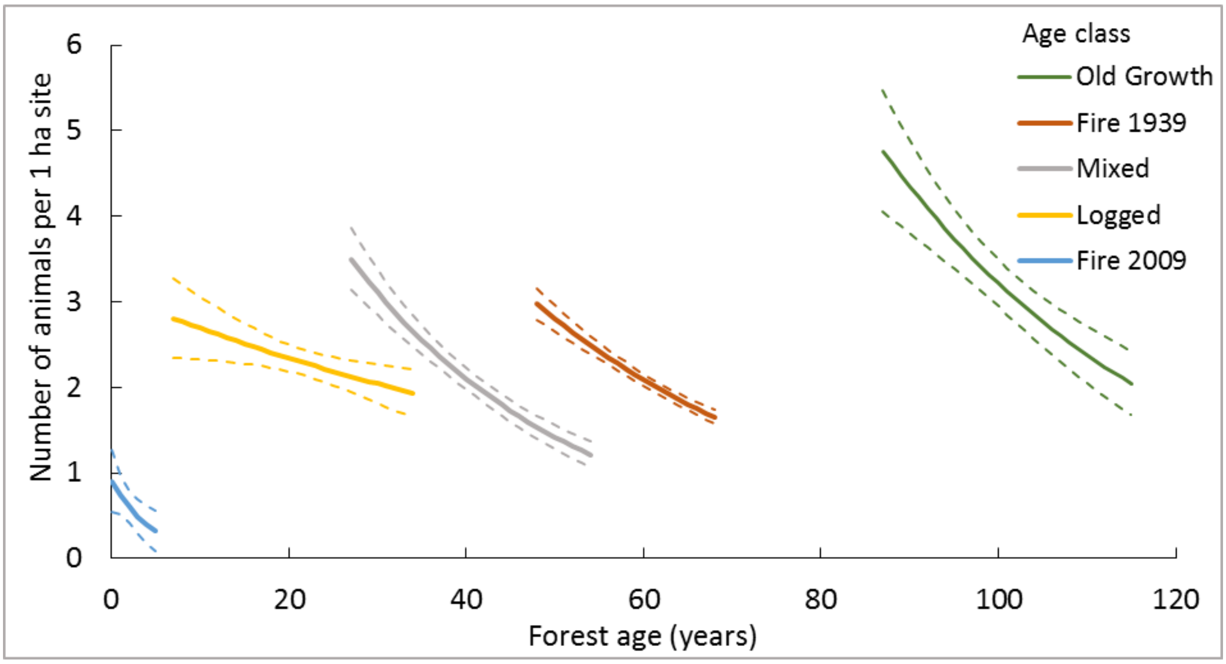
One of the arboreal marsupial species is Leadbeater's Possum (*Gymnobelideus leadbeateri*), the animal emblem of Victoria, and it is listed as critically endangered. It requires a specific habitat of montane ash forests with large decayed trees with hollows to provide den sites, a dense understorey of *Acacia spp*. for food, and a complex vertical structure to provide transport routes through the forest. These characteristics of complex forest structure also provide the most diverse habitat for a large range of other species, and hence Leadbeater's Possum is indicative of more general biodiversity.

Results of monitoring of arboreal marsupials over 28 years include:

- Significant positive relationship between animal occurrence and hollow-bearing trees.
- Old growth forests have significantly higher numbers of animals and species than regrowth forests (Figure 9).
- Numbers of animals have significantly decreased over time in all forest age classes, which represent the time period of regeneration (Figure 9).
- Numbers of hollow-bearing trees increase with forest age, with old growth having 2 – 3 times the number of hollow-bearing trees than regrowth forest.
- Loss of hollow-bearing trees in regrowth forest was four times the rate in old growth forest. Gain in hollow-bearing trees in regrowth forest was about three times less than in old growth forest.
- Change over time during the monitoring period has resulted in 47% of the total number of hollow-bearing trees being lost across all site age classes, with 17% of sites no longer having any hollow-bearing trees.
- **Wildfire has caused a 42% loss of hollow-bearing trees. Logging has caused a 70% loss of hollow-bearing trees**.

Figure 9. Change over time in numbers of arboreal marsupial animals within each forest age class

Sites in each of the five forest age classes have been monitored from 1987 to 2015, except age class Fire2009 that has regenerated since the fire. The monitoring data represent number of animals per 1 ha site each year, and how this has changed over the 28 years as forest age has increased. Solid lines represent the mean value and dashed lines are the upper and lower confidence limits.



It is unlikely that new hollow-bearing trees will be recruited in the next 40-50 years in the montane ash forest region because most of the forest extent is regrowth from the 1939 fire (trees currently 75 years old), or more recent fires and logging. Cavities first begin forming in Mountain Ash after about 120 years and exist for the time that the tree remains standing, whether alive or dead. Therefore, harvesting on rotations of less than 120 years results in no recruitment of hollow-bearing trees. **The key threatening process for arboreal marsupials is the accelerated loss of existing hollow-bearing trees and the impaired recruitment of new cohorts of these trees**.

Accounting for biodiversity at a regional scale has challenges in scaling up site data spatially across the region. Sites used for monitoring are selected to be suitable habitat for particular animals, and so are not necessarily sufficiently representative to provide quantitative information about abundance of animals spatially. Translating the value of biodiversity as a natural asset or determining its contribution to ecosystem services was not attempted. Species occurring within the study area clearly have value, as evidenced by the efforts made to conserve many of them and the tourist visitor numbers to the region.

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