Environmental-Economic Accounting

Victorian Experimental Ecosystem Accounts

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Foreword

Environmental-economic accounting aims to provide decision makers with the information they need to maintain and improve ecosystems and the ecosystem services that benefit society. Decision makers need information to monitor the effectiveness of environmental policy over time and across landscapes. The information helps them understand the current state of ecosystems, the changes in the states of ecosystems, and the causes of those changes. Policy makers and natural resource managers need information to understand the outcomes of past expenditure, and to improve resource allocation and maximise returns on natural resource investments.

This paper, Environmental-Economic Accounting, Victorian Experimental Ecosystem Accounts, demonstrates that it is possible to provide information on ecosystems and their changing condition through time in an accounting format. It shows how changes in ecosystems can be attributed to human intervention (e.g. revegetation), natural change or environmental events (e.g. flood and fire). The paper also suggests how changes in the condition of ecosystems can be linked with changes in ecosystem services, and with the socio-economic contexts of the ecosystem assets.

The accounts presented in this paper were constructed using methods prescribed in the System of Environmental-Economics Accounting: Experimental Ecosystem Accounts (SEEA: EEA), an internationally recognised framework for ecosystem accounting that aligns with the System for National Accounts (SNA) and the work of the Australian Bureau of Statistics in national and environmental accounting. The underlying data were sourced from Commonwealth and Victorian databases, and classified in a manner relevant to policy makers, natural resource managers and decision makers. The tables were designed to present information that is comparable over time and across regions, allowing users to objectively review the outcomes of natural resource management decisions in a broader context.

In the future, these accounts should provide decision makers with better information on the contributions ecosystems make to society. This will enable private and public investments in the environmental sector to be better targeted to provide the greatest environmental, economic and societal wellbeing.

As this is an experimental set of accounts, comments and feedback are encouraged.

We would like to acknowledge Michael Vardon and Carl Obst for their valuable input to the design and production of this report. We would also like to thank Gordon Forbes for his contribution to data management and programming within EnSym.

Mark Eigenraam, Joselito Chua and Jessica Hasker

State of Victoria, Department of Sustainability and Environment

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Introduction

The development of an ecosystem accounting framework evolved from a need to integrate environmental and economic information to inform policy discussion in a range of areas.

The policy relevance of ecosystem accounting for economic and environmental assessments stems from the understanding that policy responses should recognise the fundamental connections between economic activity and ecosystems[1]. Increasingly, policy in different areas of public concern is being considered in a more integrated, multi-disciplinary fashion with economic, social and environmental factors being assessed jointly when determining appropriate policy responses.

Environmental-economic accounting has been under development internationally for more than two decades, with the first handbook released by the United Nations (UN) and other international organisations in 1993. After a major revision to the handbook in 2003, and several minor revisions thereafter, the System of Environmental-Economic Accounting: Central Framework (SEEA: CF) was adopted in 2012 as an international statistical standard by the United Nations Statistical Commission. This put Environmental-Economic Accounting at the same level as the System of National Accounts, which among other things, provides the framework for the measurement of gross domestic product (GDP).

This year the UN added Experimental Ecosystem Accounts (SEEA: EEA) to the SEEA family of publications. The Experimental Ecosystem Accounts build on the SEEA: CF by recognising that the environment operates as a system. For example, it recognises that the extraction of timber from a forest will have implications on the services provided by the forest to society, like air filtration and water filtration.

The Victorian Government, through the Department of Sustainability and Environment (DSE), has contributed extensively to the development of SEEA: EEA, working closely with the Australian Bureau of Statistics and others in Australia and internationally. For the past ten years, DSE has established the information systems required for government to make cost-effective investments in the provision of ecosystem services. These systems have relied on an extensive array of information including spatial layers, ecosystem condition assessments, ecosystem condition modelling, ecosystem service modelling and ecosystem change modelling. As a result of these systems, innovative investment approaches like market-based instruments are now commonplace in Victoria. This unique experience and data availability allows DSE to experiment with the SEEA: EEA framework and to critique its on-ground feasibility and usefulness.

This paper presents a series of experimental ecosystem accounts that follow the SEEA: EEA framework using datasets relevant to Victoria. The paper provides a brief overview of the accounting framework applied to develop the Victorian Experimental Ecosystem Accounts. There is a short discussion on how DSE has approached some complex concepts (e.g. ecosystem “flows”) that are necessary to build a complete set of accounts. Finally, the series of Victorian Experimental Ecosystem Accounts is presented.

Accounting Framework

Newly-established frameworks often give rise to a set of new concepts and terminologies. This section provides an overview of the concepts and terms associated with ecosystem accounting.

Due to the experimental nature of environmental-economic accounting, some concepts and terms are still being debated. The concepts of ‘environmental accounting’ and ‘ecosystem accounting’, and the terms ‘ecosystem asset’, ‘ecosystem services’, ‘ecosystem intra-flows’ and ‘ecosystem inter-flows’ are described here from the perspective of the approach used in the Victorian Experimental Ecosystem Accounts. This paper does not seek to critique alternative descriptions and approaches, but to highlight the applicability of the chosen methodology.

Environmental asset accounting

Environmental asset accounting is an accounting framework applied in the SEEA: CF to monitor the physical and monetary stocks and flows of environmental assets. Environmental assets are naturally-occurring living and non-living components of the Earth, together comprising the biophysical environment that may provide benefits to humanity[2]. In the environmental asset accounting context, environmental assets are considered in terms of individual components such as mineral and energy resources, land, soil, aquatic, timber and other biological and water resources[3].

A critical component linking ecosystem accounts with economic information are the land accounts. Asset accounts for land are described in SEEA: CF, section 5.6. This linking is important for ecosystem accounting because land is the fundamental input to terrestrial-based ecosystem services and economic activities, like production, ownership and management, and can be referenced spatially through land accounts.

In late 2012, the Australian Bureau of Statistics (ABS) produced *Land Account: Victoria, Experimental Estimates, 2012* which contains a set of land accounts for the State of Victoria. The information provided in the land accounts provides a link between ecosystems and the economy. This link is explored in further detail later in this report.

Ecosystem accounting

Ecosystem accounting is based on the same fundamental biophysical structures as environmental accounting, but with a focus on ecosystem assets and services as a system rather than its separate components[4]. Amongst other things, it aims to organise information on the environment from a spatial perspective describing in a coherent manner linkages between ecosystems and economic and other human activity. The overarching objective of developing an ecosystem accounting structure is the integration of environmental and economic information to inform policy discussions in a range of areas.

From an ecosystem perspective, ecosystem accounting focuses (i) on the flows of ecosystem services to enable improved understanding of the relationship between ecosystems and economic and other human activity; and (ii) on the stock and changes in stock of ecosystem assets to enable an understanding of changes in ecosystems and their capacity to generate ecosystem services into the future. Some key terms used in ecosystem accounting are described below.

Ecosystem Assets: Ecosystem assets are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together[5]. In the SEEA: EEA, ecosystem assets are measured from two perspectives. First, ecosystem assets are considered in terms of ecosystem condition and ecosystem extent. Second, ecosystem assets are considered in terms of expected ecosystem service flows. In general terms, the capacity of an ecosystem asset to generate a basket of ecosystem services can be understood as a function of the condition and the extent of that ecosystem.

Ecosystem flows: Ecosystem flows represent all ecological transactions that occur within and between ecosystems (Figure 1). They represent both the flows of physical goods (e.g. moving water from one ecosystem to another) and functional processes (e.g. air filtration being provided by one ecosystem for the benefit of another). All flows within an ecosystem are coined intra-ecosystem flows (e.g. nutrient processes). The volume of intra-ecosystem flows is assumed to be directly related to the condition of an ecosystem asset. Flows between ecosystems are called inter-ecosystem flows (e.g. seed dispersal) and are estimated with both the condition and connectedness of an ecosystem. The subset of inter-ecosystem flows that directly provides benefit to humanity are considered to be ecosystem services (e.g. water extracted for irrigation).

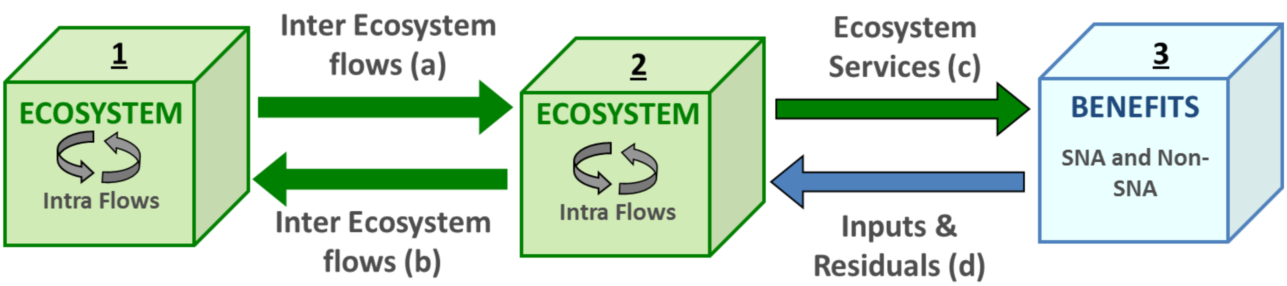

Figure 1. Ecosystem flows and services[6]

The flows that move from society into ecosystems are known as **residuals**. For instance, the movement of nutrients from a farm to a wetland or a bay is an example of a residual flow. There are many instances where the quality of an ecosystem asset is heavily influenced by the flow of residuals. Residuals are also important because there may be an economic trade-off between an ecosystem undertaking the filtration or an artificial facility built to perform the same filtration function.

It is important to note that in ecosystem accounting, changes in intra-ecosystem flows and inter-ecosystem flows (which relate to the general operation of ecosystem processes and dependencies between ecosystems) are not accounted for explicitly. Rather, changes in these flows are captured through their effect on the extent and condition of ecosystem assets and on the ecosystem services[7].

Ecosystem services: Ecosystem services are the contributions of ecosystems to benefits used in economic and other human activity[8]. In this context, "use" includes both the transformation of materials (e.g. use of timber to build houses or for energy) and the passive receipt of non-material ecosystem services (e.g. amenity from viewing landscapes). Defining ecosystem services as "contributions" highlights the view that ecosystem services are only one part of a broader set of inputs that are combined to provide the benefits.

In SEEA: EEA, three broadly agreed categories of ecosystem services are used: (i) provisioning services, (ii) regulating services and (iii) cultural services. These three categories have emerged from the project to develop a Common International Classification for Ecosystem Services (CICES) [9], which has drawn on the Millennium Ecosystem Assessment[10] and The Economics of Ecosystems and Biodiversity (TEEB) study[11].

Classification of ecosystem services

i. **Provisioning services** reflect material and energy contributions generated by or in an ecosystem (e.g. a fish or a plant with pharmaceutical properties).

ii. **Regulating services** result from the capacity of ecosystems to regulate climate, hydrological and bio-chemical cycles, earth surface processes, and a variety of biological processes.

iii. **Cultural services** are generated from the physical settings, locations or situations which give rise to intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection. This may involve actual visits to an area, indirectly enjoying the ecosystem (e.g. through nature movies), or gaining satisfaction from the knowledge that an ecosystem containing important biodiversity or cultural monuments will be preserved.

Victorian approach

In Victoria, work has been underway over the past 10 years to extend and apply market principles to the management of ecosystem assets. In order for environmental markets to operate, it is necessary to define how ecosystem flows will change as a result of changes in land use and management. Models have been developed to represent the current levels of ecosystem flows and to predict the change in ecosystem flows resulting from changes in land use and management. This information, originally designed to assess the most effective management interventions, can also be used for the purposes of ecosystem accounting.

Applying the Victorian environmental markets approach to ecosystem accounting uses a "bottom-up" methodology by (i) quantifying all intra-ecosystem flows using a measure of asset condition; (ii) quantifying the volume of inter-ecosystem flows as a function of the asset condition and its context in the landscape; and (iii) quantifying the volume of ecosystem services as a function of the inter-ecosystem flows and a measure of "significance" representing an anthropocentric preference for the flows. In contrast, the SEEA: EEA advises the use of a "top-down" approach whereby only the ecosystem services are quantified and measurements of the intra- and inter-ecosystem flows are not required.

The bottom-up approach has the advantage of collating data along a chain of causes and effects which might be overlooked in the top-down approach. Mapping this chain may be particularly important in order to assess the ecosystem-wide implications of specific decisions. For example, the loss of a forest may have consequences on stream water quality which may in turn affect the downstream estuary, impacting fish stocks. To understand fully the changes (in this case the fish stocks) and to enable effective intervention, it is necessary to understand the whole system. The bottom-up approach makes it possible to model and monitor cumulative chains of complex processes across the whole system.

Victorian Experimental Ecosystem Accounts

The Victorian Experimental Ecosystem Accounts demonstrate an experimental application of the SEEA: EEA. This provides a practical case study to inform discussions on how ecosystem accounting may assist environmental policy, natural resource investments and decision making.

The experimental accounts can be grouped into four types, depending on the information they provide:

1. **Ecosystem Asset Accounts** provide a record of the stock of ecosystem assets at a given point in time
2. **Asset Flow Accounts** record the changes in stock over a defined period of time
3. **Physical Flow Accounts** record the expected flows between ecosystem assets and the services that contribute to human benefits
4. **Environmental Payment Accounts** record the economic transactions that affect the stocks and flows of ecosystem assets (e.g. expenditure for improvement and maintenance of ecosystem assets)

This section presents a subset of the account tables. Refer to Appendix A for links to the full datasets.

Ecosystem Asset Accounts

The Ecosystem Asset Accounts provide a record of the extent and condition of ecosystem assets at a given point in time. Aggregated measurements of extent and condition indicate the quantity and quality of stocks of ecosystem assets. Measurements taken at various points in time can show how the stocks change over time. Spatial references indicating the geographic location of the ecosystem assets provide insights to the socio-economic contexts of the trends in stocks.

Table 1 shows the Ecosystem Asset Accounts for Victoria at two time-points: 1750 and 2005. The rows list the types of ecosystem assets. The classification of ecosystem assets into various types for accounting purposes is a fundamental part of SEEA: EEA. Each unit of stock is referenced spatially as a geographic area called a **Basic Spatial Unit (BSU)**. Each BSU belongs to a **Land Cover/Ecosystem Unit (LCEU)** which represents an ecosystem asset of a particular type. The accounts tabulate the stocks according to the classification of the ecosystem assets. In Table 1, the ecosystem assets are classified based on the **Major Vegetation Groups (MVG)**[12,13] used in the **National Vegetation Information System (NVIS)**[14]. Note that other classification schemes, such as Victoria's Ecological Vegetation Classes (EVC)[15], could be used instead. The MVG classification scheme in NVIS was adopted in this publication for national consistency.

The columns in Table 1 show the aggregate extent (in hectares) and mean condition (per hectare) for each type of ecosystem asset. The condition measure is the normalised "Site Condition" component of the Habitat Hectares approach[16] for assessing the quality of native vegetation. A mean condition of 1.00/Ha represents the benchmark condition. The tabulated data for 1750 are modelled estimates of the extent of the ecosystem assets prior to European settlement. The modelled condition of the ecosystem assets in 1750 serves as the benchmark condition.

There are two sets of estimates for 2005, based on different sources: column "2005(a)" was based on estimates published in 2006 (NVIS Version 3.1), whereas column "2005(b)" was based on revised estimates published in 2013 (NVIS Version 4.1) to supersede the "2005(a)" estimates. The "2005(a)" estimates are included in this publication for consistency with the source data for the ABS Experimental Land Accounts[17]. Note the significant differences in the estimated 2005 stocks. For example, column "2005(a)" shows approximately 1.5m Ha of Eucalypt Woodlands with a mean condition of 0.57/Ha compared to the 1750 benchmark, whereas column "2005(b)" shows approximately 2.5m Ha with a mean condition of 0.46/Ha. The discrepancies illustrate how improvements in data quality can lead to significant revisions to the estimated stocks of ecosystem assets. How to account for better or new information in an ecosystem accounting context is still being resolved.

Table 1. Victorian terrestrial extent and condition classified by Major Vegetation Groups: 1750, 2005

	1750		2005 (a)		2005 (b)	
Major Vegetation Group (NVIS)	Extent (Ha)	Mean condition/Ha	Extent (Ha)	Mean condition/Ha	Extent (Ha)	Mean condition/Ha
Native vegetation						
Acacia Forests and Woodlands	22,885	1.00	41,237	0.60	18,845	0.64
Acacia Open Woodlands	271	1.00	NA	NA	256	0.61
Acacia Shrublands	15,874	1.00	109	0.35	10,053	0.59
Callitris Forests and Woodlands	5,549	1.00	464	0.33	1,934	0.40
Casuarina Forests and Woodlands	1,003,122	1.00	186,411	0.48	190,513	0.51
Chenopod Shrublands, Samphire Shrublands and Forblands	214,488	1.00	55,516	0.51	113,563	0.56
Eucalypt Open Forests	6,346,166	1.00	3,899,116	0.65	4,976,481	0.63
Eucalypt Open Woodlands	1,223,235	1.00	1	0.60	250,677	0.46
Eucalypt Tall Open Forests	53,605	1.00	632,333	0.68	53,576	0.71
Eucalypt Woodlands	7,532,842	1.00	1,559,369	0.57	2,459,569	0.46
Heathlands	299,343	1.00	35,914	0.63	244,461	0.59
Low Closed Forests and Tall Closed Shrublands	206,330	1.00	NA	NA	35,241	0.44
Mallee Open Woodlands and Sparse Mallee Shrublands	213,785	1.00	NA	NA	43,380	0.53
Mallee Woodlands and Shrublands	3,395,152	1.00	1,509,023	0.56	1,577,654	0.56
Mangroves	7,025	1.00	1,010	0.53	5,006	0.55
Melaleuca Forests and Woodlands	89	1.00	14,910	0.50	65	0.57
Naturally bare - sand, rock, claypan, mudflat	4,619	1.00	3,066	0.35	4,459	0.44
Other Forests and Woodlands	63,290	1.00	287,940	0.59	55,756	0.69
Other Grasslands, Herblands, Sedgelands and Rushlands	202,082	1.00	142,010	0.59	97,547	0.54
Other Open Woodlands	122	1.00	NA	NA	77	0.41
Other Shrublands	295,419	1.00	103,193	0.61	159,251	0.58
Rainforests and Vine Thickets	44,109	1.00	36,630	0.71	40,164	0.70
Tussock Grasslands	1,302,356	1.00	28,486	0.33	139,989	0.40
Unclassified native vegetation	45,808	1.00	1	0.73	8,074	0.61
Total native vegetation	**22,497,566**	**1.00**	**8,536,739**	**0.61**	**10,486,591**	**0.57**
Land not classified as native vegetation						
Sea and estuaries	*1,677*	*NA*	-	*NA*	1,613	*NA*
Inland aquatic - freshwater, salt lakes, lagoons	*197,128*	*NA*	*177,406*	*NA*	243,637	*NA*
Cleared, non-native vegetation, buildings	-	*NA*	*365,180*	*NA*	11,955,418	*NA*
Unknown/no data	-	*NA*	*575,185*	*NA*	10,166	*NA*
Unclassified	*2,976*	*NA*	*13,044,837*	*NA*	1,922	*NA*
Total non-native vegetation	*201,781*	*NA*	*14,162,608*	*NA*	*12,212,756*	*NA*

The two-period tabulation of the Ecosystem Asset Accounts in Table 1 illustrates the estimated changes in stocks between 1750 and 2005. The 2005(b) extent of native vegetation is about half pre-European settlement, and the average condition is 0.57 in 2005(b) compared to 1.0 in 1750. Within the table, it is possible to identify vegetation types that appear to be relatively healthy. For example, Eucalypt Tall Open Forests increased in total area since 1750, with a mean condition of 0.8/Ha. Contrast that to Tussock Grasslands which has a present extant that is about 10% of the 1750's extent and a mean condition of only approximately 0.35/Ha.

Ecosystem Asset Accounts are not meant to provide information that explains the changes in stocks. For example, the gains and losses in Table 1 could be due to actual physical changes in the extent and condition of the ecosystem assets, but the differences could also be due to revised estimates based on improved information about the assets. Information that explains the changes in stocks are described in the Asset Flow Accounts and is discussed in the next section.

The Ecosystem Asset Accounts present the extent and condition of ecosystem assets as separate columns without combining them into a single indicator of the overall condition of ecosystem assets. SEEA: EEA does not explicitly prescribe a method for formulating a combined indicator of stock condition. However, there are several possible approaches for doing so. For example, regional natural resource management groups are trialling the Wentworth Group's *Accounting for Nature*[18] model for measuring the condition of environmental assets. In the Victorian approach, the expected future flows tabulated in the Physical Flow Accounts (discussed below) represent the overall condition of ecosystem assets.

Ecosystem Accounting Units

The aggregation and reporting of stocks in SEEA: EEA are based on Ecosystem Accounting Units (EAU). An EAU is a spatially-fixed area about which there is interest in understanding and managing the stocks over time. For example, Victoria has ten catchment regions (see Figure 2 below), each managed by a Catchment Management Authority (CMA). EAUs based on the administrative boundaries of the catchment regions enable the aggregation and reporting of stocks for each CMA. Table 2 shows an example of the Ecosystem Asset Accounts for the Corangamite Catchment Management Authority. The Appendix at the end of this document contains a link to the data sets for all CMAs.

Figure 2. Catchment management regions in Victoria

Table 2. CCMA - Corangamite Catchment Management Authority: Terrestrial vegetation type by area and average vegetation condition, 1750 and 2005

	1750		2005	
Major Vegetation Group (NVIS)	Extent (Ha)	Mean condition/Ha	Extent (Ha)	Mean condition/Ha
<u>Native vegetation</u>				
Acacia Forests and Woodlands	2,538	1.00	1,477	0.50
Acacia Open Woodlands				
Acacia Shrublands				
Callitris Forests and Woodlands				
Casuarina Forests and Woodlands	1,707	1.00	1,368	0.54
Chenopod Shrublands, Samphire Shrublands and Forblands	78	1.00	74	0.59
Eucalypt Open Forests	401,952	1.00	232,434	0.62
Eucalypt Open Woodlands	206,440	1.00	19,590	0.36
Eucalypt Tall Open Forests				
Eucalypt Woodlands	290,684	1.00	73,000	0.52
Heathlands	13,078	1.00	2,582	0.57
Low Closed Forests and Tall Closed Shrublands	26,925	1.00	3,579	0.46
Mallee Open Woodlands and Sparse Mallee Shrublands				
Mallee Woodlands and Shrublands				
Mangroves	4,431	1.00	3,332	0.57
Melaleuca Forests and Woodlands				
Naturally bare - sand, rock, claypan, mudflat				
Other Forests and Woodlands	195	1.00	62	0.45
Other Grasslands, Herblands, Sedgelands and Rushlands	23,038	1.00	6,189	0.49
Other Open Woodlands				
Other Shrublands	25,850	1.00	7,311	0.55
Rainforests and Vine Thickets	10,773	1.00	9,579	0.69
Tussock Grasslands	275,731	1.00	18,761	0.40
Unclassified native vegetation				
Total native vegetation	**1,283,420**	**1.00**	**379,338**	**0.57**
<u>Land not classified as native vegetation</u>				
Sea and estuaries				
Inland aquatic - freshwater, salt lakes, lagoons	*50,473*	*NA*	51,962	*NA*
Cleared, non-native vegetation, buildings			902,588	*NA*
Unknown/no data				
Unclassified	*170*	*NA*	175	*NA*
Total non-native vegetation	*50,643*	*NA*	*954,725*	*NA*

The EAUs can also be based on large-scale natural features and processes. For example, Australia's landscapes have been classified into several geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information19. Victoria has 28 bioregions across the state (Figure 3). EAUs based on the bioregion boundaries enable the aggregation and reporting of stocks for each bioregion.

Table 4 shows an example of the Ecosystem Asset Accounts for the East Gippsland Lowlands bioregion. The Appendix at the end of this document contains a link to the data sets for all the bioregions in Victoria.

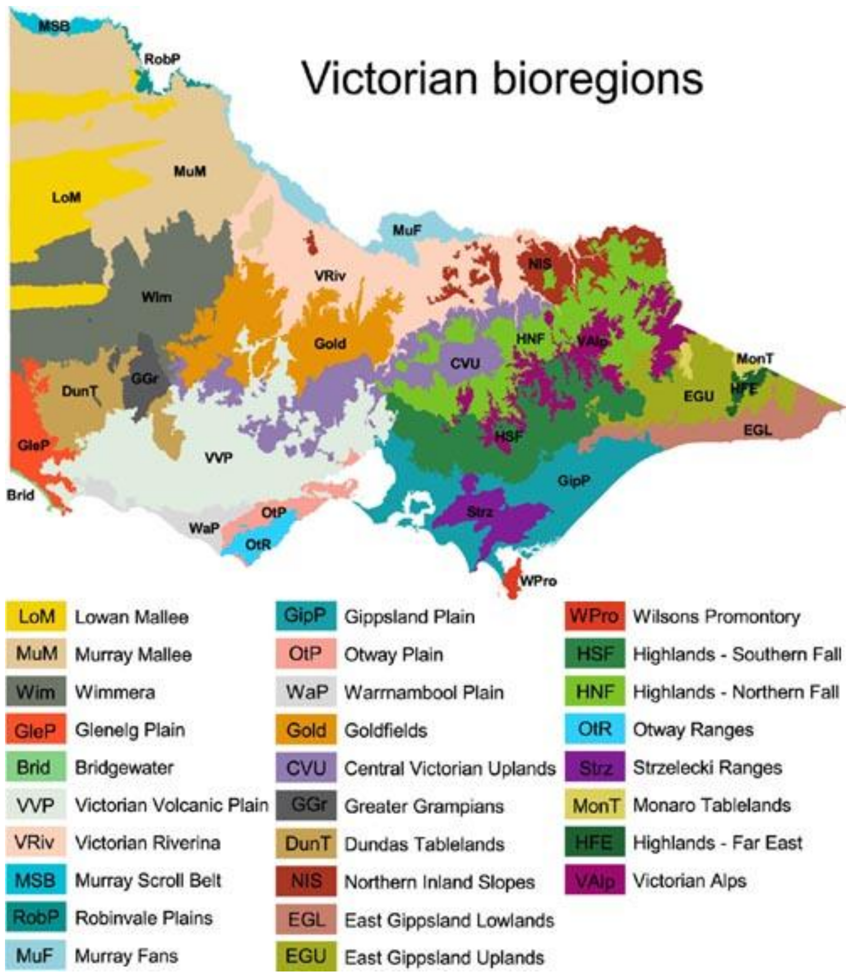

Figure 3. Bioregions in Victoria

Table 3. Bioregion - EGL - East Gippsland Lowlands: Terrestrial vegetation type by area and average vegetation condition, 1750 and 2005

	1750		2005	
Major Vegetation Group (NVIS)	Extent (Ha)	Mean condition/Ha	Extent (Ha)	Mean condition/Ha
Native vegetation				
Acacia Forests and Woodlands	231	1.00	227	0.66
Acacia Open Woodlands				
Acacia Shrublands	11	1.00	13	0.58
Callitris Forests and Woodlands				
Casuarina Forests and Woodlands				
Chenopod Shrublands, Samphire Shrublands and Forblands	749	1.00	743	0.60
Eucalypt Open Forests	434,262	1.00	379,099	0.69
Eucalypt Open Woodlands				
Eucalypt Tall Open Forests				
Eucalypt Woodlands	27,674	1.00	23,571	0.67
Heathlands	11,812	1.00	11,132	0.70
Low Closed Forests and Tall Closed Shrublands	284	1.00	150	0.45
Mallee Open Woodlands and Sparse Mallee Shrublands				
Mallee Woodlands and Shrublands				
Mangroves				
Melaleuca Forests and Woodlands				
Naturally bare - sand, rock, claypan, mudflat	1,758	1.00	1,731	0.39
Other Forests and Woodlands	43,185	1.00	41,677	0.72
Other Grasslands, Herblands, Sedgelands and Rushlands	3,049	1.00	2,893	0.59
Other Open Woodlands				
Other Shrublands	4,027	1.00	3,910	0.61
Rainforests and Vine Thickets	2,445	1.00	2,402	0.70
Tussock Grasslands				
Unclassified native vegetation				
Total native vegetation	**529,487**	**1.00**	**467,548**	**0.69**
Land not classified as native vegetation				
Sea and estuaries	*1,673*	*NA*	1,609	*NA*
Inland aquatic - freshwater, salt lakes, lagoons	*624*	*NA*	669	*NA*
Cleared, non-native vegetation, buildings			61,826	*NA*
Unknown/no data				
Unclassified	*147*	*NA*	279	*NA*
Total non-native vegetation	*2,444*	*NA*	*64,383*	*NA*

Links to Land Accounts

The EAUs provide a link between the Ecosystem Asset Accounts and the socio-economic information contained in the ABS Experimental Land Accounts as well as other social and economic data compiled by the ABS. For example, EAUs based on CMA boundaries make it possible to overlay ecosystem stocks information on land valuation data reported in the ABS Land Accounts (Figure 4).

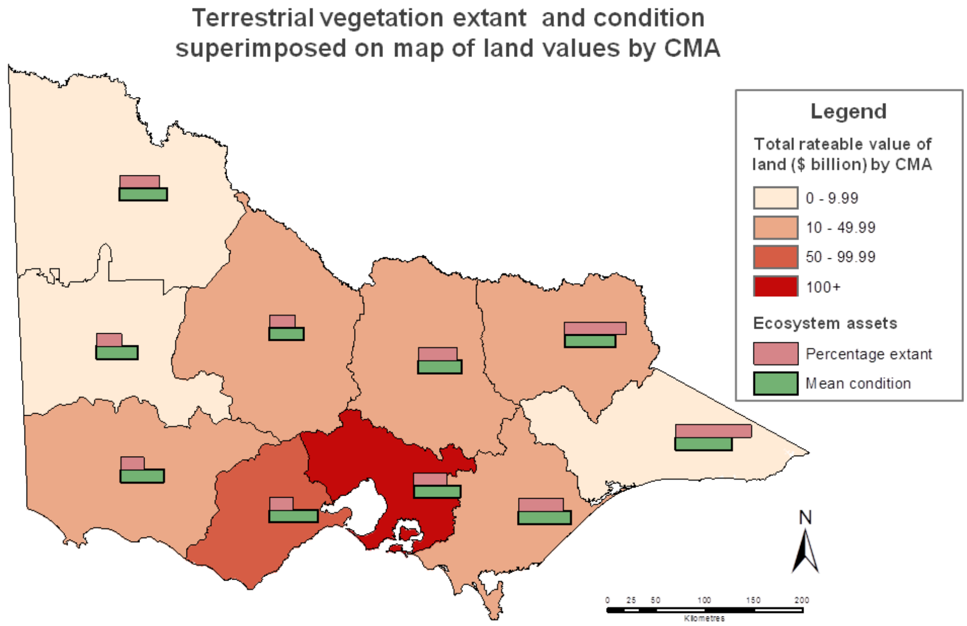

Figure 4 Terrestrial vegetation and extent superimposed on map of land values by CMA

The ABS Statistical Areas[20] provide multi-scale hierarchical EAUs for the aggregation and reporting of ecosystem stocks, and for linking the ecosystem accounting information to socio-economic data in the ABS Land Accounts. Table 4 shows an example of the Ecosystem Asset Accounts for a Level-4 Statistical Area (SA4-205 – Latrobe-Gippsland). Table 5 shows the corresponding socio-economic data compiled by the Australia Bureau of Statistics for the same Statistical Area.

Table 4. SA4-205 - Latrobe - Gippsland: Terrestrial vegetation type by area and average vegetation condition, 1750 and 2005

	1750		2005	
Vegetation type (NVIS)	Extent (Ha)	Mean condition/Ha	Extent (Ha)	Mean condition/Ha
Native vegetation				
Acacia Forests and Woodlands	15,134	1.00	15,095	0.69
Acacia Open Woodlands				
Acacia Shrublands	9,386	1.00	7,690	0.63
Callitris Forests and Woodlands				
Casuarina Forests and Woodlands	15	1.00	15	0.72
Chenopod Shrublands, Samphire Shrublands and Forblands	1,585	1.00	1,284	0.58
Eucalypt Open Forests	2,719,123	1.00	2,212,247	0.67
Eucalypt Open Woodlands	62,128	1.00	60,314	0.61
Eucalypt Tall Open Forests	53,434	1.00	53,407	0.71
Eucalypt Woodlands	819,180	1.00	428,821	0.56
Heathlands	59,616	1.00	43,602	0.66
Low Closed Forests and Tall Closed Shrublands	99,715	1.00	*23,389*	*0.47*
Mallee Open Woodlands and Sparse Mallee Shrublands	6,281	1.00		
Mallee Woodlands and Shrublands				
Mangroves	1,638	1.00	1,061	0.53
Melaleuca Forests and Woodlands				
Naturally bare - sand, rock, claypan, mudflat	3,111	1.00	2,977	0.38
Other Forests and Woodlands	52,416	1.00	48,567	0.70
Other Grasslands, Herblands, Sedgelands and Rushlands	25,433	1.00	18,590	0.55
Other Open Woodlands				
Other Shrublands	57,335	1.00	47,282	0.63
Rainforests and Vine Thickets	21,557	1.00	18,819	0.69
Tussock Grasslands	35,783	1.00	2,775	0.30
Unclassified native vegetation	31,682	1.00	4,233	0.59
Total native vegetation	**4,074,552**	**1.00**	**2,990,168**	**0.65**
Land not classified as native vegetation				
Sea and estuaries	*1,677*	*NA*	*1,613*	*NA*
Inland aquatic - freshwater, salt lakes, lagoons	*35,238*	*NA*	*40,030*	*NA*
Cleared, non-native vegetation, buildings			*1,078,468*	*NA*
Unknown/no data			*557*	*NA*
Unclassified	*666*	*NA*	*1,297*	*NA*
Total non-native vegetation	*37,581*	*NA*	*1,121,965*	*NA*

Table 5. SA4-205 Latrobe Gippsland socio-economic data

SA4: Latrobe - Gippsland (205)	Turnover size, business count				
Industry	$50k to less than $100k	$100k to less than $200K	$200k to less than $500k	$500k to less than $2m	$2m or more
A Agriculture, Forestry and Fishing	1,092	1,011	1,107	916	115
B Mining	6	3	15	9	12
C Manufacturing	150	120	178	185	89
D Electricity, Gas, Water and Waste Services	3	21	12	27	9
E Construction	958	869	883	558	178
F Wholesale Trade	50	58	74	99	73
G Retail Trade	181	213	402	488	202
H Accomodation and Food Services	122	211	324	187	51
I Transport, Postal and Warehousing	211	266	295	152	63
J Information Media and Telecommunications	15	9	12	6	15
K Financial and Insurance Services	208	144	117	80	24
L Rental, Hiring and Real Estate Services	377	276	243	152	42
M Professional, Scientific and Techincal Services	233	261	253	165	52
N Administrative and Support Services	127	124	80	83	24
O Public Administration and Safety	9	15	15	6	-
P Education and Training	43	33	21	6	15
Q Health Care and Social Assistance	97	147	200	134	24
R Arts and Recreation Services	51	36	36	21	-
S Other Services	168	247	232	170	27
Not Classified	148	43	60	6	12
Grand Total	**4,249**	**4,107**	**4,559**	**3,450**	**1,027**

The stocks can also be aggregated and reported in a manner that relates directly to the classification schemes in the ABS Experimental Land Accounts. For example, Table 6 shows the stocks in relation to land use. Note that although land use classifications do not define spatially-fixed EAUs, land use classification is a primary key in the ABS Land Accounts.

Table 6. Land-ecosystem asset account - Victorian land classified by Major Vegetation Groups (NVIS), aggregated by land use (VLUIS, 2005)

	Land use (VLUIS)											
Major Vegetation Group (NVIS)	Primary production	Residential	Industrial	Commercial	Extractive Industry	Infrastructure/ Utilities	Community Services	Sport Recreation and Culture	National Parks Conservation Areas Forest Reserves and Natural Water Reserves	Non-active assessments and Header records	Unclassified	**Total**
Acacia Forests and Woodlands	1,519	138	33	1	5	152	35	16	16,938		8	**18,845**
Acacia Open Woodlands	100								156			**256**
Acacia Shrublands	1,367	296		3		222	77		8,088			**10,053**
Callitris Forests and Woodlands	1,161	284	1	3	1	90		60	332		2	**1,934**
Casuarina Forests and Woodlands	50,888	563	128	61	270	11,915	513	72	125,989		114	**190,513**
Chenopod Shrublands, Samphire Shrublands and Forblands	34,426	162	7	16	2,791	3,104	49	8	72,995		5	**113,563**
Eucalypt Open Forests	782,813	157,594	1,156	3,491	4,061	88,425	12,743	4,027	3,921,191	17	963	**4,976,481**
Eucalypt Open Woodlands	94,267	11,762	296	499	370	11,296	2,522	3,018	126,641		6	**250,677**
Eucalypt Tall Open Forests	16					364			53,196			**53,576**
Eucalypt Woodlands	1,127,834	117,490	1,967	4,583	6,173	108,635	8,970	3,059	1,079,878	2	978	**2,459,569**
Heathlands	11,311	466	84	58	12	1,977	60	370	230,109		14	**244,461**
Low Closed Forests and Tall Closed Shrublands	15,035	2,971	80	24	18	1,395	61	54	15,602		1	**35,241**
Mallee Open Woodlands and Sparse Mallee Shrublands	12,104	88	2			1,286	27	1	29,871		1	**43,380**
Mallee Woodlands and Shrublands	180,416	4,563	140	40	5,432	35,874	765	201	1,350,187		36	**1,577,654**
Mangroves	1,019	180	18	2	1	84		25	3,664		13	**5,006**
Melaleuca Forests and Woodlands	10	5				3			47			**65**
Naturally bare - sand, rock, claypan, mudflat	83	17	22			35	7	3	4,267		25	**4,459**
Other Forests and Woodlands	2,937	642	5	108	36	875	89	129	50,920		15	**55,756**
Other Grasslands, Herblands, Sedgelands and Rushlands	34,346	1,344	53	29	23	4,602	59	85	56,942		64	**97,547**
Other Open Woodlands	-								77			**77**
Other Shrublands	37,030	1,878	70	135	98	3,056	1,235	788	114,833		128	**159,251**
Rainforests and Vine Thickets	3,975	190		8		170	4	24	35,793			**40,164**
Tussock Grasslands	107,805	8,305	822	168	1,190	5,855	404	198	15,238		4	**139,989**
Unclassified native vegetation	2,067	224	20		2	306	272	150	5,001		32	**8,074**
Total native vegetation	2,502,529	**309,162**	**4,904**	**9,229**	**20,483**	**279,721**	**27,892**	**12,288**	**7,317,955**	**19**	**2,409**	**10,486,591**

Alternative classification schemes

The SEEA: EEA framework allows for flexibility in the choice of classification schemes for Ecosystem Asset Accounts. The classification of Land Cover/Ecosystem Units (LCEU) depends on the type of ecosystem assets that are of interest. For example, the Major Vegetation Groups in NVIS focus on terrestrial vegetation. In Victoria, there are alternative classification schemes that focus on wetland and river assets. The classification schemes are important because they also determine the methodology for measuring the quantity and quality of the stocks.

Table 7 shows an example of the Ecosystem Asset Accounts where the LCEUs are classified based on wetland types. The table shows the estimated extent and condition of naturally and non-naturally occurring Victorian wetland systems across three time periods – 1750 (pre-European settlement), 1994 and 2012. The extent is measured in hectares, but the condition is a normalised measure based on the Index of Wetland Condition[21] from wetlands sampled by the Victorian government. The table shows that although the current total extent of wetlands is similar to that of pre-European settlement, considerable changes in the extent of various types of wetland systems have occurred. There was a 154,000 hectares increase in non-naturally occurring wetlands and a loss of 165,000 hectares of natural wetlands. The table also shows how the mean condition of the remaining wetland systems is approximately 0.7/Ha compared to 1.0/Ha in 1750.

Table 7. Victorian wetland extent and condition classified by wetland system and origin: 1750, 1994, 2012

	1750		1994		2012	
Wetland system type and origin (2012)	Extent (Ha)	Average condition	Extent (Ha)	Average condition	Extent (Ha)	Average condition
Origin - Naturally occuring wetlands						
Estuarine	41,001	1	31,455	unknown	35,467	0.71
Lacustrine	152,437	1	138,998	unknown	169,083	0.65
Marine	3,216	1	3,160	unknown	3,302	unknown
Palustrine	218,763	1	187,497	unknown	289,405	0.78
Palustrine or Lacustrine (unknown specifics)	3,745	1	1,005	unknown	6,919	0.40
Unclassified	250,418	1	-	unknown	-	NA
Total natural wetlands	**669,580**	**1**	**362,115**	**unknown**	**504,176**	**0.70**
Origin - Non-naturally occuring wetlands						
Estuarine	-	NA	25,331	unknown	26,860	0.71
Lacustrine	-	NA	84,606	unknown	98,399	0.57
Marine	-	NA	41	unknown	633	unknown
Palustrine	-	NA	11,535	unknown	26,169	0.72
Palustrine or Lacustrine (unknown specifics)	-	NA	47	unknown	2,015	unknown
Unclassified	-	NA	46,499	unknown	-	NA
Total non-natural wetlands	**-**	**NA**	**168,059**	**unknown**	**154,076**	**0.64**
Total wetlands	**669,580**	**1**	**530,174**	**unknown**	**658,252**	**0.69**
Land not classified as wetland	*22,029,767*	*NA*	*22,169,173*	*NA*	*22,041,095*	*NA*

Table 8 is another example of an alternative classification scheme based on river systems. The extent is measured in kilometres of river reach. The condition is a normalised measure based on the Index of Stream Condition[22]. The table shows the average condition across two time periods - pre-European settlement (1750) and 2004. It shows how, on average, the condition of rivers in 2004 was 0.44/km compared to 1.0/km pre-European settlement. It also shows how some river systems are under more stress than others. For instance, the Hopkins river basin has an average condition of 0.27/km compared to the East Gippsland river basin with an average condition of 0.76/km.

Table 8. Victorian river reaches length and condition classified by river basin: 1750, 2004

		1750	2004
River basin	River Reach total length (km)	Mean condition	Mean condition
Upper Murray	1199	1.00	0.57
Kiewa	356	1.00	0.56
Owens	1201	1.00	0.51
Broken	915	1.00	0.40
Goulburn	2097	1.00	0.45
Campaspe	643	1.00	0.38
Loddon	1888	1.00	0.32
Avoca	536	1.00	0.37
Mallee	692	1.00	0.33
Wimmera	1333	1.00	0.38
East Gippsland	664	1.00	0.76
Snowy	855	1.00	0.61
Tambo	760	1.00	0.59
Mitchell	772	1.00	0.64
Thomson	925	1.00	0.46
Latrobe	839	1.00	0.48
South Gippsland	952	1.00	0.38
Bunyip	583	1.00	0.37
Yarra	614	1.00	0.37
Maribyrnong	416	1.00	0.42
Werribee	503	1.00	0.42
Moorabool	452	1.00	0.33
Barwon	642	1.00	0.34
Corangamite	482	1.00	0.36
Otway	702	1.00	0.51
Hopkins	1287	1.00	0.27
Portland	464	1.00	0.42
Glenelg	1326	1.00	0.38
Millicent Coast	unknown	1.00	unknown
Total	24098		0.44

Asset Flow Accounts

The Asset Flow Accounts record the changes in stock of ecosystem assets over a defined period of time. These accounts provide an insight into the drivers of change in stocks over time. For instance, they highlight how management of ecosystem assets relates to changes in the extent and condition of the stocks.

Table 9 shows an example of Asset Flow Accounts for the extent of terrestrial native vegetation. The table accounts for the changes in the extent of stocks over the 10-year period between 1994 and 2004[23]. The rows describe the changes based on the following classification scheme:

Additions:

- Growth in terrestrial extent
  - Managed revegetation: land previously classified as non-native vegetation now classified as native vegetation as a result of revegetation with indigenous species.
  - Unmanaged regeneration: land previously classified as non-native vegetation now classified as native vegetation as a result of regeneration of indigenous species (predominantly passive recovery of no longer utilized farmland).
- Upward reappraisals: no physical increase in native vegetation extent, but land previously classified as non-native vegetation now classified as native vegetation as a result of new information.
- Reclassifications: no physical increase in terrestrial vegetation extent, but increase in native vegetation under management by land manager classification.

Reductions:

- Extractions of terrestrial extent
  - Vegetation clearing: land previously classified as native vegetation now classified as non-native vegetation as a result of vegetation clearing.
- Normal loss of stock

- in fragmented landscapes
- in largely intact landscapes

- Catastrophic losses: land previously classified as native vegetation now classified as non-native vegetation as a result of a natural disaster.
- Downward reappraisals: no physical loss of terrestrial vegetation extent, but land previously classified as native vegetation now classified as non-native vegetation as a result of new information.
- Reclassifications: no reduction in physical terrestrial vegetation extent, but reduction in native vegetation under management by land manager classification.

Table 9. Change in Victorian extent of terrestrial vegetation between 1994 to 2004, disaggregated by land tenure

Terrestrial extent (Ha), Victoria	**Public land**	**Private land**	***Total***
Opening extent of terrestrial assets (~1994)	**7,317,778**	**3,152,928**	**10,470,706**
Additions			
Growth in terrestrial extent			
• Managed revegetation	-	14,485	*14,485*
• Unmanaged regeneration	-	4,000	*4,000*
Upward reappraisals	unknown	unknown	-
Reclassifications	14,270	unknown	*14,270*
Total additions to terrestrial extent	*14,270*	*18,485*	*32,755*
Reductions	-		
Extractions of terrestrial extent			
• Vegetation clearing	-2600		- *2,600*
Normal loss of stock			
• Fragmented landscapes	-	-	-
• Largely intact landscapes	-	-	-
Catastrophic losses	unknown	unknown	-
Downward reappraisals	unknown	unknown	-
Reclassifications	unknown	- 14,270	- *14,270*
Total reductions in terrestrial extent	- *2,600*	- *14,270*	- *16,870*
Total change in terrestrial extent	*11,670*	*4,215*	*15,885*
Closing extent (~2004)	**7,329,448**	**3,157,143**	**10,486,591**

The columns in Table 9 compare the change in the extent of terrestrial native vegetation on public and private land. The table shows an overall increase in extent of 15,885 Ha over the 10-year period between 1994 and 2004. The increase was attributed to either regeneration or revegetation on private land. The losses in native vegetation extent are attributed mostly to vegetation clearing[i] (2,600 Ha). However, there were also changes in tenure with 14,270 Ha being reclassified from private to public.

Physical Flow Accounts

The SEEA: EEA Physical Flow Accounts provide measures of ecosystem services flowing from a given ecosystem asset – the definition of “physical flows” is limited to ecosystem services (provisioning, regulation and cultural). The physical flow accounts limit the reporting of inter-ecosystem flows to those that can be clearly attributed as ecosystem services making contributions to benefits used in economic and other human activity.

The reporting of inter-ecosystem flows when attribution is not possible currently remains an open question. A reasonable approach would be to account for all inter-ecosystem flows and then identify the subset that can be attributed as ecosystem services. The current SEEA: EEA does not prescribe an accounting approach to inter-ecosystem flows. The remainder of this section is an experimental approach to estimating and accounting for how inter-ecosystem flows contribute to benefits used in economic and other human activity.

In order to make a connection between changes in ecosystem stocks and changes in ecosystem services, the volume of inter-ecosystem flows is estimated as a function that combines the condition of an asset and its context in the landscape. Asset condition represents the intra-ecosystem flows. The landscape context represents the interdependence between

[i] The source data do not indicate whether the change was on public or private land.

an ecosystem asset and other ecosystems. The volume of ecosystem services on the other hand, is estimated as a function combining the inter-ecosystem flows and the “significance” representing an anthropocentric preference for the flows. The result is an index that represents an aggregate estimate of ecosystem services.

Disaggregating the index into measures of various classes of ecosystem services (i.e. provisioning, regulation and cultural) is not straight-forward. The “significance” information represents the anthropocentric demand (preference) for intra- and inter-ecosystem flows. For instance, suppose the significance is based on models of the distribution of rare or threatened fauna populations in Victoria. The models can indicate the varying degrees of significance of the habitats provided by terrestrial assets across the landscape. It can be argued that significance based on such models reflects the varying degrees of cultural ecosystem services (e.g. existence, genetic diversity as insurance for future generations) that those habitats provide. However, it is important to recognise that those terrestrial assets may also yield provisioning (e.g. pest control, pollination, water filtration) and regulating (e.g. wind control, flood control) ecosystem services.

Case study: Habitat

Table 10 is a case study on the reporting of inter-ecosystem flows involving habitat. In terrestrial ecosystems, habitat measurements indicate an asset’s ability to support faunal populations. This includes populations that are part of the ecosystem asset (e.g. keystone species), as well as populations that are considered part of other ecosystem assets. Habitat measurements provide a proxy for some inter-ecosystem flows that depend on the condition of an asset and its context in relation to other neighbouring assets. Context refers to patch size, core area and the structural and functional connectivity of the asset to its neighbours.

A terrestrial habitat measure known as “habitat hectares” (HHa)[24] is used as an indicator of inter-ecosystem flows. This measure combines the asset’s extent, condition and landscape context. The measurements represent the equivalent hectares of habitat compared to pre-European settlement. Note that the 1750 data represent the benchmark inter-ecosystem flows, where every hectare of terrestrial asset provides a hectare of habitat. This is indicative of the relative volume of inter-ecosystem flows in pristine ecosystems. Thus, the extent and inter-ecosystem flows columns in Table 10 show identical amounts in 1750. In 2005, however, most of the entries in the inter-ecosystem flows column show amounts that are well below the extents. The difference reflects the decline in both the asset condition and the landscape context (e.g. connectivity) reducing the inter-ecosystem flows involving terrestrial habitat.

Table 11 is a case study on how an indexed measure of ecosystem services can be derived from estimates of inter-ecosystem flows. In this example, the conservation significance of terrestrial habitats is used as a proxy for the anthropocentric demand for the inter-ecosystem flows. That is, it is assumed that the conservation significance reflects some valuable ecosystem services (e.g. cultural) and benefits that can be attributed to the inter-ecosystem flows. A function that indexes the inter-ecosystem flows in Table 10 according to their conservation significance leads to the relative measurements shown in Table 11. These indexed measurements can be interpreted as relative indicators of ecosystem services.

Note that the indexed measurements in Table 11 are meaningful only in terms of their relative magnitudes. For example, although Table 10 shows that “Mangroves” and “Naturally bare” assets have similar total extents (approx. 5,000 Ha) and inter-ecosystem flows (approx. 2,500 HHa) in 2005, however Table 11 indicates that “Mangroves” provide approximately 4 times more ecosystem services than “Naturally bare” assets. The greater value is most likely driven by our (anthropocentric) view that mangrove habitat is more important. Also note that although the indexed measure of physical flows may be indicative of the relative volume of some ecosystem services, the table is not an account of ecosystem services as described in SEEA: EEA. Further work is required to produce an account of ecosystem services where the rows contain a classification of the ecosystem services instead of a classification of the ecosystem assets.

Table 10. Victorian terrestrial extent and inter-ecosystem flows classified by Major Vegetation Group (NVIS): 1750, 2005

	1750		2005	
Major Vegetation Group (NVIS)	Extent (Ha)	Inter-ecosystem flows	Extent (Ha)	Inter-ecosystem flows
Native vegetation				
Acacia Forests and Woodlands	22,885	22,885	18,845	12,841
Acacia Open Woodlands	271	271	256	157
Acacia Shrublands	15,874	15,874	10,053	6,324
Callitris Forests and Woodlands	5,549	5,549	1,934	732
Casuarina Forests and Woodlands	1,003,122	1,003,122	190,513	97,980
Chenopod Shrublands, Samphire Shrublands and Forblands	214,488	214,488	113,563	65,558
Eucalypt Open Forests	6,346,166	6,346,166	4,976,481	3,371,130
Eucalypt Open Woodlands	1,223,235	1,223,235	250,677	120,004
Eucalypt Tall Open Forests	53,605	53,605	53,576	42,709
Eucalypt Woodlands	7,532,842	7,532,842	2,459,569	1,189,308
Heathlands	299,343	299,343	244,461	156,323
Low Closed Forests and Tall Closed Shrublands	206,330	206,330	35,241	15,406
Mallee Open Woodlands and Sparse Mallee Shrublands	213,785	213,785	43,380	23,874
Mallee Woodlands and Shrublands	3,395,152	3,395,152	1,577,654	934,773
Mangroves	7,025	7,025	5,006	2,777
Melaleuca Forests and Woodlands	89	89	65	36
Naturally bare - sand, rock, claypan, mudflat	4,619	4,619	4,459	2,320
Other Forests and Woodlands	63,290	63,290	55,756	43,552
Other Grasslands, Herblands, Sedgelands and Rushlands	202,082	202,082	97,547	53,732
Other Open Woodlands	122	122	77	34
Other Shrublands	295,419	295,419	159,251	96,819
Rainforests and Vine Thickets	44,109	44,109	40,164	31,118
Tussock Grasslands	1,302,356	1,302,356	139,989	55,640
Unclassified native vegetation	45,808	45,808	8,074	5,083
Total native vegetation	**22,497,566**	**22,497,566**	**10,486,591**	**6,328,229**
Land not classified as native vegetation				
Sea and estuaries	*1,677*	*NA*	*1,613*	*NA*
Inland aquatic - freshwater, salt lakes, lagoons	*197,128*	*NA*	*243,637*	*NA*
Cleared, non-native vegetation, buildings	*-*	*NA*	*11,955,418*	*NA*
Unknown	*-*	*NA*	*10,166*	*NA*
Unclassified	*2,976*	*NA*	*1,922*	*NA*
Total non-native vegetation	*201,781*	*NA*	*12,212,756*	*NA*

Table 11 Victorian terrestrial extent and indexed measurements indicative of ecosystem services: 2005

	2005	
Major Vegetation Group (NVIS)	Extent (Ha)	Indexed measurements indicative of ecosystem services
<u>Native vegetation</u>		
Acacia Forests and Woodlands	18,845.00	78,708.74
Acacia Open Woodlands	256.00	1,547.00
Acacia Shrublands	10,053.00	26,742.43
Callitris Forests and Woodlands	1,934.00	8,250.60
Casuarina Forests and Woodlands	190,513.00	677,441.72
Chenopod Shrublands, Samphire Shrublands and Forblands	113,563.00	245,015.51
Eucalypt Open Forests	4,976,481.00	5,472,889.55
Eucalypt Open Woodlands	250,677.00	568,374.15
Eucalypt Tall Open Forests	53,576.00	44,607.97
Eucalypt Woodlands	2,459,569.00	6,577,832.82
Heathlands	244,461.00	378,372.72
Low Closed Forests and Tall Closed Shrublands	35,241.00	168,027.43
Mallee Open Woodlands and Sparse Mallee Shrublands	43,380.00	74,397.95
Mallee Woodlands and Shrublands	1,577,654.00	2,156,610.46
Mangroves	5,006.00	24,899.39
Melaleuca Forests and Woodlands	65.00	296.10
Naturally bare - sand, rock, claypan, mudflat	4,459.00	6,772.20
Other Forests and Woodlands	55,756.00	64,271.68
Other Grasslands, Herblands, Sedgelands and Rushlands	97,547.00	342,322.49
Other Open Woodlands	77.00	376.50
Other Shrublands	159,251.00	374,731.56
Rainforests and Vine Thickets	40,164.00	239,379.79
Tussock Grasslands	139,989.00	631,654.88
Unclassified native vegetation	8,074.00	43,640.80
Total native vegetation	10,486,591.00	18,207,164.51
<u>Land not classified as native vegetation</u>		
Sea and estuaries	*1,613.00*	*NA*
Inland aquatic - freshwater, salt lakes, lagoons	*243,637.00*	*NA*
Cleared, non-native vegetation, buildings	*11,955,418.00*	*NA*
Unknown/no data	*10,166.00*	*NA*
UNCLASSIFIED	*1,922.00*	*NA*
Total non-native vegetation	*12,212,756.00*	*NA*

Table 12 is an example of an account showing the change in inter-ecosystem flows for two periods. Like previous tables in this section, this table uses habitat hectares as a proxy for inter-ecosystem flows. One habitat hectare is equivalent to one hectare of land in pristine condition. The table shows the changes in habitat hectares on public and private land in the period between 1994 and 2004[25]. The rows provide a classification of the causes of change. For example, there was an overall loss of 54,200 habitat hectares over the ten year period. This is equivalent to a loss of 54,200 hectares of pristine ecosystems.

The majority of increases in inter-ecosystem flows occurred on public land due to remnant management. The majority of losses in inter-ecosystem flows were on private land due to natural degradation in fragmented landscapes. There were also some losses as a result of vegetation clearing (1,752 habitat hectares), but these were more than offset by gains from revegetation (2,932 habitat hectares). There was also a change in management of terrestrial vegetation over the time period, with some land reclassified from private to public land.

Table 12. Change in Victorian terrestrial inter-ecosystem flows between 1994 to 2004

Terrestrial inter-ecosystem flows (HHa), Victoria	Public land	Private land	*Total*
Opening inter-ecosystem flows (~1994)	**1,182,532**	**5,199,897**	**6,382,429**
Additions			
Growth in inter-ecosystem flows			
• Managed improvement - remnant	80,320	43,770	*124,090*
• Revegetation	-	2,932	*2,932*
• Unmanaged regeneration	-	300	*300*
Upward reappraisals	unknown	unknown	-
Reclassifications	unknown	unknown	-
Total additions to inter-ecosystem flows	*80,320*	*47,002*	*127,322*
Reductions	-		
Extractions of inter-ecosystem flows			
• Vegetation clearing	-1752		- *1,752*
Normal loss of stock			
• Fragmented landscapes	- 28,500	- 148,200	- *176,700*
• Largely intact landscapes	- 3,070	-	- *3,070*
Catastrophic losses	unknown	unknown	-
Downward reappraisals	unknown	unknown	-
Reclassifications	unknown	unknown	-
Total reductions in inter-ecosystem flows	- *33,322*	- *148,200*	- *181,522*
Total change in inter-ecosystem flows	*46,998*	- *101,198*	- *54,200*
Closing inter-ecosystem flows (~2004)	**1,229,530**	**5,098,699**	**6,328,229**

Environmental Payment Accounts

The Environmental Protection Expenditure Accounts in the SEEA: CF, and the SEEA: EEA provide the combined information necessary to analyse the cost-effectiveness of expenditures on habitat and species conservation and the returns on investment at both national and regional scales. A significant area of interest is the link between physical measures of ecosystems assets and ecosystem services and standard economic transactions that are considered related to the environment. All of the definitions and treatments for these transactions as outlined in the SEEA: CF apply equivalently in SEEA: EEA.

Payments by government are recorded in a number of places in the national accounts and government finance statistics. The treatment largely depends on how the payments relate to production and consumption and whether they are considered to be current or capital in nature. The SEEA: CF provides a classification of environmental activities within the structure of the Classification of Environmental Activities (CEA). The CEA is a functional classification used to classify environmental activities, environmental products and environmental expenditures and other transactions. It covers two types of environmental activities: environmental protection and resource management[26]. There are 9 classes within the CEA environmental protection activities:

1. Protection of ambient air and climate
2. Wastewater management
3. Waste management
4. Protection and remediation of soil, groundwater and surface water
5. Noise and vibration abatement (excluding workplace protection)
6. Protection of biodiversity and landscapes
7. Protection against radiation (excluding external safety)
8. Research and development for environmental protection
9. Other environmental protection activities

The classes most relevant to the work undertaken by the DSE in environmental markets are 4, 6 and 9 (the Victorian government undertake work other classes but these are not discussed in this paper). Further, within functional accounts there is a need to determine whether the expenditure is considered current or capital in nature. In general, current expenditure focuses on the maintenance of an asset and capital expenditure of the improvement of an asset; the latter results in a long term net increase in services.

Environmental payments in Victoria

An important aspect of the Victorian approach to ecosystem accounting is the inclusion of information on payments for both current and capital expenditure in natural resource management. The aim of the expenditure is to maintain currently threatened assets and halt their decline over time and to increase the capital value of the asset so it produces more ecosystem services in the future. At this stage it is not possible to disaggregate the payments into current and capital expenditure.

The DSE has been designing and implementing environmental markets for over a decade with a focus on payments for ecosystem services using competitive allocation methods, specifically auctions for conservation contracts[27][28]. For example, the Victorian ecoMarkets program invests in actions (e.g. building a fence to exclude stock) that result in the protection of ecosystem assets and the generation of ecosystem services (e.g. clean water, improvement in catchment condition and habitat).

The following tables are based on an environmental tender valued at $2.4m ('EcoTender') that took place in the West Gippsland region, Victoria, Australia[29]. The results are limited to reporting the impacts of the tender and not other changes in stocks or services.

The account presented in Table 13 classifies the land according to land use and area. It shows 1,263 ha of agricultural land was reclassified from "Agriculture" to "Land used for maintenance and restoration of environmental functions" as a result of the landholders entering into environmental management contracts in the tender.

Table 13. Land Asset Flow Account, disaggregated by land use

Land - Physical (ha)	Agriculture	Forestry	Aquaculture	Use of built up and related areas	Land used for maintenance and restoration of environmental functions	Other uses of land	Land not in use	Total
Opening stock	739,687	120,430	-	82,359	758,572	3,400	9,371	1,713,819
Additions to stock								
Acquisitions								
Reclassification					1263			
Reduction in stock								
Natural losses								
Reclassification	-1263							
Closing balance	738,424	120,430	-	82,359	759,835	3,400	9,371	1,713,819

The land asset flow account does not reflect the change in flows of ecosystem services that have occurred as a result of the program. Table 14 below gives an example of how the land accounts can be used to present this information. This table is classified according to land use, as in Table 14 above, but now the unit is a composite index of the change in ecosystem services. The Environmental Benefits Index ('EBI') is designed to represent a composite estimate of provisioning, regulating and cultural services. This table shows that ecosystem services on "Agriculture" land declined over the period, whereas ecosystem services on "Land used for maintenance and restoration of environmental functions" increased as a result of improved management.

Table 14 is an experimental approach to producing SEEA: EEA physical accounts[30] without the ecosystem services being further classified into as provisioning, regulating and cultural services.

Table 14. Ecosystem service flow account, by land use, 2010 and 2015 (predicted)

Environmental Benefits Index (EBI)	Agriculture	Forestry	Aquaculture	Use of built up and related areas	Land used for maintenance and restoration of environmental functions	Other uses of land	Land not in use	Total
Annual EBI Flow to 30 June 2010	271,304,904							271,304,904
Increase in EBI flow due to:								
Improved management					35,855,034			35,855,034
Reclassification					270,155,361			270,155,361
Reduction in EBI flow due to:								
Natural losses	(84,838)							(84,838)
Reclassification	(270,155,361)							(270,155,361)
Annual EBI Flow to 30 June 2015	1,064,706				306,010,395			307,075,101
Change in annual flow								***35,770,196***

Concluding remarks

The paper has developed a series of experimental ecosystem accounts for Victoria based on principles from the SEEA: CF and the SEEA: EEA. The availability of data sets on ecosystem assets and environmental market transactions in Victoria makes it possible to test the practical application of SEEA: EEA. The paper demonstrates that SEEA: EEA provides an important framework for ecosystem accounting and a solid foundation for exploring the applications of ecosystem accounting in policy decisions and natural resource investments. However, there are still several challenges that require further research and discussion.

Work in Victoria will continue in a number of areas including:

- Linking intra- and inter-ecosystem flows to ecosystem services
- Refining methodologies for measurement and aggregation to better characterise intra- and inter-ecosystem flows
- Continuing to refine local data sets and work with both the Commonwealth and other state agencies to ensure a coordinated approach to the collection and presentation of data sets
- Improving the linkages between local environmental transactions and classification methods used in functional accounts in both the SNA and the SEEA:CF through work with the ABS
- Tailoring reporting and accounting to meet the needs of local, state and federal agencies.

Appendix A: Full data sets

All data sets and tables were produced with the aid of Victoria's Environmental Systems Modelling Platform (EnSym). For more information on EnSym, see https://ensym.dse.vic.gov.au/cms/

Please click on the links below to access the full data sets.

Victorian data sets

Tables Victoria for publication.xls

CMA data sets

Tables by CMA for publication.xls

Bioregion data sets

Tables by bioregion for publication.xls

SA4 data sets

Tables by SA4 for publication.xls

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