

Resources

Lifting farm gate profits: the role of natural capital accounts

Project number: RRD030-1617

February 2021



Photo credit: CSIRO

Level 11, 10-16 Queen Street
Melbourne VIC 3000, Australia
T +61 (0)3 9927 3200 E info@fwpa.com.au
W www.fwpa.com.au



**Forest & Wood
Products Australia**

Lifting farm gate profits: the role of natural capital accounts

for

Forest & Wood Products Australia

by

A.P. O'Grady, E.A. Pinkard, R.K. Schmidt, & I.D. Cresswell

Forest & Wood Products Australia Limited
Level 11, 10-16 Queen St, Melbourne, Victoria, 3000
T +61 3 9927 3200 F +61 3 9927 3288
E info@fwpa.com.au
W www.fwpa.com.au



Publication: **Lifting farm gate profits: the role of natural capital accounts**

Project No: RRD030-1617

This work is supported by funding provided to FWPA by the Department of Agriculture, Water and Environment (DAWE).

Rural R&D for Profit program (16-03-003)

© 2021 Forest & Wood Products Australia Limited. All rights reserved.

Whilst all care has been taken to ensure the accuracy of the information contained in this publication, Forest and Wood Products Australia Limited and all persons associated with them (FWPA) as well as any other contributors make no representations or give any warranty regarding the use, suitability, validity, accuracy, completeness, currency or reliability of the information, including any opinion or advice, contained in this publication. To the maximum extent permitted by law, FWPA disclaims all warranties of any kind, whether express or implied, including but not limited to any warranty that the information is up-to-date, complete, true, legally compliant, accurate, non-misleading or suitable.

To the maximum extent permitted by law, FWPA excludes all liability in contract, tort (including negligence), or otherwise for any injury, loss or damage whatsoever (whether direct, indirect, special or consequential) arising out of or in connection with use or reliance on this publication (and any information, opinions or advice therein) and whether caused by any errors, defects, omissions or misrepresentations in this publication. Individual requirements may vary from those discussed in this publication and you are advised to check with State authorities to ensure building compliance as well as make your own professional assessment of the relevant applicable laws and Standards.

The work is copyright and protected under the terms of the Copyright Act 1968 (Cwth). All material may be reproduced in whole or in part, provided that it is not sold or used for commercial benefit and its source (Forest & Wood Products Australia Limited) is acknowledged and the above disclaimer is included. Reproduction or copying for other purposes, which is strictly reserved only for the owner or licensee of copyright under the Copyright Act, is prohibited without the prior written consent of FWPA.

ISBN: 978-0-9586704-0-1

Authors:

A.P. O'Grady, E.A. Pinkard, R.K. Schmidt, & I.D. Cresswell
CSIRO Land and Water

Forest & Wood Products Australia Limited

Level 11, 10-16 Queen St, Melbourne, Victoria, 3000

T +61 3 9927 3200 F +61 3 9927 3288

E info@fwpa.com.au

W www.fwpa.com.au



Australian Government
**Department of Agriculture,
Water and the Environment**



Cover photos provided under a Creative Commons license from www.scienceimage.csiro.au.
Cotton on cotton plants. Photographer: CSIRO Plant Industry
The growth tips of a group of pine trees in a pine plantation. Photographer: CSIRO Forestry and Forest Products
A prawn. Photographer: CSIRO Marine Research

Contents

1	Abbreviations and glossary	1
	Plain English summary	5
2	Project rationale and objectives	8
3	Method and project locations	10
3.1	Biophysical conceptual models of natural capital in primary industries.....	10
3.2	Location	13
4	Project outcomes	15
4.1	Project-level achievements.....	15
4.2	Contribution to program objectives.....	30
5	Extension and adoption activities	31
5.1	Extension.....	31
5.2	Recommendations for future adoption.....	32
6	Lessons learnt	34
6.1	Were our hypotheses supported?	34
6.2	User capacity for implementing natural capital accounting.....	37
6.3	Data management and processing lessons.....	37
6.4	At what scale should natural capital accounting be applied?	39
6.5	Other insights.....	39
7	Recommendations	41
8	Appendix - additional project information	43
8.1	Project, media and communications material and intellectual property.....	1
8.2	Equipment and assets.....	2
8.3	Monitoring and evaluation.....	2
8.4	Budget.....	2

1 Abbreviations and glossary

Glossary

Account	<p>An organised set of records of transactions usually produced with double-entry bookkeeping methods.</p> <p>To recount a situation, provide a description of the situation from a particular perspective, '...to provide an account'.</p> <p>To be held accountable, '...to be called to account'. (BoM, 2013)</p>
Accounting boundaries	<p>A boundary is required to define what is to be covered by each of the accounts, also known as 'the territory', and what is the 'rest of the world'. For this project, depending on the account purpose, an accounting boundary may be:</p> <p>(i) an enterprise's biophysical boundary, where biophysical materials cross into or out of the enterprise's domain (whether owned, as for forestry or cotton, or licensed, as for fisheries);</p> <p>(ii) a region, district or sector (e.g. a forestry production region);</p> <p>(iii) any other relevant boundary, such as economic or ecological boundaries. For example, for economic purposes, it may be useful to define boundaries related to entities (typically enterprises, governments or households, see 'entity'). Ecological boundaries may be defined by impacts or dependencies that extend beyond the enterprise's biophysical boundary.</p>
Accounting framework	<p>Provides the standard concepts, definitions, classifications, accounting rules and tables for producing and organising statistics and data. (BoM, 2013)</p>
Accounting period	<p>Time period for which accounts are prepared and balanced. Usually annual (especially for economic accounts) but may be any set length of time. (BoM, 2013)</p>
Accumulation	<p>In economics, accumulation is the acquisition of tangible assets during a period of account minus the incurred liabilities.</p> <p>In ecosystems, accumulation is variously called 'biomass' or a 'reservoir' and the process of accumulation is known as 'growth' or 'sequestration'.</p>
Asset	<p>In economics, an asset is 'a store of value representing a benefit or a series of benefits accruing to the owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another'. (United Nations et al., 2009).</p> <p>An ecosystem asset is a store of value representing a series of benefits and opportunities accruing to all ecosystem participants by maintaining the processes of primary productivity, reproduction, growth (respiration), accumulation, release¹ and evolution (adaptation) over a period of time'. (Adapted from the economic definition)</p>
Basic spatial unit (BSU)	<p>Given the spatial nature of much environmental and ecosystem accounting, 'basic spatial units' (BSU) are defined for the purposes of compiling and arranging data. These BSU spatially partition the surface of the land to assist with quantification and, where appropriate, may be aggregated for statistical purposes.</p>
Biodiversity	<p>'The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and ecosystems.' (Convention on Biological Diversity—United Nations, 1992). In the SEEA-EEA, biodiversity is an ecosystem characteristic (United Nations, 2014a).</p>
Biophysical	<p>Encompasses all the physical and biological characteristics and interactions of the environment and ecosystems including geology, topography, climate, soils, solar energy, water, genetics, species and ecosystem structures, functions and processes.</p>
Biophysical boundary	<p>The boundary enclosing the biophysical elements of an entity, such as an enterprise. Typically, it will be defined spatially by property boundaries though, for public goods such as fisheries, it may be defined as the location of the relevant activity (e.g. fishable waters).</p>
Capital	<p>In economics, capital is a form of wealth, often an asset, owned or controlled by an individual or organisation and able to be used to produce goods and services.</p>
Causal pathway	<p>A causal pathway describes how the business interacts with natural capital and, where relevant, with society. There are two types of causal pathways; dependency pathways and impact pathways (See the specific glossary entries for those terms).</p>

Rural Research and Development for Profit program
Final report for *Lifting farm gate profits: the role of natural capital accounts*

Consumption	In economics, consumption is the use of goods and services for the satisfaction of individual or collective human needs or wants. In ecosystems, consumption (of ecosystem capital) is related to degradation and depletion.
Dependency	See 'natural capital dependency'
Dependency pathway	A dependency pathway shows how a particular business activity depends upon specific features of natural capital. It identifies how observed or potential changes in natural capital affect the costs and/or benefits of doing business. (Natural Capital Coalition, 2016)
Ecosystem	An ecosystem is 'a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit'. (United Nations, 1992; 2014a). Ecosystems include those that are human-influenced such as rural and urban ecosystems.
Ecosystem accounting	An 'integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activity.' (United Nations, 2014a).
Ecosystem asset	An ecosystem asset is an ecosystem that may provide benefits to humanity. They are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together (United Nations, 2014a). A subset of environmental assets with an emphasis on the living systems. They are environmental assets seen from a systems perspective according to the SEEA-EEA.
Ecosystem characteristic	'Ecosystem characteristics relate to the ongoing operation of the ecosystem and its location. Key characteristics of the operation of an ecosystem are (i) its structure (e.g. the food web within the ecosystem); (ii) its composition, including living (e.g. flora, fauna and micro-organisms) and non-living (e.g. mineral soil, air, sunshine and water) components; (iii) its processes (e.g. photosynthesis, decomposition), and (iv) its functions (e.g. recycling of nutrients in an ecosystem, primary productivity). Key characteristics of its location are (i) its extent; (ii) its configuration (i.e. the way in which the various components are arranged and organised within the ecosystem); (iii) the landscape forms (e.g. mountain regions, coastal areas) within which the ecosystem is located; and (iv) the climate and associated seasonal patterns. Ecosystems also relate strongly to biodiversity at a number of levels. For this reason, ecosystem characteristics include within and between species diversity, and the diversity of ecosystem types.' (Paragraph 2.4 in United Nations (2014a)).
Ecosystem service	Ecosystem services 'are the contributions of ecosystems to benefits used in economic and other human activity' ² (United Nations, 2014a).
Entity	In accounting terms, a clearly defined unit, such as an individual or an organisation, that engages in economic activities. Can be applied to other frameworks; for example, in the National Water Account, an entity is defined as holding or transferring water, or engaging in the management of water, and can include a physical reservoir. (BoM, 2013)
Environment	There are many potential meanings for the word environment but for this project, it is 'the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment...' (derived from United Nations, 2014b).
Environmental asset	See 'natural capital asset'
Flow	In economic accounts, flow refers to changes in the volume, composition or value of stocks. In ecosystem accounts, flows include the intra- and inter-ecosystem flows; flows of ecosystem services to humans; and flows of residuals (waste) to the environment. (Adapted from BoM (2013))
Impact	See 'natural capital impact'
Impact cause	A human activity or natural event that initiates a causal pathway. (Adapted from Bioregional Assessment Programme (2016)).
Impact investment	Refer to investments made into companies, organisations and funds with the intention to generate a measurable, beneficial social or environmental impact alongside a financial return
Impact mode	the way in which a causal pathway (initiated by an impact cause) could result in an impact. There might be multiple impact modes for each impact cause or causal pathway. (Bioregional Assessment Programme, 2016)
Inter-ecosystem flows	'Inter-ecosystem flows are flows between ecosystem assets that reflect ongoing ecosystem processes. An example is the flows of water between ecosystem assets via rivers.' (United Nations, 2014a)

Rural Research and Development for Profit program
Final report for *Lifting farm gate profits: the role of natural capital accounts*

Intra-ecosystem flows	'Intra-ecosystem flows are flows within ecosystem assets that reflect ongoing ecosystem processes. An example is nutrient cycling.' (United Nations, 2014a)
Joint Perspectives Model	A conceptual model of the relationships between the economy, society, and the environment. It is a systems-based approach that embeds the economy in society and then, in turn, society in the environment. Each horizontal slice represents a perspective unique to each system based on its emergent properties or characteristics (e.g., money in the economic system; genes in the living system). (BoM 2013)
Materiality	In the Natural Capital Protocol, an impact or dependency on natural capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision (Natural Capital Coalition, 2016)
Measurement unit	The unit used to measure the subject of the account and the 'currency' in which the account is set. This can be a monetary unit such as dollars or yen or a physical unit such as megalitres (of water) or tonnes (of carbon dioxide equivalents).
Natural capital	Natural capital is a relatively broad colloquial term that, when used in the non-specialist way, refers to the stock of environmental assets (including ecosystem assets and natural resources) and the flow this stock produces of ecosystem goods or services into the future. It is the living and non-living environment including, minerals, land, air, water, ecosystems and living organisms. More technically, natural capital consists of the environmental and ecosystem assets that produce the flow of ecosystem goods and services.
Natural capital accounting	The use of the System of Environmental-Economic Accounting (SEEA) methods to produce a natural capital account
Natural capital assessment	The process of measuring and valuing relevant ('material') natural capital impacts and/or dependencies, using appropriate methods, such as the System of Environmental-Economic Accounting (SEEA) (adapted from the Natural Capital Coalition, 2016).
Natural capital asset	Natural capital assets 'are the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity'. (United Nations, 2014a)
Natural capital impact	The negative or positive effect of business activity on natural capital. (Natural Capital Coalition, 2016)
Natural Capital Protocol	A standardized framework to identify, measure, and value direct and indirect impacts (positive and negative) and/or dependencies on natural capital.
Natural resources	Natural resources are a subset of environmental assets that are inputs to the economic system and that include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources.
Production	In economics, production is an activity that uses inputs of labour, capital, and goods and services to produce outputs of goods or services (OECD, 2013). Commonly, primary production refers to the outputs of farming. In ecosystems, production is an activity that uses inputs of ecosystem assets and flows to produce ecosystem assets and flows (adapted from the economic definition). In ecosystem science, primary production is the creation of plant biomass via the function of photosynthesis, that is, the basis of the food chain.
Residual (waste)	Outflow from the economy to the environment (e.g. solid, liquid and gas waste).
Resilience	'The capacity of a system to absorb disturbance and reorganise so as to retain essentially the same function, structure and feedbacks' (Walker and Salt, 2006).
Spatial boundary	The geographic area covered by the assessment, for example, a site, watershed, landscape, country, or global level. The spatial boundary may vary for different impacts and dependencies and will also depend on the organizational focus, value-chain boundary, value perspective, and other factors. (Natural Capital Coalition, 2016)
Stakeholder	Any individual, organization, sector, or community with an interest or "stake" in the outcome of a decision or process. (Natural Capital Coalition, 2016)
Temporal boundary	The time horizon of the assessment. This could be a current "snapshot", a 1-year period, a 3-year period, or a 25-year period, or longer. (Natural Capital Coalition, 2016)
Statistical unit	Statistical units are the entities about which information is sought and about which statistics are ultimately compiled. It is the statistical unit that provides the basis for compilation of statistical aggregates and to which tabulated data refer. In economic statistics, the statistical

Rural Research and Development for Profit program
Final report for *Lifting farm gate profits: the role of natural capital accounts*

	<p>units are the various establishments, enterprises, government and household entities about which economic data are collected.</p> <p>The statistical units of ecosystem accounting are spatial areas about which information is collected and statistics are compiled. For this project, the statistical units may be defined by (i) an individual enterprise's biophysical boundary, (ii) a group of enterprises' biophysical boundaries or (iii) any other relevant administrative, economic or ecological area. (adapted from United Nations, 2014a)</p>
Stock	<p>In economic accounts, stock is the amount of an asset (financial and non-financial) held at a particular time that has the capacity to produce goods or services.</p> <p>In environmental accounts, stock is the amount of an environmental or ecosystem asset that at a particular time has the capacity to produce environmental or ecosystem goods or services.</p>
Valuation	<p>In the Natural Capital Protocol, the process of estimating the relative importance, worth, or usefulness of natural capital to people (or to a business), in a particular context. Valuation may involve qualitative, quantitative, or monetary approaches, or a combination of these. (Natural Capital Coalition, 2016)</p>
Valuation technique	<p>The specific method used to determine the importance, worth, or usefulness of something in a particular context. (Natural Capital Coalition, 2016)</p>
Value (noun)	<p>The importance, worth, or usefulness of something. (Natural Capital Coalition, 2016)</p>
Value perspective	<p>In the Natural Capital Protocol, the perspective or point of view from which value is assessed; this largely determines which costs or benefits are included in an assessment.</p> <ul style="list-style-type: none"> – Business value: The costs and benefits to the business, also referred to as internal, private, financial, or shareholder value. – Societal values: The costs and benefits to wider society, also referred to as external, public, or stakeholder value (or externalities). (Natural Capital Coalition, 2016)
Value transfer	<p>A technique that takes a value determined in one context and applies it to another context. Where contexts are similar or appropriate adjustments are made to account for differences, value transfer can provide reasonable estimates of value. (Natural Capital Coalition, 2016)</p>
Value-chain boundary	<p>The part or parts of the business value chain to be included in a natural capital assessment. For simplicity, the Natural Capital Protocol identifies three generic parts of the value chain: upstream, direct operations, and downstream. An assessment of the full lifecycle of a product would encompass all three parts.</p> <ul style="list-style-type: none"> – Upstream (cradle-to-gate): covers the activities of suppliers, including purchased energy. – Direct operations (gate-to-gate): covers activities over which the business has direct operational control, including majority-owned subsidiaries. – Downstream (gate-to-grave): covers activities linked to the purchase, use, reuse, recovery, recycling, and final disposal of the business' products and services. (Natural Capital Coalition, 2016)
Worldview	<p>The philosophy and set of values and objectives that an individual or organisation brings to conceptualising its interactions with the environment and society.</p>

Plain English summary

Natural capital is the stock of renewable and non-renewable resources that ecosystems supply and that enterprises use. Ecosystems can be considered as assets that produce bundles of goods and services that humans use. Growing concerns about the depletion of natural resources and the capacity of ecosystems to continue to provide these goods and services has been a key driver in developing methods for taking stock of, and accounting for, the value of the goods and services that nature provides.

All business relies to some extent on natural capital. However, primary industries are particularly exposed to risks associated with the changing stocks of natural capital. Historically, little consideration has been given to natural capital formally as inputs into production as they have been considered to be largely limitless resources. However, as demand grows for agricultural produce and access to natural capital is more contested, new approaches are required to better track, account for and manage these shared natural resources.

Objectives

The objective of the Rural Research for Development and Profit program is to lift farm gate profitability of primary producers across Australia, by investing in emerging tools and technologies, strengthening the path to adoption and fostering new collaborations. This project targeted the program objective of better management of natural resources to improve certainty of supply, sustainably develop new production areas and improve the resilience of existing production to potential future shocks associated with factors such as climate change.

The project tested the application of natural capital accounting in three primary industries: cotton, fisheries and forestry. Natural capital accounting measuring stocks of ecosystem assets, their changes through time and the flow of ecosystem services from these ecosystem assets. The 'invisibility' of these stocks and flows constrains the capacity for industries to measure and report their environmental performance and track against financial performance. Initially we hypothesised that natural capital accounting could increase farm gate profitability via three pathways:

- increased sustainability credentials and access to premium markets,
- discounted finance associated with reduced natural capital risk,
- improved capacity to engage in emerging environmental markets.

The primary objectives of the project were to:

- develop detailed conceptual models of the relationships between natural capital and the industries
- use these conceptual models to define the scope and objectives of natural capital accounts
- trial the application of natural capital accounting.

Methods

The project applied the principles of natural capital assessment as outlined by the Natural Capital Protocol to characterise the relationship between enterprises and natural capital (NCC, 2016). This involved the development of a conceptual model of the dependencies and impacts of each industry on natural capital and ecosystem assets. Cost-efficient and measurable indicators of the extent and condition of these ecosystem assets were then chosen and measured. The resultant accounts were designed to be coherent with the System of Environmental-Economic

Accounting – Experimental Ecosystem Accounting (UN, 2014). SEEA-EEA allows ecosystem assets to be reported in an accounting framework in a manner that is consistent internationally and can ultimately be integrated into the System of National Accounts.

Outputs

The main outputs were:

- syntheses of extensive stakeholder consultation within each industry to test the value proposition for natural capital accounting, better understand the level of knowledge and awareness of natural capital thinking within the industry, and to help define the objectives for natural capital accounts within each industry.
- conceptual models of the interactions of enterprises with natural capital.
- proposed shell accounts so that enterprises can get started with standardised reporting within each industry
- example accounts for each of the case studies, enabling an improved understanding of the logistical challenges associated with compiling and interpreting relevant information.

Outcomes and collaborations

Application of natural capital accounting is at its infancy in Australia, and capacity and capability for natural capital accounting is currently low. Key outcomes from this work have been:

- An improved understanding of the objectives and value propositions for natural capital accounting across the primary industries that highlight a broader range of benefits than originally hypothesised, particularly in relation to reporting environmental performance, management and risk disclosure.
- A framework for standardised industry-specific accounting and a pathway for individual enterprises to trial accounts, using our conceptual models and shell accounts.
- Methods and examples of biophysical accounts, which are directly useful, and provide the foundation for future valuation of the stocks and flows in monetary terms (if desired).
- Raising of the profile of natural capital accounting, and its associated benefits, through extensive engagement with stakeholders across diverse primary industries. We have seen growing interest and increased evidence of adoption by leading enterprises and land managers across the primary industries.
- Unique collaborations have emerged across quite disparate cotton, fisheries and forestry industries, and their respective Research & Development Corporations. A surprising overlap in the value propositions for each industry provides common ground for industries to move forward.
- New projects emerged during this work in both fisheries and forestry with good prospects for ongoing development of the foundations established in this project.

Recommendations for future research and adoption

Future investments in this area should be focused on mainstreaming enterprise-scale natural capital accounting within the primary industries. This should focus on three key pre-competitive areas:

- improving natural capital capability and capacity within primary enterprises and particularly within primary producers, their advisors and accountants
- addressing key knowledge gaps in the relationship between enterprises and natural capital:
 - asset condition

- the flows of ecosystem services
- improving the supply of account-ready data and indicators to reduce entry barriers for enterprises who want to adopt natural capital accounting.

Benefits of the project to primary producers

Primary producers who adopt natural capital accounting will have early-mover advantages on global trends in sustainable production.

- Primary producers will be able integrate the environmental costs of production into the financials and decision making of the enterprise.
- Global supply chains are now starting to make decisions based on their perceived sustainability of production. Natural capital accounting speaks directly to this push.
- Global markets and impact investors are demanding investments in natural capital. Savvy Australian producers will be well primed when they can demonstrate and verify environmental outcomes associated with management.
- Markets for environmental services – for example in biodiversity and land stewardship – are emerging in addition to existing markets for carbon. Natural capital accounting provides a robust framework for demonstrating and verifying the concept of additionality, central to these markets.

Collaborations

The project has seen new collaborations emerge across quite disparate primary industries: cotton, fisheries and forestry. Although these might be deemed quite contrasting industries, the considerable overlap in the value propositions provides a common grounding for these to move forward. New projects have emerged during this work in both forestry and fisheries with good prospects for ongoing development of the foundations established in this project.

2 Project rationale and objectives

Australian agriculture has evolved under an economic and environmental context that is likely to be vastly different in the future (Grundy et al. 2016). The agricultural industry has laid out a vision to increase agricultural production to \$100 bn by 2030 (NFF Roadmap). However, achieving this vision faces significant challenges. For example, climate change, increasing pressure for environmental resources, environmental degradation and growing consumer awareness of the potential impacts associated with production are driving a requirement for greater transparency and accountability around the dependencies of agricultural production on natural capital and the associated impacts of production on those resources.

The Australian situation is not unique. Globally there is growing awareness of the limits to economic growth associated with unsustainable exploitation of natural resources and the potential risks associated with rising demand for agricultural production required to feed and clothe a population approaching 10 billion by 2050. In a recent analysis of natural capital costs associated with agriculture, natural capital costs of production were up to 170% of the production value of the commodity, with approximately 65% of these costs associated with the management practices (FAO, 2017). Australia's environmental performance may be considerably better than this however, there is a lack of credible information with which to make such assessments and there is growing awareness that many of these risks are potentially material. Australian agricultural industries are stewards of significant pools of natural capital and have significant dependencies on this natural capital. However, it currently lacks the tools and approaches required to integrate knowledge of the status and trends of the environmental assets under management with the financial performance of the farming system. The invisibility of these risks leading to potential disruption of the continued flow of these environmental goods and services could potentially constrain the flow of capital required to grow the industry as outlined by the 2030 vision for Australian Agriculture.

To address these concerns, there is growing interest in the concept of natural capital assessment and natural capital accounting (England 2000, Ekins, Folke et al. 2003, Guerry, Polasky et al. 2015, Helm 2019). Natural capital refers to the pools of renewable and non-renewable resources that ecosystems provide, are used by society in conjunction with other forms of capital, e.g. financial, manufactured social and human to generate goods and services that society values (Guerry et al. 2015, Costanza et al., 2014). Natural capital assessment is a structured process for systematically analysing the dependencies of an enterprise on underlying natural capital assets (the natural inputs to production) and identifying material risks to those dependencies. Natural capital accounting is the process of documenting the stocks of natural capital assets and the flows of environmental services that are generated by these and their interaction with the financial performance of the company, allowing a more complete view of the costs of production and the state of the underlying natural capital. Together these approaches provide a powerful foundation upon which natural capital dependencies can be identified, tracked and linked to financial performance.

Whilst there is considerable and growing interest in the potential of natural capital assessment and natural capital accounting to support sustainable production in the longer term, there are relatively few examples of its application in the primary industries, making it difficult to assess how easily the concepts can be applied and how useful they are in actual decision making at the

enterprise scale. Furthermore, there is only limited understanding of the underlying concepts and hence its potential to create further value for enterprises.

In this project we have trialled the application of two emerging natural capital frameworks to the primary industries sector in Australia. The natural capital protocol (NCC, 2016) has emerged from and builds on a considerable body of work aimed at better incorporating natural capital thinking into business decision making for example the TEEB initiative (The Economics of Ecosystems and Biodiversity, (TEEB, 2010) the corporate ecosystem review (WBCSD 2008), and the guide to corporate ecosystem valuation (WBCSD 2011). The protocol provides a framework for systematically exploring the risks and opportunities associated with a business's dependencies on natural capital, with the intent to provide better business intelligence to decision makers. The framework outlines nine steps for framing, scoping and executing a natural capital assessment. However, it remains flexible in the approaches required to execute each of the steps.

Simultaneously the United Nations System of Environmental and Economic accounting (UN 2014a, UN 2014b) has led the development of approaches for national and regional environmental accounting, and it has emerged as an international standard for capturing the flows of environmental goods and services and their contributions to the economy. While principally designed to support the System of National Accounts, there is growing interest in its application at enterprise level. The advantages of developing internationally consistent approaches are twofold. Firstly, this potentially facilitates the aggregation of environmental data collected at enterprise scales to national environmental accounts. Secondly, the application of internationally agreed environmental accounting standards ensures that environmental performance is reported consistently and facilitates benchmarking within and between sectors of the economy.

The future growth of Australian agriculture is dependent on the maintaining and improving the flow of environmental goods and services to support production (Cork et al 2012). Furthermore, increasing the productivity and profitability of the sector is central to the Australian government's policy agenda. In this project we set out explore the proposition that natural capital thinking is pivotal to this goal. We argued that for business to remain profitable, assessing and accounting for its impacts on natural capital and adjusting operations to minimise depletion of key pools of natural capital would drive future productivity and profitability of the sector. Improved productivity and profitability would be driven by:

- an improved readiness and capacity to engage in environmental markets as they emerge
- reduced costs associated with finance, as the finance sector is increasingly looking to price in risks associated with the natural capital
- consistent and accountable environmental reporting to potentially attract price premiums as downstream processors increasingly include production sustainability into their procurement decision making.

The primary objectives of the project were to:

- develop detailed conceptual models of the relationships between natural capital and the industries
- use these conceptual models to define the scope and objectives of natural capital accounts
- trial the application of natural capital accounting.

3 Method and project locations

3.1 Biophysical conceptual models of natural capital in primary industries

A large and complex environmental system produces the environmental goods and services that underpins primary production. Often these interactions are poorly understood making selection of what should be measured a daunting task. It is not feasible to measure all of the natural capital that comes together as inputs into the production of the foods and fibres that Australian agriculture produces. Nor is it feasible to measure all of the ways that agricultural activities can deplete and degrade the very natural capital upon which the enterprises rely. Yet natural capital accounting is reliant on exactly that measurement of the stocks and flows of environmental goods and services. In the early phases of natural capital accounting this becomes a particularly vexing problem.

This is the problem that this project has challenged. We have applied systems-based thinking to identify and define the measurement of natural capital and built an evidence base to support that conceptualisation.

The starting point for this conceptualisation was the Joint Perspectives Model (Figure 1) which recognises that human cultural systems and the economic system are subsets of and build upon the underlying natural systems, the stocks of which form the basis of the natural capital that underpins the human and economic systems (BoM, 2013). With this as a starting point the project then set out to develop a conceptualisation of the Joint Perspective Model for Australian Agriculture. The broad approach used for this conceptualisation was grounded in the Natural Capital Protocol (NCC, 2016). The natural capital protocol has emerged internationally as an important tool for conceptualising the interactions of enterprises with natural capital and exploring the risks and dependencies associated with the use of those natural capital assets.

Acknowledging this complexity, we adapted the Natural Capital Protocol to define the interactions of the human and economics systems with the underlying natural capital; the living and physical earth systems. The Natural Capital Protocol provides a standardised framework designed to assist business identify, measure and value the direct and indirect impacts, positive and negative, and /or the dependencies on Natural capital. An overview of the structure of the Natural Capital Protocol is shown in Figure 2.

Finally, we have tested our approach by developing a set of natural capital accounts for case studies in each industry. The approach involved the application of the United Nations System of Environmental-Economic Accounting-Experimental ecosystem accounts. While primarily designed to address issues associated with national scale environmental economic accounting, we have tested the application of SEEA at the enterprise scale.

Within this framework the research was built around 5 major activities (Figure 2):

- Activity 5.1 – Define the objectives for enterprise-scale natural capital accounting
- Activity 5.2 – Identify the key sources of natural capital in each industry
- Activity 5.3 – Identify approaches to measure and report key impacts and dependencies
- Activity 5.4 – Develop framework for data processing and synthesis
- Activity 5.5 – Pilot natural capital accounting in cotton, fisheries and forestry.

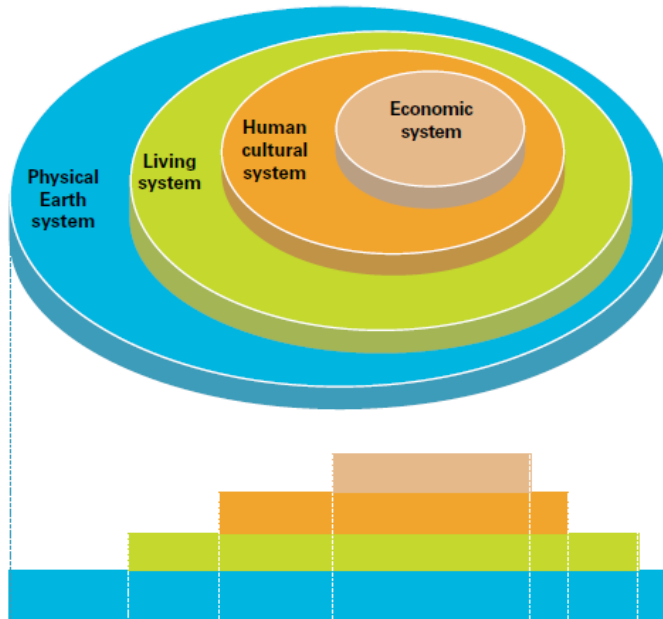


Figure 1 Joint perspective model

In this cross section, vertical lines delineate the systems, while the horizontal slices represent the different perspectives from which systems can be viewed. Thus, while the economic system is generally viewed from the economic perspective, it can also be viewed from the physical earth, living system or the human cultural system perspectives, because it is in turn made up of components from each of these systems. Source: (BoM, 2013).

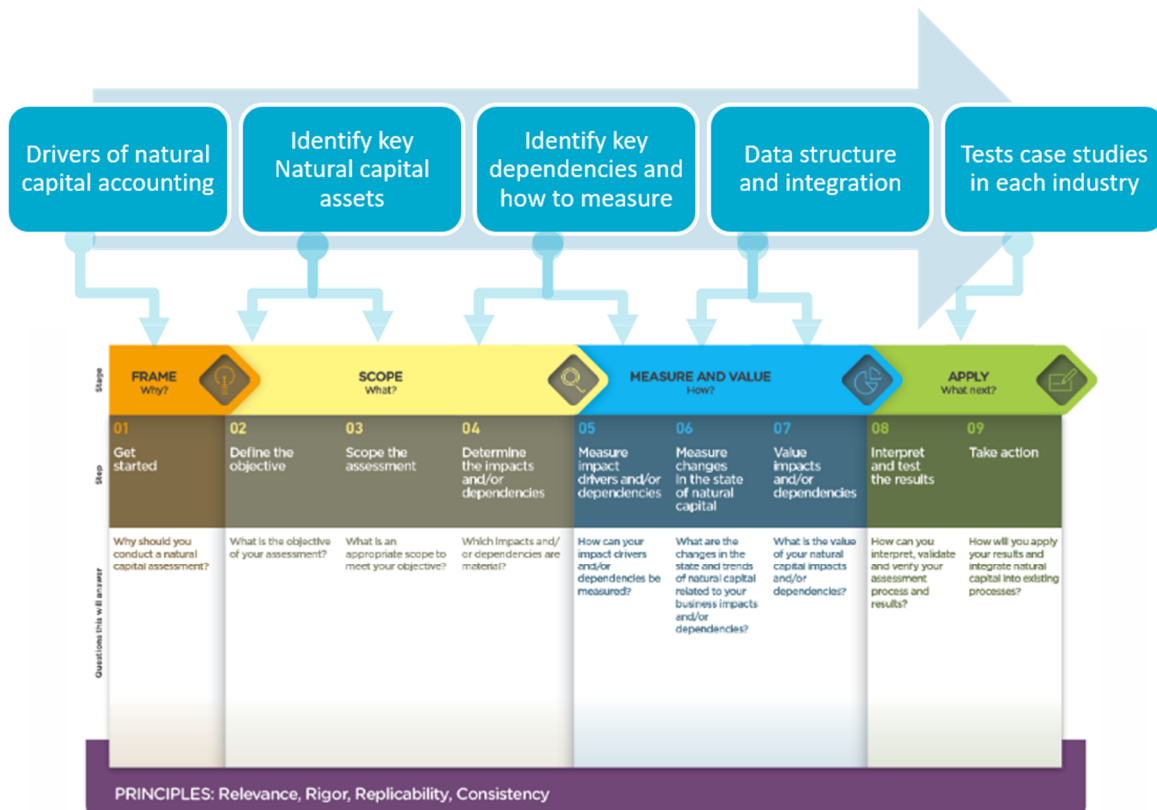


Figure 2 Alignment of the project activities with the major steps proposed by the Natural Capital Protocol for natural capital assessment

3.1.1 Define the objectives for enterprise-scale natural capital accounting

We conducted extensive stakeholder consultation with representatives of each of the three industries and broader interest groups. This involved approximately 140 one-on-one interviews with a broad cross section of stakeholders. We used a semi-structured interview process aimed at identifying:

- the level of knowledge among stakeholder in relation to natural capital
- the value proposition for natural capital accounting in the primary industries and its alignment to the value propositions proposed as part of the project conceptualisation
- what natural capital information the industry currently collects and how it uses this information
- how natural capital accounting would influence key operational and financial decisions within the industry
- key stakeholders the industry would engage with using the additional information gleaned from a set of natural capital accounts.

3.1.2 Identify the key sources of natural capital in each industry

Using literature review and insights gleaned from the stakeholder engagement process, we developed a detailed conceptualisation of the interactions of each industry with the underlying natural capital associated with key system drivers for that industry.

Based on this we constructed an evidence based conceptual model of each industry and its relationship with natural capital.

3.1.3 Identify approaches to measure and report key impacts and dependencies

Using the conceptual model developed above we identified high-priority dependencies and impacts on natural capital:

- We developed a structured natural capital impact analysis (NCIA) tool to assess and prioritise the causal pathways identified in the conceptual model. The NCIA is an adaptation of a well-established risk assessment framework, failure modes and effect analysis (Ostrom and Wilhelmssen, 2012).
- Expert elicitation, in either workshop or one on one settings, was used to rank causal pathways, and evidence reviews were conducted to test the underlying assumptions of the experts.
- We conducted a systematic review of existing indicator schemes to identify existing indicators that were relevant to the identified causal pathways. Indicators were then assessed for their potential usefulness for natural capital accounting and the availability and cost of data acquisition.

3.1.4 Develop approaches for data structure and integration

Workflows used in this project were developed using concepts embedded in reproducible research. This philosophy was used to develop a custom-designed spatial information system named SynthEEA (Synthesis for Environmental-Economic Accounting) to streamline natural capital accounting and provide standardised, reproducible, auditable and efficient methods for processing the disparate datasets required for the compilation of natural capital accounts. SynthEEA uses a series of R scripts to interact with a spatial databases, and other

information types to manage the accounting process from data ingestion through to generating charts and tables, consistent with the measurement and reporting principles in the UN System of Environment and Economic Accounting, and to ensure that analysis of data can be performed in a consistent and reproducible way across the case studies.

3.1.5 Test the application of natural capital accounting

Experimental natural capital accounts were trialled for the cotton, fisheries and forestry case studies using the System of Environmental-Economic Accounting-Experimental Ecosystem Accounts to guide the structure and development of accounts

The project outputs and case studies have broader relevance to each of the industries involved as the conceptualisation of the industry was designed to be useful for multiple enterprises in one location or industry, and/or could be adapted at the scale of an individual enterprise. The proposed natural capital accounts provide a basis for any enterprise within the industry to adopt and trial natural capital accounting within their enterprise, industry or region.

3.2 Location

The locations of the case studies are shown in

Figure 3.

- The cotton case study was a private enterprise in Emerald, Queensland.
- The fisheries case study focussed on the prawn-fishing industry in Wallis Lake estuary in NSW.
- The forestry case study was focussed on the forestry industry in the Green Triangle, a National Plantation Inventory region that spans the border of Victoria and South Australia.

Forest and Wood Products Australia led the project from Melbourne.

The core of the research team was based in CSIRO in Hobart and Canberra. Two of the case study teams were based in Hobart, Tasmania (forestry and cotton) and the third team (fisheries) was led from Canberra, with contributions from scientists in Hobart and at the University of Newcastle.

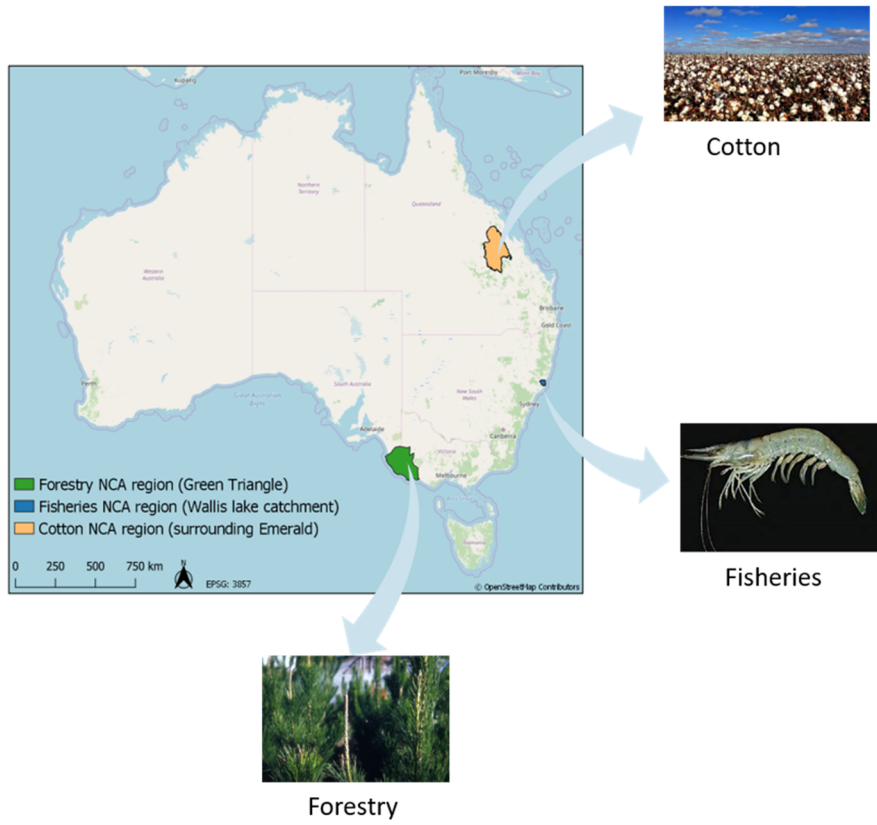


Figure 3 Location of the case studies

4 Project outcomes

4.1 Project-level achievements

Overall, the project ran according to the project plan. Progress against the indicators in the monitoring and evaluation plan was excellent, with most of the indicators met or exceeded. There was a strong focus on communications and extension, with the project team leading or contributing to a range of communication activities including one-on-one elicitation, stakeholder meetings, national workshops and international meetings. The broad range of stakeholders involved – ranging from primary producers to international investment managers – highlights the diverse and growing interest in natural capital accounting.

There was excellent progress toward project outcomes. Evaluation of the project against indicators demonstrates these were achieved. The project outputs provide a framework for those in the sector to start to apply natural capital accounting at the enterprise scale. An increasing number of case studies underway or planned in the short term suggests that activity and adoption in natural capital accounting will accelerate quickly over the next five years.

It is too early to assess the progress towards the three planned impacts of this project:

- improved profitability of primary industries
- improved resilience of rural communities
- improved management of Australia's natural resources and enhanced outcomes for the environment.

Our work has demonstrated the value proposition for natural capital accounting is strong. Natural capital accounting provides a robust method for tracking the condition of environmental assets and linking with an enterprise's financial performance. International standards are emerging, and markets in natural capital finance are evolving rapidly. A robust and verifiable system of natural capital accounting in Australian primary industries positions the sector well to capitalise on these opportunities.

Challenges remain, however, mainly associated with developing capacity and building capability within the sector, particularly amongst primary producers and their advisors, and accessing affordable and fit-for-purpose data. However, it is anticipated that these barriers to entry will come down quickly as existing case studies and new projects roll out natural capital accounting within primary industries.

4.1.1 Grant activity

Grant activities were built around 5 key activities:

- Activity 1: project initiation
- Activity 2: project planning and management
- Activity 3: communication and extension
- Activity 4: monitoring and evaluation
- Activity 5: research activities.

A summary of project achievements against each of these activities is provided below. A summary table of the status of project milestones and KPIs is provided at Table 1.

Table 1 Overview of project milestone status at the time of this final report

Milestone	KPI	Status
Milestone 1	Execution of agreement	Achieved
Milestone 2	KPI 2.1, 2.2	Achieved
Milestone 3	KPI 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7	Achieved
Milestone 4	Annual financial report	Delivered
Milestone 5	KPI 5.2, 5.2, 5.3, 5.4, 5.5	Achieved
Milestone 6	KPI 6.1, 6.2, 6.3, 6.4, 6.5	Achieved
Milestone 7	Annual financial report	Delivered
Final report	Final report as per template	This report
Final financial report	Final financial report	Pending

4.1.2 Project initiation

Key achievement: The head agreement with the Commonwealth was signed on the 22nd June 2017. Signing of individual partner agreements took approximately 6 months to complete, delaying the start of key project activities for this period. Final agreements with all partners were completed by 18 January 2018 (KPI 1.1) allowing for formal commencement of project activities.

4.1.3 Project planning

Key achievement: Overall, the project has been run to the milestone schedule as outlined in the grant agreement. No variations in the agreement were sought during the life of the project and the project was run largely to the plan outlined by the heads of agreement. Input into the project by the steering committee was excellent, and feedback to the research team constructive and helpful. Final project reports were delivered slightly later than planned, variance <1 month. This was largely due to the delayed start to the research activities (Activity 5) associated with the six-month timeframe for signing of partner agreements. More detail on research activities is provided below.

Progress notes: The project steering committee was convened at the project inception meeting on 20th April 2018. The meeting, held at the Melbourne Park Royal, was chaired by Jim Houghton of FWPA and was attended by representatives of all project partners. A schedule of steering committee meetings for the project is shown in Table 2. The key objectives of the inception meeting were to present the draft project plan, monitoring and evaluation plan and communications and extension plan for consideration by the steering committee (KPI 2.2). Feedback from the steering committee was incorporated and the plans were accepted as final by Milestone 3, on 11 June 2018 (KPIs 3.1, 3.2, and 3.4).

All milestones were met by the due date during the execution of the project. Milestone 6 on 15 July 2019 was provisionally accepted by the department pending further feedback on the midterm evaluation of the project (KPI6.2) and an update on the status of condition (KPI 5.3, 6.4). Additional information on these was provided to the department by the 12th Feb 2020.

Table 2 Schedule of steering committee meetings throughout the project

Steering committee	Date	Venue	Purpose	Attendance
Inception meeting	14 th April 2018	Airport Park Royal	Overview of project plan, Monitoring and evaluation plan and communications and extension plan	100%
Steering committee	26 th Nov 2018	Holiday Inn, Melbourne airport	Presentation of project progress on industry conceptualisations for each case study.	80%
Steering committee	8 th August 2019	Holiday Inn, Melbourne airport	Progress on enterprise conceptualisations and example accounts	80%
Steering committee	May 2020	PHU	Final report.	

4.1.4 Communications and extension

Purpose: An important objective of the Rural Research for Development and Profit Program is to ensure that research activities and programs are exposed to a wide range of stakeholders from across the innovation sector with a focus on strengthening pathways to extend the results of rural R&D.

Key achievements:

- A communications and extension plan was developed and approved by the project steering committee (KPI3.2). A detailed list of communications and extension activities is provided in Section 8.1. The project team were actively engaged in a wide range of fora, promoting the project at a range of scales, varying from the enterprise scale to international forums on natural capital accounting and environmental-economic accounting.
- A fact sheet was developed for the project and distributed as part of the stakeholder engagement.
- The project team conducted extensive stakeholder engagement (~140 one-on-one interviews) throughout the project (CSIRO ethics permits 10/18, 140/190). The primary aim of these was exploring the value proposition for natural capital accounting. However, industry experts and professionals were also engaged in identifying and prioritising causal pathways for impacts and dependencies, ensuring that outcomes were relevant to the industry. These have built awareness of the project within the cotton, fisheries and forestry industries.

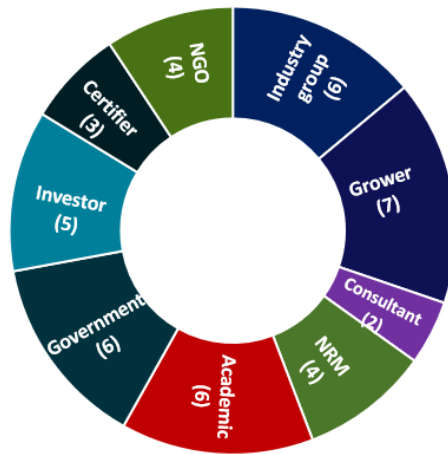
"We are really looking forward to seeing the outputs of your research into this field"

-- forestry industry professional

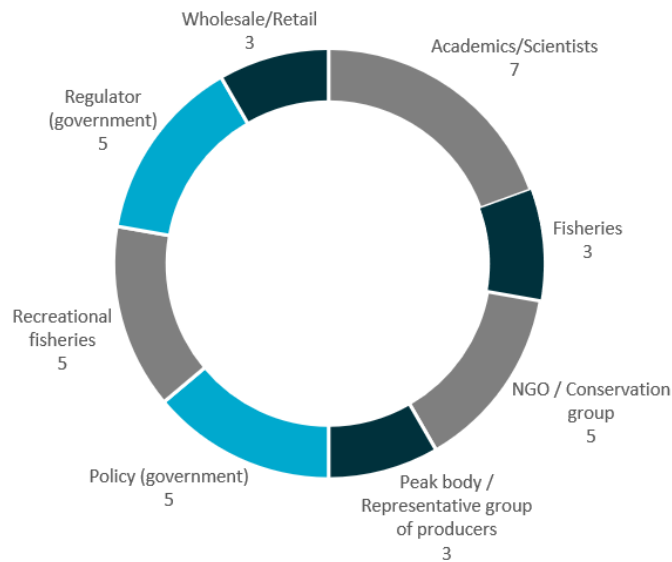
- Seven reports have been developed that summarise the outcomes from the research activities. This includes an industry-specific conceptualisation of natural capital and a set of example accounts relevant to each of the case studies.
- A stakeholder information packet is under development for the fisheries case study as part of a related FRDC project *2017-175 Linking ecosystem services to profitability of prawn fisheries* and will be developed for the cotton and forestry industries on request.
- In total, the project team contributed to or led more than 25 meetings promoting the project and its aims to develop natural capital accounting for primary industries in Australia (Figure 5). Many of these were invited presentations.
- Stakeholder workshops were held within each industry throughout the project as a key communication tool aimed at engaging industry stakeholders.
- Three manuscripts for publication in peer-reviewed journals have been drafted and are being prepared for external review. See Section 8.1.
- The project team has worked one on one with case study participants to ensure that example accounts are relevant and fit for purpose and have committed to tailoring these for ongoing application within the industry.

Rural Research and Development for Profit program
 Final report for *Lifting farm gate profits: the role of natural capital accounts*

(a) cotton case study



(b) fisheries case study



(c) forestry case study

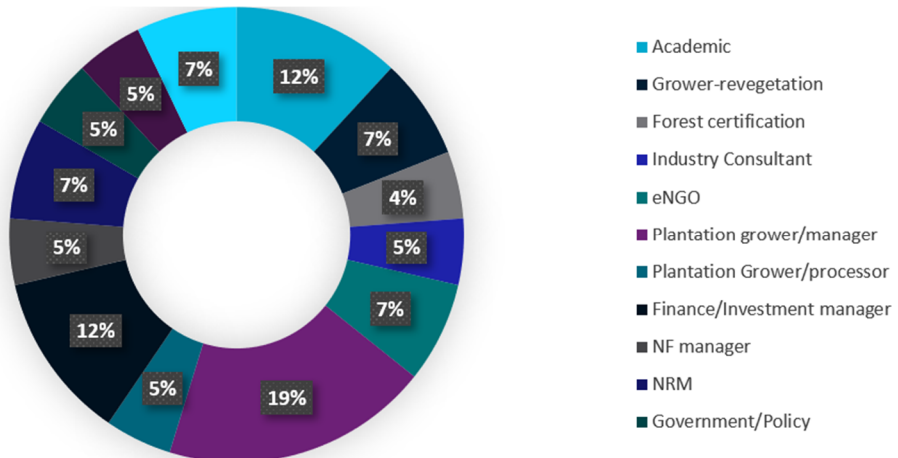


Figure 4 Summary of the cross-sections of stakeholders consulted during this project

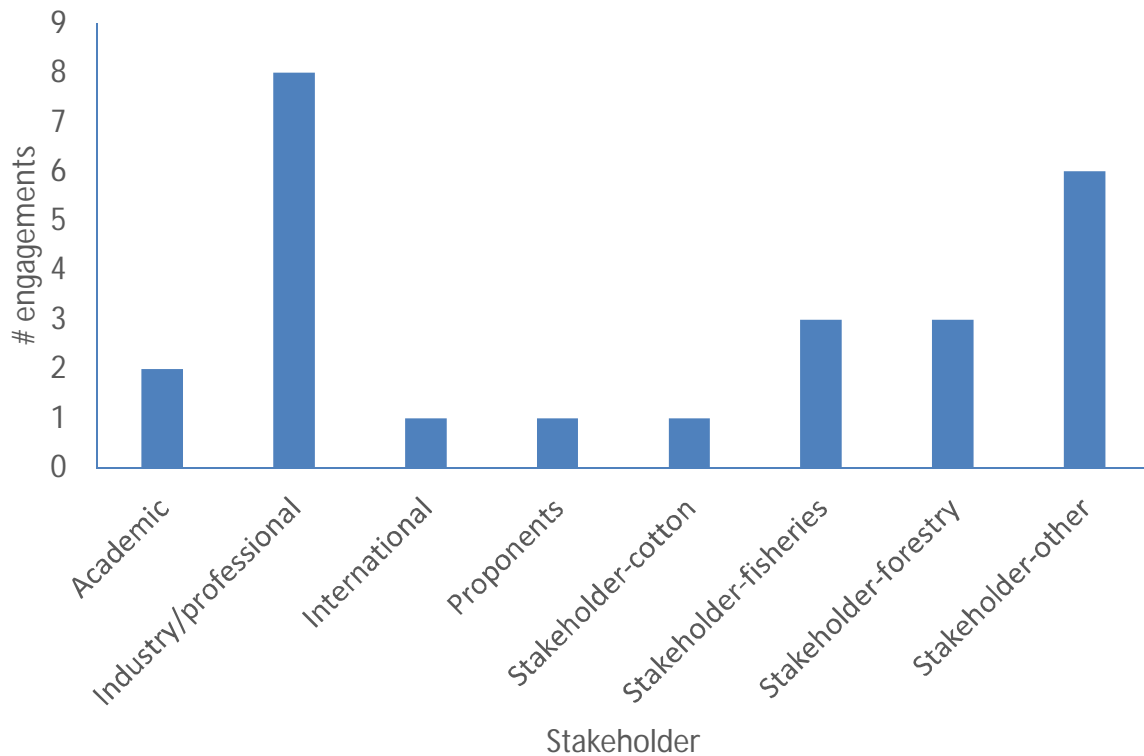


Figure 5 Distribution of communications and extension engagements during the *Lifting farm gate profits: the role of natural capital accounts* project

4.1.5 Monitoring and evaluation

Monitoring and evaluation of the project is described in a separate monitoring and evaluation report.

Purpose: Monitoring and evaluation of the project was conducted to track and monitor progress of project activities and outputs against the planned outcomes and impacts.

Key achievements:

- A monitoring and evaluation plan was prepared and endorsed by the project steering committee (KPI 3.3) that outlined the outcomes and impacts associated with project activities.
- A midterm monitoring and evaluation report was delivered (KPI 6.2). The project was on target against the indicators outlined in the monitoring and evaluation plan.
- Overall assessment is that the project has tracked well against indicators for outcomes and impact.

Output: A final monitoring and evaluation report is included as an appendix (Section 8.3).

4.1.6 Research activities

The primary objective of the project was to explore the application of natural capital accounting in the primary industries using case studies. Within the project there was a strong focus on the biophysical conceptualisation of the case study industries' interactions with natural capital.

The project was framed around five research activities:

- Activity 5.1 – Define the objectives for enterprise-scale natural capital accounting

- Activity 5.2 – Identify the key sources of natural capital in each industry
- Activity 5.3 – Identify approaches to measure and report key impacts and dependencies
- Activity 5.4 – Develop framework for data processing and synthesis
- Activity 5.5 – Pilot natural capital accounting in cotton, fisheries and forestry.

The overarching approach to these activities is outlined in Section 3. Key achievements for each research activity are outlined below.

Table 3 maps these activities to outputs and outcomes.

Activity 5.1 – Define the objectives for enterprise-scale natural capital accounting

Purpose: Natural capital accounts need to have relevance to users to be effective. This includes the enterprises producing the accounts and the stakeholders across the value chain.

Stakeholders will have varied information needs and it is essential to understand these when designing natural capital accounts for an enterprise.

Key achievements: We conducted one-on-one interviews with approximately 140 stakeholders across the three primary industries we have examined. The interviewees were drawn from a broad base of stakeholders including:

- primary producers
- regulators/government
- environmental NGOs and NRM
- academic
- finance industry (investors and insurance)
- certification bodies
- industry peak bodies
- community
- industry consultants
- R&D agencies
- wholesale and retail sectors.

The aim of these interviews was to explore the assumptions we had around the value proposition for natural capital accounting in the primary industries, gain insights to industry objectives and better understand the information requirements for the industries stakeholders (KPI 3.4, Activity 5.1a,b,c).

A key insight from this elicitation was that our framing of the value proposition in the project proposal was too narrow. The original framing was based on a business case that natural capital accounting would lead to increased revenue for the business. This revenue stream was hypothesised to stem from attracting premium prices for agricultural outputs, increased access to cheaper finance or improved capacity to engage in environmental markets. Our broader articulation of the value propositions gleaned from this stakeholder engagement indicated the hypothesised value propositions represented less than 10% of the total pool of responses from the stakeholders we interviewed (Figure 6).

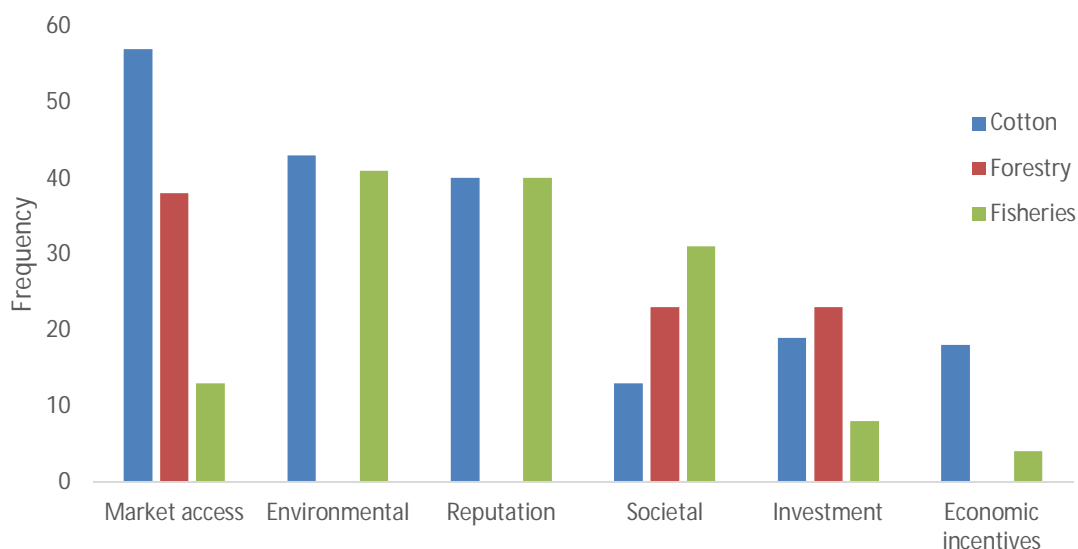


Figure 6 Themes of value propositions (objectives) for natural capital accounting, derived from stakeholder interviews across the primary industries

The much broader role for enterprise-scale natural capital accounts identified in this work provided a basis for the framing of the biophysical conceptualisation of the industries' dependencies and impacts on natural capital. It also highlighted the importance of understanding a wide range of perspectives on the management of natural capital by primary industries, as well as the importance of a consistent and robust method of reporting and disclosing natural capital impacts and dependencies. While natural capital accounting has some way to go before it can be mainstreamed, positioning Australian primary producers ahead of trends in reporting and disclosure helps them capture the opportunities that are emerging in impact investing and natural capital financing.

Outputs: A detailed discussion of the stakeholder engagement is included as a chapter in each of the industry-specific conceptual modelling reports. A synthesis manuscript has been drafted and at the time of this report is undergoing review.

Activity 5.2 – Identify the key sources of natural capital in each industry

Purpose: All enterprises depend on natural capital. As primary producers, enterprises are particularly reliant on that natural capital base. The underlying natural capital assets and the ecosystem services they supply are important inputs into the production processes at the enterprise scale; however, these inputs are largely invisible or only considered informally within existing business models. While many primary producers will have a well-developed intrinsic understanding of the condition of the natural capital base, natural capital accounting provides a disciplined and structured process for reporting this to external stakeholders. The purposes of that disclosure will vary depending on the stakeholder; however, the potential to streamline

data collection and reporting is appealing to all in the primary industries, based on the feedback collected during the stakeholder engagement.

Key achievements: For each industry we have developed a detailed biophysical conceptual model of the interactions of the industry with the underlying pools of natural capital – soil, water, air and biodiversity. This provides a framework for exploring the key causal pathways of dependencies and impacts (Activity 5.2, KPI 3.5, 5.2, 6.3). Within the Natural Capital Protocol this analysis of dependencies and impacts is central; however, guidance on how to do this is limited. Conceptual models simplify complex systems, particularly where the underlying process-based knowledge is poorly quantified (BoM, 2016).

To support these conceptual models, we developed a natural capital impact analysis tool, by adapting a risk assessment methodology known as Failure Modes and Effects Analysis (Ostrom and Wilhelmsen, 2012). This systematically identifies all the pathways within our conceptual models and ranks individual pathways based on the severity, likelihood and detectability of potential impacts, which enables weighting of impacts and prioritisation of ‘causal pathways’ within the enterprise. Our approach assesses natural capital on logical cause and effect, which is coupled with evidence from the literature to result in an evidence-based assessment of impact and dependencies. Our application of FMEA to the analysis of impact and dependency pathways in natural capital assessment is to the best of our knowledge the first time such a detailed systematic analysis of primary enterprises’ impacts on natural capital has been attempted in Australia.

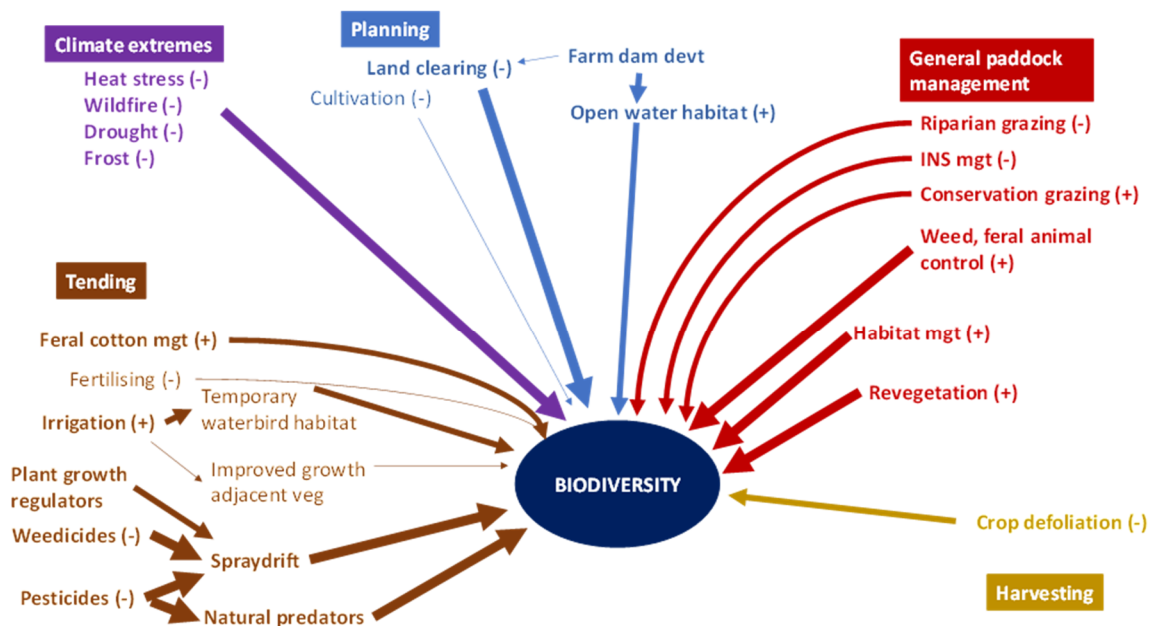


Figure 7 Example of a conceptual model for the potential impacts of activities in cotton enterprises on biodiversity, with the weight of the arrows reflecting the scale of potential impacts

This conceptualisation and analysis of the pathways within the conceptual model has allowed the identification of high-priority impact and dependency pathways that are potentially of material interest for the primary industries we have worked with. There are a large number of potential natural capital accounts that could be developed, and it is neither sensible or

productive to try and populate all of these (see for example, Figure 7). Focusing on material dependencies and impacts introduces a significant efficiency into the collection of data and reporting in natural capital accounts. It also focuses reporting of the aspects of the enterprise management on actions that are likely to have the largest impact (positive or negative) on the supporting natural capital base. The prioritisation of the pathways was done in close consultation with industry experts, practitioners and academics, facilitating co-design of natural capital accounts. Within the fisheries conceptual model, we identified three high-priority causal pathways, and with cotton and forestry six high-priority pathways, providing insights into the types of natural capital accounts that will be useful within the context of the industry. In this respect the conceptualisation of the dependency and impact pathways in this project provide decision support for enterprises that don't necessarily have the capacity to answer the question; what really matters?

An important outcome of this conceptualisation is its visualisation for external stakeholders. It also identifies management activities that have the largest impacts on natural capital, enabling targeting of interventions that either restore or minimise potential negative effects on natural capital. It can also be used to identify future risks and opportunities associated with the impact and dependency pathways (Activity 5.2, KPI 5.2).

Outputs: Industry-relevant conceptual models and all associated analyses are reported and detailed as a chapter within the industry-specific conceptual modelling reports.

Activity 5.3 – Identify approaches to measure and report key impacts and dependencies

Purpose: A primary objective of natural capital accounting and assessment is to understand the contributions from natural capital – that is, the flow of ecosystem services to the enterprise. Maintaining or improving the condition of the underlying natural capital is thus critical to sustaining the future flows of these ecosystem services to the enterprise, or to society more generally. Thus, natural capital accounts of condition are central to tracking the quality of underlying ecosystem assets. 'Condition' describes the overall quality of an ecosystem asset in terms of its characteristics (UN, 2014). In practice, measuring and accounting for ecosystem condition requires:

- the selection of suitable condition indicators
- evaluation of that indicator against an appropriate reference condition
- decisions on how to integrate those characteristics into a comparable condition score for accounting purposes.

It requires an understanding of the relationships between ecosystem condition, biodiversity and links to the supply of ecosystem services, and an understanding of the pressures or drivers of change that continue to impact on ecosystems (Czucz et al., 2019). Measurement of condition remains challenging within the context of natural capital accounting as the linkages between ecosystem assets, condition and the flow of ecosystem services are likely to be highly context specific and sensitive to the management objectives of the enterprise.

Condition accounting within the UN System of Environmental-Economic Accounting is currently being revised as part of the broader revision of the Experimental Ecosystem Accounts methodology, and new a new chapter on condition has been recently released for global consultation (March 2020).

Key achievements: Activity 5.2 provided an evidence-based framework to identify key cause and effect relationships between system drivers and the underlying natural capital. This resulted in a

list of high-priority causal pathways as well as attributes of natural capital that are potentially impacted. These attributes are important to measure and report in natural capital accounts.

Stakeholders highlighted that industries already collect information on attributes of natural capital for a range of sustainability or certification purposes. Therefore we reviewed existing indicator protocols within each industry (Activity 5.3, KPI 5.3, 6.4) and evaluated indicators for their:

- utility in natural capital accounts (i.e. utility as an indicator of extent, condition or ecosystem service)
- practicality of measurement (data availability, cost etc)
- relevance to causal pathways in the conceptual model of the enterprise or industry.

This approach was adopted for two reasons. Firstly, there is a large literature on the selection of environmental indicators, and a full review of this literature was beyond the resources available to the project team. Secondly, there was clear feedback from stakeholders that they were keen to see increase in efficiency and more capture from the efforts that were already being applied in sustainability reporting. Thirdly, there was concern among some stakeholders that natural capital accounting should not become another layer of compliance for industry. It is also worthy of noting that increased enterprise efficiency was also identified as an important value proposition by industry stakeholders in Activity 5.1.

Key outputs: The review of indicators is presented within each industry-specific conceptual modelling report. These and the high priority causal pathways provide the framework for condition accounting that was tested in the example accounts (Activity 5.5).

Activity 5.4 – Develop framework for data processing and synthesis

Purpose: Natural capital accounting at enterprise scales requires highly detailed data that is often available in disparate formats (e.g. points, polygons, raster grids) across a range of spatial and temporal extents and resolutions. This creates complex technical and provenance challenges that must be addressed to facilitate future verification and auditing. Thus, an information system that can provide standardised technical workflows while maintaining data provenance is critical to ensuring that natural capital accounts are reproducible and traceable.

Key achievement: Using concepts embedded in reproducible research we have developed a custom-designed spatial information system named *SynthEEA* (*Synthesis for Environmental-Economic Accounting*) to streamline natural capital accounting and provide standardised, reproducible, auditable and efficient methods for processing disparate datasets. *SynthEEA* uses a series of R scripts to interact with a spatial database and manages the accounting process from data ingestion through to generating charts and tables and ensures that analysis of data can be performed in a consistent and reproducible way across the case studies (Activity 5.4, KPI 5.4).

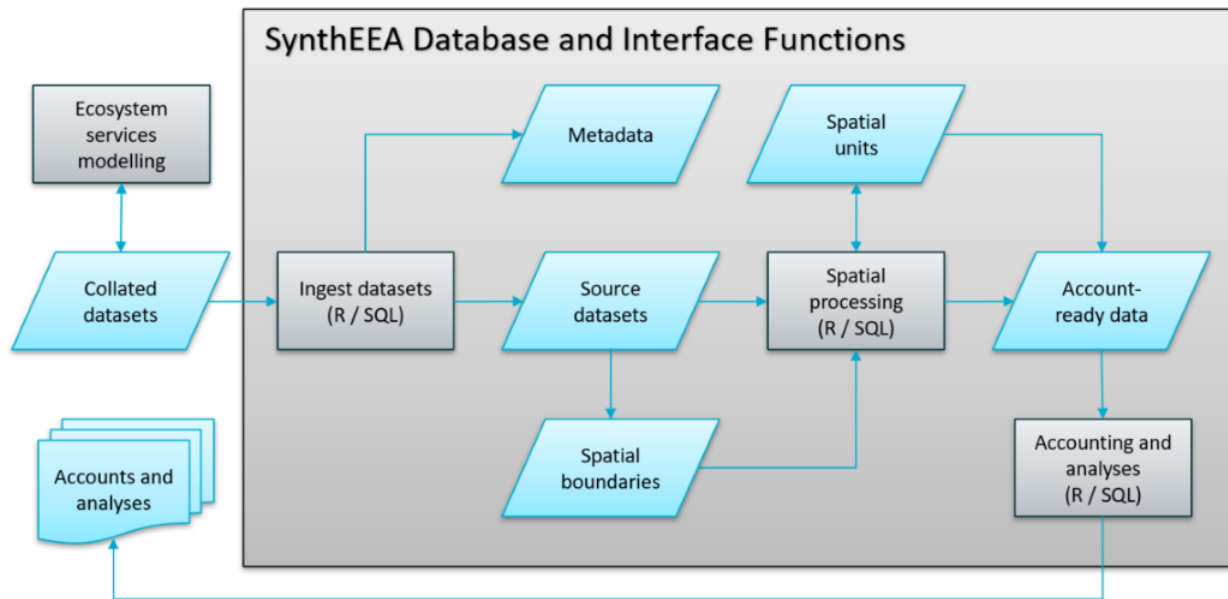


Figure 8 generalised workflow in *SynthEEA* (Synthesis for Environmental-Economic Accounting)

The key features of *SynthEEA* include:

- Source datasets are stored at their native extent and resolution alongside metadata.
- Source metadata can be traced throughout the entire data schema.
- Spatial data are clipped to the assessment boundary of interest as required, allowing for rapid transferability to new regions.
- Spatial processing is performed using a vector tiling approach (Mount and Sudholz, 2017) that allows for rapid recombination of disparate data sources and complex cross-dataset queries using unique location identifiers.
- Spatial accounts can be processed using pre-defined reporting areas that allow for increased accounting granularity (e.g. account by property boundaries).
- Raster datasets are converted to polygons during spatial data processing, allowing for area weighted calculations and ensuring that accounting areas always sum to assessment boundaries.
- Semi-automated functions produce output tables and charts for presenting accounts.
- Financial years were used as a common reporting period for all accounts to align with enterprise reporting requirements. Data was aggregated to annual values aligned with financial years where possible (e.g. precipitation, evapotranspiration). In many cases the datasets used for accounting did not neatly align with a common accounting period, and therefore values were brought forward to the end of the current financial year using the embedded functionality of the *SynthEEA* reporting functions.
- Additions and reductions in stock over time are reported cumulatively as an indicator of relative variability. The specific timing of these additions and reductions can be seen in the time-series charts presented. Areas are reported in hectares (ha) across all accounts where applicable.

Outputs: All of the experimental accounts with spatially explicit information have been produced using *SynthEEA*. This means that accounts that are relevant across case studies have been

compiled in a consistent and comparable way using the same workflows and data streams. In a small number of cases accounts did not include spatial information and were produced using spreadsheets.

Activity 5.5 – Pilot natural capital accounting in cotton, fisheries and forestry

Purpose: Activities 5.1 – 5.4 focussed strongly on developing biophysical conceptual models of the enterprise, identifying the key impact and dependency pathways to decide which accounts to develop. Activity 5.5 tested those conceptual models by designing and compiling accounts.

Key achievement: We have trialled natural capital accounting in three case studies from around Australia (Activity 5.5, KPI 3.7, 5.5, 6.5). The locations of the case studies are shown in

Figure 3. We have used, where possible, publicly available data to produce experimental accounts for a case study in each industry.

We have trialled application of the UN System and Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA). At the time of writing SEEA-EEA is in the process of being revised and updated:

SEEA-EEA is primarily designed as a standard for national-scale accounting, and its application at enterprise scales is still being tested. The aim of this project was to develop enterprise-relevant accounts. It would be an enormous effort to develop natural capital accounts that relate to every individual enterprise, thus the accounts we have produced are relevant to a range of enterprises in the industry but would need to be populated with data specific to the enterprise.

These experimental accounts are intended to illustrate the types of accounts that are achievable with current publicly available data. To fully take advantage of the benefits of long-term accounting requires a commitment to regular updates of the data and accounts and ongoing effort from individual enterprises or from across the industry.

Where data were unavailable or not forthcoming, we have used models to fill gaps that could be filled and thus data in accounts may not always be reflective of the enterprises represented in the study area. In these situations, the accounts are for demonstrative purposes.

Key outputs: Experimental accounts are presented in a report for each case study.

Table 3 Summary of key achievements and links to project activities through KPIs

Achievement	Description of achievement	Relationship to project KPIs
Cotton, fisheries and forestry conceptual modelling reports	<p>Summarised stakeholders' value propositions for natural capital accounting</p> <p>Assessed each industry's dependencies and impacts on natural capital</p> <p>Prioritised causal pathways and provides framework for measuring condition</p> <p>Reviewed indicators</p> <p>Provided a biophysical conceptual model that underpins natural capital accounts</p> <p>Proposed shell natural capital accounts (without results)</p>	KPIs 3.5, 3.6, 5.2, 5.5
Experimental natural capital accounts for case studies for cotton, fisheries and forestry	Based on the conceptual modelling report and the prioritised impacts and dependencies, example natural capital accounts documented in a report	KPIs 3.7, 5.5
Project brochure for <i>Lifting farm gate profits: the role of natural capital accounts</i> project Draft stakeholder information packet for fishery case study	<p>Project brochure distributed widely as part of the stakeholder engagement process</p> <p>In progress: developing a draft 4-page summary of the results for fisheries case study for distribution to stakeholders, including a draft article for FISH magazine</p>	KPIs 5.1, 6.1
Journal articles and draft scientific papers arising from project	<p>Write draft scientific papers providing the technical information underpinning the reports. Draft manuscript for:</p> <ul style="list-style-type: none"> • Consolidated stakeholder analysis • Lesson learned manuscript • Isotope model for Wallis Lake 	KPIs 3.4, 3.5, 3.6, 5.2, 5.5
Workshops & expert elicitation	<p>July 2018: Field visit to Wallis Lake including meeting with relevant officers from NSW Local Land Services</p> <p>July 2018: workshop and field visit with cotton growers in Emerald</p> <p>Feb 2019: workshops with Wallis Lake Estuary Management Committee</p> <p>May 2019: workshops with Wallis Lake Estuary Management Committee</p> <p>June 2019: workshops with CRDC and cotton growers, Narrabri and Emerald</p> <p>June-August 2019: one-on-one elicitation with forest industry professionals</p> <p>Feb 2020: Forestry workshop on NCA, Tasmania</p>	KPI 3.4
Stakeholder engagement	~140 interviews conducted from 2018 to 2019, as summarised in conceptual modelling reports	KPI 3.4

Achievement	Description of achievement	Relationship to project KPIs
Testing in international domain	Conceptual modelling report reviewed by author of Natural Capital Protocol Engagement with national and international environmental-economic accounting fora and workshops, including SEEA-EEA revisions and the London Group on Environmental Accounting Engagement at international Natural Capital Week in 2018 (Paris)	KPI 6.5
Trial to combine Natural Capital Protocol and SEEA-EEA	There are few examples of case studies or trials of combining Natural Capital Protocol & SEEA-EEA – the published results will be one of the first, particularly strong given it is applied similarly to three industries	KPI 3.7, 5.5, 6.5
Collaborative networks and relationships developed	Links developed or strengthened with: Cotton case study: University of New England, CRDC, NSW DPI Fishery case study: University of Newcastle, NSW DPI, FRDC, NSW LLS Forestry case study: Forest industry in Green Triangle and Tasmania, University of Tasmania General: ClimateWorks, National Farmers Federation, National Australia Bank, Dairy RDC, University of Tasmania, Accounting for Nature, Bush Heritage Australia, Land Restoration Fund, University of Melbourne, IDEEA	

4.2 Contribution to program objectives

4.2.1 Benefits of the project to primary producers

Natural capital accounts will serve many purposes, but as primary managers of natural capital, primary producers who adopt natural capital accounting will receive first advantage on global trends in sustainable production.

Primary producers will be able integrate the environmental costs of production into the financials and decision making of the enterprise.

Global supply chains are now starting to make decisions based on their perceived sustainability of production. Natural capital accounts speak directly to this push.

There is a growing demand in global markets for investments in natural capital, particularly from impact investors. Savvy Australian producers will be well positioned to respond to this market with systems and processes to verify environmental outcomes associated with management.

Markets for environmental services, e.g. biodiversity and land stewardship, are emerging in addition to existing markets for carbon. Central to these is the concept of additionality, natural capital accounting provides a robust framework for demonstrating and verifying this.

5 Extension and adoption activities

5.1 Extension

Extension activities throughout the project were focused on three strategies:

- presenting research outputs at meetings addressing a range of stakeholder interests and organisations (Figure 5)
- closely engaging with industry during the conceptualisation of and input into the design of industry-relevant natural capital accounts
- producing reports, papers and stakeholder information packages.

5.1.1 Presenting research outputs at meetings

The project addressed at least 25 meetings with stakeholders. These meetings ranged from small focused workshops working directly with primary industries to contributions to international meeting on the trends and directions for natural capital accounting and Environmental-Economic accounting. A summary of the communications and engagement activities is given in Appendix 7.1.

5.1.2 Closely engaging with industry during the conceptualisation of the accounts

Co-design of the accounts with industry input was an important focus of this project. Of the project communications activities identified above, at least 7 workshops were conducted that directly involved engaging industry in the analysis of the conceptual models and the assessments of risks and opportunities associated with natural capital within the industry with a direct objective to seek ongoing feedback on the conceptualisation process as it evolved.

One-on-one interviews with approximately 140 industry stakeholders were a key pathway for defining the objectives of natural capital accounts within the sector but also communicating the project activities broadly, including international stakeholders. This involved direct engagement with stakeholders ranging from growers and producers to asset managers and finance professionals. This step has helped to raise awareness of natural capital accounting among stakeholders, an important first step on the broader pathway to adoption. This was a key feature of the co-design of accounts that the project set out to achieve, as it involved gaining a detailed understanding of the objectives for natural capital accounting from a range of perspectives. It is too early to gauge the impact of this on the adoption of accounts, however organisations within the forestry industry, for example, are already trialling natural capital accounts and have engaged in ongoing collaboration with the team to continue this research.

The project was deliberately focused on the application of the outcomes of the detailed conceptualisation in three real world case studies. The locations of the case studies are shown in Figure 3. This has ensured that the team worked directly with industry partners to design experimental accounts for industry grounded in real world applications. This has led to the co-production of three sets of experimental accounts for further evaluation by the industry. The team has committed to ongoing interaction with the industry partners to help embed natural capital thinking into their organisation.

The project team has worked closely with consultants working within the natural resources management sector. This provides a valuable path to impact as the consultants have been

directly involved in the development of the cotton accounts as part of the project team and have been exposed to the challenges and opportunities involved with natural capital accounting. The project team has also developed close collaborations with service providers for enterprise-scale natural capital accounts (admittedly a small industry at present), and have additional active projects underway that will endure beyond this RnD4P project, providing evidence of the project's path to impact.

We have committed to open and transparent data principles and will make published data that is not commercially sensitive on CSIRO's data portal.

5.1.3 Producing reports, papers and stakeholder information packages

To date the team has produced seven reports that are directly relevant to each of the three industries we have been working with. The model adopted by the project team has been to develop a conceptualisation of the natural capital that is of broad relevance for each industry and to test this in a specific case study. The approach used has potential to be expanded to other industries within the agricultural sector. It is aimed at facilitating a learning-by-doing approach to adoption. Future extensions of natural capital accounting should consider this as a core component of project design in order to fast track adoption.

Each case study conceptualisation report requires further industry testing to help define a base set of accounts that is largely relevant to the broader industry. This could fast-track, although not replace, the selection and design of enterprise specific accounts and drive consistency in reporting across enterprises in each industry. Within the forest industry particularly there was a strong desire for a standard approach to accounts, and the recommendations we have provided for each industry will go some way to providing the industry with the confidence to start trialling natural capital accounting.

A stakeholder package has been developed specifically for the fisheries industry case study that summarises the detailed conceptualisation report into a five-pager flyer. If the response to this is positive a similar package can be developed rapidly for the forestry and cotton industries.

Three scientific manuscripts are in advanced stages of preparation, that address a combined analysis of the stakeholder engagement process; reviews the lessons learned from this project and describes the models used to track habitat requirements in the fisheries case study. These will be subject to the normal peer review and revision process before being published in international journals. This supports the scientific rigour and underpins the credibility the industry conceptualisations.

5.2 Recommendations for future adoption

- Project team to continue working with project stakeholders to help them interpret and use the conceptualisation reports produced during the life of this project.
- Consider ongoing support to better integrate each of the case studies into enterprise financial accounts, by supporting ongoing natural capital accounting and seeding the integration of natural capital accounting into normal business practice.
- Ensure that future projects in natural capital accounting adopt action learning principles to embed natural capital accounting into all aspects of enterprise reporting.

- Consider working closely with users of account information, e.g. banks and investors to further tune the integration of natural capital accounting into enterprise financial reporting.
- Consider funding projects that directly build capacity with enterprise advisors and consultants to embed natural capital accounting into their service offerings.
- Identify and develop account-ready data streams that facilitate the provision of fit-for-purpose natural capital data streams that can then be used to auto-populate farm accounts.
- Establish a peak body to oversee the development of natural capital standards and auditing processes, or support existing organisations to build this capacity.

6 Lessons learnt

6.1 Were our hypotheses supported?

Hypothesis 1: The value proposition for natural capital accounting revolves around access to premium markets, access to discounted finance and access to markets for ecosystem services.

Partially supported

Our stakeholder analysis determined that the value propositions for natural capital accounting were much broader than the three we originally proposed. Only for the cotton case study did the three initial value propositions rank as relatively important. Stakeholder groups identified often unique value propositions, highlighting the importance of consulting widely across value chains when defining the purpose or use of natural capital accounting. If this is not done effectively there is a strong possibility that accounts will not be relevant to stakeholders and will not be used to support decision making.

Key lessons learned from the stakeholder engagement were as follows.

Value propositions

There were a broad range of value propositions for natural capital accounting. Revenue is not the only perceived value of natural capital accounting. A much broader range of values revolve around improved long-term environmental and business sustainability; managing and disclosing risks; improved communication with stakeholders; and demonstrating environmental credentials to society.

Marketisation of ecosystem services was considered to be challenging. Marketisation of ecosystem services is challenging due to lack of markets; lack of buyers; rules such as the need to demonstrate additionality; and social restrictions and expectations.

Tangibility of benefits varied with stakeholder group. While the perceived benefits of natural capital accounting were clear to government officials, NGOs and academics, they were less tangible for primary producers. This differentiation could also be seen in a language 'gap' between specialists (academics, policy professionals, NGOs) and primary producers, with the specialists more likely to use more theoretical language without a direct pathway to adoption.

Knowledge

Knowledge of natural capital accounting across stakeholders is widely variable. Stakeholder engagement highlighted a high level of interest in and enthusiasm for the concept of natural capital accounting. Knowledge of the concepts varied considerably across the stakeholders. Generally, stakeholders in the forestry industry had the highest levels of knowledge. Within the forestry industry there was a high level of awareness which possibly reflects an understanding of historical attempts to launch carbon markets, whereas the cotton industry demonstrated a moderate level of awareness, and the fisheries industry a lower level of awareness. There was a

variable level of awareness of the potential to marketise these ecosystem services between the industries.

Putting natural capital accounting into practice

Broadscale application of natural capital accounting requires a common language across stakeholders, and this currently does not exist. While our stakeholder analysis revealed that there is general understanding of the concepts of natural capital and natural capital accounting, there is no consistent definition of these terms across stakeholder groups.

Engage early and often. A key learning from the project has been the need to engage early and often with the potential end-users of natural capital accounts to test which factors are the most important to them. These may be time-dependent, that is, certain factors will be more urgent in the short term (e.g. annual decision-making) compared to factors that have longer term implications (e.g. climate, water quality).

Generating user-relevant, scientifically credible accounts is not for everyone. The methodological steps used in our study require technical and scientific expertise and may not be something that primary producers are prepared to take on. Our study suggests that it is possible to develop tools and approaches that can be populated at a industry level, and then tweaked by primary producers and/or their agri-consultants to meet specific enterprise needs.

There is no – or at best a weak – market driver currently. The lack of market drivers is likely to limit uptake of natural capital accounting by primary enterprises at least in the short term.

A supply chain approach is required. There is a strong need to make links between those generating accounts and those wanting to use them, to ensure broad uptake. Natural capital accounting needs to be fit for purpose, meaning that understanding stakeholder needs is critical if natural capital accounting is to be useful. To some extent this is achieved by better understanding the purposes of the accounts and clearly identifying issues that are material to the enterprise; however, this would be difficult to generalise at an industry scale.

On-ground benefit remains intangible. There is a clear differentiation between academic consideration of the perceived benefits of natural capital accounting and the reality of the reward achieved at an enterprise scale for developing accounts, although this partially reflects the level of knowledge amongst primary producers relating to natural capital accounting.

Valuing benefits. A major impediment to natural capital accounting is the lack of a system that can value the benefits and costs of natural capital. The finance system is beginning to recognise the problem (e.g. insurance industry, banking) but there is no pathway for large-scale adoption of natural capital accounting into general accounting procedures that would provide immediate or near-term measures of benefit to producers. Until this resolved it is unclear why there would be wholesale adoption of natural capital accounting by Australia's primary producers.

Corporate accounting standards are already equipped to include natural capital information in either monetary or physical terms. What is less clear is how to journal the flows of benefits associated with natural capital or how to meet accounting standards with respect to the aspects of qualitative characteristics of useful information (i.e. comparability, verifiability, timeliness and understandability) particularly with respect to relevance to the accounts and the capacity to meet the requirements of faithful representation. Furthermore, few accountants would be equipped to address natural capital accounts for primary enterprises, suggesting that some capability development with this industry is required.

Hypothesis 2: The System of Environmental-Economic Accounting and Natural Capital Protocol could be applied to generate enterprise-scale natural capital accounts.

Supported

Combining the System of Environmental-Economic Accounting and the Natural Capital Protocol adds value. The SEEA framework (UN 2014, 2017) combines usefully with the protocol (NCC 2016), particularly when informed by the BoM's Guide to Environmental Accounting in Australia.

The value of this combination is that the protocol provides business-oriented language and methods, while the SEEA structures data into capital stocks and flows and enables complete integration with financial accounting, where monetary valuation is possible.

Scientific rigour of methods. The SEEA-based conceptual models of the enterprise's biophysical systems enabled the definition of a large number of causal pathways and the subsequent identification of priority causal pathways material to the enterprise as required by the protocol. This systematic and objective prioritisation is innovative in the field of natural capital accounting and provided a strong scientific basis for the selection of accounts that track key stocks and flows of natural capital relevant to each primary industry.

Visualisation tools are important for communication. Developing causal pathways to describe systems is an important part of the combined approach developed here. Stakeholder workshops determined that causal pathways are a useful way of visualising dependencies and impacts in a simplified way, aiding communication.

Hypothesis 3: Similar approaches can be applied to different industries.

Supported

Combining the System of Environmental-Economic Accounting and the Natural Capital Protocol provides a suitable framework across industries. We demonstrated that the methods we developed could be applied across the three industries, although the way that the results were presented did differ, reflecting differences in the objectives and value propositions within each industry. For example, enterprise-level accounts were considered appropriate for cotton and forestry case studies, whereas for the fisheries case study, accounts were more appropriately developed for a collection of enterprises that shared the same estuary (as the estuary is not owned or licensed by any one enterprise, and the location of fishing within the estuary can change). The conceptualisation, stakeholder analysis and indicator assessment were applicable for generation of both enterprise- and industry-scale accounts across the three industries.

Natural capital accounting can be streamlined within each industry. For example, identifying causal pathways of dependencies and impacts could be completed at a whole-of-industry scale,

with the prioritisation then individualised to meet specific enterprise needs. This approach is likely to increase accessibility of natural capital accounting for primary enterprises and drive increased adoption.

6.2 User capacity for implementing natural capital accounting

Some industries are better equipped to adopt natural capital accounting than others

Capacity to adopt will differ between industries. Adopting natural capital accounting will be easier for some primary industries than others. The forest industry, for example, has high uptake of certification with rigorous data requirements, which can be used for natural capital accounting. In contrast, non-fishery data collection by prawn fisheries is limited, meaning that the burden of collecting new data is greater.

Capacity to develop natural capital accounting will depend on availability of appropriate data. Industries vary in the availability of appropriate data, where 'appropriate data' means suitable for generating accounts as per the three conceptual modelling reports. The costs of collecting additional data will be a barrier to uptake.

Barriers to entry are currently high, although we would anticipate that these will come down quickly. Natural capital accounting is an obvious extension for data service providers (e.g. Digital Agriculture Services or Farm map 4D) who are currently providing high-resolution enterprise-scale data on natural capital. Enterprises are also emerging that specialise in the development of natural capital accounts. These will become a critical part of the path to impact for this work. We did not explore the possibility of services to provide account-ready data in this project, but the potential does exist.

Some industries will have a greater need to apply natural capital accounting

Rates of adoption will reflect market pull. Some industries have stakeholders that are more advanced in their thinking about natural capital accounting and are already generating a market pull. Market leaders are already trialling natural capital accounting – that is, learning-by-doing. Incentivising these efforts will increase the adoption rate and speed up the normalisation of this as a practice.

6.3 Data management and processing lessons

Data is a key challenge for natural capital accounting

Is there enough data? All accounts are only as good as the data used to generate them. There is a need to develop guidelines on natural capital account-ready data, where to access it, and the types of data most appropriate for generating different accounts. This will not only build confidence in the accounts being presented but also facilitate the adoption of accounts. A key lesson learned is that:

" for natural capital accounting to be widely adopted it will require greater availability of core datasets in a form readily suited for enterprise-level natural capital accounting".

This project has identified some of the key data requirements in each industry, and developed accounts based on data that is already largely in the public share, but this required a significant

processing and compilation effort to make these useable. Issues associated with this data included:

- Resolution of some of the data was inadequate for the type of enterprise-scale analysis that could inform business decision-making. For example, extent accounts on primary biological and abiotic information can usually only be compiled at a much coarser scale than the typical scale of decision-making required for an enterprise.
- Data were often compilations of historical interpretations of input datasets making it difficult to verify source and accuracy of the data.
- Naming conventions, resolution, mapping methods and accuracy varied considerably across reporting jurisdictions, e.g. enterprise versus state mapping. There were often large gaps in concordance across attributes purporting to measure the same thing.
- Remote sensing data are powerful but often requires considerable expertise to apply at local and enterprise scales, as validation of national and international 'products' is often at too coarse a scale to provide accurate estimates of indicators at local scales.

There is value in developing data products to support regional-scale extent and condition accounting. These can provide enterprises with a regional context for their accounts in terms of the state and trend of natural capital assets. There would be large efficiencies in developing pre-processed regional-level or industry-relevant data that would support enterprises in generating accounts. This would have the additional benefit of repeatability, comparability and interoperability. When overseen by appropriate technical expertise these could also provide confidence that data are credible.

Challenges with remotely sensed data. Currently available remotely sensed data are impacted by a range of limitations that are barriers to use in many applications. These are not necessarily issues that can be addressed in the immediate future. Examples include:

- a disconnect between remote sensing products and what we actually want to measure (e.g. soil nutrients, carbon stocks)
- general noise occurring in both space and time, leading to unstable stocks and flows. This can be reduced but not eliminated by smoothing techniques, but the optimal technique will vary depending on the application and will result in effective resolution
- the trade-off in spatial and temporal resolution between satellite platforms e.g. Lidar vs MODIS
- the cost involved in acquiring and processing airborne imagery, with limited options for scalability in space and time (e.g. Lidar acquisitions, drone imagery)
- analysis and interpretation require a considerable level of technical expertise
- general behaviour of datasets where values near thresholds cause flickering between classes
- errors in positional accuracy that cause spatial shifts in classified products
- compounding errors as a result of combining multiple products.

Lack of consistency between datasets. There is currently a lack of consistency between datasets across government, agency and enterprise boundaries that makes it difficult to generate comparable accounts when boundaries are crossed.

Is data 'fit for purpose'? Natural capital accounting ideally requires dynamic data that enables spatial and temporal changes to be tracked. For some indicators, only static approaches are currently available (e.g. for some biodiversity indicators).

For some types of indicators, it is challenging to identify suitable data. An example is condition assessment of soils. Most primary industries have a very high dependence on soils. Understanding soil condition in particular requires intensive sampling and sound statistical knowledge to interpret and aggregate this sampling effort. The value proposition for this effort is emerging but is yet to be tested in the market, (e.g. with impact investors etc.).

Data can be streamlined to support natural capital accounting and other environmental sustainability reporting

Data collected for other reporting purposes, and the indicators generated from these data, will in many cases be compatible with natural capital accounting, meaning there is scope to streamline data collection and collation to meet multiple reporting requirements. Primary industries that have already invested effort in identifying suites of indicators for sustainability reporting will find that many of these can be used in the development of natural capital accounts. Specifically, efficiencies can be created in the collection of data to support an understanding of the enterprise's impacts and dependencies. This in turn leads to greater confidence in the quantifiable measurement and evaluation of environmental performance against set targets required for most industry certification schemes acceptable for third-party auditing.

6.4 At what scale should natural capital accounting be applied?

One of the key lessons emerging from our case studies is that natural capital accounting, to be effective for comparing performance and informing management, must be meaningful at multiple scales simultaneously. These scales may be an individual enterprise, an industry (e.g. cotton or plantation forestry) or a region (e.g. the Green Triangle forest production zone, ecological bioregions, or the Wallis Lake estuary and surrounding catchment). While it is extremely useful to understand how individual assets are tracking, particularly with respect to condition, condition may be influenced by flows of ecosystem services generated outside of the enterprise boundary. This is particularly true for intermediate services (or disservices) that the enterprise depends on. Nested assessments of natural capital can help to identify flows of ecosystem services that are material at this scale and help to identify and target action. Other relevant scales could be administrative regions (e.g. local government or water catchments), states, nations or the globe. The embedding of natural capital accounts of individual enterprises within a broader context is essential, to enable comparability in multiple settings and to provide standardisation, scientific credibility and social legitimacy.

6.5 Other insights

Explicit consideration of natural capital accounting can make a significant contribution to value generation in business models. In turn this may help to develop the value proposition for natural capital accounting, especially for business models geared towards sustainability reporting. For example, the Integrated Reporting Framework helps companies demonstrate how to deliver value to customers in a sustainable way via two aspects, the business model and a business risk assessment. Together these provide a useful way to show responsible value generation. This project was largely focused on measuring and producing accounts, rather than integrating into

business models. Testing the integration of natural capital accounts with business tools (e.g. Integrated Reporting Framework, business model canvas etc) would be useful, as it helps enterprises develop purposeful accounts and articulate the value proposition.

Much of the ecological evidence required to underpin future natural capital accounting is incomplete, patchy or not directly relevant to the enterprise, making compilation of the evidence base for natural capital difficult. However, this should not constrain adoption. Evidence-based and systematic reviews provide dispassionate approaches to examining ecological evidence and are becoming more common in the literature. However, evidence-based materiality assessments are intensive and require considerable expertise and knowledge to conduct systematic reviews of the scientific literature across a range of disciplines, weight the evidence and then to assess the materiality for the enterprise. The multidisciplinary nature of this task is probably beyond the reach of most primary enterprises but could be facilitated at the industry or sector scales.

This would

- streamline materiality assessments
- identify and target important knowledge gaps
- facilitate the adoption of enterprise-scale accounting consistently across the industry or sector.

7 Recommendations

At the current level of technical readiness, most enterprises will find natural capital accounting difficult and may not have the understanding or resources to engage. This is particularly true for smaller enterprises. There are some clear areas of efficiency that will make natural capital accounting both feasible and useful at the enterprise level. Investment at a pre-competitive level would support primary enterprises to be able to realise the economic benefit from the production of natural capital accounts. Future investments in this area should be focused on mainstreaming enterprise-scale natural capital accounting within primary industries. This should focus on three key pre-competitive areas:

- building capability and capacity within primary enterprises and particularly within farm advisors and accountants
- addressing key knowledge gaps in the conceptualisation of the relationships between enterprises and natural capital around asset condition and the flows of ecosystem services
- improving the supply of account-ready data and indicators to reduce the burden for account builders.

Capability building

- Improve awareness of the basic concepts and benefits associated with natural capital accounting in the primary industries by adopting an action learning framework across a broad range of primary enterprises.
- Improve the capability and capacity of farm advisors and accountants to collate and interpret the complex streams of environmental information required to populate natural capital accounts.
- Integrate data on stocks and flows of natural capital with productivity and profitability data within the primary industries.

Addressing gaps in conceptualisation

- The links between ecosystem condition and the flow of ecosystem services remain largely conceptual for most ecosystem services. This issue is made even more complex by a lack of clarity around the purpose and measurement of condition and its implications for the long-term productivity and profitability of these enterprises. Further research into defining fit-for-purpose condition metrics will help to address this gap and standardise reporting across sectors.
- The integration of environmental and financial information as a standardised set of accounts remains in its infancy in primary industries. However, this is critical for demonstrating the value of good environmental management in terms of farm profitability and sustainability.
- While aggregating enterprise accounts into national accounts is already done to some extent with financial information, the addition of complex ecological information will make this scaling up even more challenging. The emergence of international accounting standards (e.g. the System of Environmental-Economic Accounting – Experimental Ecosystem Accounting) should help facilitate this.

Supplying account-ready data

- Integrated data and modelling platforms that synthesise complex environmental information into account-ready data relevant to primary enterprises will enhance the capacity to mainstream enterprise-scale accounting. Examples of such environmental information systems are emerging (e.g. DAS, FarmMap4D); however, these are not equipped to produce basic environmental accounts. Standardised and federated data will make this data more comparable and accessible.
- Further research is required to improve the useability and functionality of the numerous streams of remote sensing data that are emerging. This could include the development of automated routines, required to streamline the conversion of these spatially and temporally complex data streams into meaningful account ready metrics.

References

- BoM (2013) Guide to Environmental Accounting in Australia. Bureau of Meteorology, Canberra, Australia.
- BoM (2016) Methods for evidence-based conceptual modelling in environmental accounting; a technical note. Bureau of Meteorology, Canberra.
- Costanza R, Anderson S, Bohensky E, Butler J, Edyvane K, Howe S, Kirkman H, Kubiszewski I, Pert P, Stoeckl N, Sutton P and Walshe T (2014) Ecosystem Services From Healthy Oceans and Coasts.
- Czúcz B, Keith H, Jackson B, Maes J, Driver A, Nicholson E and Bland L (2019) Discussion paper 2.3: Proposed typology of condition variables for ecosystem accounting and criteria for selection of condition variables.,
<https://seea.un.org/sites/seea.un.org/files/documents/EEA/ec_discussionpaper23_typology-v22-clean.pdf>.
- FAO (2017) The future of food and agriculture-trends and challenges. Rome.
<<http://www.fao.org/3/a-i6583e.pdf>>.
- Grundy MJ, Bryan BA, Nolan M, Battaglia M, Hatfield-Dodds S, Connor JD and Keating BA (2016) Scenarios for Australian agricultural production and land use to 2050. *Agricultural Systems* 142, 70-83. Doi: <https://doi.org/10.1016/j.agsy.2015.11.008>.
- Guerry AD, Polasky S, Lubchenco J, Chaplin-Kramer R, Daily GC, Griffin R, Ruckelshaus M, Bateman IJ, Duraiappah A, Elmqvist T, Feldman MW, Folke C, Hoekstra J, Kareiva PM, Keeler BL, Li S, McKenzie E, Ouyang Z, Reyers B, Ricketts TH, Rockström J, Tallis H and Vira B (2015) Natural capital and ecosystem services informing decisions: From promise to practice. *Proceedings of the National Academy of Sciences* 112(24), 7348-7355. Doi: 10.1073/pnas.1503751112.
- Mount RE and Sudholz C (2017) Basic spatial partitioning of large multi-sourced vector datasets to massively increase query yield for users. *MODSIM (22nd International Congress on Modelling and Simulation)*. Hobart, Australia
- NCC (2016) Natural Capital Protocol. Natural Capital Coalition.
- Ostrom LT and Wilhemlmsen CA (2012) Failure Mode and Effects Analysis. *Risk Assessment*, 118-134.
- UN (2014) System of Environmental-Economic Accounting 2012 - Experimental Ecosystem Accounting. United Nations.

8 Appendix - additional project information

8.1 Project, media and communications material and intellectual property

Table 8.1 Summary of project outputs and intellectual property

Output	Name	Lead	Title	Summary
Report	O'Grady, AP, Pinkard EA, Mount, RE, Schmidt, RK, Cresswell ID, Stewart SB	CSIRO/FWPA	Conceptual model to support natural capital accounting of a forestry enterprise	<ul style="list-style-type: none"> • Introduction into the concepts of natural capital accounting • Rationale for natural capital accounting in forestry • Stakeholder engagement to define the objective for natural capital accounts • Natural capital impacts and dependencies assessment • Review and selection of indicators • Proposed shell accounts for forestry
	Pinkard, EA, O'Grady AP, Wall J., Mount, RE, Stewart S, Schmidt RK, Cresswell I	CSIRO/CRDC	Designing natural capital accounts for irrigated cotton enterprises	<ul style="list-style-type: none"> • Introduction into the concepts of natural capital accounting • Rationale for natural capital accounting in cotton • Stakeholder engagement to define the objective for natural capital accounts • Natural capital impacts and dependencies assessment • Review and selection of indicators • Proposed shell accounts for cotton
	Schmidt RK, Raoult V, Cresswell ID, Ware C, Taylor MD, Mount RE, Stewart SB, O'Grady AP, Pinkard EA, Gaston TF	CSIRO/FRDC	Designing natural capital accounts for the prawn-fishing industry	<ul style="list-style-type: none"> • Introduction into the concepts of natural capital accounting • Rationale for natural capital accounting in the prawn-fishing industry • Stakeholder engagement to define the objective for natural capital accounts • Natural capital impacts and dependencies assessment • Review and selection of indicators • Proposed shell accounts for the prawn-fishing industry
	Ware C, Stewart, SB, Cresswell ID, Schmidt RK, Raoult V, Taylor MD, Mount RE, Pinkard EA, Gaston TF, O'Grady AP	CSIRO/FRDC	Experimental natural capital accounts for the prawn-fishing industry in the Wallis Lake estuary	<p>Provides experimental ecosystem accounts for the prawn-fishing industry (~10 to 20 enterprises), in Wallis Lake estuary, NSW</p> <ul style="list-style-type: none"> • Definition of accounting boundaries • Inter-ecosystem flow accounts for precipitation and freshwater pulses • Land use accounts for Wallis Lake catchment • Extent accounts for terrestrial and riparian vegetation

Rural Research and Development for Profit program
Final report for *Lifting farm gate profits: the role of natural capital accounts*

				<ul style="list-style-type: none"> • Extent and condition accounts for prawn habitat • Ecosystem services accounts: provisioning of prawns • Discussions of limitations to accounts and recommendations to improve
	Stewart S, Pinkard, EA, O'Grady AP Wall J		Experimental ecosystem accounts for Cowal Agriculture Holdings, Emerald Australia (Commercial-in-confidence)	Provides experimental ecosystem accounts for an irrigated cotton enterprise, Cowal Agriculture in Queensland <ul style="list-style-type: none"> • Definition of accounting boundaries • Natural capital accounts for land, biodiversity, water, soils and atmosphere • Discussions of limitations to accounts and recommendations to improve
	Stewart, SB, O'Grady AP, Mount R, England J, Opie, K, Roxburgh S, Ware C, Scheufele, G, McVicar T, van Niel T	CSIRO/FWPA	Experimental natural capital accounts for forestry in the Green Triangle	Provides experimental accounts for the plantation forestry in the Green Triangle. <ul style="list-style-type: none"> • Definition of accounting boundaries • Ecosystem extent and condition of the forestry footprint • Ecosystem services: provisioning (timber), regulating (carbon sequestration), cultural (recreation) • Thematic/ancillary accounts: water, climate, biodiversity • Discussion of limitations to accounts and recommendations to improve
	Wall J	2Roj/CRDC	Biodiversity assets of NSW and QLD Cotton growing areas: a project for the Cotton Research and Development Corporation	Provides industry relevant data on biodiversity assets across the cotton growing footprint in Queensland and New South Wales
Package	Stewart S, Mount, R, Ware C., Pinkard R, Schmidt RK, Cresswell ID	CSIRO	SynthEEA: an integrated data analysis and reporting ecosystem for environmental-economic accounting	Description of all R code and workflows in SynthEEA.
Fact Sheet	O'Grady AP	CSIRO	Natural capital Accounting in the Primary Industries	Fact sheet distributed to project contributors and stakeholders. Provides an overview of the project and its objectives

Rural Research and Development for Profit program
Final report for *Lifting farm gate profits: the role of natural capital accounts*

	Schmidt RK	CSIRO/FRDC	Stakeholder information packet	Stakeholder information packet developed for the Wallis Lake case study (fisheries) as part of related FRDC project <u>2017-175 Linking ecosystem services to profitability of prawn fisheries</u> - one part is article for FISH magazine (draft, unpublished) - the full packet is under development, to be delivered 30 June 2020 to FRDC
Manuscripts	O'Grady AP, Smith G, Pinkard AE	CSIRO	Natural capital for forestry: opportunities and barriers	An editorial for the Journal Australian Forestry summarising outcomes from the <i>Lifting farm gate profits: the role of natural capital accounts</i> project (unpublished draft)
	Van Putin I, Pinkard EA, O'Grady AP, Schmidt RK, Cresswell ID, Mount R, Raoult, V., Taylor M	CSIRO	Stakeholder perspectives of the value proposition of enterprise level natural capital accounting for three natural resource sectors	Synthesises stakeholder engagement on value propositions and objectives for natural capital accounting in the primary industries (unpublished draft)
	Raoult V, Taylor MD, Schmidt RK, Cresswell ID, Ware C, Gaston TF	University of Newcastle	The value of estuarine habitats for commercial fisheries in a seagrass-dominated estuary	Values estuary habitats using Bayesian stable isotope mixing models with isotopes of C, N and S for the commercial fisheries of a seagrass-dominated estuary, Wallis Lake in New South Wales, Australia. This draft manuscript will be updated with additional data once analysed.
	Cresswell ID, Mount RE, O'Grady AP, Pinkard EA, Schmidt RK	CSIRO	Application of the Natural Capital Protocol and the System of Environmental-Economic Accounting to Australian Primary Industries: lessons learned	Analysis of the learnings of application of the Natural Capital Protocol and its integration with the System of Environmental-Economic Accounting to design natural capital accounts for primary industries in Australia (unpublished draft)

Table 8.2 Summary of project communication and extension activities

Year	Title	Engagement	Purpose
2017	NCA for cotton farmers workshop	Stakeholder	Introduction to NCA in cotton
	CRDC case study meeting	Stakeholder	Case study scoping meeting
2018	Valuing mangroves and saltmarshes to improve economic, social and environmental outcomes	Industry/ professional	Coast to Coast National Conference, Hobart
	Wallis Lake case study meeting	Stakeholder	Case study scoping meeting
	South East Forests Condition workshop	Industry/ Professional	Review Montreal protocol indicators
	Combining Forces	Industry/Professional	Launch of the Combining Forces Initiative (NCP-SEEA)
	Tasmanian Forestry and Environmental accounts	Stakeholder	Scoping of potential for forestry environmental accounts in Tasmania
	National Environmental Accounts Workshop, Canberra	Industry/Professional	Understanding Synergies between NCA and EEA
	2019	Accounting for Natural Capital: frameworks and futures	Industry/Professional
Wallis Lake Management Committee		Stakeholder	Project progress
Natural capital accounting		Stakeholder	Introduction to NCA in forestry
The role of saltmarshes to improve economic, social and environmental outcomes in a prawn fishery		Industry/professional	The Australian Mangrove and Saltmarsh Network Annual Conference
SynthEEA:synthesis for environmental accounts		Stakeholder	Directions in Environmental accounts-for DoEE
Lifting farm gate profits: the role of natural capital accounts		Stakeholder	Overview of project -for DoEE
Forest valuation: what about natural capital?		Industry/Professional	Meeting of IFA forest valuation committee, Hobart
Wallis Lake Management Committee		Stakeholder	Case study update

Rural Research and Development for Profit program
Final report for *Lifting farm gate profits: the role of natural capital accounts*

	SEEA-EEA Revisions	Industry/Professional	ABS-progress on SEEA-EEA revisions
	Cotton causal pathways	Stakeholder	Cotton case study update
	Natural Capital Summit	Industry/Professional	Community of practice, Diverse practitioner and policy makers' meeting of government, business and research interests
	Symposium of environmental-economic accounting	Industry/Professional	Interjurisdictional Steering committee on environmental economic accounting
	London Group on Environmental accounting	Industry/Professional	Progress in the implementation of Environmental accounting
	Valuing Agriculture's Natural Capital Roundtable	Industry/Professional	Exploring ecosystem services in Australian Agriculture
	Environmental-Economic Accounting	Industry/Professional	Contributions to a national Approach to EEA
	Indicators and metrics: linking stakeholder need, impacts and dependencies	Industry/Professional	National symposium on carbon farming and valuing co-benefits
	Natural capital accounting	Industry/Professional	Natural capital accounts: supporting conservation in production landscapes presentation to Midlands Conservation trust
	NCA for primary enterprises	Industry/Stakeholder	Brief the NFF Environment Committee about NCA
2020	Unlocking the value of natural capital	Stakeholder	Progress on natural capital accounting projects in the forestry sector

8.2 Equipment and assets

Not applicable

8.3 Monitoring and evaluation

Report attached

8.4 Budget

Below is a summary of the financial transactions for the project entitled *Environmental and Economic accounting in Primary Industries (Natural Capital Accounting)* (RnD4Profit-16-03-003). The summary of transactions covers the financial year 16-17 to 2019-20. The completion date for the agreement is 29 July 2020. Note all figures are exclusive of GST.

The total amount of the Grant is \$900,000 with contributions of cash of \$450,000 and in-kind contributions of \$911,992. With the total project budget of \$2,261,992.

As of 30 June 2020 the funding received from the Commonwealth (from 16-17FY to 19-20 FY) was \$810,000 with \$450,000 from other contributors including FWPA funds. The total expended funds to the project until 30 June 2020 has been \$1,160,000 (Table 1).

The MS8 invoice (\$100,000) for the submitted final report was withheld awaiting approval before payment. The MS9 invoice (\$90,000) is yet to be received and the due date for this milestone is 29 July 2020.

Table 1. Final statements for the receipt, holding, expenditure and commitment of the Grant for the period of 16-17 to 19-20 financial year.

Receipt of funds from Commonwealth			
Milestone(s)	Anticipated date	Amount (ex GST)	date received
Milestone Report 1	Jun-17	\$ 378,000	Jun-17
Milestone Report 2	Feb-18	\$72,000	Mar-18
Milestone Report 5	Dec-18	\$180,000	Dec-18
Milestone Report 6	Aug-19	\$180,000	Jan20
Total Amount		\$810,000	
Funds Pending			
Final Financial Report	Jul-20	\$90,000	TBA
Project Expenditure of funds			
Milestone(s)	Institution	Amount (ex GST)	date paid
Milestone Report – Sign On	CSIRO	\$ 378,000	Jan-2018
Milestone Report 2	CSIRO	\$ 292,000	Feb-2018
Milestone Report 3	CSIRO	\$0	Jun-2018
Milestone Report 4	CSIRO	\$0	Oct 2018
Milestone Report 5	CSIRO	\$255,000	Jan 2019
Milestone Report 6	CSIRO	\$235,000	Jan 2019
	TOTAL	\$1,160,000	
Payments Pending			
Milestone Report 8 Final Report	CSIRO	\$100,000	pending
Milestone Report 9 Audited Financial	CSIRO	\$90,000	pending

Table 2. Final statements for the receipt of other contributions, including Grantee’s contributions during the period of 17-18 to 19-20 financial year.

Milestone	17-18	18-19	19-20
Forest and Wood Products Australia	\$50,000	\$55,000	-
Cotton Research and Development Corporation	\$100,000	\$35,000	\$30,000
Fisheries Research and Development Corporation	\$40,000	\$40,000	\$30,000
Hancock Victorian Plantations Pty Ltd	\$5,000	\$10,000	\$10,000
One-Forty-One Plantations Ltd	\$10,000	\$10,000	\$10,000
VicForests	\$15,000	-	-
Total Amount	\$220,000	\$150,000	\$80,000
Grand Total Amount	\$450,000		

Table 3. Interest that the Grantee has earned on the Grant for the period of 17-18 to 19-20 financial year. Interest calculated on the official cash rate 1.5% per annum.

Milestone	Annual interest	Amount
17-18 financial year	12 months	\$3,398
18-19 financial year	12 months	\$919
19-20 financial year	12 months	\$907
Grand Total Amount	Full FY	\$5,224

Table 4. Partner in-kind contributions received 17-18 to 19-20FY.

	Name of partner	17-18	18-19	19-20
1	Forest and Wood Products Australia	\$17,000	\$10,000	\$10,000
2	Cotton Research and Development Corporation	\$17,600	\$8,610	\$10,000
3	Fisheries Research and Development Corporation	\$6,000	\$6,000	\$10,000
4	Hancock Victorian Plantations Pty Ltd	\$4,000	\$4,000	\$4,000
5	One Forty One Plantations Ltd	\$4,000	\$4,000	\$4,000
6	VicForests	\$4,000	\$4,000	\$4,000
7	CSIRO	134,567	\$277,499	\$181,219
8	Ecological Australia	\$26,666	\$26,666	\$15,000
9	ABS	\$16,815	nil	nil
10	BOM	\$24,992	nil	nil
		\$255,640	\$340,776	\$238,219
	Grand Total in-kind	\$834,635		