

5. Ecosystem accounting to inform decisions about forest management in the Central Highlands, Australia

By Heather Keith, Michael Vardon and David Lindenmayer

Fenner School of Environment and Society, Australian National University

Summary

Ecosystem accounts developed for the Central Highlands region, near Melbourne, informed government decisions about forest use. Currently, native forest timber harvesting conflicts with water provisioning, carbon sequestration, biodiversity conservation and recreation. The native forest on public land is managed under an agreement that guarantees wood supply within a defined area on public land and conservation within a national park boundary. This agreement is currently being re-negotiated. Synthesizing environmental and economic information in the form of ecosystem accounts allowed quantitative comparisons in physical and/or monetary terms that enabled trade-offs to be defined explicitly and spatially.

The accounts included values of ecosystem services and of economic value-added of industries that rely on the ecosystem services. Results demonstrated that a transition away from native forest harvesting would improve the condition of ecosystem assets, the conservation of biodiversity, and the provision of ecosystem services for other land uses, and would reduce the threat of extinction of critically endangered species. Economic gains from increased water supply and carbon storage exceeded the losses from ceasing native timber production. Results from the study are contributing to government decision making and public education.

5.1 The need for information to inform policy

This paper reports on the development and application of natural capital accounting (NCA) in the Central Highlands of Victoria, in south-eastern Australia. The accounts were developed over a 2-year period, specifically to feed information into government decisions about forest use in an area close to Melbourne, the capital city of Victoria.

Current land use activities in the Central Highlands of Victoria include timber production, biodiversity conservation, agricultural production, water supply, carbon sequestration, recreation and tourism. These activities are dependent on ecosystem assets and services, and their use can be either complementary or conflicting. Land can be managed for biodiversity conservation, water supply, carbon sequestration and ecotourism (minimal impact activities) in a complementary manner. Harvesting of native forests conflicts with the assets and services used by the previous activities. Agricultural production and plantations occur on different areas of land, but use some ecosystem services generated on the native forest land. The region is home to a wide range of species, including the endemic and critically endangered Leadbeater's Possum and Helmeted Honeyeater, the two faunal emblems of Victoria, as well as the world's tallest flowering plant, a eucalypt called Mountain Ash. The area provides practically all the water for Melbourne, a city of 4.4 million people, making it the second biggest in Australia. Water is also supplied for irrigating crops in

the surrounding farmland. The forests are some of the most carbon dense in the world and maintaining this stable and resilient store of carbon in a natural ecosystem is important for climate change mitigation. With its proximity to Melbourne, the region supports a large and growing tourism industry. There is a small timber industry that uses both wood supplied from native forests and plantations that produce paper pulp and sawlogs.

The region forms part of the Central Highlands Regional Forest Agreement that is due for re-negotiation in 2018. These agreements are made between state and national governments and legislate a 20-year plan for forest management that guarantees wood supply from defined areas. Proponents within the native timber industry have called for a guaranteed and expanded allocation of native forests for timber harvesting. By contrast, stakeholders within the environmental and tourism sectors have promoted an expansion of the national park network, proposed as the Great Forest Reserve System, to promote biodiversity conservation and eco-tourism. Negotiations of previous agreements have been protracted with controversial processes involving debates among public, industry, government and non-government organizations.

Managing the various activities within the region is complex and requires evaluation of the trade-offs between different land uses. Synthesizing environmental and economic information in the form of ecosystem accounts provided a basis for quantitative comparisons in physical and/or monetary terms that enabled trade-offs to be defined explicitly and spatially.

The study involved collating and synthesizing site and spatial data, and functions describing ecosystem processes to generate a time series. Data at different spatial and temporal scales required integration to develop consistent accounts that aligned with the area and timeframe of study. Data in the accounts were analyzed using physical and monetary metrics, ecosystem services and Industry Value Added, trends over time, and scenarios with changing land use to provide results relevant to natural resource management policy. In this paper, we describe briefly the process of developing the accounts; the outcomes in terms of results from the analyses and how they could inform decision making; communication strategies for the results about the Central Highlands to inform policy makers, scientific community and the public; and general lessons from this case study that are applicable for future work on ecosystem accounting. We compare experiences from this case study with the 10 living principles for making NCA fit-for-policy.

5.2 Process of developing ecosystem accounts

The study was undertaken within an academic institution using multi-disciplinary expertise. The need for information that can be provided by ecosystem accounts was identified by us as a useful input to the Regional Forest Agreement negotiations, as well as to inform both policy makers and the public. Additionally, developing a case study demonstrated the value of ecosystem accounting for policy making as part of the ongoing process of dissemination of the concepts and practices of NCA. Synthesizing information in the form of accounts was based on long-term ecological research in the region and understanding of the ecosystem. The goal was to provide an information system that would improve decision making by quantifying the relative values of different ecosystem services, the contributions of industries (native and plantation timber, tourism, water supply and agriculture) to the economy, and the potential trade-offs in changing land use activities. Goods and services that lie outside current economic systems were identified as unrecognized contributions of ecosystems to economic activity and human well-being, for example carbon storage and sequestration. The researchers provide and communicate information in the accounts but are not part of the policy process.

The framework of ecosystem accounts enabled a large amount of ecological and spatial data to be organized so that decision makers could see the potential for trade-offs. Previous reports about the region were polarized about the relative importance of specific environmental or economic factors. Ecosystem accounting provided a framework to incorporate a range of ecosystem assets and services, so that the analysis became broader than the two opposing viewpoints by incorporating a range of land uses and explicitly comparing their costs and benefits.

The process of developing the accounts involved collation and analysis of data from long-term research sites; adaptation and calculations using existing ecological models to describe ecosystem assets and services both temporally and spatially; and investigation of publicly available environmental, productivity and financial data in reports and spatial data. Key factors in synthesizing these data from varied sources was good ecological knowledge of the ecosystem, co-ordination of inputs from a range of disciplines, and the principle of using the best available data in terms of the most recent and highest resolution with subsequent aggregation where necessary.

A draft set of accounts was presented for discussion.¹ These were available on the web and presented at a workshop in Melbourne of key stakeholders and data providers in August 2016. The draft report was reviewed by national and international experts in accounting. Feedback from all these comments was incorporated in revisions of the accounts and their analysis. The updated and final accounts incorporated additional information on plantation forestry, new and corrected spatial data. The final set of accounts were published as a full report² and appendices³ on the web, as well as a summary report⁴ and factsheet⁵ in June 2017. A scientific paper based on the accounts was published in September 2017.⁶ Other forms of communication were also undertaken and are outlined below.

¹ Draft document for discussion 2016: https://fennerschool-associated.anu.edu.au/documents/CLE/VCH_Accounts_Summary_FINAL_for_pdf_distribution.pdf

² Full Report: <http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-full-report-high-res-40mb>

³ Appendices: <http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-full-report-high-res-31mb>

⁴ Summary Report: <http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-summary>

⁵ Fact Sheet: http://www.nespthreatenedspecies.edu.au/Ecosystem%20factsheet_single_V3.pdf

⁶ Keith H, Vardon M, Stein JA, Stein JL, Lindenmayer D 2017. Ecosystem accounts define explicit and spatial trade-offs for managing natural resources. *Nature Ecology and Evolution* 1: 1683-1692. DOI:10.1038/s41559-017-0309-1.

[https://www.nature.com/articles/s41559-017-0309-](https://www.nature.com/articles/s41559-017-0309-1.epdf?author_access_token=k0P9vV4GBmSSWVctcJwW19RgN0jAjWel9jnR3ZoTv00ZKuhU197jBGp3TvgY6Mmn9h7beuyfb07Vtkqzygh4co05os54UEUKASFsIz9SSgzdUTtb0Q4u3PhPkA66WrQoYYxJhtZwk5CZbK2kWGxxIA%3D%3D)

[1.epdf?author_access_token=k0P9vV4GBmSSWVctcJwW19RgN0jAjWel9jnR3ZoTv00ZKuhU197jBGp3TvgY6Mmn9h7beuyfb07Vtkqzygh4co05os54UEUKASFsIz9SSgzdUTtb0Q4u3PhPkA66WrQoYYxJhtZwk5CZbK2kWGxxIA%3D%3D](https://www.nature.com/articles/s41559-017-0309-1.epdf?author_access_token=k0P9vV4GBmSSWVctcJwW19RgN0jAjWel9jnR3ZoTv00ZKuhU197jBGp3TvgY6Mmn9h7beuyfb07Vtkqzygh4co05os54UEUKASFsIz9SSgzdUTtb0Q4u3PhPkA66WrQoYYxJhtZwk5CZbK2kWGxxIA%3D%3D)

Table 5.1 Accounts produced for the Central Highlands, their data layers and time periods

Account	Layers	Metrics Physical (P) and/or Monetary (M)	Years*
Land	Land cover	P	2005, 2013, 2015
	Land use	P	2006, 2010, 2014
	Land management	P	2015
Ecosystem extent	Land cover	P	1750, 1990 - 2015
Ecosystem condition	Logging history	P	1932 - 2015
	Fire history	P	1903 - 2015
	Forest age	P	1990 - 2015
Water asset (storage)		P & M	1990 - 2015
Water yield (inflows)		P & M	1985 - 2012
Water supply (abstractions)		P & M	1990 - 2015
Carbon stock		P & M	1990 - 2015
Carbon sequestration		P & M	1990 - 2015
Native forest timber	Wood volume & yield	P & M	2005 - 2014
Plantation timber	Wood volume	P & M	2006 - 2014
Agricultural		M	2010 - 2015
Tourism		M	2006 - 2014
Biodiversity	Threatened species	P	1990 - 2015
	Indicator species	P	1987 - 2015
	Habitat attributes	P	1998 - 2015

*A span of years refers to annual data, compared with individual years.

5.3 Outcomes from the accounts

Structuring information in the form of ecosystem accounts revealed the interactions between human activities and ecosystem assets, and their impacts on ecosystem extent and condition. Outcomes from accounts that can provide policy-relevant information often require analyses and interpretation of the data to provide quantified trends, scenarios or trade-offs. Data in the accounts were analyzed to investigate the relative benefits of ecosystem services and industries within the region to inform natural resource management decisions. Analyses were based on existing data and functions describing ecosystem processes (for example, tree growth and decomposition) to generate historical time series. Analyses were performed at three levels:

1. Values of ecosystem services, both currently valued but hidden in other information, and previously unrecognized, such as carbon storage and sequestration, and water yield
2. Values of economic output of industries that use ecosystem services as their contribution to industry value added (IVA) (with the sum of all IVA equal to GDP for the entire economy)
3. Potential gains and losses in IVA and ecosystem services under scenarios of changes in land use from timber production to forest protection.

The key outcome was the capacity to quantify ecosystem services and their contribution to industries, and hence explicitly reveal the trade-offs made or required when use of services by different industries conflicted or resulted in a reduction in ecosystem extent or condition.

For the Central Highlands, the time series of data in the ecosystem accounts and their subsequent analyses can inform decision making by:

1. Identifying change in ecosystem extent and condition and potential drivers from land use change, including the changing balance of economic activities in the region, biodiversity loss, carbon emissions and reduction in carbon stocks, influence of climate change and variability on water supply, expansion of built-up land and infrastructure and fragmentation of habitats
2. Tracking progress towards policy targets (based on historical time series), such as improving regional economic outlook or decreasing risks to threatened species and ecosystems
3. Assessing the sustainable use of natural resources, especially timber and water, by analyzing supply and use of ecosystem services and their change over time
4. Assessing the cost-effectiveness of expenditure on conservation of species or habitats
5. Enabling analysis of trade-offs between land uses with conflicting use of ecosystem services, and scenario modelling of change in land use from timber production for forest protection
6. Identifying goods and services that can be replaced easily while others cannot. Most of the timber from the native forest is used by a pulp and paper mill. Ready alternative products exist in the form of de-inked newsprint, recycled paper and plantation timber, so while ceasing native forest logging may increase costs of product supply, the production of paper can continue. Alternatives for the supply of water indicated likely problems: the quality of recycled water is insufficient for drinking water; transport from another region conflicts with local use and requires high energy inputs; desalination is expensive and has high energy inputs. The Mountain Ash forest is a unique ecosystem that provides services for recreation, particularly with its proximity to Melbourne.

The conclusions from the analyses of trade-offs between land uses, based on the data in the ecosystem accounts for the Central Highlands, were that a transition away from harvesting of native forests would improve the condition of ecosystem assets and provision of ecosystem services for other activities, such as water supply, carbon storage, culture and recreation, and biodiversity conservation. The accounts demonstrated that solutions to conflicting land uses could be seen as a process of maximizing benefits for the greatest number of beneficiaries.

Presenting information in the form of the accounts showed the relative economic contributions of key industries within the region, and the contributions of ecosystem services that were not recognized explicitly in economic data. The value of market goods was estimated, and the contribution of ecosystem services was undertaken. The information in the accounts identified trade-offs between land uses. The trade-offs were considered in the following terms:

1. The economic gains from increased water supply and carbon storage exceeded the losses from ceasing native timber production. Entering the carbon market could replace the money from native timber harvesting if the right regulatory framework was established.
2. A judgement about whether conservation of biodiversity in the threatened ecosystem of the Mountain Ash forest and reducing the threat of extinction of the critically endangered Leadbeater's Possum is worth the loss of the AUD\$12 million per annum from ceasing native forest timber harvesting

5.4 Communication

Outputs and analysis from the accounts have been communicated widely to government policy makers, political leaders, community groups, business community, organizations implementing accounting, and the academic community. Providing information in a policy-relevant form and

timely manner were important to contribute effectively to the public and political negotiations about forest management in the region.

Report

- Publication of the full report and appendices on the web
- Summary report and factsheet printed for distribution to stakeholders

Publication in the scientific literature

- Synthesis paper published in *Nature Ecology and Evolution*
- Papers on thematic accounts for carbon, water and biodiversity are in preparation and will be submitted to *Environmental Science and Policy*, *Ecosystem Services* and *Biological Conservation*.
- Methodological paper about carbon measurements will be submitted to *Austral Ecology*.
- Papers about accounting processes were contributed to the London Group Meeting on Environmental Accounting, including water accounts, ecosystem condition, methodologies and policy processes.

Publication in the popular literature and newsletters

- Science for Saving Species
- The Conversation, with an extensive online discussion with more than 50 comments
- EnviroNews
- World Bank global partnership Wealth Accounting and the Valuation of Ecosystem Services (WAVES) website and newsletter

Media

- Interviews on national radio plus local radio in Canberra and Melbourne
- ANU media release
- Short videos about ecosystem accounting and the Central Highland region available on YouTube

Government engagement

- Results from the accounts were used by the Victorian government forest industry taskforce.
- Researchers met with the Victorian Minister for Environment. The Victorian government is negotiating potential changes to the Regional Forest Agreement, with considerations about changing government regulations, subsidies, planning rules and industry support.
- Invited presentation at a workshop on environmental-economic accounting by the Commonwealth Department of Environment and Energy, held in Melbourne
- Invited contribution to a Department of Environment and Energy document on the national strategy for environmental-economic accounting, to be presented to the Meeting of Environment Ministers in December 2017
- Briefing to the Department of Environment and Energy sections on forest policy, threatened species conservation and environmental accounting
- Communication and response to the Assistant Minister for Agriculture and Water Resources about the Regional Forest Agreement

Education

The research from the Central Highlands is being used for teaching at ANU:

- ANU-ABS course Introduction to Environmental Accounting⁷
- Guest lecture to 3rd year course Complex Environmental Problems in Action

⁷ <http://fennerschool.anu.edu.au/education/short-courses/introduction-environmental-accounting>

The synthesized information presented in the accounts and the links between environmental and economic values has produced greater traction in political considerations than previous conservation advocacy. The ultimate impact is not yet known, as political decisions have not yet been made, but the accounts are being influential in shaping discussions.

5.5 Lessons for ecosystem accounting development

Implementing the SEEA ecosystem accounts in the Central Highlands has identified conceptual issues, data gaps and topics that require further consideration. These considerations include scale (1 to 4), dynamics (5, 6), and boundaries (7, 8):

1. Data are collected mostly at the site scale, but this must be scaled up to the landscape scale to be used in ecosystem accounts that relate physical and biological components of ecosystems within spatial areas. This is one of the most critical processes in implementing ecosystem accounting.
2. The experimental design for establishing monitoring systems and collecting site data is paramount so that the data can be scaled up successfully.
3. Site and spatial data need to be linked through relationships derived between site data and ecosystem characteristics that can be presented spatially, from remote sensing, survey, or ground-based classifications. The most relevant ecological processes that determine these relationships for different ecosystems need to be identified.
4. Economic data are generally available for large spatial areas not related to biophysical characteristics. More detailed economic and cadastral data, which is region- and industry-specific, would be valuable to improve spatial attribution of economic and social data to match environmental data.
5. Ecological processes need to be defined in terms of dynamic functions used to derive time series of accounts" for example carbon accumulation, decomposition, mortality, reproduction, dispersal, and collapse of dead trees.
6. Drivers of ecological change need to be identified and quantified, such as disturbance events and degradation processes. These drivers are important to understand the reasons for change in the past that are documented in the accounts, and to allow prediction of future changes.
7. Selecting the boundary for a study area is complex because the many sources of data integrated in the accounts use different boundaries, such as natural resource management area, catchments, local government, statistical areas, ecosystem types and land use regions. No single boundary will accommodate all the different sources of data. Furthermore, social, geographical and policy considerations all play a role in the selection of appropriate boundaries. Thus, consideration should be given to the appropriate boundaries and how these may impact findings, particularly in terms of how the choice of study area can best address the policy questions that need to be answered. In the Central Highlands, no existing boundary was appropriate, so a simple rectangular boundary was used that encompassed the site data and the area of forest under contention.
8. The boundary between market and non-market contributions from ecosystem services is difficult to define in many cases, but decisions are needed to ensure boundaries are defined explicitly and classifications are compatible and mutually exclusive. An example is the ecosystem service of water provisioning as the inflow to reservoirs and the water supply as the outflow from reservoirs.

5.6 Assessment of study in light of the “10 living principles”

The study was initiated before the 10 living principles for making NCA fit-for-policy that emerged from the 1st Policy Forum were conceived. In reviewing the principles now, only a few months since the publication of the final accounts, a number of observations may be made (Table 5.2).

Table 5.2 Assessment of the Central Highlands NCA against the “10 Living principles for making NCA fit-for-policy”

Principles	Observations from Central Highlands
Comprehensive	
Inclusive – acknowledging the diverse stakeholders concerned with decisions affecting natural capital, responding to their information demands, respecting different notions of value, and using appropriate means of engagement	A draft report and workshop were the primary means used to engage stakeholders. Much of the engagement was technically focused. The polarized positions about forest management were revealed in the workshop as well as in online discussion fora.
Collaborative – linking the producers of NCA, the users of NCA for policy analysis, and the policy makers using the NCA results; and building their mutual understanding, trust and ability to work together	The production of the accounts involved a multi-disciplinary team primarily of data producers, although some with experience in the policy area. Ongoing work is aimed at strengthening the links with policy.
Holistic – adopting a comprehensive, multi/interdisciplinary approach to the economic and environmental dimensions of natural capital and to their complex links with policy and practice	
Purposeful	
Decision-centered – providing relevant and timely information for indicator development and policy analysis to improve and implement decisions with implications for natural capital	Relevant information was provided in time for consideration of the accounting information in the decision-making process targeted.
Demand-led – providing information actually demanded or needed by decision makers at specific levels	Information was provided on the key industries (agriculture, forestry, water supply and tourism) within the region as well as key aspects of biodiversity. The study was initiated by researcher to inform policy and to demonstrate the benefits of accounts for policy.
Trustworthy	
Transparent and open – enabling and encouraging public access and use of NCA, with clear communication of the results and their interpretation including limitations of the data sources, methods and/or coverage	The draft and final accounts were published with extensive details of methodology and data sources. There was expert review of the accounts as well as a workshop to discuss the data sources and methodology. Comments received were incorporated into the final accounts.
Credible – compiling, assessing and streamlining data from all available sources; deploying objective and consistent science and methodologies	The journal article was published after a standard international peer-review process.

Mainstreamed	
<p>Enduring – with adequate, predictable resourcing over time; continuous application and availability; and building increasingly rich time series of data</p> <p>Continuously improving – learning-focused, networked across practitioners and users, trialing new approaches, and evolving systems to better manage uncertainty, embracing innovation and taking advantage of emerging opportunities</p> <p>Embedded – NCA production and use becoming part of the ‘machinery’ of government and business, building capacity, improving institutional integration for SD, and incorporating NCA use in procedures and decision-support mechanisms</p>	<p>The accounts were produced within an academic institution and not by government.</p> <p>The data sources and methods used could be used to repeat the accounts for the area and some could be applied to other areas.</p> <p>The process of developing the accounts has been shared with both national and state government agencies and are feeding into the development of environmental accounting in Australia and internationally.</p>

5.7 Future work

We are planning to apply the SEEA framework in a landscape dominated by agriculture to assess the relative values of land management activities on farm productivity compared with water supply, carbon storage, soil conservation, and biodiversity conservation. This will provide information to policy makers in a complex agri-environmental landscape.

Based on practical accounting in regional studies and developing conceptual frameworks for accounting, we will be continuing contributions to the following issues:

1. Biodiversity accounting, measurement, interpretation and recommendations for monitoring
2. Aligning results from carbon accounts with the policy needs for emissions reduction targets and payments for abatement activities
3. Developing the processes of linking accounting to government and business decision making

5.8 References

Experimental Ecosystem Accounts for the Central Highlands of Victoria. Keith H, Vardon M, Stein JA, Stein JL, Lindenmayer D 2017

Draft document for discussion 2016: https://fennerschool-associated.anu.edu.au/documents/CLE/VCH_Accounts_Summary_FINAL_for_pdf_distribution.pdf

Full Report: <http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-full-report-high-res-40mb>

Appendices: <http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-full-report-high-res-31mb>

Summary Report: <http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-summary>

Fact Sheet: http://www.nespthreatenedspecies.edu.au/Ecosystem%20factsheet_single_V3.pdf

Keith H, Vardon M, Stein JA, Stein JL, Lindenmayer D 2017. Ecosystem accounts define explicit and spatial trade-offs for managing natural resources. *Nature Ecology and Evolution* 1: 1683-1692. DOI:10.1038/s41559-017-0309-1.

[https://www.nature.com/articles/s41559-017-0309-](https://www.nature.com/articles/s41559-017-0309-1.epdf?author_access_token=k0P9vV4GBmSSWVctcJwW19RgN0jAjWeI9jnR3ZoTv00ZKuhU197jBGp3TvgY6Mmn9h7beuyfbO7Vtkqzygh4co05os54UEUKASFSiz9SSgzdUTTb0Q4u3PhPkA66WrQoYYxJhtZwk5CZbK2kWGXXlA%3D%3D)

[1.epdf?author_access_token=k0P9vV4GBmSSWVctcJwW19RgN0jAjWeI9jnR3ZoTv00ZKuhU197jBGp3TvgY6Mmn9h7beuyfbO7Vtkqzygh4co05os54UEUKASFSiz9SSgzdUTTb0Q4u3PhPkA66WrQoYYxJhtZwk5CZbK2kWGXXlA%3D%3D](https://www.nature.com/articles/s41559-017-0309-1.epdf?author_access_token=k0P9vV4GBmSSWVctcJwW19RgN0jAjWeI9jnR3ZoTv00ZKuhU197jBGp3TvgY6Mmn9h7beuyfbO7Vtkqzygh4co05os54UEUKASFSiz9SSgzdUTTb0Q4u3PhPkA66WrQoYYxJhtZwk5CZbK2kWGXXlA%3D%3D)