Toward a methodology for incorporating ecological capital into the accounts of individual entities

Susan Ogilvy

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Susan Ogilvy

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Under the Guideline: Editing of Research Theses by Professional Editors, Dr Joyce Wilkie provided third party editorial services per the Australian standards for editing practice.

Related publications

This thesis includes content in the chapters below that is updated and revised from material published during development of the ideas expounded herein.

Chapter 2 – Foundations for analysis includes content from Ogilvy, S. (2015). Developing the ecological balance sheet for agricultural sustainability. *Sustainability Accounting, Management and Policy Journal*, *6*(2), 110-137. doi:doi:10.1108/SAMPJ-07-2014-0040 and refers to research published by the Centre for Policy Development in Ogilvy, S., Kulkani, A., Hurley, S., & MacLeod, T. (2015). *From Vicious to Virtuous Cycles: a sustainable future for Australian Agriculture*. Retrieved from Carlton, Victoria Australia: http://cpd.org.au/wp-content/uploads/2015/08/Vicious-to-virtuous-cycles-2015.pdf [Ogilvy's contribution 65%]

Chapter 3 – Framework incorporates some materials drawn from or updated following publications conceptualising the ecological balance sheet (Ogilvy 2015), valuing ecosystems in livestock grazing enterprises published in Ogilvy, S., & Vail, M. (2018). "Standards-compliant accounting valuations of ecosystems". *Sustainability Accounting, Management and Policy Journal, 9*(2), 98-117. doi:doi:10.1108/SAMPJ-07-2017-0073 [Ogilvy's contribution 85%] and contains some text prepared for Ogilvy, S., Burritt, R., Walsh, D., Obst, C., Meadows, P., Muradzikwa, P., & Eigenraam, M. (2018). Accounting for liabilities related to ecosystem degradation. *Ecosystem Health and Sustainability, 4*(11), 261-276. doi:10.1080/20964129.2018.1544837 [Ogilvy's contribution 75%].

Chapter 4 – Accounting for physical values updates and extends concepts and methods developed and tested in a case study of natural capital accounting for rangeland pastoral stations managed by indigenous communities Ogilvy, S., Mitchell, P. Obst, C. Walsh, D.S (2017 - Unpublished). This project "Natural Capital Accounting for Rangelands: Report and demonstration accounts prepared for the Australian Agribusiness Company" developed and tested methods of incorporating the measurements that support sustainable management of grazed rangeland ecosystems into the physical accounts. [Ogilvy's contribution 90%]

Chapter 5- Monetary valuations of ecological assets includes content published in (Ogilvy, S. & Vail, M. 2018)

Chapter 6 – Accounting for liabilities for ecosystem degradation has adapted accounting tables and contains some text prepared for (Ogilvy et al. 2018). Tables were adapted to match the scenario used to demonstrate the physical accounts (chapter 4).

Abstract

Concern is increasing that degradation of land and ecosystems important to food production is occurring and that some agricultural practices are drivers of degradation. In response, governments and businesses are investing to establish collaborative and transformative initiatives to manage these threats. Global leaders are describing sustainable development goals for resources, including land and ecosystems, for the economic and social wellbeing of current and future citizens. The United Nations has invested in capacity for measurement and accounting for environmental resources in the system of national accounting used for macroeconomic analysis and planning. Responsible businesses are increasingly using sustainability reporting to communicate their past environmental performance and future commitments including estimates of their impact and dependence on a range of resources including ecosystems.

Information available from business sustainability reporting does not presently meet the needs of investors and other stakeholders because it lacks standardisation of concepts and measurement methods and it is not comparable or verifiable. It also cannot be compiled into national or subnational accounts for complementary macroeconomic analysis. As a result, reliable information about the current quality and condition of our land and ecosystems and the economic implications of condition change is not available.

International accounting standards used by individual entities are currently silent on the concept of ecosystems owned and controlled by individual entities as assets (separately from land) but have the potential to provide useful information about them. To address this potential, this study explores how the principles and concepts of international accounting standards and the United Nations system of environmental-economic accounting could be applied or adapted to describe an entity-level accounting framework for ecosystem assets. It focuses on livestock grazing in northern Australia as an example of a sector that owns and controls a significant proportion of Australia's land-based ecosystems and where degradation is a concern.

The international accounting standards are examined to identify concepts, accounting elements and methods applicable to ecosystem assets used by livestock grazing entities. The applicability of principles and guidance provided by these and the United Nations system of environmental-economic accounting is tested against the functional and economic descriptions of rangeland ecosystems to suggest a provisional framework for ecosystem accounts for this industry. Demonstration accounts reflecting this framework are prepared using a scenario produced from industry data.

The study reveals that current good practice sustainable management of rangeland ecosystems can be reflected in ecosystem accounts that are coherent with the United Nations system of environmental-economic accounting. It finds that the principles of international accounting standards fair value measurement can be applied to estimate the monetary value of ecosystems based on their income-earning potential, as a supplement to the real estate value of the property. Under the framework created by the study, changes to asset values and liabilities associated with ecosystem investment and degradation are coherent with the system of national accounts.

These findings imply that entity-level environmental-economic accounts for agricultural entities can be used in the compilation of ecosystem accounts under the United Nations system of environmental-economic accounting and contribute to macroeconomic analysis and planning. They also have the potential to provide a foundation of verifiable, comparable information for businesses and other organisations in the agricultural value chain to gain visibility of the ecosystem stewardship of their suppliers and to collaborate with governments to meet the sustainable development goals.

This study makes a significant contribution towards how entity-level environmental-economic accounts can assist governments and the private sector to design microeconomic and macroeconomic policies to improve its environmental performance and sustainability. The case study accounts in this thesis provide a foundation for consultation with ecologists, accountants and stakeholders involved with livestock grazing to enable empirical evaluation and further development of environmental-economic accounting theory and practice. Further research would be able to test the applicability of the accounting proposed in this study to other types of agriculture and to other types of land holders such as conservation organisations and government owners of national parks and reserves.

The thesis is structured as follows:

- Chapter 1 introduces the study, the context for the research and the research question;

- Chapter 2 describes a normative foundation for the purpose and principles for information that should be communicated in entity-level environmental-economic accounts and outlines a pragmatic approach to meeting these needs;

- Chapter 3 describes a framework for applications of and adaptations to current international accounting standards and concepts to accommodate unique characteristics and sustainable management of ecosystem assets;

- Chapter 4 and 5 apply the framework to a model enterprise to demonstrate accounts of physical values (chapter 4) and methods of fair value measurement of ecosystems separately from land valuations (chapter 5);

- Chapter 6 addresses the issue of accounting for liabilities related to ecosystem degradation to demonstrate accounting valuations and processes that are coherent with the United Nations System of National Accounts;

- Chapter 7 presents a synthesis of a statement of ecological position (analogous to a statement of financial position) including a demonstration of methods to incorporate entity-level information into the national accounts. It discusses the implications of these including for reporting by companies in the value chain for agriculture;

- Chapter 8 describes the conclusion of the study, my contribution to the field and recommendations for future research to build on this work.

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Abbreviations

AAS	Australian Accounting Standards
AASB	Australian Accounting Standards Board
AE	Adult Equivalent
BBA	Bearer Biological Assets
CMP	Conservation management practice
DAM	Direct Apportionment Method
EPBC	Environmental Protection and Biodiversity Conservation
EP&L	Environmental Profit & Loss (Kering)
EY	Ernst and Young a global accounting and consulting firm
GFS	Government Financial Statistics
GPFR	General Purpose Financial Reports
GPER	General Purpose Ecological Reports
IAS	International Accounting Standards
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
NPV	Net Present Value
PPE	Property, Plant and Equipment
PV	Present Value
SGG	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
SEEA EEA	System of Environmental-Economic Accounting - Experimental Ecosystem Accounting
SEEA CF	System of Environmental-Economic Accounting Central Framework
SCC	Sustainable Carrying Capacity

SSR	Sustainable Stocking Rate
SNA	System of National Accounts
TEV	Total Economic Value
UNSD	United Nations Statistical Division
URR	Unit Resource Rent

Glossary

Biodiversity	Biodiversity refers to all the variety of life that can be found on Earth (plants, animals, fungi and micro-organisms) as well as to the communities that they form and the habitats in which they live.
Broadacre agriculture	Broadacre agriculture describes farms or industries engaged in the production of crops and livestock using extensive parcels of land.
Capacity	The amount of ecosystem services that an ecosystem can produce.
Contingent Liability	A possible obligation that arises from past events and whose existence will be confirmed only by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the entity. Or a present obligation that is not recognised because the amount of the obligation cannot be measured with sufficient reliability.
Degradation	Ecosystem degradation is defined in relation to the decline in condition of an ecosystem asset as a result of economic and other human activity.
Ecological capital	The stock of ecosystems owned and controlled by an entity and used to generate economic benefits for the entity.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Ecosystem asset	Ecosystems that are a present economic resource and that are owned and controlled by an economic entity as a result of past events.
Ecosystem condition	The overall quality of an ecosystem asset in terms of its characteristics. Measures of ecosystem condition are generally combined with measures of ecosystem extent to provide an

	overall measure of the state of an ecosystem asset. Since ecosystem condition also underpins the capacity of an ecosystem asset to generate ecosystem services, changes in ecosystem condition will impact on expected ecosystem service flow.
Ecosystem extent	The area of an ecosystem in hectares or square kilometres.
EPBC Act	Environmental Protection and Biodiversity Conservation.
Environmental-Economic Accounting	The measurement, compilation and presentation of information about ecosystem assets and services in physical and monetary terms. The system that helps people to understand the present and prospective condition, service capacity and economic value of ecosystems and to assess the quality of stewardship of and accountability for this class of resources.
Financial statements	A particular form of financial reports that provide information about the reporting entity's assets, liabilities, equity, income and expenses. Consolidated financial statements provide information about assets, liabilities, equity, income and expenses of both the parent and its subsidiaries as a single reporting entity.
General Purpose Financial Reports (GPFR)	General purpose financial reports are those intended to meet the needs of users who are not in a position to require an entity to prepare reports tailored to their particular information needs. They represent economic phenomena in words and numbers to assist users to understand the prospects for future net cash inflows to the entity and management's stewardship of the entity's economic resources.
General Purpose Ecological Reports (GPER)	General purpose ecological reports are supplements to the GPFR. They are prepared by entities that own and control ecosystems to meet the needs of users for information about the

	contribution the entity's ecological capital to the prospects for future net cash inflows to the entity and managements' stewardship of the entity's ecological resources.
Greenwashing	The practice of making an unsubstantiated or misleading claim about the environmental benefits of a product, service, technology or company practice.
Impairment of assets	An asset is described as impaired if its carrying amount (its value in the accounts) exceeds the amount to be recovered through use or sale of the asset. If this is the case, IAS 37 requires the entity to recognise an impairment loss.
Liability	A present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits.
Natural Capital	The stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people. A broader scope than ecological capital because it includes ecological stocks and flows that may not be considered to produce benefits to humans.
Monetary valuation	The practice of expressing ecosystem assets and ecosystem services in monetary terms
Pastoral	The term used to describe livestock operations in the Australian rangelands as distinct from livestock operations in higher rainfall areas.
Produced Capital	Non-financial assets that have come into existence as outputs from production processes that fall within the production boundary of the SNA. Usually referring to plant and equipment.
Rangelands	Grasslands, shrublands, woodlands, wetlands and deserts that are grazed by domestic livestock or wild animals. They are distinguished from pasture lands by low and erratic rainfall and

	being comprised of mostly native vegetation rather than plants established by humans.
Revaluation	The action of assessing the value of the assets and liabilities to ensure that the value in the accounts does not differ materially from that which would be determined using fair value at the end of the reporting period.
Standard Accounting Concepts (SAC)	Standard Accounting Concepts are the concepts in respect of the nature, subject, purpose and broad content of general purpose financial reporting. They should assist preparers, auditors and other parties to understand better the general nature and purpose of information being reported. They may also provide guidance for preparers and others in analysing new or emerging issues in the absence of applicable Accounting Standards and other authoritative documents.
Supply chain	The network of all the individuals, organisations, resources, activities and technology involved in the creation and sale of a product, from the delivery of source materials from the supplier to the manufacturer, through to its eventual delivery to the end user.
System of National Accounts	The System of National Accounts (SNA) consists of a coherent, consistent and integrated set of macroeconomic accounts, balance sheets and tables based on a set of internationally agreed concepts, definitions, classifications and accounting rules.
Transaction	The exchange of value between entities or between accounts within an entity.
Value chain	The process or activities by which a company adds value to an article, including production, marketing and the provision of after-sales service.

1 Research context

1.1 Introduction

Concern is increasing that land (ecosystem) degradation caused by human activities, especially food production (for example Willett et al. 2019), is undermining the well-being of humanity and compromising achievement of the sustainable development goals (SDG) (IPBES 2018a; United Nations 2018). One of the strongest drivers of degradation is agricultural practices that fail to maintain biodiversity and avoid soil erosion (FAO & GEF 2018; IPBES 2018a; UNCCD 2014; UNCTAD 2013; Willett et al. 2019). Recently, the Food and Agriculture Organization of the United Nations (FAO) estimated that one-third of the world's agricultural land has become degraded, putting global food security and nutrition at risk (FAO & GEF 2018).

Degradation of agricultural land is of concern to the families and entities that depend on it for their livelihoods, it is also a concern for global leaders of public and private sectors responsible for assuring sufficient resources for future generations (FAO & GEF 2018; IPBES 2018a; Kwon et al. 2018; Stiglitz, Sen & Fitoussi 2010; United Nations 2018).

Governments will need to be part of the solution to global environmental and social challenges, companies and investors will mobilise much of the capital needed to overcome these threats. To achieve change, it is necessary to support organisations to allocate capital to entities that are halting or reversing land degradation trajectories (Generation 2012; Guthrie 2016; IFAC 2016). There are already examples of companies who are attempting to do this (NCC 2015). Apparel companies Kering and Patagonia, for example, consider land condition-based goals in supplier selection decisions (Kering 2017; Patagonia 2014) and investors around the world increasingly integrate environmental, social and corporate governance factors into their capital allocation decisions (Bartels et al. 2016; FSC and ACSI 2015; Kwon et al. 2018; Loweth 2017).

The experience of these leaders has led to the realisation that, to achieve the transformative action needed to tackle the root causes of land and ecosystem degradation governance, it is necessary to implement enabling frameworks and stewardship incentives across all levels of the agricultural sector (see for example Adams, C A 2017; AITHER 2018; FAO & GEF 2018; IPBES 2018a; NCC 2015). It is well-accepted that a foundation for these initiatives is the capacity for measurement and communication of environmental-economic performance at individual entity, national and subnational levels (Adams, C A 2017; FAO & GEF 2018; IPBES 2018a; Kwon et al. 2018; NCC 2015; Ostrom 1990; UNEP-WCMC, IUCN & NGS 2018; United Nations 2018; Willett et al. 2019). In addition to providing useful input to policies relating to the stewardship incentives, an entity-level approach is also needed to correct the situation where many of those who benefit from overexploitation of natural resources are among the least affected by the economic burden of resource degradation (Guthrie 2016; IPBES 2018a). While this situation persists, many potential restoration activities may remain unfunded making continued ecosystem decline almost inevitable.

1.1.1 The current state of sustainability-measurement frameworks

At present there are hundreds of different approaches promoted to help businesses measure and communicate their commitment to environmental responsibility and their impact and dependence on natural capital (Bartels et al. 2016; Guthrie 2016; Loweth 2017). Some approaches provide guiding principles for investors as they consider social and environmental impacts of investment. These include the Global Reporting Initiative (GRI) the Integrated Reporting Framework (<IR>), Climate Disclosure Standards Board (CDSB) and the Principles for Responsible Investment (PRI) (see for example CDSB 2018a; GRI 2016; IIRC 2013; PRI 2019). Others such as the Natural Capital Protocol (NCP) and Sustainability Accounting Standards Board (SASB) aim to assist organisations to estimate their impact and dependence on natural capital (NCC 2015; SASB 2013, 2018) or to estimate the economic value of biodiversity (TEEB Foundations 2010). Some approaches assess and report on whether corporations satisfy certain standards. For example B Corporations certifies organisations as being socially and environmentally responsible (B Lab 2019).

The enormous choice and diversity of approaches may, in fact, be constraining business progress on sustainability. The lack of standardisation and verification of the information reduces the usefulness of it for comparing the performance of different businesses and therefore allocating capital on the basis of environmental and sustainability performance (CDSB 2018b; EY & BCCCC 2017; FSC and ACSI 2015; Guthrie 2016; Hoogervorst 2019; Kwon et al. 2018; Lambooy et al. 2018; Loweth 2017; SASB 2013; Slack &

Campbell 2016). In addition, attempts to use a simpler approach of certifications of better environmental performance to enable markets to generate better outcomes have produced mixed and sometimes perverse outcomes (Brad et al. 2018). In response to these insights, there are increasing calls for a framework that guides preparation of standardised and verifiable environmental and sustainability information so it can be used to compare, inform and manage the performance of policy interventions as well as the performance of entities and sectors on these factors (see for example Bartels et al. 2016; Blackrock 2016; CDSB 2018b; Hoogervorst 2019; Lambooy et al. 2018; Slack & Campbell 2016).

1.1.2 The System of National Accounts and the SEEA

National economic policy is underpinned by macroeconomic theory developed and updated with the support of a range of statistics collected and arranged using the System of National Accounts (ABS 2012; Obst, Hein & Edens 2015; Obst & Vardon 2014; UN 2008; Vardon et al. 2018). The SNA provides a systematic statistical framework for summarising and analysing economic events, the wealth of an economy and its components. National accounts record the income generated by production, the distribution of income among the factors of production and the use of the income, either for consumption or acquisition of assets. They record the value of the stock of assets and liabilities of an economy and record the events that bring about changes in the value of the stock of wealth (ABS 2012; UN 2008). Economic targets can be formulated in terms of major national accounting variables that can also be used for other economic performance measures. These can be used to design policies that change the value of transactions between entities or motivate different transactions (Vardon et al. 2018).

Reflecting the increased awareness of the usefulness of environmental information, the United Nations Statistical Commission has endorsed the integrated System of Environmental-Economic Accounting (SEEA) that describes a statistical framework for recording the interactions between the national economy and the nation’s environment, including estimation of the stocks and changes in stocks of environmental assets (United Nations et al. 2014a). The SEEA framework applies the same accounting principles and measurement boundaries as used for the standard economic accounts described in the System of National Accounts (SNA) and hence allows for direct integration of environmental and economic data (United Nations et al. 2014a, 2014b; UNSD 2017b).

The SEEA – Experimental Ecosystem Accounting (SEEA EEA) endorsed in 2013, provides a starting point for the development of ecosystem accounting. It integrates complex biophysical data with socio-economic data so that changes in ecosystems and biodiversity can be linked to changes to economic and other human activity at national and subnational levels (United Nations et al. 2014b).

Following experimental applications of the SEEA EEA over several years and in several countries, the SEEA Experimental Ecosystem Accounting: Technical Recommendations (SEEA EEA: Tech. Rec.) was published to support further development (UNSD 2017b). The SEEA EEA: Tech. Rec. describes the desirability of integrating ecosystem information with standard economic data to allow the derivation of extended measures of national and sector net wealth and to facilitate the derivation of measures of national income and economic activity that are adjusted for depletion or degradation of ecosystems (UNSD 2017b). However, it is not designed for or applied to individual entities.

1.1.3 Why consider adapting the IAS to provide information about land degradation?

Land and the ecosystems on it, is owned or controlled by individual entities that are governments, or private or corporate landholders. Most jurisdictions around the world already require governments and businesses to prepare information about their financial performance according to the international accounting standards (IAS) [1] (Hoogervorst 2019; IFRS 2019b; Loweth 2017). Invisible to most, these institutionalised standards underpin modern commerce, including primary production, and may be the most widely adopted economic standard in the world (Hoogervorst 2019).

The purpose of the IAS is to meet the needs of users for information that is useful in making economic decisions (IASB 2018; IFRS 2017a). Economically useful information supports people when making decisions to buy, hold, or sell an equity investment or to assess the security for amounts lent to the entity. It includes assessments of the quality of the resources of the business and the resource stewardship or accountability of

[1] Generally Accepted Accounting Principles (GAAP) are an alternative, principle-based accounting standard with similar conceptual foundations to IFRS ((Blanchette, Racicot & Sedzro 2013)). While significant differences in reports of financial performance can emerge depending on whether IFRS or GAAP are applied (Blanchette, Racicot & Sedzro 2013), the principles established in this study for inclusion of ecosystems in financial reporting are expected to be applicable to both standards.

management (IASB 2018). Importantly, it also includes information about the quality and quantity of resources that should be transmitted to future generations (Arrow et al. 2012; Barbier 2013; Dasgupta 2001; Lange et al. 2018; Stiglitz, Sen & Fitoussi 2010).

The IAS already provides for a range of material sustainability issues such as climate change impacts on property, plant and equipment asset values, or environment-related liabilities (AASB 2018; Hoogervorst 2019; Ji & Deegan 2011; Linnenluecke, Birt & Griffiths 2015; Linnenluecke et al. 2015). They also already provide an input into the national accounts of a country that are used to evaluate the financial and economic performance of sectors and countries and identify policy responses to improve economic performance (ABS 2012; IASB 2018; UN 2008).

The IAS does not presently provide guidance on the inclusion, separately from land, of ecosystems, soil, or biodiversity in the general-purpose financial reports of entities. As a result, stakeholders of entities such as agriculture that are dependent on (and responsible for) the condition of these resources for food and fibre production may not have information that might be important to their economic decisions. Accounts and reports prepared under IAS have the potential to be adapted to provide this.

If the condition of ecological capital owned or controlled by individual entities were able to be made visible and if the methods to do so are coherent with the UN SEEA (United Nations et al. 2014a, 2014b; UNSD 2017b), then entities and governments may have improved information for input to decisions about allocation of resources that would alter the interactions and transactions in the economy so that agricultural land is more likely to be maintained in a condition that is productive, economic and sustainable.

1.2 Statement of the research question and research purpose

A review of the field of sustainability accounting, environmental accounting and ecosystem accounting indicates no research has been published related to adaptations of IAS to enable ecosystems to be accounted for as assets under IAS. This study contributes to theory and practice of accounting by describing methods and practices to include information about ecological capital in the general purpose financial reports (GPFR) for individual entities. It explores how the principles, concepts and methods of IAS and the

UN SEEA could be applied or adapted to describe an entity-level accounting framework for ecosystems and is guided by the following research question:

How can ecological capital best be incorporated into the financial statements of individual entities?

Addressing this question requires consideration of:

1. *the purpose of incorporating ecological capital in IAS and the ecosystem-specific information needs of users;*

2. *the degree to which accounting standards and standard accounting concepts need to be adapted to accommodate the unique characteristics of ecosystems;*

3. *the degree to which current accounting standards and concepts can enable visibility of the condition of ecosystems and accountability for ecosystem degradation; and*

4. *how information resulting from the recognition and reporting of ecosystems in the financial statements of entities can assist with preparation and use of national statistics and support the agricultural supply chain to influence land and ecosystem condition.*

1.3 Theoretical perspective and research methodology

This study reviewed present and past standard accounting concepts, conceptual frameworks and accounting standards published by the IAS and AASB to test the alignment of the concepts and conceptual frameworks to measurement and management concepts developed for sustainable agriculture. It considered the relationship of accounting standards to the operationalisation of legal and regulatory frameworks that create and enforce obligations of owners and leasers of land to avoid land and ecosystem degradation. It applied and adapted accounting concepts to economic concepts of externalities to elucidate solutions to improving the information available for good resource governance.

The study focused on livestock grazing in northern Australia as an example of a sector that owns and controls a significant proportion of Australia’s land-based ecosystems (ABS 2018) and where degradation is a key concern (Metcalfe & Bui 2016). It is also an example of an industry that is well-supported by significant investment in research and practice for sustainable management of ecosystems used for livestock grazing (see for example Ash et al. 2015; Dorrough 2010; Dorrough, Stol & McIntyre 2008; Hunt et al. 2014; McIntyre, McIvor & Heard 2002; Walsh & Cowley 2016; Walsh & Cowley 2014b).

The study took the perspective that the purpose of the adaptations to IAS were in support of mobilising governance frameworks and stewardship incentives across all levels of the agricultural supply chain to prevent further land degradation and assure sustainable land management. This framed the objective of the study as identifying practical adaptations to existing accounting standards to provide the information required by government and business stakeholders, including agriculture. It also took the perspective that, where an industry had developed and adopted scientifically coherent monitoring good practice for sustainable ecosystem management, that these measures should be reflected in the formal accounting framework.

The purpose of the literature review in this study was to construct a pragmatic research agenda that will help move the field of ecological and environmental accounting to the next stage of development. It used an integrative literature review across disciplines (following Christ, KL & Burritt, RL 2017) to synthesise a transdisciplinary view of how ecological capital of agricultural businesses could be included in financial statements. It established what is known and has been accepted to identify shortcomings in knowledge or challenges that must be overcome to advance the field. This formed a normative foundation for a pragmatic approach to possible IAS adaptations that might satisfy these information needs.

A framework for the accounting for ecosystems assets and services of grazing entities was developed by incorporating the current good practice of sustainable agricultural and rangeland systems management. The stocks and flows identified by these practices were conceptualised as analogues of accounting elements and concepts defined in IAS. Individual accounting standards were examined to assess whether they could be applied without change or needed to be adapted to represent any characteristics unique to ecosystems. The ability of the framework to produce useful information was demonstrated in accounts prepared using realistic case studies produced from industry data. The implications of these are discussed.

1.4 Research scope

The research scope included accounting for ecosystems that are owned and controlled by an entity and focused on the adaptations to accounting standards. It addressed accounting for entities who do not own or control ecosystems, but who wish to report on the environmental performance of suppliers. It excluded measurement and accounting for carbon storage or emissions, water use and waste generation. It did not address the magnitude, causes or economic costs of ecosystem degradation.

Exploration of accounting for ecological capital requires the use of typologies and condition classifications for ecosystems. At the time of this research, the methods and protocols for this are undergoing rapid development (Hein et al. 2016; Keith et al. 2019; La Notte et al. 2017; UNSD 2017b). This research therefore used methods of typology and classification that are already used for sustainable management of ecosystems in economic production and are appropriate for the purpose of exploring valuation methods and accounting processes. These are coherent with recommendations from the United Nations Expert Working Group on condition accounting (described in Czücz et al. 2019; Keith et al. 2019; Maes et al. 2019).

The valuation of ecological capital in this research was confined to the exchange values required by the formal accounting frameworks (Obst, Hein & Edens 2015). It is acknowledged that wealth and welfare valuations that value the existence of nature, the non-monetary benefits of health and personal security, and the multiplier effect of changes to the natural resource base provide very useful information (see for example Arrow et al. 2012; Barbier 2007; Barbier 2013; Deloitte Access Economics 2017; Obst, Hein & Edens 2015; Stern 2007; Stiglitz, Sen & Fitoussi 2010). In future it might be useful for decision making to present these values alongside exchange values.

1.5 Outline of the thesis

This study used a literature review (in Chapter 2) to establish a normative foundation for the purpose of including ecosystems in IAS. Chapter 3 establishes a framework for the design of accounting concepts, principles, processes and methods. Chapters 4, 5 and 6 apply this framework to demonstrate accounting valuations and accounts in physical and monetary terms that accommodate scientifically established practice of ecological capital management. Chapter 7 presents a synthesis and discussion of the findings in previous chapters and describes possible implementation pathways and future research to facilitate these. Chapter 8 describes the contributions this study has made to address the research questions and advance the field of environmental-economic accounting for sustainability.

Figure 1 illustrates the structural framework and sequence of this thesis.

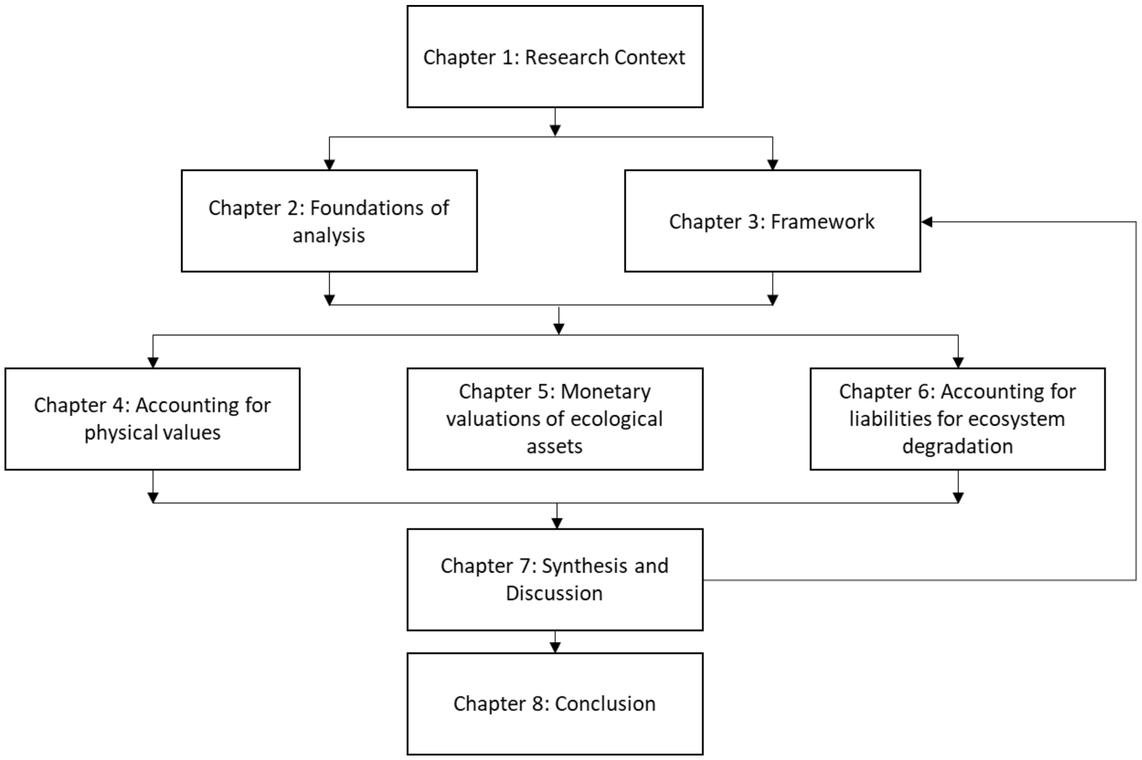

Figure 1: Structural framework of the thesis

2 Foundation for analysis

2.1 Introduction

The International Accounting Standards Board (IASB) uses a conceptual framework to assist it to develop IAS that are based on consistent concepts so that investors, lenders and other creditors of businesses get useful information about an entity. The conceptual framework assists all parties to understand and interpret accounting standards and to develop accounting policies when no Standard applies or where a Standard allows a choice of accounting policies (IASB 2018; IFRS 2018).

This chapter describes information that a future conceptual framework for accounting for agricultural ecological capital should accommodate to assist with making economic decisions related to agricultural ecological capital. This normative foundation is used to identify concepts and standards that can be adopted to provide ecosystem-related information and that need to be adapted or created.

The chapter is structured as follows. Section 2.2 addresses agricultural ecological capital at the farm entity level. Section 2.3 elucidates information about agricultural ecological capital needed by members of the agricultural supply chain. Section 2.4 describes information needed to compile national and subnational accounts under the SNA. The information needs for each of these types of users is summarised at the end of each section. Section 2.5 synthesises these needs with the principles of useful information under IAS to provide the normative foundation.

Section 2.2 draws on agricultural economics literature as well as the agricultural ecology and animal production science literature. It considers the following questions:

1. What is ecological capital and what governs its economic value to agriculture?

2. Why is information about ecological capital relevant to entities beyond the farm gate?

3. What information needs to be available?

Section 2.3 draws on a broad review of extant and recent literature relating to sustainability investment and sustainability accounting to elucidate information needed to enable corporations and governments beyond the farm gate to manage risks related to ecological capital and influence land degradation and biodiversity loss in agriculture. It considers the questions of:

1. When and why is information about agricultural ecological capital important to firms that do not own or control it?

2. What information do firms need to help them detect and prevent ecosystem condition-related financial and other risk emerging from their value chains?

Section 2.4 provides an overview of the role of the SNA in analysing and planning for a sustainable economy including the role of the IAS in compilation of national accounts. It draws on the UN SEEA to describe information about ecological capital needed by governments. It considers the question of the obligation to assure resources for future generations and the accounting for expenditures related to degradation or damage to ecosystems.

Section 2.5 discusses IAS guidance for the qualitative characteristics of information that is useful in making economic decisions. The chapter concludes with a synthesis of information needs with IAS principles for useful information. A framework for adapting the IAS to provide this information is developed in the following chapter (Chapter 3).

2.2 Ecological capital in agriculture

Ecosystems are complex ecological communities that provide flows of economically significant goods and services (Mace, Norris & Fitter 2012; United Nations et al. 2014b). Ecosystems have a range of functions and processes that generate ecosystem services from microscopic to global scales and can affect all industries and geographies directly or indirectly (See for example Bennett et al. 2010; Costanza & Daly 1992; Daily 1997; Dasgupta 2008; de Groot et al. 2010; Ekins 2003; Lal 2012; Mace, Norris & Fitter 2012). The extent and condition of ecosystems is fundamental to their service potential (capacity) for future flows of ecosystem goods and services including the contributions ecosystems can make to reduce a company's cash outflows (Hein et al. 2016; Keith et al. 2019; La Notte, Vallecillo & Maes 2019; UNSD 2017b).

For accounting purposes, ecosystem services are grouped into three broadly agreed categories; provisioning services which reflect physical or energy characteristics generated by or in an ecosystem; regulating services such as soil erosion protection or carbon storage; and cultural services, such as benefits from biodiversity conservation or landscape amenity (United Nations et al. 2014b). Within ecosystems, biological elements live in complex interrelationships dependent on providing and receiving a range of provisioning and supporting goods and services to each other (Dominati 2010; Mace, Norris & Fitter 2012; Maes et al. 2012; Maes et al. 2013; Palmer & Febria 2012; Robinson et al. 2013; United Nations et al. 2014b; UNSD 2017b).

In agriculture, ecological capital[2] is conceptualised as ecosystem assets that are privately owned and controlled as result of a purchase or lease of land for agricultural use (Ogilvy 2015). While the term 'natural capital' is often used interchangeably with 'ecological capital', this study uses 'ecological capital' to distinguish ecosystems managed and manipulated for agriculture from extensive (wild) ecosystems that are untouched by humans. Under this definition, ecological capital includes ecosystem assets such as grasslands and pastures, riparian areas, pastures, crops, trees and shrubs, soil biology and soil. Sometimes ecological capital produces intra-ecological goods and services (Hein et al. 2016). These may be intermediate inputs to production and sometimes final products. Figure 2 provides a conceptual diagram of these for the purpose of exploring the concepts and standards that might apply to accounting for them.

2

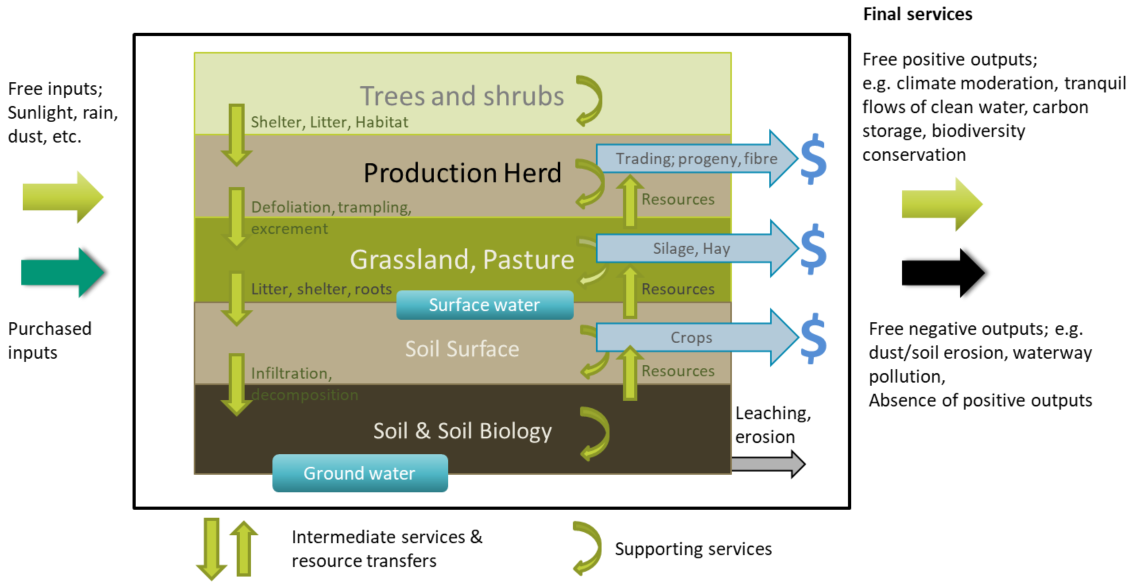

Figure 2: Conceptual diagram of Ecological Capital in Extensive Agriculture depicting inter-ecological and intra-ecological functions and processes that generate provisioning, regulating and habitat services that influence the production of crops and livestock and the regenerative capacity of ecological capital.

Described in Ogilvy (2015), the production herd (breeding stock) and grasslands or pastures are productive (or provisioning) assets that produce progeny via procreation or forage via growth of grasses. Grasses are intermediate goods (resources) that, in becoming forage for livestock, are transformed into final goods for sale (meat or fibre). Grasses and grazing disturbances can provide important regulating and nutrient cycling functions to improve soil health and affect the stability of soils and their ability to withstand erosive pressure from wind and water (Lavelle & Spain 2005; McIntyre & Tongway 2005). Decisions about the timing, duration and intensity of disturbance of grasslands and pastures can affect, positively or negatively, the structure and composition of grasses, forbs and herbs of these assets (see for example Dorrough, McIntyre & Scroggie 2011; McIntyre, McIvor & Heard 2002).

Soils that provide decomposition services to infiltrate, cycle and store reserves of soil-water and nutrients (resources) for future plant growth are productive assets that also provide temperature stabilisation functions (Lal 2012). Trees and shrubs provide ‘supporting services’ such as shade and shelter for livestock, pasture and crops as well as habitat for economically productive insects and birds (pollinators and pest predators). Shade and shelter reduce the diversion of energy to body temperature maintenance and make livestock healthier and more productive (Baker et al. 2018; Fleming et al. 2019;

Landis, Wratten & Gurr 2000; Mendam 2018). Habitat for predators of pest insects and birds can improve crop productivity (Colloff, Lindsay & Cook 2013; Landis, Wratten & Gurr 2000).

In addition to these private benefits to the entity, agricultural ecosystems also provide public benefits including regulating services that prevent water pollution from agricultural areas, enable sequestration of atmospheric carbon in vegetation and soils as well as generate inheritance value in their capacity to continue to provide food and other ecosystem services for the benefit of future generations (Dale & Polasky 2007; Dasgupta 2008; Farley & Costanza 2010; Keith et al. 2019; McDonald et al. 2019; Swinton et al. 2007).

If the functions and processes within and between elements of ecological capital decline, the capacity to capture, store and cycle free inputs from nature declines (Lavelle & Spain 2005; Tongway & Hindley 2004; Tongway & Ludwig 2011b). This is often accompanied by loss of soil protection services resulting in reduced regulatory capacity and increased leaching and erosion of soils (Bennett et al. 2010; Dominati 2010; Dominati et al. 2014). These can affect the farm business by increasing the reliance on purchased inputs to substitute for free inputs from nature (see for example Culman et al. 2010; ELD Initiative 2013; Kremen & Miles 2012). Figure 4 in Chapter 3 complements the conceptualisation presented in Figure 2. It depicts the role of purchased inputs, labour and produced capital as it combines with ecosystem services to generate economic benefit.

2.2.1 Ecological capital quality is an economic factor

At the farm business level, ecological and agronomic studies have demonstrated that the interactions between each of the ecosystems that make up agriculture’s ecological capital can affect the productivity and sustainability of the enterprise. Biodiversity (the species richness and genetic diversity of plants and the soil microbiology) significantly improves the productivity and regenerative capacity of pastures and grasslands and the herbivores that depend on them (de Deyn et al. 2012; Glover et al. 2010; Hector 1999; Isbell et al. 2015; Kotowska 2010; Kremen & Miles 2012; Liebman et al. 2008; McDonald et al. 2019; Tilman 1996, 1997; van der Heijden, Bardgett & van Straalen 2008).

Ecosystems can be degraded to a state which may generate different ecosystem goods and services, or may hardly generate any services at all (McIntyre, McIvor & Heard 2002; Prober, Thiele & Lunt 2002; Walker et al. 2004; Walsh & Cowley 2014a, 2014b; Watson & Novelly 2012; Westoby, Walker & Noy-Meir 1989). Absence of ecological functions can reduce enterprise productivity via a range of mechanisms. For example, annual grasses and crops are less effective at water and nutrient cycling than perennials and are unable to replenish soil-water and nutrient reserves as efficiently. This impairs soil structure, stability and fertility and increases risk of erosion or degradation (Lavelle 2005; McIntyre & Tongway 2005; Tongway et al. 2003). Decreased ecological function in cropping soils can significantly increase fossil energy use (Cruse et al. 2010), decrease economic returns (Liebman et al. 2008) and constrain agronomic performance (Kremen & Miles 2012; Lavelle & Spain 2005).

Livestock experiencing inadequate nutrition (due to poor quality forage) or exposure to extreme weather (in the absence of shade and shelter) demonstrate reduced performance including reduced ability to gain weight, reduced wool quality, reduced fertility and problems with parturition. Lack of consideration of local adaptation of livestock (and plants) to the landscape and genetic selection of animals to perform in confinement feeding systems may have resulted in development of animals and plants that have low genetic diversity and are maladapted to natural grasslands and rangelands and low-input systems (Lammerts van Bueren et al. 2011; Murphy et al. 2007; Siebert, Hunter & Squires 1992). This in turn may be driving increased physiological dependence on artificial supplementation (fertilisers, lime, veterinary medicines) in order to produce the plant communities (grain crops) and nutrients these animals require to achieve reliable and satisfactory yields (Provenza et al. 2007).

2.2.2 **Sustainable management of ecological capital**

Through improved management of ecosystems functions, farmers can have a significant impact on the efficiency with which an agricultural enterprise generates income and regenerates its asset base. Research suggests that local adaptation of livestock combined with management of animal density, paddock rest and grazing duration positively influences livestock productivity and regeneration of the plant community, soil-water and soil-nutrients (Hunt et al. 2014; Jakoby et al. 2014; McDonald et al. 2019; O'Reagain &

Scanlan 2013; Post et al. 2006; Teague et al. 2013; Teague et al. 2011; Tongway et al. 2003; Tongway & Ludwig 2011a; Weber & Gokhale 2011). Described further in Chapters 3 & 4, management that preserves ecological functions of natural ecosystems creates a more climate-resilient ecological capital base (see for example Isbell et al. 2015; Lavorel et al. 2015; O'Reagain & Scanlan 2013).

In contrast, common practices in agriculture can degrade ecological capital. Overgrazing of rangelands reduces the numbers and quality of perennial grass species and increases the proportion of unpalatable (non-nutritious) annual grasses (Ash & Corfield 1998; Hunt et al. 2014; O'Reagain & Scanlan 2013; Ryan et al. 2013; Stafford Smith et al. 2007; Teague et al. 2013; Tongway et al. 2003; Walsh & Cowley 2011; Walsh & Cowley 2014a, 2014b; Walton & Pringle 2010). Fertilisers alter the morphological and regenerative traits of woodland and grassland plants including species type and richness (Ash et al. 1995; Dorrough et al. 2006; Laurent, Betin & Nicolas 2006; McIntyre & Lavorel 2007; Stafford Smith et al. 2007; Teague et al. 2011). Clearing, soil-nutrient enrichment and 'tidying-up' of fallen timber threatens the health and ecological functions of the grassy woodlands biome of Eastern Australia (Dorrough et al. ; Dorrough & Moxham 2005; Dorrough et al. 2006; McIntyre, McIvor & Heard 2002; Prober, Lunt & Thiele 2002; Prober & Thiele 2005; Prober, Thiele & Lunt 2002) eliminating many of the regenerative and climate-adaptive functions of these ecosystems.

2.2.3 A vicious cycle of environmental and economic degradation

Ecosystems used for extensive agricultural production systems (broadacre, rain-fed grazing and cropping) cover an estimated 40% of global terrestrial ecosystems (MEA 2005; World Resources Institute 2000) and present a significant sustainability challenge. As a primary industry that supports population health and economic well-being through its provision of food and fibre, agricultural sustainability is of critical importance but is not assured (FAO 2015; FAO & GEF 2018; UNCTAD 2013; UNEP 2014; UNEP 2012).

Approximately 38% of land under agriculture is judged to be degraded due to overgrazing, excessive cultivation, clearing of forests and draining of wetlands (FAO & GEF 2018; MEA 2005; SOE 2011; UNEP 2014; Von Braun et al. 2013; World Resources Institute 2000). Degradation of agricultural landscapes is judged to be a current threat to food security and intergenerational equity (Dasgupta 2008; ELD Initiative 2013; Kurth et al.

2018; Lal 2009; Lawrence, Richards & Lyons 2013; Turner et al. 2018; UNEP 2014; UNEP 2012).

In Australia, concerns have existed for decades about links between financial aspirations for pastoral enterprises and land degradation caused by overgrazing. This has led to suggestions that many of these enterprises are not ecologically sustainable (Ash et al. 2015; Ash et al. 2011; Ash et al. 1995; Curry & Hacker 1990; Holmes 2015; Hunt et al. 2014; McKeon, Stone & Syktus 2009; O'Reagain & Scanlan 2013; Stafford-Smith 1994; Tongway et al. 2003). More recently, research has suggested that the owners of many pastoral enterprises in Australia's rangelands may not have sufficient financial literacy to detect whether their operations are economically sustainable (McLean, Holmes & Counsell 2014). It has been suggested that many of these enterprises may be uneconomic because the ecosystems that underpin their businesses are incapable of producing sufficient inputs to production[3] to allow the businesses to meet financial commitments (Ash et al. 2015; Holmes 2015; Novelly & Warburton 2012; Safstrom & Waddell 2013).

A 'vicious cycle' of causally linked environmental and economic decline is well known to ecological economists as a phenomenon of commodity markets that rely on natural systems (Ogilvy et al. 2015). Market prices in commodity systems reflect production and distribution costs, variability of demand, intensity of competition and availability of substitutes. The vicious cycle arises because the condition of the primary resources that enable agricultural production are not adequately valued in the global commodity markets. Where price and availability are the dominant means of competition, and resource condition is invisible, participants in global commodity markets have no incentive to address fundamental issues of resource decline. In fact, they have an imperative to keep increasing volume due to price reductions and to cut back on investment in resource replenishment to maintain earnings. They are compelled to do this to remain financially profitable, even if the primary resources that underpin production demonstrate decline (Hatfield-Dodds, Binning & Yvanovich 2006; Mallawaarachchi & Green 2012; Mallawaarachchi & Szakiel 2007; Monast, Sands & Grafton 2018; Ogilvy et al. 2015; Pannell, DJ & Roberts, A 2015).

[3] Forage and shelter for livestock

The invisibility of resource condition in agricultural commodity markets – combined with the vast and deep supply chains for agricultural produce – means that individually rational and well-intentioned decisions by producers, other actors in the supply chain and consumers are adding up to collective behaviour that systemically erodes environmental human and social resources (Rapacioli et al. 2013; Sawin et al. 2003). This problem is not unique to agricultural markets but is particularly visible in a sector that is at the front line of natural resource management in Australia (Monast, Sands & Grafton 2018; Ogilvy et al. 2015).

Finally, some entities responsible for degradation do not experience the economic burden of it. While some Australian states and territories (see for example WA Government 1997) require land condition to be maintained, activities to prevent or remediate degradation are not uniformly enforced (Safstrom & Waddell 2013; Stoate 2012).

2.2.4 **Information requirements of landholders**

Information needs for the supply chain are briefly summarised. The literature examined for Section 2.2 confirms that it is generally accepted that ecological capital has economic relevance for agricultural producers. It also suggests that information about the nature and quantity of interrelationships within the ecosystem is important. This provides insights into the provisioning and supporting goods and services within the ecosystem that contribute to its productivity and its regenerative capacity. These are useful in assessing the present productivity and prospects for the future. This need is satisfied by ensuring that information about the ecosystem includes vegetation composition and structure as well as ecological processes and functions. A framework for ecological capital information to help managers and other users assess the quality of the ecological capital and make decisions about their involvement with the farm enterprise should provide guidance about the preparation and communication of this information.

The literature examined for Section 2.2.1 has also suggested that the past and present management practices affects the nature and productivity of agricultural ecological capital in the present and in the future. Accordingly, a framework for ecological capital information should include information about these and the implications for the future condition and productivity of ecological capital.

Finally, the phenomenon of the vicious cycle stemming from the invisibility of ecological capital to the markets of primary produce suggests that information about the quality and quantity of ecological capital should be made visible to the market and the economic cost of its maintenance incorporated into market pricing.

2.3 Ecological capital for the supply chain

The growing importance of accounting towards sustainability reflects the growing expectation that problems with environmental performance are increasingly taken into account in business (see for example Burritt & Schaltegger 2014; Generation 2012; Guthrie 2016; IFAC 2016; Kwon et al. 2018; Lambooy et al. 2018; Linnenluecke, Birt & Griffiths 2015). As discussed in Chapter 1, while governments and civil society will need to be part of the solution to global environmental and social challenges, ultimately it will be companies and investors that will mobilise the capital needed to instigate the change (Adams, C. A. 2017; Adams, C A 2017; Blackrock 2016; Generation 2012; KPMG International 2014).

2.3.1 The issues of ecological unsustainability for the supply chain

Economic risk related to agriculture's ecological capital is not confined to the farm business. Through their relationships as value-added processors of agricultural commodities or suppliers of financial capital to agriculture, companies in the private sector may risk economic loss associated with depletion of agriculture's natural resources (see for example ACCA, FFI & KPMG 2012; Ascui 2018; Bateman et al. 2013; Costanza et al. 2014; Dasgupta 2008; EY 2014; KPMG International 2014; NCC 2015; PPR 2010; Trucost 2013; UNEP 2011).

Operational activities which impact on environmental health and biodiversity within a company's supply chain, direct operations or products can have far reaching implications to shareholder value (FSC and ACSI 2015; Lambooy et al. 2018). Environment-related economic risks include product disruptions due to incidents as well as capital costs and compensation associated with environmental remediation (see for example FSC and ACSI 2015; Ji & Deegan 2011; Kashmanian & Moore 2014; NCC 2015; Schaltegger & Burritt 2010; Seuring & Müller 2008). In addition, environment-related problems can impact on the company's regulatory or social licence to operate (Brindley & Oxborrow 2014; CIE 2015; Deegan & Islam 2014; Kashmanian & Moore 2014; Kumar & Christodoulopoulou 2014; NFF 2013; Seuring & Müller 2008). These can manifest as new regulation, additional reporting, insurance expenses or as additional expenses to recover from reputational damage, protests or product boycotts (FSC and ACSI 2015). As a result, environment-related economic risk is perceived to be significant to firms in the financial services sector and to the discharge of fiduciary duty (CISL 2015; CISL & UNEP FI 2014; Mareuse 2011; NCC 2015).

Among the clearest pieces of evidence that risks stemming from environmental or social factors can impact investor perceptions of business performance is the evidence for investor estimates of stranded asset risk (EY 2015). Stranded assets are assets that become subject to unanticipated or premature write-downs, devaluations or conversions to liabilities (Caldecott, Howarth & McSharry 2013; EY 2015). Assets can become stranded because of non-financial factors such as increasing environmental risks, evolving social attitudes, government regulation, disruptive technology or geopolitical risk (EY 2015). For example, under action to reduce carbon pollution, the assets of companies that intensively use fossil fuels could become stranded (Linnenluecke et al. 2015).

In their report on investor requirements for non-financial information, EY reveal that over 60% of respondents are concerned about stranded asset risk (EY 2015). Caldecott et al., (2013) observe that environment-related risk factors can strand assets throughout the global agricultural supply chain and that the amount of value potentially at risk is significant. They note that understanding environment-related risks that can induce stranding can help investors, businesses and policy makers develop effective risk-management strategies (Caldecott, Howarth & McSharry 2013).

Research exploring the different types of business cases advanced by corporations with regard to sustainability suggest they arise from different ethical motivations, including a reactionary concern for the short-term financial interests of the business, a narcissistic concern to protect the reputation of the firm, a responsible motivation to achieve better social and environmental outcomes and a collaborative motivation to understand who may be vulnerable to perverse outcomes as a result of the firm’s activities. They find that these different ethical motivations have very different effects on the design of business cases for management activity and the firm’s economic performance (Schaltegger & Burritt 2018).

2.3.2 Internalising externalities

There is general acceptance that negative externalities in the form of rising inequality, ecosystem degradation, resource depletion and rising concentrations of greenhouse gas in the atmosphere are detrimental to communities, businesses and long-term economic performance (ACCA, FFI & KPMG 2012; Burritt 2004; NCC 2015; PWC 2015; Rapacioli et al. 2013; Reynolds 2015; Schaltegger & Burritt 2010; Schaltegger & Synnestvedt 2002). There is also increased expectation that they are taken into account by managers (Blackrock 2016; Burritt & Schaltegger 2014; CAER 2019; EY 2014; KPMG International 2014; Kwon et al. 2018; Maas, van 't Foort & van Tilburg 2018; Rapacioli et al. 2013).

Externalities are defined in the SNA as unsolicited services, or 'disservices', delivered by one unit to another without mutual agreement. They are not market transactions between entities and, as there is no mechanism to ensure consistency of valuations between the parties, they are not recorded in the national accounts (ABS 2012 para. 3.21).

The literature reviewed for this study revealed four main approaches to corporations' accounting for externalities. The first approach referred to as 'Pragmatism' is a pragmatic analysis of the potential for regulatory or social pressure to increase expenditure to prevent generation of negative externalities. The second approach referred to as 'Positive Externalities' communicates a corporation's positive impact by estimating the value of positive externalities generated by their services such as improvements to human health and wellbeing and appending this to corporate performance reporting. The third approach referred to as 'Negative Externalities' estimates the value of negative externalities generated by business. These are used to motivate and inform changes to supply chains and production methods. The fourth approach 'Resource Allocation' focuses on the future by recommending that corporations should use no more than their 'share' of planetary resources if they are to be sustainable.

The premise of Pragmatism is that putting a monetary value on environmental impacts caused by corporations allows companies to take these into account in their decision-making and enables them to deliver better outcomes for the company as well as the environment and society (see for example PWC 2015; Reinhardt 1999). For decades, studies of corporate sustainability reporting have consistently found that companies who lead the market in forecasting community responses to environmental problems and can consider the material issues associated with sustainability had higher profitability compared to those who considered sustainability to be a peripheral issue (Generation 2012; Hoepner 2013; Khan, George & Yoon 2015; Reinhardt 1999; Schaltegger & Burritt 2010).

An important factor in a pragmatic approach towards accounting for sustainability is the identification of key sustainability issues and purposive sustainability goals (Burritt & Schaltegger 2014). Burritt and Schaltegger (2014) explored the potential, where companies are keen to engage, for accounting to be a catalyst of increased sustainability of production and supply chains. They find that a pragmatically informed approach to accounting for sustainability that involves collaboration with various tiers of suppliers may support management to overcome trade-offs and create win-wins for all stakeholders (Burritt & Schaltegger 2014). Burritt and Schaltegger (2014), the Natural Capital Coalition (2014), and Kering (2017) suggest that it is possible to identify points of dependency on ecosystem services, whether direct as in the case of supply of wool or leather for garments, or indirect as in the case of reduction of storm intensity or flood risk (Burritt & Schaltegger 2014; Kering 2017; also NCC 2015; Stonebraker, Goldhar & Nassos 2009). They also observe evidence for the potential for this to lead to greater market share for corporations with better performance on these issues.

The Positive Externalities approach estimates the total economic value of positive externalities to communicate their environmental (and social) performance. For example, Parks Victoria and Yarra Valley water estimated the value of the positive externalities they generate for society as managers of national parks and Melbourne’s water supply (Baldock et al. 2016; Varcoe, Betts O'Shea & Z. 2012). Similarly, EFTEC, PWC and RSPB aimed to develop a methodology for corporate natural capital accounting (CNCA) so that companies who owned or relied on significant stocks of natural capital could measure and value the public benefits (total economic value) being generated by natural capital assets and recognise as a liability the funding required for its maintenance and enhancement (Provins et al. 2015).

The Negative Externalities approach acknowledges that corporate activities often result in destruction of environmental resources. Under this premise, corporations estimate the value of their historical impact and are observed to use these to set targets and strategies for avoidance of further destruction. These motivate and inform them to reduce their future impact. For example, the Environmental Profit & Loss (EP&L) estimated by Kering communicates the total economic value of negative externalities - environmental degradation, resource use and waste attributable to its supply chain (Kering 2014). This enables them to use and measure the impact of selective sourcing to reduce their future impact (Kering 2019).

The fourth approach, Resource Allocation, aims to deal with future impact. Recommendations for action under this approach include reporting on attainment of Sustainable Development Goals (see for example IFAC 2016; Ruijs, van der Heide & van den Berg 2018) and recommending that corporations confine their generation of negative externalities related to science-based targets about future resource availability (for example Barker 2019; Barker & Mayer 2017; Rapacioli et al. 2013; Schaltegger & Burritt 2018; Schaltegger, Etxeberria & Ortas 2017). For example, Barker and Mayer (2017) argue that individual companies should include two measures of profit: financial profit as currently reported under IAS and sustainable profit. They conceptualise sustainable profit as a hypothetical measure of the financial profit if the total economic value of the externalities generated by the company were internalised. The criterion for sustainable profit would be developed from science-based targets (Barker & Mayer 2017).

The common premise of these approaches is of externalities to shared resources such as the atmosphere (via greenhouse gas emissions), waterways (via emissions to water), and biodiversity (via land use change and management). The other premise that should be considered is at the local scale. Positive and negative externalities between farm properties and between farm properties and neighbouring or local landscapes are described in Chapter 3 as part of the exploration of a possible framework for estimating and disclosing their value.

2.3.3 Issues of estimating and communicating sustainability performance

Accounting has a role to play in creating awareness of the underlying reasons for investing in analysis of externalities, as well as estimating financial and social trade-offs related to changes to land use planning and regulation (Schaltegger & Burritt 2010).

However, the approaches to internalising externalities described above do not provide the information needed to accomplish this.

Total economic values (TEV) of positive and negative externalities provide insight into future regulatory and reputational risk but they do not represent the expenditure (or the potential income) required to respond effectively to these risks (Barton et al. 2019; Fenichel & Obst 2019; Obst, Hein & Edens 2015; PWC 2015; Vardon, Birt & Carter Ingram 2017). Environmental profit and loss accounts are unable to clarify the financial relevance of ecological capital to a company or to society (Lambooy et al. 2018) and cannot be incorporated into financial statements under IAS (IASB 2011; PWC 2015) or SEEA (Obst, Hein & Edens 2015). The amounts reported in the EP&L as conceptualised by Kering do not represent a liability to satisfy an obligation to restore the environment (Kering 2017; PWC 2015). In the absence of a liability, a reversal of an environmental loss is likely to remain unfunded.

With respect to the Resource Allocation approach of internalising externalities, it is likely to be possible to use planning strategies to set science-based targets to set goals for resource use such as atmospheric carbon storages (Science Based Targets 2019) and biodiversity (Arlidge et al. 2018; Mace et al. 2018; Maron et al. 2018; Maron, Simmonds & Watson 2018). These can be used to set targets or allocations for sectors such as agriculture (see for example Usubiaga-Liaño, Mace & Ekins 2019). Another example is the EAT-Lancet Commission on healthy diets from sustainable food systems (2018) that has suggested scientific targets for the agricultural sector to stay within ‘safe operating space’ as a way to mobilise economic policy and private sector collaboration to ensure that the SDGs (and the Paris climate agreement) are achieved (Willett et al. 2019). This may enable countries, sectors in agriculture, and perhaps even individual entities to fit within their ‘allocation’ of resource use (Willett et al. 2019). To do this, they need information about the size of the sector, the resources being consumed in total and the proportionate share allocated to the entity. Information compiled under the SNA and SEEA (described in Section 3) would be the logical source of much of this information.

2.3.4 **Agricultural land: a form of common pool resource?**

Evidence that corporations understand that degradation of agricultural ecological capital creates financial and other issues for them reveals acknowledgement of dependence of the agricultural supply chain on agricultural ecological capital. The evidence of approaches to management of externalities and attempts to communicate stewardship reveals acceptance of at least some responsibility for these outcomes, or that companies should find a way to influence future management of these resources. These resemble the combination of structural features that Ostrom (2009) suggests are crucial to cooperation for management of common pool resources (Ostrom 2009).

A common pool resource (CPR) is a resource whose characteristics make it impossible or costly to exclude potential beneficiaries from obtaining benefits from its use and where use of a resource by one user decreases resource benefits for other users (Heikkila & Carter 2017; Ostrom 1990).

Commonly, CPRs are conceptualised from the point of view of multiple harvesters of natural resources such as forests, ground-water, fisheries and pastures in the present time (Heikkila & Carter 2017). Most agricultural ecosystems would not usually be considered CPRs because they are privately-owned or controlled and therefore the beneficiaries are considered to be the asset owners. If future generations are also considered beneficiaries of agricultural land, then agricultural land might also be considered a CPR in temporal terms. However, agricultural land also exhibits characteristics of CPR in economic terms. The beneficiaries of agricultural land include many private entities along the agricultural supply chain including investors, lenders and current consumers who finance, transform or consume agricultural goods. The markets by which agricultural products are sold into this supply chain are mostly commodity markets making it expensive for a producer to exclude individuals or organisations in the supply chain (Marshall 2015; Stallman 2011). This suggests that beneficiaries of agricultural landscapes include members of the agricultural supply chain.

In discussing the possibility for cooperation to manage CPRs, Ostrom (2009) noted that empirical studies have identified a large number of variables that increase the likelihood of cooperation. The most important of these are:

(1) information about the immediate and long-term costs and benefits of actions is available;

(2) the individuals involved see the common resource as important for their own achievements and have a long-term time horizon;

(3) those involved attach importance to having a reputation for being a trustworthy reciprocator;

(4) individuals can communicate with at least some of the others involved;

(5) informal monitoring and sanctioning is feasible and considered appropriate; and

(6) social capital and leadership exist as a result of previous successes in solving joint problems (Ostrom 2009).

There are indications that many of these variables are already established in the agricultural supply chain or may be emerging. Social leadership is widespread. Many consumers, brands and agricultural suppliers have already agreed to changes in behaviour and to act as being jointly responsible with agriculture and other companies in the supply chain for environmental performance (see for example Brindley & Oxborrow 2014; Crooke 2009; Kering 2014; Kurth et al. 2018; Schaltegger & Burritt 2018; Schaltegger & Burritt 2010; Sustainable Fashion 2018). Companies are voluntarily enforcing codes of conduct to improve the environmental performance of their supply chains (see for example Kashmanian & Moore 2014; Patagonia 2014). The exposure in Chapter 1 of a lack of comparable and standardised information and common methodologies to prepare information (Blackrock 2016; EY 2015; Kwon et al. 2018; Lambooy et al. 2018) suggests that elements 1 and 5 are still absent.

Discussed in Section 2.4 of this chapter, information about the immediate and long-term costs and benefits of actions (element 1) is one of the purposes of macroeconomic analysis. Data about transactions and assets related to financial and produced capital and socioeconomic information is compiled under the SNA to facilitate this. Without information about ecological capital in these datasets, an important element of cooperation to improve management of agricultural ecological capital will remain weak.

The absence of effective monitoring and sanctioning (element 5) can enable greenwashing[4] to help companies avoid interrogation of the intended and actual impacts of environmental change and prevent evaluation of how fit-for-purpose company strategies actually are in light of the real environmental concerns (CAER 2019; Schaltegger & Burritt 2010). The variability of ecological literacy amongst company directors and contested stakeholder interests is causing a range of alternative environmental standards to be defined amongst the private sector and non-government organisations (EY & BCCCC 2017; Kwon et al. 2018). In addition, consumer concerns around sustainability and a desire to differentiate premium products have contributed to a proliferation of labelling and certification schemes so that consumers can use environmental (and animal welfare) attributes as part of the product selection criteria (Australian Government 2015; Blackrock 2016; CAER 2019; EY & BCCCC 2017; Feger & Mermet 2017; Kwon et al. 2018; Ogilvy et al. 2015).

The multiplicity of standards increases compliance costs without necessarily generating the best environmental or sustainability outcomes or providing the accurate information needed for the marketplace to function effectively to engender cooperation to get better environmental outcomes (Blackrock 2016; Brad et al. 2018; EY 2015; Lambooy et al. 2018; NCC 2015). Brad et al., (2018) notes that voluntary certifications of environmental performance may be hindering sustainability of supply chains by allowing a false sense of progress to be conveyed. For example, certifications for ‘responsible production of palm oil’ have not halted (or even slowed down) deforestation or peatland and biodiversity loss, and assessments of sustainably harvested fish have inadequate methods to measure fish stocks. The Better Cotton Initiative focuses only on flows of pollutants and on water use but not stocks of ecosystems (Brad et al. 2018). Like Stiglitz et al., (2010), the OECD recommends that outcomes-based measures of environmental performance are the most efficient mechanism for improving prospects of sustainable resource management (OECD 2010).

[4] The marketing of mainstream investment products as ethical, sustainable, or otherwise ‘green’ without applying or changing the product process or outcome (CAER, 2019)

2.3.5 Information requirements of the supply chain

Information needs for the supply chain are briefly summarised. There is broad acceptance that organisations should evaluate and report on their sustainability performance (e.g. Blackrock 2016; CAER 2019; CDSB 2018a; Feger & Mermet 2017) and that this should help them to use their investment in sustainability measurement and action to create a real competitive advantage or retain their position in markets (Brindley & Oxborrow 2014; Kumar & Christodoulopoulou 2014; Lambooy et al. 2018; Liu, Kasturiratne & Moizer 2012). Linnenluecke et al., (2015) observe that accounting research and practice to date have focused on impairment of assets due to changes in condition of the asset or external economic conditions rather than impairment due to environmental change (Linnenluecke et al. 2015).

Lambooy et al., (2018) suggest that the potential for financial institutions to be agents of improved management of environmental resources can be realised when they exert leverage over investee companies that impact environmental resources and/or are dependent on them (Lambooy et al. 2018). To realise this potential, they need information that helps them to understand the business and the financial risks and opportunities associated with the ecological characteristics underpinning it (ACCA, FFI & KPMG 2012; Adams, C. A. 2017; CDSB 2018a; Christ & Burritt 2018; EY 2014; Lambooy et al. 2018; Rapacioli et al. 2013; Schaltegger & Burritt 2018; Schaltegger & Burritt 2010; Schaltegger, Etxeberria & Ortas 2017). EY (2014) note that investors need information that:

- comes directly from companies rather than from third parties;
- focuses on measurable performance factors such as regulation, cost and risk, information;
- is based on standard, industry-specific criteria that allow comparisons between companies in the same sector;
- clearly explains the links between non-financial risks and expected performance; and

- has a company's top-level approval (EY 2015).

In advocating for integrated reporting to be mandated for publicly listed companies, Generation (2012) suggest accountants provide assurance on non-financial information that is comparable to that provided on financial metrics (Generation 2012). Economic decision-makers need information about:

- materiality of environmental factors of the organisation's operation;
- environmental factors that relate to legal or constructive obligations on the organisation; and
- valuation of environmentally related liabilities, or provisions to create new assets - for example to avert carbon emissions or prevent land degradation (IFAC 2015).

Potential resolutions to capturing information about a company's use of environmental resources have been explored in development of activity-based costing and in the development of standards for material flow cost accounting (MFCA)[5] which may lead to improved company performance on environmental and financial grounds via a better understanding of sources of production costs related to environmental factors (Burritt & Schaltegger 2014; Christ, KL & Burritt, R 2017). Unfortunately, the complexity of the task of data-gathering and analysis may be constraining the realisation of these opportunities (Burritt & Schaltegger 2014; Kering 2017).

There is strong support for accounting to provide at least some of the information required. A responsibility of accountants is to establish approaches to information gathering, analysis and reporting for items of materiality that adds credibility to the organisation's reporting and provides internal benefits (IFAC 2015). The majority of Chartered Global Management Accountants (CGMAs) believe they should include environmental and social factors in their reports to decision makers, but only 45% do so (IFAC 2015). This problem may be resolved (at least partly) if agricultural businesses were enabled to collect

[5] MFCA is an environmental management accounting approach which supports an encompassing calculation of internal company costs of material throughputs of production.

and communicate the characteristics of their ecological capital including its economic value and this was available to their supply chain.

Information to enable a company to estimate its sustainable share of total resource base (the 'Resource Allocation' approach to internalisation of externalities) relies on information about the total resource base available and the proportion that is presently allocated to the company. For example, if science-based targets for agriculture were set as described earlier, they would affect land use planning and regulation. While companies may influence these, (local) governments have a vested interest in and a responsibility to encourage businesses to incorporate sustainability thinking as part of economic planning because social stability, community revitalisation and business attraction are public goods (ABS 2012; Generation 2012; Lambooy et al. 2018).

As a result of international and domestic obligations to biodiversity and environmental performance, governments also play a central role in defining and agreeing targets for these in the context of society's other needs including for economic activity. To set targets for resources such as ecological capital including biodiversity and greenhouse gas emissions, governments also need information about any economic implications for society and business (Lambooy et al. 2018; Mace et al. 2018; Reynolds 2015; Stiglitz, Sen & Fitoussi 2010). The SEEA and the SNA are important sources of this information.

2.4 System of National Accounts

2.4.1 Overview

As in other countries, Australian governments have a range of purposes for environmental information. These include understanding the contribution of natural resources to the Australian economy as well as satisfying international reporting obligations and policy-making about natural resource management (DoEE 2018). In addition to the SDGs, international reporting obligations include the Convention on Biological Diversity (CBD), Ramsar Conventional on Wetlands, and the Convention Concerning the Protection of World Cultural and Natural Heritage (summarised in NLP 2019). Domestic legislative requirements such as the Environmental Protection and Biodiversity (EPBC) Act (DoEE 1999) and biodiversity conservation acts (for example NSW Government 2016) and Land Acts (see for example WA Government 1997) specify the collection and communication of other types of information. Many of these reporting and legislative frameworks are designed to assure that environmental resources are retained for future generations.

Due to the significance of agriculture as a manager of land and natural resources, governments need an understanding of the environmental resources being managed on agricultural lands. They also need to understand the extent to which improved land and ecosystem condition assists agricultural production (AITHER 2018; Mallawaarachchi & Green 2012; Pannell, DJ & Roberts, A 2015). In agriculture, positive ecological outcomes are not the entity's primary motive but may be produced as a 'joint product', or a 'complementary good'. Information about the relationship of different ecological characteristics of an agricultural property to the profitability of the farm business are an important guide in designing public policies such as cost sharing arrangements to encourage farmers to provide a greater proportion of public environmental goods (Mallawaarachchi & Green 2012). If improved land or ecosystem condition contributes to improving or sustaining production benefits, farmers may consciously invest in it (Aisbett & Kragt 2010; Mallawaarachchi & Szakiel 2007; Pannell, D & Roberts, A 2015; Pannell 1999; Pannell et al. 2006).

To have influence on policy processes and impact on policy outcomes, information about environmental resources must be useful for policy actors (Czúcz et al. 2019), for example, by setting targets for environmental (and social) resource development including biodiversity (Maron, Simmonds & Watson 2018; Prober et al. 2019) and adopting appropriate measures to track their contribution to the economy (Reynolds 2015; Vardon, Burnett & Dovers 2016; Vardon et al. 2018). For Australia, this may mean that the SEEA should compile information that would be useful to reporting on performance under the EPBC Act or the various state land and biodiversity Acts, the CBD or other international obligations (DoEE 2018). It may also mean that it should compile information for analysis of the effect of different ecological characteristics on short-term and long-term agricultural profitability and productivity. To do this it needs to capture information about the type, extent and condition of ecosystems managed by agriculture (described in Section 2.2) and the profitability of (and other useful economic information about) agricultural businesses using these resources (Vardon, Burnett & Dovers 2016).

2.4.2 Compilation methods

The sources and methods currently used to compile the national accounts for non-government sectors are many and varied. They commonly include the use of surveys of representative samples of businesses to gather the required information. Estimates for public non-financial corporations are drawn from annual financial statements and Auditors' General Reports, estimates for private non-financial corporations are derived from other statistics and estimates for households (including family farms) are not compiled (ABS 2012). Estimates for governments are drawn from government financial statistics (GFS) (ABS 2015).

In the SNA (and Australian SNA), land (including the soil covering) and associated service water over which ownership rights can be enforced and from which economic benefits can be derived by their owners is a natural resource. Land cannot be formed or consumed and is regarded to be a non-produced non-financial asset that has come into existence in ways other than through processes of production (ABS 2012; UN 2008). Due to the lack of data, estimates for value of land in the Australian SNA represent only those transactions identified in the accounts of non-residents, general government and public corporations. No entry is presently shown for households (including family farms) (ABS 2012 para. 14.111).

The SEEA Central Framework (CF) is designed to overcome this deficiency with the concept of land accounts (United Nations et al. 2014a). Land accounts compile information about the land use, vegetative cover and monetary value. The Australian Government Department of the Environmental and Energy is investing in the development of a common national approach to environmental-economic accounting. This approach consists of adopting the SEEA framework and advocating for consistency in the principles and methods used for development of environmental-economic accounts (DoEE 2018). A priority for this program is the publication of national land accounts (DoEE 2018).

In Australia, monetary values for land are based on unimproved values (excluding cultivated areas, plantations of vines or perennial crops and buildings) compiled from the Valuer General (see for example the experimental land account produced for the Great Barrier Reef ABS 2017a). To date in Australia, land accounts have been produced using the dynamic land cover types and general classifications of vegetative cover into major types (ABS 2017a). Because these land accounts do not compile information about vegetative cover into ecosystems, they currently cannot be used to supply information about stocks of ecosystems for conservation planning purposes (such as described in Maron, Simmonds & Watson 2018) or for analysis of the effect of different ecological characteristics on short-term and long-term agricultural productivity.

2.4.3 **Accounting for resources for future generations**

Described in Chapter 1, systemic depletion of ecosystems and ecological and natural capital is posing threats to current and future human well-being (Haines-Young & Potschin 2010; MEA 2005; Rockström et al. 2009; SOE 2011; UNEP 2012; Von Braun et al. 2013) because ecosystems and the goods and services they produce are highly significant to human well-being and are important components of national wealth. Prevention of further degradation is essential because it is widely accepted that it is very difficult and mostly uneconomic to restore degraded ecosystems (IPBES 2018b; Nkonya, Gerber, PBaumgartner, et al. 2011; Nkonya, Gerber, Von Braun, et al. 2011; Scholes et al. 2018; Von Braun et al. 2013).

In their report of measurement of economic performance and social progress, Stiglitz et al. (2010) observe that the degree to which current levels of well-being can be sustained over time depends on whether stocks of capital that matter for our lives; natural, physical, human and social are passed on to future generations (Stiglitz, Sen & Fitoussi 2010). They suggest that national accounting systems may have been failing us by not helping us to work out whether the growth of the world economy has been achieved because of investments in the productivity of these stocks or at the expense of future growth due to consumption of them (Stiglitz, Sen & Fitoussi 2010).

Stiglitz et al., (2010) argue that assurance of the sustainability of an economy is based on whether it can transmit capital to future generations so that they have at least the same range of opportunity as current generations (Stiglitz, Sen & Fitoussi 2010). According to Stiglitz et al., (2010), sustainability requires the maintenance of a constant stock of “extended wealth” which includes physical and productive capital, institutions, human capital, natural capital and other resources necessary to provide future generations an opportunity set that is at least as large as that currently available to living generations.

They observe that while current income and economic flows are an important gauge of standard of living, the economic benefit possibilities over time are governed by the changes to assets and net wealth over time, making a holistic definition of wealth, encompassing natural and social capital as well as financial and physical capital an important indicator of the sustainability of current economic flows (Stiglitz, Sen & Fitoussi 2010). These observations echo those made by Ekins (2003) in introducing a concept of critical natural capital (Ekins 2003) and Neumayer (2010) in introducing a concept of strong sustainability (Neumayer 2010) and others working on wealth accounting (see for example Arrow et al. 1995; Arrow et al. 2012; Barbier 2013; Dasgupta 2008; Lange et al. 2018).

Stiglitz, et al., (2010) observe that non-monetary indicators may be preferable when the monetary valuation is very uncertain or difficult to derive, where it does not incorporate all the externalities (positive and negative) associated with their use and accumulation, and where consumer ignorance prevents prices of goods and services from playing their role as carriers of correct economic signals (Stiglitz, Sen & Fitoussi 2010).

2.4.4 Information requirements of governments

The expert working group for the UN SEEA EEA 2020 Revision (UNSD 2017a) suggest that ecosystem condition is a foundational component in the ecosystem accounting framework. This is because it establishes the link between the biophysical elements of ecosystem assets and the ecosystem services they produce (Keith et al. 2019). The condition accounts demonstrate changes over time in the characteristics of each ecosystem type and this can be used to measure past trends and current states as well as be used to predict future changes (Keith et al. 2019). They note that the purposes for ecosystem condition accounts may range from representing their intrinsic values (the integrity of the ecosystem in terms of its structure, function and composition) and their instrumental values (the capacity to supply specific ecosystem services). They may include describing the condition of an ecosystem with respect to its natural state or its desired state, identifying changes in ecosystem condition and linking these to human activity, assessing progress towards restoration targets or describing condition in relation to present and future flows of ecosystem services (Keith et al. 2019).

The UNSD Expert Working Group on ecosystem condition accounting suggests that indicators of environmental characteristics should be selected subject to meeting the following criteria for individual variables. They should be relevant and describe the state of the ecosystem, they should be differentiated from other components of the SEEA EEA framework and have spatial and temporal consistency. It should be feasible to collect the data, and quantitative scales should be well-defined and comparable over space and time. The data should be reliable, and the resultant indicators should support a normative interpretation. Finally, ecosystem condition indicators should be as simple as possible and should convey as much information as possible to reduce the number of indicators needed (Czücz et al. 2019 Table 1).

To enable the use of ecosystem condition within an accounting standard, the UN SEEA EEA expert working group describe the qualitative characteristics of compliant metrics for condition accounting (Keith et al. 2019) and 2.3 (Czücz et al. 2019). These include emphasising that selection criteria for metrics should align with the scope and purpose of the accounting (Czücz et al. 2019; Keith et al. 2019). Selection of metrics should also reflect the current and potential data availability as well as the uses and policy applications of the accounts (Keith et al. 2019). In addition, accounts should distinguish clearly between ecosystem condition, capacity and ecosystem service accounts. They recommend that the ecosystem condition account should be compiled in biophysical terms describing the characteristics of each ecosystem asset using a variety of measured variables and derived indicators (Keith et al. 2019).

In addition to these, Vardon et al., (2018) describe several principles of a “Shared Environmental Information System” (SEIS). These include that information should be managed as close as possible to its source, collected once and shared with others for many purposes. It should be easily available to all users and accessible so that comparisons can be made and so that citizens can access it. It should be supported through common, free, open software standards (Vardon et al. 2018).

2.5 International Accounting Standards: Principles of useful information

The International Accounting Standards (IAS) developed by the International Accounting Standards Board (IASB) guide corporations and governments in the Group of Twenty (G20) to prepare their general-purpose financial reports (GPFR) (IFRS 2019a). In Australia, corporations and governments prepare financial reports according to the Australian Accounting Standards (AAS) set by the Australian Accounting Standards Board (AASB) which are harmonised with IAS (Attorney-General's & Treasury 2018). The principle purpose for standardised financial reports was to meet the needs for financial information of users who are not in a position to require an entity to prepare reports tailored to their specific needs (CPA Australia 2015; Hamidi-Ravari 2014).

The objectives and principles of accounting are described in the IAS Conceptual Framework for Financial Reporting (the conceptual framework) and the standard for Presentation of Financial Statements. The conceptual framework helps all parties to understand and interpret accounting standards. It also helps preparers of financial reports develop consistent accounting policies for transactions where no standard applies or a choice of accounting policies are allowed (IASB 2018). The Framework for Financial Reporting provides guidance for the presentation and disclosure of financial information (IFRS 2017a). The other IAS provide guidance for valuation, recognition and disclosure of elements of financial reports.

2.5.1 Information for users making economic decisions about the entity

The objective of financial reporting under the IAS is to provide financial information that is useful to users in making decisions about investing in or providing resources to the entity or influencing the actions of management. These decisions rely on information about the entity’s economic resources, claims against the entity and changes in those resources and claims. They also rely on information about how efficiently and effectively management is discharging its responsibilities to use the entity’s economic resources (IASB 2018).

To guide preparers of financial reports to satisfy the objective, the IASB describes useful information as information that is relevant and that provides a faithful representation of what it purports to represent. It notes also that the benefit of providing the information needs to justify the cost of providing and using the information. This leads to the concept of materiality.

2.5.2 The going concern assumption

An underlying assumption of financial statements under IAS is the going concern assumption. Under the going concern assumption, entities preparing GPFR under IAS must prepare financial statements and disclosures on the basis that there no material uncertainties related to events or conditions that may cast doubt upon the entity’s ability to continue as a going concern. In assessing whether the going concern assumption is appropriate, management takes into account all available information about the future including consideration of a wide range of factors relating to its current and expected profitability (IASB 2018; IFRS 2017a).

An implication of the going concern assumption for agricultural businesses is that land is not being degraded or that a substitute for land can be found. If regulation is developed and enforced to assure that agricultural lands are transmitted to future generations, it may mean entities that are agricultural businesses are reliant on maintenance of the condition of their ecosystem assets. In this case, they should disclose any events or conditions that may cast doubt on the future quality of these assets.

2.5.3 Materiality

Under IAS, information is said to be material if omitting it or misstating it could influence decisions that users make. Materiality is entity-specific based on the nature or magnitude, or both, of the items to which the information relates (IFRS 2017a, 2017b). When considering whether information is material, entities must consider whether to provide information not specified by IAS (such as environmental information) if that information is necessary for their primary users to understand the impact of particular transactions, other events and conditions on the entity’s financial position, financial performance and cash flows (IFRS 2017b para. 10). In making these judgements, entities need to consider the methods of assessment the users apply in estimating the amount, timing and uncertainty of future cash flows and assessing the management’s stewardship of resources (IFRS 2017b para. 18).

2.5.4 Relevant information and a faithful representation

The Conceptual Framework suggests that information is judged to be relevant if it can make a difference to the decisions made by users (IASB 2010) and describes a "faithful representation" of economic phenomena as a depiction that is complete, neutral and free from error (IASB 2010). A complete depiction includes all information necessary for a user to understand the phenomenon being depicted including all necessary descriptions and explanations such as the quality and nature of it and circumstances that might affect their quality and nature. A neutral depiction is not manipulated to increase the probability that it will be received favourably or unfavourably by users. Free from error means there are no errors or omissions in the description of the phenomena or in the process used to produce the information. This does not mean that the information is perfectly accurate in all respects. Estimates can be faithful if they are clearly described as such and the nature and limitations of the estimating process are explained (IASB 2010).

The conceptual framework suggests that application of these fundamental qualitative characteristics begins with the identification of the economic phenomenon that has potential to be useful to users of financial information. The type of information that would be most relevant and whether that information is available and faithfully represents the phenomenon is then evaluated (IASB 2010). The conceptual framework suggests that comparability, verifiability, timeliness and understandability enhance the usefulness of information and may help to determine how phenomena should be depicted.

Ecological capital may be most faithfully represented by physical information (IFRS 2013; Stiglitz, Sen & Fitoussi 2010). In considering amendments to IAS 16 to incorporate BBAs (bearer plants) as a subclass of PPE, the preference of investors and analysts for physical information (yield, extent, age etc) was noted (IFRS 2013). Similarly, IAS 41 Agriculture observes that the fair value of biological assets can change due to both physical changes and price changes and that to faithfully represent them, ecosystems need to be described in both physical and monetary ways.

2.5.5 The appropriate basis of measurement

Frequently, financial performance is measured as profit and return on capital (IASB 2018). Under IAS, only inflows of economic benefit in excess of amounts needed to maintain capital may be regarded as profit and therefore a return on capital (IASB 2018). IASB

(2010) notes that the concept of capital that is chosen indicates the goal to be attained in determining profit, even though there may be some measurement difficulties in making the concept operational (IASB 2010). The concept of capital also determines the measurement basis for income and expenses, assets and liabilities (IASB 2018).

Under a financial concept of capital, capital is synonymous with the net assets or equity of the entity measured in currency units or monetary terms. The measurement basis is historical cost which is the cost incurred in acquiring or creating the asset (incurring or taking on the liability) updated over time to depict any consumption of the asset or fulfilment of the liability (IASB 2018). The IASB notes that financial statements are most commonly prepared using the concept of financial capital maintenance and recoverable historical cost, but other models and concepts may be more appropriate for making economic decisions (IASB 2018).

Under a physical concept of capital, such as operating capability, capital is regarded as the productive capacity of the entity and could be based for example on units of output per year (IASB 2018). A profit is earned if the physical productive capacity of the entity increases over the accounting period (IASB 2018). Under a physical concept of capital, assets should be measured using a current value measurement basis including fair value, value in use, fulfilment value and current cost. "Current cost" in relation to an asset means that assets are carried at the amount of cash or cash equivalents that would have to be paid if the same or an equivalent asset was acquired currently (IASB 2018). All price changes affecting the assets and liabilities of the entity are viewed as changes in the measurement of the physical productive capacity of the entity and treated as capital maintenance adjustments that are part of equity, not profit (IASB 2018).

Entities such as agricultural businesses are reliant on the productive capacity of their ecosystems. Consequently, an appropriate measurement of profit for these entities should incorporate measures of whether ecological capital has been maintained. A concept of ecological capital maintenance is analogous to the physical concept of capital (Barker & Mayer 2017; Barton 1999; Provins et al. 2015). It would measure productive capacity as the capacity of the ecological capital to produce the ecosystem services (for example provision of forage for livestock, habitat for biodiversity and regulation of resources) intended by management. Under this concept a profit would be earned if the ecological capacity (to produce the ecosystem system services) is maintained or increased over the accounting period. Inflows (outflows) of ecological capacity would be included in equity as capital maintenance adjustments or revaluation reserves, consistent with the accounting convention for financial and physical capital.

The choice of concept of capital maintenance has implications for the basis of measurement of capacity. Adoption of the physical maintenance concept requires the adoption of the current cost basis of measurement. Under this basis, all price changes affecting the assets and liabilities of the entity are viewed as changes in the measurement of the physical productive capacity of the entity and are treated as capital maintenance adjustments and part of equity, not profit (IASB 2010 para. 4.64).

2.6 Normative Foundation for adaptation of IAS to include ecological capital

This review of user responsibilities and needs for information provides guidance for an approach to a conceptual framework and future standards for accounting for ecological capital.

Landowners and managers need physical as well as financial information about their ecological resources. They need this information to be available and useful for operational decisions as well as relevant to investors, lenders, clients and creditors. Complementing a comprehensive characterisation of ecological resources, landowners and managers need early indicators of condition change so that decline can be avoided. Related to this they need indicators of whether their management of these resources will sustain their condition or change it, for example whether the practices will degrade the ecosystem.

Lenders, creditors, investors and corporations in the agricultural supply chain need to know the quality of the ecological resource base used by an agricultural entity and how to interpret implications of this on financial performance. In addition to needing information they can use to judge the productivity and dependability of the operation they need information about environmental factors that are relevant to reputational risk. These include condition factors that positively or negatively affect biodiversity or externalities (such as agricultural runoff into waterways and coastal areas). The information presented must be verifiable and standardised so that performance of different entities can be compared.

It is plausible that science-based targets based on planetary boundaries for externalities and biodiversity (Maron, Simmonds & Watson 2018; Willett et al. 2019) would either be adopted voluntarily or enforced in the future. To achieve these, each country, sector and entity will need information about their allocation. The public sector will probably be the main source of this information and related decisions about regulation and public investment in enabling markets to allocate resources efficiently.

In addition to this, to fulfil its responsibility for managing regulation and markets to generate sustainable economic prosperity, the public sector needs to understand the characteristics of the ecological resources being managed by agriculture and determine whether public investment is required. To determine the type of investment, it needs information about the environmental-economic performance of agriculture. This should enable distinction of environmental factors that confer productivity, resilience and private benefits for landowners and the factors that generate public benefits but reduce private benefits. It should communicate this information to motivate and inform private individuals to respond to opportunities for ecological investment.

Figure 3 illustrates flows of economically relevant information between the supply chain (private sector), farm sector (farm businesses) and the public sector (policy makers). Agricultural entities should provide information about their environmental performance to the entities they supply to and to governments to assist both sectors to adjust sourcing and market policies to collaborate with farmers to assure financial and environmental sustainability of the sector. Information provided by analysis of national and subnational environmental-economic statistics can motivate and inform the private sector and producers to adopt better practices by providing information about comparative environmental-economic performance.

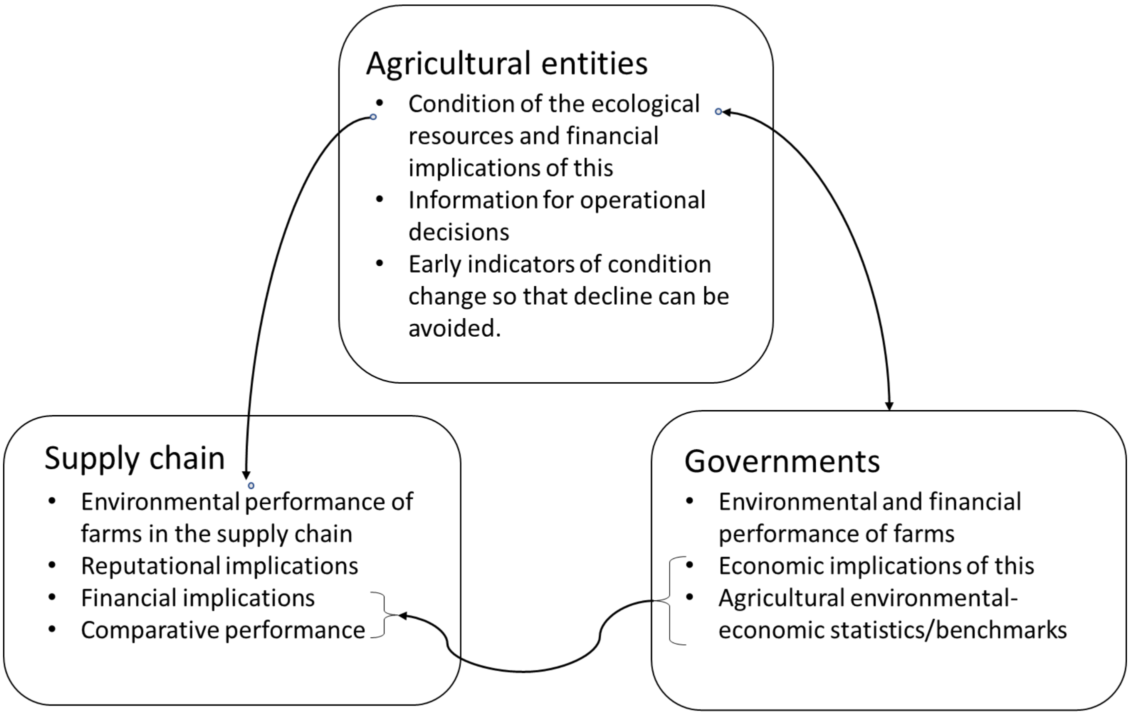

Figure 3: Information flows between economic decision makers in the agricultural supply chain

IAS principles described in Section 2.5 are used to frame analysis of present IAS concepts and standards to design a pragmatic approach to provide this information. Under this framing:

- the ecological characteristics and operating capacity of the ecological capital of an agricultural entity is material to users who are evaluating the past performance of the business, estimating the amount, timing and uncertainty of future cash flows, and assessing the management's stewardship of these resources. These users include landowners (and land managers), investors, lenders, creditors and businesses in the supply chain;

- relevant and useful information for users making economic decisions about allocation of resources within or to an agricultural entity includes:

    - information about the type, extent and condition of ecosystems on the property, past trends in condition and forecasts for future condition. This information should enable estimation of the ecosystem services being generated and consumed. Representations of this information should support a normative interpretation and incorporate characterisation of the intermediate ecosystem services that are relevant to production, biodiversity and system resilience;

  - information about ecosystems not on the property that generate externalities affecting the ecosystems of the property and the performance of the business; and

  - information capable of influencing decisions needs to be timely, understandable and enable users to compare performance over time and between entities.

- entities should disclose information that suggests they may not satisfy the going concern assumption. They should disclose information about unsustainable patterns of use of the ecosystem(s) or other events that may affect the future type, extent and condition of ecosystem assets.

Chapter 3 examines the IAS and SEEA guidance and develops a possible framework for providing this information.

Finally, adaptations to IAS or SNA methods should enable policy makers to design or modify regulations or markets to induce all levels of the agricultural sector to produce greater public benefits. Adaptations to IAS to support the preparation of useful environmental-economic information about agricultural ecological capital should incorporate standards to facilitate compilation into the SEEA and SNA for the use in macroeconomic analysis and planning. Methods to do so are discussed in Chapter 7.

3 Framework

3.1 Introduction

This chapter describes a framework for adaptations to current international accounting standards and concepts to accommodate unique characteristics and sustainable management of ecosystem assets to meet the information needs identified on the normative framework established in Chapter 2.

The chapter is structured in the following order. Section 3.2 provides a detailed conceptual model of ecological capital in agriculture and describes economically relevant ecological functions and processes for grazing enterprises. Section 3.3. describes the formal accounting standards that apply to agriculture. Sections 3.4, 3.5 and 3.5 explore adaptations and additions to concepts, principles and guidance presently in the IAS framework to accommodate the unique characteristics of ecological capital. Following these, the chapter presents a discussion of accounting for local scale externalities and a discussion of accounting for conservation assets. The chapter concludes with a discussion and summary of adaptations and additions to IAS.

3.2 Conceptual model of ecological capital in agriculture

Ecological capital is conceptualised as the privately held ecosystems of agricultural land including grasslands, pastures, crops, trees and shrubs, soil biology and soil. This reflects the premise that the economic performance and prospects of a grazing enterprise depends on the type of ecosystem, its extent and its condition and the patterns of its use.

This study uses a case study context to illustrate a provisional conceptual framework for incorporation of ecological capital in entity-level accounts under IAS. This context – grazing in the northern rangelands of Australia - is chosen because these are largely unmodified ecosystems. Management of their productivity is dependent on managing their ecological traits, functions and processes, the good practice for sustainable use of them for livestock grazing is extensively researched and methods of measuring their condition and sustainable capacity for grazing are mature. The synthesis of good practice with formal accounting principles increases the likelihood that the conceptual framework is coherent with biophysical science and the microeconomics of grazing entities in these landscapes. The resultant conceptual framework can be tested in further studies with variations to incorporate highly modified ecosystems and agronomic technologies.

3.2.1 Overview of management of northern Australian rangelands for grazing

A wide range of ecosystems are used for the grazing of livestock by pastoral enterprises in Australia and around the world. In Australia, native vegetation ecosystems used in agricultural and pastoral operations comprise approximately 45% of Australia’s land mass (ABS 2017b) and retain more than 90% of the original native vegetation (Metcalfe & Bui 2016). The rangelands of northern Australia are comprised of diverse ecosystems (also referred to as land systems[6]) which have different characteristic combinations of geology and vegetation and different levels of suitability and productivity for grazing of livestock (Ash et al. 2015; Ash et al. 1995; DAFWA 2018a; Hunt et al. 2014; McIvor, Ash & Cook 1995; O'Reagain et al. 2014; O'Reagain 2006; Schoknecht & Payne 2011; Stafford-Smith 1994; Stafford Smith & McAllister 2008; Tongway et al. 2003; Walsh & Cowley 2016). Each pastoral property typically controls a combination of ecosystems either by freehold ownership of the property or ownership of a lease for grazing use (ABARES 2016).

Concerns have existed for decades about links between financial aspirations for pastoral enterprises and land degradation caused by overgrazing and there are suggestions that many of these enterprises are not ecologically or economically sustainable (Ash et al. 2015; Ash et al. 2011; Ash et al. 1995; Curry & Hacker 1990; Holmes 2015; Hunt et al. 2014; McKeon, Stone & Syktus 2009; O'Reagain & Scanlan 2013; Stafford-Smith 1994; Tongway et al. 2003). More recently, research has suggested that many pastoral enterprises in Australia’s rangelands may not have sufficient financial literacy to detect whether their operations are economically sustainable (McLean, Holmes & Counsell 2014). It has been suggested that many of these enterprises may be uneconomic because the ecosystems that underpin their businesses are incapable of producing sufficient inputs

[6] ‘Land systems’ are characteristic combinations of geology and vegetation that have differing qualities for grazing and differ in their ability to regenerate following disturbance.

to production[7] to allow the businesses to meet financial commitments (Ash et al. 2015; Holmes 2015; Novelly & Warburton 2012; Safstrom & Waddell 2013).

Methods to manage these ecosystems for sustainable and productive grazing of livestock have been established, as have reliable methods for assessing the condition of ecosystems (see for example Abbott & Corfield 2012; Ash et al. 2015; Ash et al. 2011; Hodgkinson 1992; MacLeod & McIvor 2008; O'Reagain et al. 2014; Pettit 2011; Tongway & Hindley 2004; Walsh & Cowley 2011). The characterisation of the ecosystem assets (i.e. the rangelands) and flows of ecosystem services (here limited to forage for livestock) in the grazing context is drawn from this research. It is briefly described here to provide a context for the accounting valuations and events explored in detail in later chapters.

Current Australian good practice for management of these ecosystems includes assessment and classification of its condition-based capacity for grazing (its capacity to provide provisioning services for livestock). Western Australia has designed methods for land managers to classify their pastures to Good, Fair, Poor or Very Poor condition[8] depending on the quality and arrangement of vegetation. The condition classifications are designed for the purpose of explaining and predicting flows of provisioning services for livestock (i.e. forage) and are normative and relevant as recommended by the recently published guidance for condition accounting under the SEEA EEA (Czücz et al. 2019; Keith et al. 2019; Maes et al. 2019). They also provide an indication of the quality of native vegetation, regulating services such as soil retention services (to limit soil erosion) and habitat services (to support conservation of biodiversity) (Parsons et al. 2017).

Rangeland pasture condition measures are not designed to indicate the capacity for carbon storage (Bray et al. 2016) or cultural services, but it would be expected that land in Good and Fair condition can be regarded as providing more regulating and cultural services than land in Poor or Very Poor condition. In a livestock enterprise, regulating services would most commonly be the capture, storage and cycling of nutrients and water. These are intermediate factors of production of forage - an intra-ecological service. The associated benefits of reducing soil emissions into waterways and air is a public benefit

[7] Forage and shelter for livestock

[8] The Northern Territory and Queensland use an A, B, C, or D condition classification to indicate condition-based capacity for grazing.

produced as a ‘joint product’ or a ‘complimentary good’ (co-generated) as an ‘accidental’ outcome of production processes and policies.

Ecosystem condition will change in response to patterns of use. Modelling of changes to rangeland condition as part of the research in sustainable grazing of these landscapes indicates that land in Good condition prior to livestock grazing will often decline to Fair condition but can return to Good condition within a few years of livestock being removed. Land in Poor condition may return to Good condition in fewer than 10 years (if these years have good seasons) if it is completely destocked or in 20-30 years if stocked according to its carrying capacity. The modelling indicates that the land will most likely continue to decline in condition if heavy stocking rates continue. Improvements in condition from Very Poor (D) classification are slow (or even unlikely), even with significant management intervention.

The sustainable use of the ecosystem for grazing – i.e., its long-term carrying capacity for grazing - is defined, as the number of adult equivalent[9] (AE) cattle that can be carried on the property over a range of seasons without negatively affecting the condition of the ecosystem. Long-term carrying capacity is calculated by multiplying estimates of long term annual pasture growth by a proportion reflecting the amount available for sustainable consumption by livestock and then dividing by the biological annual forage demand for one AE (Walsh & Cowley 2011). Annual pasture production is a function of the type, extent and condition of the ecosystem asset and the seasonal conditions experienced.

The annual flow of ecosystem services that reflects sustainable consumption is estimated via a practice termed ‘forage budgeting’. Forage budgeting uses estimates of annual pasture biomass available for grazing to calculate the numbers of livestock that can be safely carried without risking ecosystem degradation. Thus, whilst total livestock numbers will vary annually depending on seasonal conditions, the long-term average of

[9] Adult Equivalent (AE) ratings are used to estimate energy requirements for cattle of different gender, age and breeding status compared to the AE standard which is a 450kg Bos Taurus steer at maintenance (neither gaining nor losing weight). AE standard ratings are useful for estimating stock numbers in terms of carrying capacity (Meat & Livestock Australia).

the annual forage budgets should approximate the long-term carrying capacity if land condition and grazing capacity are to be maintained.

If the condition of an ecosystem declines due to overgrazing (i.e., it suffers ecosystem degradation), a range of interventions can be applied to restore it. Research has established a range of practical interventions to facilitate ecosystem condition restoration over time in the northern Australian rangelands. These include prescribed burns, installation of brush packs[10] and increased rest from grazing during the growing season by reducing the number of livestock carried on the property (see for example Tongway & Ludwig 1996; Tongway & Ludwig 2011b; Walsh & Cowley 2014a, 2014b).

All these interventions involve an outflow of resources embodying economic benefit but do not guarantee the restoration of the ecosystem. In practice, improving land condition is highly dependent on the quality of the seasons and the absence of disturbances that would interfere with recovery (Ash et al. 2011; Stafford Smith & McAllister 2008; Tongway & Ludwig 2011b; Walsh & Cowley 2014a, 2014b).

The nature of the interventions suggests that estimates of the cost to restore the ecosystem should include the opportunity cost of running lower numbers of livestock as well as expenditure on goods, services and activities. Since it is possible to reliably estimate land (ecosystem) condition, the capacity for grazing and therefore the monetary value of the ecosystem asset for pastoral use, there is a basis for estimating the reduced economic value of a degraded ecosystem. This also allows design of a proportionate and effective penalty for ecosystem degradation to be incorporated into a lease agreement to be applied in the event that a lessee causes ecosystem degradation.

[10] Bundles of stems and twigs from local shrubs and trees are placed on the ground in locations that will collect wind and water-borne seeds, soil and other materials, attract animals and provide shelter for organisms that will assist vegetation to establish.

3.3 Current formal accounting standards relevant to ecosystems used in agriculture

Ecosystem accounting at the national and subnational level applies to landscapes including ones used for agricultural production. The SEEA EEA describes ecosystem accounting as involving four key steps;

1. Spatially delineating different ecosystem types (forests, wetlands, grazing lands, etc.) within a broader area of interest (e.g., pastoral lease, river catchment, country) where each instance of an ecosystem types (e.g., a patch of forest) is considered an ecosystem asset.

2. Assessing the condition of each ecosystem asset, usually based on a range of ecological variables including species diversity.

3. Measuring the flow of ecosystem services generated by that asset. Ecosystem services are generally considered to be provisioning services (e.g., for food, fibre, energy); regulating services (e.g., air and water purification, climate, and water regulation); or cultural services (e.g., use of ecosystems for recreation).

4. Assessing the relative value of the benefits obtained from those services.

With this range of information organised using standard national accounting principles, it is possible to integrate this ecosystem information with standard economic accounts for production, income, capital, and net worth (United Nations et al. 2014b).

3.3.1 Ecosystems as assets under IAS

For ecosystems to be recognised as assets of an entity under IAS, they must embody a present economic resource controlled by the entity as a result of past events, or a right that has the potential to produce economic benefits (IASB 2018). As the conceptual model for grazed ecosystems in northern Australia explained, land purchased, leased or otherwise used by agricultural entities is comprised of ecosystems. These are used to produce forage for livestock and therefore can be defined in keeping with economic and accounting convention as classes of durable non-financial assets (productive assets). They are controlled by the agricultural enterprise as a result of past events and are expected to generate future economic benefits, including by reducing cash outflows by lowering the cost of production. Accordingly, ecosystems satisfy the criteria for recognition as assets of such entities and should be accounted for under IAS 16. However, as the timing and methods of valuation of ecosystems may at times be different from land (and bearer plants) they should be accounted as a separate class (IASB 2014a).

The fact that terrestrial ecosystems cannot be separated from the land and sometimes the goods and services they provide (such as cultural services) makes them somewhat intangible but does not prevent them from being recognised as a class of asset. Exchangeability (that an item is separable from the entity) is not an essential asset characteristic - future economic benefits are not precluded by the inability to sever an asset from the entity, nor are they necessarily related to the existence of a present disposal value (AASB 1995 para. 34-36). As described in the literature review, ecosystems condition (specified by characteristics such as species, species richness and community structure) has financial significance via emergent but currently somewhat intangible properties such as productivity, resilience, adaptive capacity and regenerative capability. These properties embody future economic benefits even though they don't have physical substance, but tangibility of either the asset, or the goods and services it produces is not a necessary criteria for recognition (IASB 2017).

3.3.2 **Relevant accounting standards**

Accounting for agriculture is guided by IAS 41 Agriculture, IAS 16 Property, Plant and Equipment (PPE), IAS 13 Fair Value Measurement, and IAS 2 Inventory. Under IAS 41, agricultural activity is the "*management by an entity of the biological transformation and harvest of biological assets for sale or for conversion into agricultural produce or into additional biological assets*"(IFRS 2014). Biological assets are current assets that include livestock, crops, fruit etc. A change in physical attributes of a living animal or plant directly enhances or diminishes economic benefits to the entity.

IAS 16 applies to the land, buildings and equipment used by agriculture for its activities. These non-current assets are tangible items that; "are held for use in the production or supply of goods or services, for rental to others, or for administrative purposes and are expected to be used during more than one period".

IAS 16 does not prescribe what constitutes an item of PPE, expecting judgement to be used in deciding the assets that should be recognised under this standard (IASB 2014a para. 9). In making these decisions, preparers of accounts should consider the item's underlying substance and economic reality and not merely its legal form (AASB 2016b para. 51).

In June 2014, IAS 16 was amended to also include bearer plants (bearer biological assets that are plants that have no consumable attributes). Bearer plants related to agricultural activity are defined as living plants used in the production or supply of agricultural produce, that are expected to bear produce for more than one period and have a remote likelihood of being sold as agricultural produce, except for incidental scrap sales (IASB 2014a). The amendment was made in response to concerns from users and preparers of accounts that IAS 41 is not appropriate for accounting for mature BBA because they are no longer undergoing biological transformation and are better understood as productive assets, similar to PPE.

Adapted from the SEEA EEA (United Nations et al. 2014b), Figure 4 describes the conceptual model of ecological capital (ecosystem assets and services) in a livestock grazing enterprise. This illustration shows the IAS that are presently applied to land and the ecosystems that comprise land. These are IAS 16 Property Plant and Equipment (IASB 2014a) and IAS 41 Agriculture that guide accounting for agricultural activities including inputs, biological assets and products of agriculture (IAS 2016)). Guidance for accounting for current ecological capital assets (flows of ecosystem services such as inventories of forage for livestock) have not been developed under IAS or under SEEA.

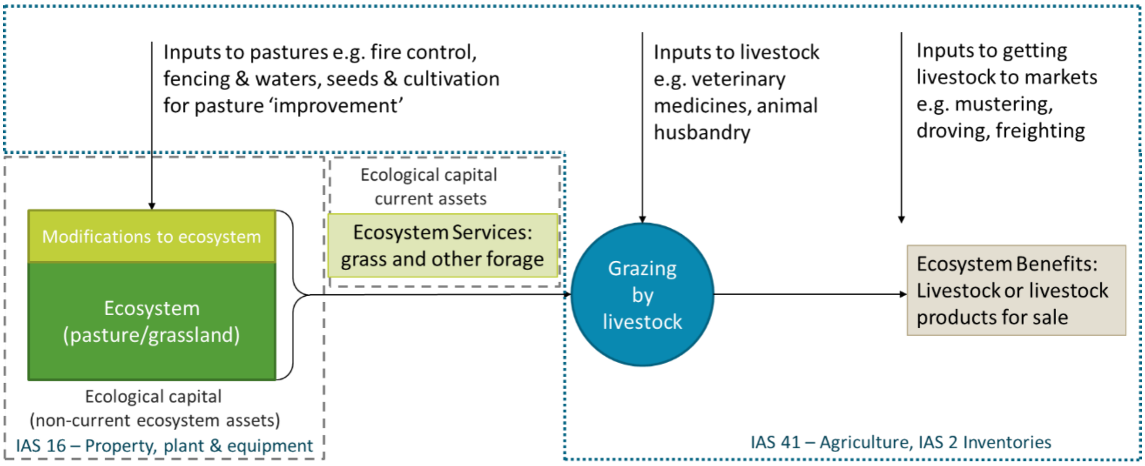

Figure 4: Adapted from Figure A.3.2 of SEEA EEA White Cover version (United Nations et al. 2014b). A conceptual model of ecological capital (ecosystems) and ecosystems services noting the relevant IAS applying to the elements.

3.3.3 Measuring performance

The normative foundation for this study exposed the concept of ecological capital maintenance as a basis for measurement of the performance of entities whose assets include ecosystems. Under this concept, only inflows of economic benefit in excess of amounts needed to maintain ecological capital may be regarded as profit and therefore a return on capital. As an analogue of physical capital maintenance, the measurement basis for income, expenses, assets and liabilities under ecological capital maintenance should also be on a current cost basis.

The next sections address the questions of measuring ecological capacity and current cost that are coherent with the principles of SEEA and the IAS.

SEEA Guidance for measurement of ecological capacity

SEEA EEA (2014) doesn't specify methods for quantifying capacity (United Nations et al. 2014b) and subsequent updates suggest that further testing is required in many areas related to measuring ecosystem capacity (Keith et al. 2019; UNSD 2017b). In the interim, capacity is generally described as being related to expected ecosystem services including expectations of sustainable flows of services and a function of the type of ecosystem and its location, extent and condition. Workers contributing to the development of the SEEA EEA have suggested some strategies for conceptualising and measuring ecological capacity including how to judge whether patterns of use are likely to assure maintenance of the capacity. Hein et al., (2016) observe that methods to conceptualise and measure physical capacity are essential to being able to understand ecosystems in monetary terms and that capacity must reflect the ecosystem asset and its ability to supply individual services as a flow over time (Hein et al. 2016).

These authors also observe that, to be used in accounting, ecosystem capacity should be understood in context of the current condition and patterns of use[11] of the ecosystem and the potential supply of services and related to specific ecosystem services, even though ecosystems provide a basket of services. They define capacity for individual ecosystem services as the ability of an ecosystem to generate a service under current ecosystem condition and uses, at the highest yield or use level that does not negatively affect the future supply of the same or other ecosystem services from that ecosystem (Hein et al. 2016). To describe flows of goods or services from ecosystems that may not be presently of benefit to humans (and therefore not be recorded as ecosystem services (United Nations et al. 2014a, 2014b)), Hein et al., (2016) propose the use of concepts of ecosystem capability[12] and potential use[13] (Hein et al. 2016).

The utility of the additional concepts of capability and potential use for policy makers is evident in the land use planning advice done by most Australian government agencies. For example, the Western Australian government assesses the biophysical characteristics of the ecosystems and judges their productivity and sustainability under different types of land use (DAFWA 2018a). Similarly, while a property valuer might incorporate consideration of potential uses and markets for the attributes of the property into the valuation of the property, IAS fair value requires that the asset is valued in relation to the current principle market for its goods and services (IASB 2011).

La Notte et al., (2019) suggest a conceptualisation of capacity as a virtual stock to separate the notion of an ecosystem asset from the notion of its capacity (based on the ecosystem type and condition). The virtual concept expresses the meaning of the ability to keep on generating an ecological process over time. It is measured as the flows of ecosystems

[11] The same ecosystem might have different values under different patterns of use.
[12] An ecosystem's ability to sustainably generate one ecosystem service under current condition and type of use, and irrespective of potential impacts of increasing supply on the supply of other ecosystem services.
[13] The ecosystem's ability to generate services irrespective of demand for such services.

services generated under sustainable use patterns and distinguished from the flows of ecosystem services that are consumed (La Notte, Vallecillo & Maes 2019). These authors also recommend that the sustainable flow and the actual flow of the service should be calculated separately to enable an assessment of the sustainability of current use of ecosystem services (La Notte et al. 2017).

The approach by La Notte et al., (2017) that distinguishes sustainable flows generated from actual flows consumed is similar to the conceptualisation of grazing capacity and sustainable use suggested by rangeland science for sustainable management of rangelands grazing[14]. This suggests that the notion of ecological capacity being evolved for use in the SEEA is already operationalised for pastoral entities.

The capacity to produce the individual ecosystem services can be related to the condition of the ecosystem (Keith et al. 2019) and can help to inform stakeholders of the economic implications of condition change. Because of the differences in the meanings of ecosystem asset condition and ecosystem asset capacity, good practice in ecosystem accounting would distinguish clearly the indicators for these from each other and from the indicators in ecosystem service accounts (Keith et al. 2019). In addition, separate measures of the sustainable flow of the service and the consumption of the service allow stakeholders to understand whether patterns of use of the ecosystems are sustainable.

3.4 Valuing ecological capital

For ecosystems to be recognised as assets under IAS they must be valued, and these values must be relevant and faithful representations of what they purport to measure (IASB 2018). As exposed in Chapter 2, ecological capital may be most faithfully represented by a combination of physical and monetary information. Accordingly, the framework for incorporating ecological capital under IAS developed for this study includes guidance for physical as well as monetary valuations.

[14] From the overview of management of northern Australian Rangelands for pastoral use. “The sustainable use of the ecosystem for grazing – i.e., its long-term carrying capacity for grazing - is defined, as the number of adult equivalent (AE) cattle that can be carried on the property over a range of seasons without negatively affecting the condition of the ecosystem.”

3.4.1 Physical valuation

The SEEA EEA encourages the use of physical characteristics in ecosystem accounts (United Nations et al. 2014b). Ecosystem condition *"reflects the overall quality of an ecosystem asset in terms of its characteristics"* (United Nations et al. 2014b; UNSD 2017b). It is regarded as a foundational component in the ecosystem accounting framework because *"It establishes the link between ecosystem assets, their quantity or extent, changes in assets over time and ecosystem services, that is, the stocks and flows of benefits derived from the stocks"* (Keith et al. 2019).

The usefulness of insights provided by physical values for biological assets related to the operating capacity and prospects for the entity was echoed in guidance in IAS 141 Agriculture (IAS 2016) and responses to the consultation on whether bearer plants should be accounted for under IAS 16 PPE (IAS 2014, 2016; IFRS 2013). However, the literature review for this study was not able to locate detailed guidance for the preparation and presentation of this information for use with IAS.

The purpose of condition accounting

Keith et al., (2019) explain that a purpose of physical valuations is to contribute to the compilation of ecosystem 'condition accounts' that allow different sources of information to be integrated to describe the characteristics of ecosystem assets (Keith et al. 2019). The condition account should communicate change over time, to detect and avoid degradation and contribute to estimation of future generation of ecosystem services (Keith et al. 2019).

Ecosystem condition is inherently a multidimensional concept and, like ecosystems, the purposes of ecosystem condition accounting are diverse (Keith et al. 2019). To create a reporting and aggregation structure to accommodate diversity without losing comparability, a comprehensive hierarchical classification of metrics for ecosystem condition variables and indicators is recommended (Keith et al. 2019). Metrics need to be specific to ecosystem types and their characteristics and can divided into:

- Variables: measurable quantities describing physical, chemical or biological phenomena that have units to indicate what they measure;

- Indicators: variables with a normative interpretation such as values and comparisons with relevant reference levels that relate to decisions with respect to policies of management; and

- Indices: (thematically) aggregated characteristics into a single indicator for an information purpose (Keith et al. 2019). An example of this is the eCond developed by the Wentworth Group of Concerned Scientists for their Accounting for Nature Program (Sbrocchi, Davis, Grundy M., et al. 2015; Steinfeld & Cosier 2018).

The expert working group further note that grouping different measures of ecosystem variables into condition categories reduces the complexity of ecosystem accounting (Czücz et al. 2019) and is useful for display of the information (Maes et al. 2019).

Measures of provisioning and regulating capacity already exist

While reliable and useful ways of describing ecosystem condition for accounting purposes are acknowledged as a priority for the further development of environmental-economic accounting (Keith et al. 2019; UNSD 2017b), evidence-based and repeatable methods to describe ecosystems have been available for some time, particularly in agriculture (See for example Gibbons et al. 2008; McIntyre, McIvor & Heard 2002; MLA 2014; Tongway & Hindley 2004). Ecologists and agronomists are able to characterise the role of ecosystems as intermediate inputs in agricultural production, an important input to estimations of their service capacity. For example, the relationships between the type, extent and condition of ecosystems and the numbers of livestock that can be produced per year without recourse to supplementary feeding has been described for northern Australian rangelands by rangeland science (see for example Walsh & Cowley 2011) and the relationship between soil characteristics and the number and profitability of crops that can be produced per year has been described for the irrigated croplands of south-eastern Victoria (Tisdall & Adem 1988).

Beyond agricultural applications, ecologists have already developed reliable and repeatable methods for presentation of biophysical information. These faithfully represent important characteristics of some ecosystems, including using multiple dimensions of ecosystems characteristics (Calzolari et al. 2016) and functional characteristics (Lavorel et al. 2014) that produce different 'baskets' of ecosystem goods and services. For example, Landscape Function Analysis (LFA) (Tongway & Hindley 2004) has been used for decades to quantify the capacity of a landscape to capture, store and cycle nutrients and soil-water (Tongway & Ludwig 2011b). The 'Habitat Hectares' approach was developed to provide a rapid way of assessing the quality of vegetation for biodiversity conservation and is used by the Victorian Government to assist with development and conduct of environmental markets (Parkes, Newell & Cheal 2003). A dimensionless index of deviation from natural reference condition, the Econd has been developed to provide a comparable characterisation of condition across different ecosystems (Cosier & McDonald 2010; Sbrocchi, Davis, Grundy M., et al. 2015; Sbrocchi, Davis, M., et al. 2015; Steinfeld & Cosier 2018).

There can be considerable challenges in deciding which data to collect to characterise ecosystem condition and considerable expense to collect it (Hunter Jr et al. 2016; Keith et al. 2019; Lindenmayer et al. 2012; Salafsky et al. 2019; Sbrocchi, Davis, Grundy M., et al. 2015). Consequently, the confidence with which the data reflect the condition of the ecosystem can vary considerably. The use of fragmented or poor quality data does not prevent condition accounts from being prepared and used (Keith et al. 2019). But users of accounts need to be informed of the strength of the evidence. This can be accomplished by incorporating a qualifier of confidence into the information provided (Salafsky et al. 2019; Sbrocchi, Davis, M., et al. 2015; Steinfeld & Cosier 2018). These are conceptually like the hierarchy of inputs to monetary values describe in the next section and have the same purpose.

Design of ecosystem accounts

The organisation of physical information into accounts is already demonstrated in a range of applications of the SEEA (for example see Table 4.1 United Nations et al. 2014b). The methods and designs provide a model of display and organisation similar to conventional representation of accounting tables. Adopting these conventions for privately-owned ecosystem assets may provide a way of aligning ecosystems assets reported by accounting entities in the private sector with the ecosystems assets reported in a nation's national accounts.

Under the SEEA EEA, ecosystem condition accounts should be compiled by ecosystem type within the accounting area and the specified purpose of the condition accounts should be used as an aid to the selection of indicators (Keith et al. 2019). The content of accounts will depend on the ecosystem types and their characteristics, data availability (current and potential) as well as uses of the accounts and policy applications (Keith et al. 2019).

Maes et al., (2019) make the following tentative recommendations for ecosystem condition accounting;

- Extent should be included in condition accounts which should show opening and closing values and their relationship to the reference level.

- Condition account tables constructed using individual condition indicators, condition indices or condition categories can be useful and work well for display.

- Condition accounts should be able to be disaggregated to individual ecosystem types or classes of ecosystem types (Maes et al. 2019).

3.4.2 Monetary valuation

Both the SEEA and the IAS accounting frameworks require that asset valuations are based on exchange values - prices that would be received to sell an asset in an orderly transaction between market participants at the measurement date (Barton et al. 2019; Fenichel & Obst 2019; IASB 2018; Obst, Hein & Edens 2015). IAS (and AAS) 13 Fair Value Measurement (AASB 2015b; IASB 2011) or AAS136 Impairment of Assets (AASB 2015e; IASB 2014b) are the main standards governing the estimation of asset values with additional guidance for valuation methods for property provided by the International Valuation Standards Council (IVS) (IVS 2016).

If ecosystems are accepted as a class of non-financial assets acquired as part of a property purchase, under present IAS, they would be initially recognised as part of land and improvements at the transaction price at the time of purchase. If they are included in the financial statements they should be revalued on a regular basis to ensure that the carrying amount does not differ materially from that which would be determined using fair value at the end of the reporting period (AASB 2014a, 2015b; IASB 2010, 2011).

IAS and AAS require that an entity shall use valuation techniques that are appropriate in the circumstances, and for which sufficient data are available to measure fair value, maximising the use of relevant observable inputs and minimising the use of unobservable inputs (AASB 2015b; IASB 2011). IAS 13 describes three valuation approaches; the market approach, the income approach and the cost approach. The market approach uses prices and other relevant information generated by market transactions involving identical or comparable assets. The income approach converts future amounts (of cash or profit) to a single current amount and the cost approach reflects the amount that would be required currently to replace the service capacity of an asset. Present value techniques are an application of the income approach used to link future cash flows or values to a present amount using a discount rate (IASB 2011). The SEEA also applies the market and income-based approaches to valuation (United Nations et al. 2014b) and describes a replacement cost method to estimate the value of an ecosystem service. The replacement cost estimates under SEEA are based on the costs that would be associated with mitigating actions if the service were lost (United Nations et al. 2014b).

To increase consistency and comparability in fair value measurements, IAS and AAS describe a fair value hierarchy that categorises the inputs to valuation techniques. The highest priority input is quoted prices in active markets for identical assets (level 1 inputs) and the lowest priority is unobservable inputs (level 3 inputs) to valuation (AASB 2015b; IASB 2011). Entities must disclose the level of inputs to valuation and if level 3 inputs are used, these should be explained (AASB 2015b; IASB 2011).

Markets for ecosystems assets and the goods and services they provide have only emerged recently and are still undergoing rapid development (United Nations et al. 2014b; UNSD 2017b). As a consequence, ecosystems are highly specialised assets with very few market participants who are knowledgeable about the economic significance of them. For people with appropriate knowledge, many ecosystems assets possess values that can be reliably measured either by the cost approach or the income approach described in IASB 13 – Fair Value Measurement (AASB 2015b; IASB 2011). For example, valuation of the replacement cost of water provision services provided by ecosystems in Victoria has been demonstrated (Keith et al. 2017). In grazing enterprises, the use of agistment (paying a landholder for access to their land for grazing of your cattle) is commonly used and professionals in the industry can judge the value of land for this purpose.

One method to establish Fair Value for ecological capital under the income approach requires input of a financial forecast of cash flows or profit estimated from the past performance of the asset (from the company's financial records) and consideration of future economic and environmental trends. These inputs to ecosystems assets would be considered to be 'unobservable' (Level 3) inputs to valuation (AASB 2015b para. B36 (e); IASB 2011). Financial statements that include fair value measurements using Level 3 inputs require additional information to be provided. They are required to disaggregate the assets and liabilities to different classes according to the nature, characteristics and risks of the asset or liability. They must disclose changes during the period and must provide a narrative description of the sensitivity of the fair value measurement to changes in unobservable inputs (AASB 2015b para. 93 and 94; IASB 2011 para. 93 and 94).

Sometimes, due to their complexity, empirical and static measurements of ecosystems are unavailable. To overcome this, managers of ecosystems commonly use estimates or professional judgements of their service capacity or models published in scientific journals (See for example Baral et al. 2014; Forouzangohar et al. 2014). The use of reasonable estimates is considered to be an essential part of the preparation of financial statements and does not undermine their reliability (AASB 2016b; IASB 2011).

In guiding the accounting for bearer plants (excluding the produce), the IAS note some concerns related to difficulties of estimating a fair value for bearer plants that are being grown to an operating capacity intended by management (IFRS 2013). Similar difficulties may apply to ecosystems that, at initial recognition or due to impairment are not in the condition intended by management. To estimate monetary values for bearer plants that are being grown for future production, IAS proposed a cost model such that, before being placed into production, bearer plants should be measured at accumulated cost (similar to the accounting treatment for a self-constructed item of machinery before it is placed into production). It advises that, under this approach, the recognition and disclosure and revaluation requirements of IAS 16 can be applied to bearer plants without modification.

In exploring methods for monetary valuation of ecosystems, it is necessary to consider a characteristic of ecosystems that isn’t present in financial or physical (produced) capital that, being natural, they may cost nothing to produce. Unlike the case for bearer plants or cultivated biological products, developing a natural ecosystem for productive use where the ecosystem will remain unmodified by clearing, establishment of exotic vegetation or changes to soil properties usually involves establishment of fencing and water infrastructure to allow livestock to access the ecosystem services. It doesn’t involve expenditure on the ecosystem itself. In this case, the cost to produce the ecosystem is zero. This does not mean that the value of the ecosystem is zero.

There may be a place for an accumulated cost model to faithfully represent the cost of restoration of an ecosystem to the condition intended by management for production or for conservation purposes. However, as explained in the overview of management of rangelands for grazing, the strategies for restoration of ecosystems with respect to grazing land commonly rely on exclusion from use for some period plus activities including management of invasive species and wildfire. The amount of expenditure is minimal compared to the economic loss associated with the exclusion from use – an opportunity cost. This is expected to be common to most ecosystems and indicates that, without inclusion of an ‘opportunity cost’, the cost of restoration, if limited to expenditure amounts, undervalues the economic cost of degradation whether it is paid or unpaid.

In relation to BBAs (bearer plants) as a subclass of PPE once they are in their condition intended by management, the preference of investors and analysts for information about operating performance and cash flows was noted (IFRS 2013). Discussed further in Chapter 5, it has been suggested that many agricultural enterprises may be uneconomic because the ecosystems that underpin their businesses are incapable of producing sufficient inputs to production[15] to allow the businesses to meet its financial commitments. This suggests that users of accounts of pastoral entities would benefit from methods to estimate the operating performance or cash flows (income-earning potential), or the cost

[15] Forage and shelter for livestock

of replacing (or supplementing) the ecosystem services provided by the ecosystem asset and be able to associate these with the physical value of the capacity of the ecosystem.

IAS recommends that disclosed information about each class of PPE, including the gross carrying amount and the accumulated depreciation at the beginning and end of each period, and the measurement basis used for determining these values, assists users of GPFR to interpret the valuations of assets (IASB 2014a). In cases where the entity decides that fair value cannot be measured reliably, the entity shall disclose a description of the assets, the range of estimates within which fair value is highly likely to lie, and the depreciation method and rates used (IASB 2011). Entities should also disclose the financial risk management strategies related to agricultural activity (IAS 2016).

3.5 Transactions and accounts

Discussed in the section ‘measuring performance’ earlier in this chapter, a need to record three main types of transactions has emerged from the overview of management of ecological capital in agriculture and from the requirements of IAS. The first transaction that must be recorded is where there has been a physical and/or monetary revaluation of the ecosystem asset. The second is the recording of accumulated amounts of degradation (loss) or improvement (surplus) and its effect on equity. Third, records of patterns of use are needed to determine whether these are consistent with maintaining ecosystem condition, or whether they provide the evidence required to evaluate a decline of ecosystem condition as degradation.

3.5.1 Revaluations

Revaluations of assets under PPE are required on a regular basis to ensure that the carrying amount does not differ materially from its fair value (IASB 2010 para. 31). Different classes of PPE are valued and revalued separately to avoid the reporting of amounts in the financial statements that are a mixture of costs and values as at different dates. However a class of assets may be revalued on a rolling basis provided revaluation of the class of assets is completed within a short period and provided the revaluations are kept up to date (IASB 2014a para. 38). This aligns well with the current practice of ecological monitoring of rangeland ecosystems for pastoral use that suggests that a revaluation every five years is appropriate[16].

As assets under PPE, if upon revaluation (physical and monetary), the value of the ecosystem is increased, the increase shall be recognised in other comprehensive income and accumulated in equity under the heading of revaluation surplus. The increase or decrease shall be recognised in profit or loss to the extent that it increases or reverses a revaluation decrease of the same asset previously recognised in profit or loss (IASB 2010 para. 39 and 40).

3.5.2 Sustainable use

Because the patterns of use of an ecosystem (as well as exogenous factors) are determining factors of its current and future condition and capacity to produce ecosystem services, it is important that information about these are recorded. In grazed ecosystems, sustainable flows of ecosystem services are defined by ecologists as the amount of forage that can be consumed by cattle without risking degradation of the ecosystem[17]. The amount of sustainable flow might be different to the amount of ecosystem services (forage) consumed by livestock in a season. If less is consumed, then it might cause the ecosystem to increase in condition. If more services are harvested than is sustainable, then the ecosystem may decline in condition. The separate collection and presentation of ecosystem services produced and consumed is useful in explaining changes to the performance of the organisation, judging the skill of the manager and assessing the prospects for the entity.

Czücz et al., (2019) note that there are issues with use of indicators of management intensity as way of measuring levels of exploitation of an ecosystem (Czücz et al. 2019). The explicit evidence for the patterns of use of an ecosystem used in good practice rangeland grazing management and represented in sustainable use accounts (Chapter 4) may resolve these (at least for grazed ecosystems).

[16] Ecologists and station managers tend to observe that the monitoring of ecosystem condition on pastoral stations is most practical if done on a rolling five-year basis.
[17] The amount of forage reflecting the sustainable flows of ecosystem services would not be recorded under current SEEA EEA descriptions of accounts for ecosystem services.

3.5.3 **Depreciation**

Ecosystems such as those being explored in this study are intended to be used as long-lived (perpetual) renewable resources. Under the good practice for management of these assets, asset management plans and policies incorporate the activities (including appropriate burning and periodic exclusion from livestock grazing) necessary to maintain their capacity over the long term. It is likely that expenditures to maintain asset capacity will change over time. They may increase in response to increased pressures or threats (such as climate change, biosecurity problems, or pest plants and animals being spread from neighbouring properties) or decrease in response to reduction of these threats.

Under IAS 16, Land is considered to have an unlimited useful life and is not depreciated (IASB 2014a). However, under certain patterns of use, ecosystem condition, capacity to produce and monetary value can change in a manner in some ways consistent with depreciation. The AASB Compiled Interpretation 1030 *"Depreciation of Long-Lived Physical Assets: Condition-Based Depreciation and Related Methods"* (CDB) (AASB 2014b) may provide a basis for addressing this issue for ecosystems.

This interpretation observes that some assets (for example bridges, dams, freeways) under PPE are long-lived assets that are constantly rehabilitated during the course of their lives and it is not practical to distinguish between maintenance expenditure and expenditure to enhance the future economic benefits of the asset. Under some CBD methods for long-lived assets, the estimated costs of maintaining the asset at its intended condition are converted to an annual annuity. Any increase of rehabilitation expenditures over the annuity is identified as a depreciation expense and recognised in profit or loss (AASB 2014b para. 5).

Condition assessments under AASB 1030 do not involve the pricing of the future economic benefits consumed during a reporting period but can provide input for such purposes (AASB 2014b para. 17). In agricultural (and other) ecosystems, as discussed previously, degradation of the ecosystem may reduce the physical capacity as well as the monetary value of the ecosystem asset by reducing its capacity to provide forage for livestock, but depreciation is a financial concept only. Incorporating a concept of depreciation that is a measure of the changes to the cost of maintaining an ecosystem in the condition intended by management might usefully communicate that the ecosystem is in the same condition, but the maintenance required has increased and reduced its monetary value. Under the interpretation of AASB 1030, depreciation amount can communicate the lower monetary value of the asset for livestock production even though ecosystem condition (recorded in physical terms) has been maintained.

However, where tightly prescribed and well researched production practices are used (e.g. in cropping or set-stocking of livestock), it may be possible to develop a standard depreciation schedule, based on the pattern in which asset characteristics such as plant species, soil structure and fertility are expected to be consumed by the entity. This would allow the recognition of a depreciation charge in the profit or loss (P&L) statement and inform managers of the need to make provision for expenses (e.g. purchases of fertiliser or pasture improvement activities) for replenishment of the asset.

3.5.4 **Degradation**

Ecosystem degradation is defined in the SEEA EEA as arising when the condition of an ecosystem asset declines over time as a result of economic and other human activity (United Nations et al. 2014b). Focused as it is on livestock grazing in northern Australian rangelands, this study treats ecosystem degradation as an unexpected cost, reflecting the fact that the ecosystem assets are renewable, and that it should be possible to maintain their condition. If ecosystem asset accounting follows IAS 16 as proposed in this study, degradation is recorded as a change in the value of assets on the balance sheet with the change being recorded as a revaluation loss under IAS (IASB 2014b). Under the proposed concept of ecological capital maintenance, the profit reported by the entity incorporates the reduction in value of the ecosystem in its reporting of comprehensive income (IASB 2018). This is conceptually similar to the treatment of consumption of capital or depreciation to ecosystems as proposed in Chapter 8 of the SEEA Tech. Rec. where the cost associated with ecosystem degradation is deducted from income earned from production (UNSD 2017b). However, demonstrated in Chapter 6 of this study, the change to the asset value of ecosystems would be reflected in the Other change in volume of assets in the SNA (UN 2008).

3.6 Liabilities

As discussed in Chapter 1, the issue of accountability for ecosystem condition is of increasing concern to governments and citizens. One of the ways accounting contributes to accountability is via the concept of liabilities. This section introduces the accounting standards that would apply to liabilities for ecosystem degradation. A demonstration of the accounting under IAS for individual entities and SNA for nations is provided in Chapter 6.

Under the SEEA, ecosystem degradation arises when the condition of an ecosystem asset declines over time as a result of economic and other human activity. The SEEA EEA: Tech. Rec. takes a relatively negative position on the potential to account for liabilities related to degradation of ecosystems. It notes specific challenges related to:

1. estimating the value of degradation - in particular finding an alternative to the proposed use of the unpaid cost of restoration of an ecosystem as a valuation of the degradation because it is not conceptually consistent with the methods used to value depreciation or consumption of fixed capital (Obst, Hein & Edens 2015; Obst & Vardon 2014 cited in UN, 2017);

2. determining whether liabilities should be recognised the SEEA EEA Tech. Rec. notes that *"…if there is no expectation that the restoration will take place then, at least for accounting purposes, no liability should be recognised."* (UNSD 2017b pg. 138); and

3. ensuring a coherent and balanced set of accounting entries, in particular addressing the concern that if a liability reflecting the degradation of the asset is recognised, then the fall in asset values and an increase in liabilities for the same event would reflect double-counting in terms of its impact on net wealth (UNSD 2017b).

To date, no integrated approach to accounting for liabilities in an ecosystem accounting context has been developed that responds to these challenges. The approach for accounting for liabilities related to ecosystem degradation described here and demonstrated in Chapter 6 provides a way forward.

Liabilities under corporate and national accounting frameworks arise when there is a legal or constructive obligation that needs to be satisfied. Obliging events exist where the settlement of the obligation can be enforced by law (legal obligations), or where the event (which may be an action of the entity) creates valid expectations in other parties that the entity will discharge the obligation (constructive obligations) (IASB 2010; UN 2008). A liability is recognised in the accounts when satisfaction of the obligation is expected to result in either a financial claim on the entity or an outflow of resources embodying economic benefits. The specific definitions in each framework are explored separately.

3.6.1 Formal definitions

The IAS (and AAS) define a liability as:

"A liability is a present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits"[18] (IASB 2010).

The IAS further notes that:

"The settlement of an obligation usually involves the entity giving up resources embodying economic benefits in order to satisfy the claim of the other party. Settlement of a present obligation may occur in a number of ways, for example, by: a) payment of cash, b) transfer of other assets), c) provision of services, d) replacement of that obligation with another obligation, or e) conversion of the obligation to equity." (IASB 2010).

The requirement for liabilities to have matching assets is not applied by individual entities because it may preclude some socially desirable behaviours:

"…an entity can have an obligation to other entities to make a future sacrifice of economic benefits without being obliged to make that sacrifice to those entities. For example, an entity may undertake an environmental clean up itself…in these circumstances, the entity should recognise that obligation as a liability…. " (AASB 1995 page 98).

For an entity to recognise a liability to restore a degraded ecosystem, there must be an obligating event. This arises from the combination of a legal or constructive obligation and the recognition of degradation of the ecosystem where satisfying the obligation

[18] In the 2018 conceptual framework (for adoption commencing from 2019), a liability is a present obligation of the entity to transfer an economic resource as a result of past events. An obligation is a duty of responsibility that the entity has no practical ability to avoid.

requires future sacrifices of economic benefit (that can be reliably estimated) to satisfy the obligation. Importantly, an obligation always involves another party to whom the obligation is owed (AASB 1995 para. 51). However:

"It is not necessary that the identity of the party to whom an obligation is owed be known in order for a present obligation to exist. Moreover, the party to whom a present obligation is owed may differ from the party or parties which will receive goods or services as satisfaction of the obligation" (AASB 1995 para. 52 & 53).

This can be interpreted under IAS as, even if there is no counterparty for the liability, a liability should still be recognised in corporate accounts. Examples of where a counterparty asset for a liability may not exist may include when the contractors who will provide services have not been engaged, or because the outflow of economic benefits is not financial in nature or doesn't involve a transaction between parties. Examples of non-financial liabilities include exclusion from use of an ecosystem for an extended period in order for it to recover naturally over time (Walsh & Cowley 2014a, 2014b).

In the SNA and therefore in the SEEA:

"A liability is established when one unit (the debtor) is obliged, under specific circumstances, to provide a payment or series of payments to another unit (the creditor)" (UN 2008 Glossary referencing 3.5, 3.33, 11.5).

The SNA further explains that only financial liabilities are recognised in national accounts:

"Benefits are exchanged by means of payments. From this a financial claim, and hence a liability, can be defined. There are no non-financial liabilities recognized in the SNA, thus the term liability necessarily refers to a liability that is financial in nature." (UN 2008 para. 11.4).

Together, these treatments mean that there are a wide range of situations in which liabilities should be recognised under IAS, including cases where there is no counter-part financial asset. In the SNA, the broad conceptual logic is aligned with the IAS treatment but only liabilities with counter-part financial assets are recognised in the national accounts.

3.6.2 Contingent liabilities

It is common in business for a liability to develop in response to a particular event or combination of events. To provide guidance for how preparers of the accounts should deal with this, IAS uses concepts of Contingent Liabilities and Provisions to guide preparers and users of the accounts to generate an interpret this type of information (IASB 2016).

A *"contingent liability"* is a possible obligation that arises from past events and whose existence will be confirmed only by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the entity. The condition of ecosystems can be subject in some circumstances to events such as bad weather or pest incursions that are forecastable, but which are not certain. Research related to management of rangelands (and other ecosystems) indicates that an event of overgrazing may not lead to ecosystem condition decline if it occurs during a good season (e.g. of useful and effective rainfall). If, however overgrazing combines with a poor season, then degradation is likely. The overgrazing event may or may not create a liability to restore condition, dependent on the quality of the season. The contingent liability (or asset) concept potentially provides a useful mechanism to communicate this to users of GPFR.

IAS 137 calls for contingent liabilities (and assets) to be assessed continually to determine whether an outflow of resources embodying economic benefits has become probable. If it becomes probable that an outflow of future economic benefits will be required for an item previously dealt with as a contingent liability, a provision is recognised in the financial statements of the period in which the change in probability occurs (except in the extremely rare circumstances where no reliable estimate can be made). This seems to be highly appropriate for ecosystems-related liabilities (IASB 2016).

Contingent liabilities related to ecosystems are not to be recognised but should be disclosed. Paragraph 86 of IAS 37 provides guidance on the information that should be included in the disclosure:

"…an entity shall disclose for each class of contingent liability at the end of the reporting period a brief description of the nature of the contingent liability and, where practicable: an estimate of its financial effect, measured under

paragraphs 36-52; an indication of the uncertainties relating to the amount or timing of any outflow; and the possibility of any reimbursement" (IASB 2016).

An entity with a stated commitment or legal obligation to maintain the condition of the ecosystems that are assets of the entity may, at a regular revaluation of the condition of the asset, recognise that it has become degraded and that this may result in a future compensation payment if the decline can't be reversed. Because it is possible that the actions they take will (at least partly) restore the condition of the ecosystem, the preparers of the GPFR disclose the amount of the liability that will be payable contingent on the ecosystem condition not being restored.

3.6.3 Provisions

As illustrated above, a liability may be certain, but the amount and timing of expenditure to enact the restoration to satisfy the liability may be uncertain. A combination of good seasons and natural events may reduce the expenditure required or, the expenditure may be increased by poor seasons and other external influences. This uncertainty is not confined to ecosystems. It is acknowledged as a normal factor of businesses and is catered for in IAS 37 via the concept of Provisions which are liabilities of uncertain timing or amount. The standard caters for this uncertainty by allowing many events and circumstances to be taken into account in reaching the best estimate of a provision (AASB 2015c; IASB 2016). Future events that may affect the amount required to settle an obligation shall be reflected in the amount of a provision where there is sufficient objective evidence that they will occur (AASB 2015c para. 48).

The use of estimates is an essential part of the preparation of financial statements and does not undermine their reliability. With respect to provisions for ecosystem liabilities, it is expected that an entity will be able to engage a suitably qualified ecologist to help them determine a range of possible outcomes and make an estimate of the obligation that is sufficiently reliable to use in recognising a provision consistent with the requirements of the standard. The amount recognised as a provision shall be the best estimate of the expenditure required to settle the present obligation at the end of the reporting (IASB 2016).

3.7 Externalities and defensive expenditures

This chapter has so far focused on how an entity that owns or controls ecosystems might recognise them as assets and report the value of the ecosystem services they generate. The other issue that should be explored is how entities might communicate the effect of local externalities to the users of their GPFR. Introduced in Chapter 2, externalities are defined in the SNA as unsolicited services, or 'disservices', delivered by one unit to another without mutual agreement. They are not market transactions between entities and as there is no mechanism to ensure consistency of valuations between the parties, they are not recorded in the national accounts (ABS 2012 para. 3.21).

Examples of externalities associated with changes of ecosystem condition of agricultural and other landscapes include negative externalities such as incursions of pests, weeds or pollution that cause reductions to the quality and quantity of production if not managed defensively, or lowering of water tables due to over-extraction of aquifers (Aisbett & Kragt 2010). Externalities aren't always negative. Positive externalities that agricultural and other entities experience can include pest-predation services provided by beneficial insects harbouring in shrubs alongside vineyards or moderation of wind temperature and speed by forests that reduces pasture plant stress in hot weather, or lowering of water tables to reduce salinity incursion (Aisbett & Kragt 2010).

While the benefits from ecosystems may be material to entities, an entity would not be compliant with IAS if it recognised such ecosystems as assets. Even if the entity is a recipient of economic benefits or disbenefits (burdens) from an ecosystem, the absence of control of it by the entity as a result of a past transaction means the ecosystem does not meet the criteria necessary for it to be recognised as an asset of the entity (IASB 2018).

An existing IAS-compliant mechanism for communication to stakeholders of information that cannot be recognised in the financial statements is to disclose it in the GPFR (IASB 2018). This might be an appropriate mechanism to communicate material benefits or burdens being received from ecosystems owned and controlled by other parties. For example, an entity experiencing incursions of pests or weeds from a neighbouring ecosystem may disclose the expenditure (including the effect on condition or value of their own ecosystems) related to defending the entity's productivity from these incursions.

Likewise, an entity experiencing benefits from a neighbouring ecosystem could disclose their estimates of these benefits (in monetary and physical terms) so that stakeholders can assess the impact on the prospects of the entity if the qualities of that ecosystem were changed. This approach is illustrated in the example statement of ecological performance in Chapter 7.

If available in the GPFR of entities, these disclosures may be available to be recorded in the SEEA and SNA to give some basis for estimation of the positive and negative values of externalities and ecosystem assets. If the concept of 'defensive expenditures' (Stiglitz, Sen & Fitoussi 2010) is revisited, it may provide information that would allow economic interventions to be designed that reduce or reverse depletion or degradation related to externalities (and maximise economic benefit associated with positive externalities).

Analysis of the economic impact of a record storm and flood event in the Gascoyne River catchment in December 2010 provides a relevant illustration. Due to chronic overgrazing by the pastoral industry in the catchment of the Gascoyne River, the capacity of the ecosystems to tranquilise overland water flows and infiltrate water into the soil and aquifers was compromised. This meant that instead of much of the record rainfall being regulated by the ecosystem, significant overland water flows impacted the town of Carnarvon resulting in significant loss of horticultural topsoil and damage to buildings estimated at $90million plus concomitant pollution of the coastal marine environment including seagrass meadows important for fish and carbon storage (Waddell, Thomas & Findlater 2012). The lack of capacity in the catchment to infiltrate water into the subsoil is associated with the recent insufficiency of coastal aquifers (Dodson 2009). In response, expenditure for a desalination plant to supply Carnarvon with water is being investigated (DPIRD 2018).

Identification of 'defensive' activities related to ecological condition would allow interaction between economic output and the quality of ecological (natural) capital to be taken into account. It would allow the investment in stocks of produced capital to form flood defences and desalination plants needed to substitute for the loss of ecological capital in the catchment to be discerned in the national accounts. This may assist in addressing the criticism that an increase in defensive expenditures in response to degradation of an ecosystem should not be inferred as an increase in income (GDP) and therefore living standards.

3.8 Communicating dependability and sustainability of supply of primary production

Discussed in Chapter 2, there are arguments for and activity towards the idea of collective management of agricultural ecosystems by all members of the value chain.

Environment-related risk is perceived to be of increasing significance to the success of firms and to the discharge of fiduciary duty (CISL 2015; CISL & UNEP FI 2014; Mareuse 2011). Noted in the literature review (Chapter 2), firms such as apparel brands, food brands, and banks in the value chain for ecosystem-based commodities may indirectly have a material dependence on ecosystems for the dependable quality and quantity of primary produce but who, because they don't directly own or control the ecosystems, are unable to reduce ecosystems-related risks to a satisfactory level or guarantee that they can continue to enjoy ecosystem-related benefits. As demonstrated by Kering and Patagonia, they may have an interest in communicating their management of the environmental performance of their suppliers by selection preference.

It is expected that stakeholders of such entities would find information about the current and prospective externalities (burdens and benefits) useful in assessing the prospects of the entity and in making decisions about how to assure or improve those prospects (Burritt & Schaltegger 2014; NCC 2015; Schaltegger & Burritt 2018). Good practice in assessment of materiality indicates that an entity consider what type of decisions users are making and the information needs of potential as well as existing investors, lenders, and other creditors (IFRS 2017b para. 14). This study suggests that where an entity is dependent on the stability and productivity of an ecosystem owned by another entity, they need to consider the needs of their users in decisions about how to communicate their management of this risk to their stakeholders.

Where firms can demonstrate the necessary supply contracts and management quality to detect and avoid risks associated with changes to ecosystems, how could this be communicated to users of the accounts for the purposes of comparison with other firms? In what seems to be a similar situation, a lack of transparency of 'off balance sheet vehicles' was identified as one of the drivers of the 2008 global financial crisis (IFRS 2011). In response to this, the IFRS released changes to IFRS 10 Consolidated Financial Statements to ensure that such assets were disclosed appropriately (IFRS 2011 IN5). This standard was adopted in Australia as AASB 10 Statements of Consolidated Holdings.

The objective of IAS 10 Consolidated Financial Statements is to establish principles for the presentation of financial statements when an entity controls one or more other entities with the aim that investors are provided with fair value information about the assets of the controlled entities (IFRS 2011). An entity is regarded to have control over another entity if it is exposed to variable returns from its involvement with the investee and has the ability to affect those returns through its power over the investee. Power over an investee is when the investor has the ability to direct relevant activities (that affect the investee's returns). Such power can include a lender's right to restrict a borrower from undertaking activities that could change the credit risk of the borrower. When these conditions are satisfied, the parent is required to present consolidated financial statements using uniform accounting policies for like transactions (IFRS 2011).

Where an organisation forms a long-term supply contract with a producer that includes specifications related to the condition and management of the ecosystem, they may be considered to have a form of 'sustainability control' (Antonini & Larrinaga 2017). A reporting entity defined by the boundary of this concept of sustainability control may satisfy the description of the reporting entity described in the updated conceptual framework (Deloitte 2018). In its recent update to the conceptual framework for financial reporting, the IASB has suggested that a reporting entity is an entity that is required, or chooses, to prepare financial statements. It is not necessarily a legal entity and could comprise more than one entity. The IASB suggests that where it is difficult to determine the appropriate boundary of a reporting entity, the boundary is determined by considering the information needs of the users of the entity's financial statements (Deloitte 2018).

However, to be fit-for-purpose, IAS 10 would need to be adapted to allow exclusion of non-ecosystem assets and liabilities, equity, income and expenses of the entities in the boundary of 'sustainability control'. Adaptations of concepts and standards for consolidated financial statements may support such entities to report to the users of their

GPFR the condition of ecological capital owned by companies in their supply chains. Some ideas for this are discussed in Chapter 7.

3.9 The special case of conservation assets

As well as existing on some agricultural properties, some ecosystems are owned by conservation organisations. These conservation organisations are charged with satisfying the needs of investors, donors (and volunteers) for restoration of health and vitality of ecological communities and the species they harbour. The quality of their operating performance is largely measured by the impact they have on ecosystems and biodiversity and the of their operations. Much of their work is focused on the economic efficiency of reducing threats such as weeds, feral animals and overgrazing (by native as well as feral animals) (described in Bush Heritage Australia www.bushheritage.org.au).

Although there may be private productivity benefits of conservation remnants on agricultural properties (Aisbett & Kragt 2010), this study has not identified any that are explicitly accounted as part of their income-earning assets. However, it is expected that expenses associated with management of them will be evident in their financial statements.

Some agricultural entities are paid for stewardship of important ecological communities (Burns 2016). For example, the Australian government has been providing funding to landholders to manage the condition of valuable remnants of grassy woodland. Much of the expenditure is for management of weeds and feral animals but the opportunity cost of removing those areas from production is also considered (DOE 2011). Consequently, the monetary amounts of material interest to stakeholders in relation to conservation ecosystems are mainly expenditures to reduce threats. The lower the cost of achieving the conservation outcomes, the higher the performance of the organisation.

Under current IAS, the land would be recognised as an item of PPE for the entity and it would report its conservation activities and expenditures in its GPFR. In accompanying ecological statements of performance, the value of the ecosystem(s) (or species) of conservation interest on the property would not (normally) be valued in a monetary context but may be described in physical terms (per the approach described in this study).

In conservation organisations, statements of ecological position may include a description of the condition intended by management of the ecosystem and changes since last period.

Under the requirements of IAS 13 Fair Value a monetary value for the ecosystems (or species) should not be recognised in the financial statements based on their existence value or the other public benefits. If the value of bringing these conservation assets to a condition determined by management were determined by the same method as proposed for bearer plants prior to their use in production, it would be based on the accumulated cost (Chapter 2). Once they are in the desired condition, they will require annual expenditures to maintain their condition.

These two values; the extent of the ecosystem(s) and their condition class (in physical terms) and the amount of expenditure on them would be very valuable in macroeconomic analysis. The physical information would inform policymakers of the sufficiency of total conservation and cultural assets being transmitted to future generations. The monetary information would provide insights into the cost of conservation and the quality (efficiency) of current stewardship of these assets. Total Economic Valuations (TEV), for example as used to value the Sydney Opera House and the Great Barrier Reef as Australian icons (Deloitte Access Economics 2013, 2017), can also be used to estimate icon and brand values of Australian endemic ecological communities and species. Information about the ‘cost to produce’ conservation on privately owned land and the effectiveness of private land managers at conserving ecosystems is probably of analytical interest to governments so they can compare the relative performance of farmers and conservation organisations.

3.10 Conclusions

Explicit interpretation of the IAS explored in this chapter suggests that ecosystems used by agricultural businesses satisfy the definition of an asset under IAS and can be considered a class of asset under IAS 16 – PPE. Recognition of ecosystems as assets is dependent on the ability to measure their value reliably and under IAS information is reliable when it is complete, neutral and free from error (IASB 2018). The study has exposed that the nature of ecosystem assets of a pastoral entity means that reliable information about the value of ecosystems should include information about their physical characteristics as well as their monetary value. Accordingly, a framework for supplementing GPFR with information about ecological capital must include concepts, principles and other guidance for producing useful information about physical characteristics. Outside of the valuation question, other principles and concepts for recognition and revaluation of assets under IAS 16 PPE can be applied to ecosystems.

Monetary values for ecosystem assets, separately from land can be obtained using Level 2 and Level 3 inputs to valuation and the standard IAS 13 Fair Value Measurement as it is presently documented. However, since ecosystems often establish or regenerate without human intervention, cost-to-produce (accumulated cost) can be problematic for valuations of income-producing assets. While cost-to-produce may be inappropriate for income-earning assets, it may communicate useful monetary values for ecosystem assets that produce public benefits. The present requirements for disclosures of the inputs and methods for monetary valuation should assist users of GPFR to interpret the values of ecosystem assets. Disclosures are also a useful mechanism to communicate the existence of positive externalities that the entity depends on or negative ones that related to 'defensive expenditures' by the entity.

This study finds that the concept of liabilities as presently defined in IAS (IASB 2018) can be applied to ecosystem assets. However, the study exposes that preparers of accounts might need some guidance to assess the nature, timing and amount of outflows of economic resources needed to satisfy an obligation related to the ecosystem. An approach to these is developed in Chapter 7.

Ecosystems have some unique characteristics not observed in other assets. These include that they can maintain and restore themselves but are subject to transitions to degraded states from which they may not recover. Their capacity to generate ecosystem benefits is more vulnerable to exogenous factors such as poor weather, pests and diseases, feral animals and fire than physical capital assets. The patterns of their use can influence their condition and capacity, but the consequences of overuse or underuse (to assist recovery) are contingent on external factors including weather and disturbance. These differences can be accommodated by adapting some of the concepts, principles and conventions in the present IAS. Adaptation of IAS concepts, principles and guidance is desirable because it reflects decades of adaptation to better serve the interests of stakeholders. However, some new concepts, principles and guidance is needed to help preparers of accounts produce economically relevant information about ecosystem resources and the quality of management of those resources.

This study recommends adaptation of the concept of physical capital maintenance to a concept of ecological capital maintenance. This concept depends on addition to IAS of concepts, principles and guidance for the measurement of ecological capital condition and ecological capital capacity. If the values produced by these methods are coherent with the SEEA EEA, entity-level information can be compiled into subnational and national accounts for macroeconomic analysis.

The addition of approaches to physical measures for ecosystem condition and capacity will also allow present approaches to depreciation to be adapted to accommodate ecological capital. Finally, the emerging need to incorporate environmental performance of supply chains discussed in Chapter 2 may be fulfilled with an adaptation of in IAS 10 Consolidated Financial Statements. An adaptation of this standard, including adaptation of the concept of control to a concept of 'sustainability control', may allow entities reliant on the quality of ecological capital in their supply chain to fulfil stakeholder needs for information about these resources.

The identified adaptations and additions to the IAS that provide a framework for accounting for ecological capital are summarised in tables 1 and 2.

The remainder of the study discusses and demonstrates these. It uses a case study of a representative agricultural entity operating or leasing a rangeland ecosystem for pastoral use from the Western Australian government. The compilation and presentation of ecosystem asset accounts in physical terms and sustainable flows is developed in Chapter 4. Methods to produce monetary values for ecosystems assets and services are discussed in Chapter 5. Chapter 6 addresses accounting for liabilities related to ecosystem degradation. It presents capital statements demonstrating the effect of ecosystem condition change on the equity of the entity. Chapter 7 demonstrates the experimental presentation of a statement of ecological performance and explores the use of disclosures to communicate the effect of externalities on an entity.

3.10.1 Elements of a framework for ecological capital accounting for individual entities

Table 1: Adaptations and additions to IAS to accommodate ecological capital (ecosystem assets)

Adaptation to Standard Accounting Concept	**Adaptation to accommodate ecosystem assets (ecological capital)**
Concept of Physical Capital Maintenance	*Concept of Ecological Capital Maintenance* Analogous to the physical concept of capital. Under this concept a profit would be earned if the ecological capital (capacity to produce the ecosystem system services desired by management) is maintained or increased over the accounting period. Consistent with accounting convention for financial and physical capital, inflows (outflows) of ecological capacity would be included in equity as capital maintenance adjustments or revaluation reserves. Assets and liabilities under this concept should be measured at their current cost as required for the concept of physical capital maintenance (IASB 2010).
Condition-based depreciation (CBD) in AASB 1030	*Cost-based depreciation* Adaptations to CBD would support accounting of ecosystem assets where the condition of the asset is maintained but increased maintenance expenditure and/or reduced use is required to maintain condition. Examples of ecosystem maintenance expenditures include increased requirement for exclusion from grazing (a form of opportunity cost), increased expenditure to manage threats from weeds or herbivores, or to recover from negative externalities such as climate change. If these were accounted for as depreciation it would allow them to be compiled as consumption of ecological capital in the SNA to provide useful inputs to macroeconomic analysis.
Revaluation account	*Ecological revaluation account* Adaptation in support of the concept of ecological capital maintenance. An 'ecological revaluation account' would record net accumulated changes to ecological capital in physical terms. The associated monetary value changes would be recorded in the revaluation accounts in accordance with IAS 16.

Adaptation to Standard Accounting Concept	**Adaptation to accommodate ecosystem assets (ecological capital)**
Consolidated Financial Statements IAS 10	*Consolidated Ecological Statements* An adaptation of the purpose and principles of the standard governing preparation of consolidated financial statements to enable an entity to report the condition of ecosystems in its value chain. This would include adaptation of the concept of control to a concept of 'sustainability control'. This concept reflects the influence a member of the supply chain has on the condition of ecosystems in the agricultural sector. It also reflects the concept expressed in the Kering EP&L (Kering 2013 discussed in chapter 2) that they are indirectly responsible for ecosystem loss. Such reports would give users of accounts some visibility of any environment-related operational or reputational risks emerging from the supply chain of the entity.

Table 2: New accounting concepts and new types of accounts to accommodate unique characteristics of ecosystems in IAS

New Accounting Concepts and new Accounts	**Description**
New Concept - Ecosystem asset values in physical terms	*Concepts for ecosystem condition and capacity to deliver the ecosystem service(s) desired by management* As for the SEEA EEA, physical values for ecological assets are needed to provide users of accounts with information about type of ecosystem, its extent and condition and its productive capacity. They can also be used to establish whether ecological capital has been maintained and whether there is an obligation to increase it (i.e. where ecosystem condition is a legal or constructive obligation). These should be coherent with the concepts and typology in the SEEA EEA so that accounts for individual entities can be compiled into subnational and national accounts. The quality of inputs to physical valuation should be disclosed to help users decide how strongly they can rely on the information.
New concept - ecosystem condition index	*Condition index* A condition index (such as the eCond) may provide a way of providing useful information about the condition of an ecosystem for use in supplements to GPFR under IAS

New Accounting Concepts and new Accounts	**Description**
New concept - ecosystem condition categories	*Condition categories* As a supplement or alternative to an index of condition, condition categories may make the accounting for ecosystem condition simpler to perform and simpler to use. Condition categories should reflect the qualitative characteristics of useful information described under IAS and SEEA and be aligned to the measurement purpose. An Ecological Accounting Standard could include 'standard' categories (for example the 'state' of the ecosystem from a conservation perspective, or condition quality for grazing/provisioning for livestock). Preparers may draw on these categories or disclose that they have prepared bespoke accounts and the basis of these.
New Accounting Concept: Reference condition	*Reference condition* The expert working group on SEEA EEA condition accounting (described in chapter 2), recommend nomination of a reference condition which can reflect the natural state of an ecosystem, or a desired state (Keith et al. 2019). For individual entities, this may provide a useful reference from which satisfaction of legal or constructive obligations for ecosystem condition can be assessed.
New Accounting Concept: Degradation (restoration)	*Degradation* To align with the SEEA EEA, IAS would add the concept to standards for ecosystem accounting at the entity level. This would communicate that an ecosystem asset has declined in condition due to human management (not due to exogenous factors). This information could be associated with the recognition of a liability or disclosure of a contingent liability associated with the degradation.
New concept – ecosystem capacity	*Ecosystem capacity* *(to provide the ecosystem services desired by management)* The capacity of an ecosystem to sustainably produce the ecosystem service(s) desired by management. This could include the capacity to provide (provision) forage for livestock, the capacity to support viable populations of a species, store an amount of biocarbon, or geo-biophysical features that provide the inputs to spiritual and cultural practice.
New accounts – Ecosystem condition accounts	*Ecosystem condition accounts* Condition accounts communicate the condition of an area of each type of ecosystem at a point in time. They are used to communicate changes to ecosystem condition and provide input to estimate the economic implications of condition change. They may also assist managers to identify interventions to achieve desired condition levels. They should communicate opening

New Accounting Concepts and new Accounts	Description
	and closing balances that reflect reference condition. Condition accounts can be prepared to display information at different degrees of aggregation.
New Accounts - Ecosystem capacity accounts	*Ecosystem capacity accounts* Ecosystem capacity accounts communicate the capacity of ecosystem assets at a point in time to produce ecosystem services. They are used to communicate changes to ecosystem capacity and provide input to estimate the economic implications of condition change. They should communicate opening and closing balances.
New Accounts: Patterns of Use Accounts	Sustainable use (grazing accounts) These accounts would record the amounts of ecosystem services generated (that can be sustainably consumed) and also the amounts of ecosystem services consumed. They are used to record the 'transactions' with the ecosystem. If the ecosystem condition has declined, Sustainable Use Accounts can be used to assess whether the ecosystem has been used sustainably or whether the decline in condition should be recorded as degradation.
Supplementary statement	*Statement of ecological performance* A supplement to the statement of financial performance. A statement of ecological performance would present the net natural capital position of a business at a point in time alongside the position for previous periods. It should communicate any opportunity cost associated with restoration strategies that incorporate reduced ecosystem service use.
Additional disclosures	Disclosure of positive externalities and defensive expenditures may provide useful information to stakeholders about dependencies on or threats generated by ecosystems beyond the property boundary. Ecosystem services (for example pollination and pest predation) can be valuable, free inputs to production. Likewise, threats to the condition of their ecosystem assets and capacity to generate ecosystem services (for example weeds, feral animals) may trigger regular defensive expenditures.

4 Accounting for physical values

4.1 Introduction

Discussed in Chapter 2 and 3, ecological capital may be most faithfully represented by physical information. In 2014, the IAS amended the scope of IAS 16 Property Plant and Equipment to include bearer plants related to agricultural activity. The purpose of the amendments was to treat bearer plants[19] (for example Almond trees) that are held for multiple years to grow crops as property, plant and equipment and apply the standards prescribed in IAS 16 (IAS 2014). IAS acknowledges the importance of physical valuations of bearer plants (IAS 2014), however this study could find no existing literature or standard accounting concepts (outside the SEEA) for producing accounting information about physical characteristics of bearer plants, whether these concepts might be extended to ecosystems, or how values might be communicated.

This chapter contributes to the design and compilation of physical accounts for ecological capital towards a statement of ecological position for individual entities in the broadacre (pastoral) agricultural industry. Described in Chapter 3, rangeland science has described methods for assessing the condition of pasture ecosystems and whether they are being managed sustainably (for example Ryan et al. 2013; Walsh & Cowley 2014a). These were used to design and demonstrate ecosystem asset and service accounts suggested by the SEEA EEA (United Nations et al. 2014b).

The chapter illustrates the sequence of accounts and demonstrates the compilation of physical ecosystems accounts using a hypothetical scenario based in the Kimberley region of Western Australia as the entity owning and controlling ecological capital. It demonstrates approaches to physical accounts for ecological capital under IAS that can reflect good operational practice and are practical. It also demonstrates the possibility of a physical 'balance sheet' for ecological condition and a 'statement of ecological position'.

[19] In the International Accounting Standard 16 Property, Plant and Equipment, amended in June 2014 to include bearer plants related to agricultural activity, a bearer plant is a living plant that is used in the production or supply of agricultural produce, is expected to bear produce for more than one period and has a remote likelihood of being sold as agricultural produce, except for incidental scrap sales.

4.2 Relevant, material information

The UN SEEA expert working group on condition accounting recommends that the choice of indicators of ecosystem condition is defined by the purpose of condition accounts (Czúcz et al. 2019; Keith et al. 2019; Maes et al. 2019). IAS encourages preparers of accounts to focus on issues of materiality. This chapter demonstrates the application of these principles in the design of physical ecosystem accounts for individual livestock grazing entities. Three issues of materiality are assumed for these entities:

1. the magnitude and nature of the ecosystems' contribution towards the income-earning potential of the entity;

2. whether the condition of the ecosystems could trigger extra or unexpected expenditure in response to regulation or challenges to the entity's social licence to operate; and

3. whether the condition of the ecosystems could result in extra income (for example by being able to secure advantageous contracts).

The contribution of ecosystems to income-earning potential is usually related to capacity to produce inputs to production. Described in Chapter 2, ecological (and agronomic) research suggests that current provisioning capacity and its dependence on inputs for production is governed by the type of ecosystem, its extent and condition. Future capacity is governed by the match of the type of ecosystem to the type of use of it (see for example DAFWA 2018a) and the policies of management with respect to patterns of use and whether these are expected to sustain the ecosystem's condition or cause the condition to change. To assess income-earning potential, the entity needs information about the future productivity, dependability and sustainability of the capacity of the ecosystem to produce the inputs, especially under climate change or scarcity of resources such as phosphorous.

The second aspect of materiality relates to management of reputational and regulatory risks and expenses associated with this. Agriculture's social licence to operate is under challenge and significant drivers of this include its role in land degradation and biodiversity loss and the generation of negative externalities such as pollution to waterways, and of course GHG emissions. Manifestations of the materiality of this information include reductions in demand for red meat, additional expenditure to prevent pollution (or to defend accusations) and impacts on personal feelings and motivation (see for example CIE 2015; Heard 2019; Queensland CANEGROWERS Organisation 2018).

Research suggests that it is impossible for agriculture (any human enterprise) to not generate some degree of biodiversity impact[20] and this is largely accepted (see for example Ash & Corfield 1998; McIntyre, McIvor & Heard 2002; Walsh & Cowley 2011). However, agricultural entities that are exposed to discovery that they are responsible for excessive or permanent degradation and biodiversity loss can expect increased expenditure to invest in their social licence to operate or address regulatory challenges. Stakeholders may choose not to associate themselves with these risks.

Summarised later in this chapter, ecosystems in good, productive condition for livestock grazing also exhibit characteristics of the natural biodiversity and ecological functions. As a result, some agricultural entities generate private and public positive externalities such as landscape amenity, habitat for biodiversity, regulation of wind speed as a joint product alongside the commodities they produce (Aisbett & Kragt 2010; Mallawaarachchi & Harris 2014; Mallawaarachchi & Szakiel 2007). Some entities receive income for environmental stewardship (Burns 2016; Tasmanian Land Conservancy 2018). Information about ecosystem condition is material to a pastoral entity and justifies investment in accounting if it assists the entity to secure advantageous contracts, improve profitability or reduce risk. Likewise, subject to evidence of the existence of an economic beneficiary, the SEEA might account for the regulating and cultural services such as capture, storage and cycling of soil-water and nutrients, reduction of soil erosion, biocarbon storage and natural amenity (United Nations et al. 2014b para. 4.1, 2.36, 2.37, 2.96, 4.24).

Governments have a range of uses for physical information about ecosystems. They assist governments to assess their stewardship of the resources entrusted to them, whether it is of good quality and whether they are achieving their aims under relevant conservation legislation. Ecosystem accounts in physical terms support these aims by communicating

[20] While the ecosystem is being used for livestock production. And it is generally accepted that, if the decline in condition is limited, then the ecosystem will return to a healthy, biodiverse state following livestock removal.

the quality of the assets they manage and the effectiveness of their activities in achieving the objectives related to environmental performance and biodiversity conservation including the EPBC Act (DoEE 2018). However, data for ecosystems on lands owned by agricultural entities or leased for agricultural use is currently not routinely captured.

For example, land condition monitoring for management of pastoral leases was performed every 6 years between 1997 and 2009 at the pastoral station scale by the Western Australian Government but has ceased. Monitoring of land leased or owned by pastoral entities now uses a set of fixed sites on representative areas of pastoral land to develop an indication of condition (and condition change) that it uses to infer condition at regional and vegetation-level scales. The 2017 report card suggested that in the northern rangelands (where the scenario for the accounts in this chapter is situated), 57% of the land was in good condition, 29% in fair condition and 14% in poor condition and that this condition configuration is relatively stable (Department of Agriculture and Food Western Australia 2017). If all of the land used for pastoral leases in the Kimberley were in good condition, their potential sustainable carrying capacity is estimated as 825,400 head of cattle (CU). At its present condition, it is only 584,160 or 71% of its potential. While some stations have been completely destocked to achieve conservation objectives, an estimated 30% of stations in the Kimberley region were overstocked (compared to sustainable carrying capacity), based on Annual Return of Livestock and Improvements (ARLI) submitted to the pastoral lease board (PLB) (DAFWA 2018a).

As a result of increased knowledge and skills for sustainable management practices for rangeland grazing, it can be expected that some stations are doing condition monitoring to support operational decisions[21]. AACo Ltd, a large agricultural company in WA, describes the use of measurements of the condition of its land as part of its inputs to property asset valuation (AACo 2016a).

The accounting for ecological capital being developed in this study may provide these stations, who perceive that this information is material to their entities, with a way of communicating the relative quality of their stewardship of natural resources to clients,

[21] that approximately 70% of them are judged to be not overstocked supports the proposition that they have information to help them achieve sustainable stock numbers

investors and lenders. Discussed in Chapter 7, if this information is collected and presented in a manner compliant to the SEEA, then it could be aggregated to a state and national level to improve the information available to policy makers.

4.3 Scenario – pastoral company

To demonstrate the accounting processes and tables, the chapter draws on a rangeland scenario situated in the Kimberley region of Western Australia using modelled data[22] illustrated in Figure 5 and described in Table 3 below. The scenario commences on Date 0 (D_0) when a pastoral entity starts to use a property for a ten-year period for grazing of livestock (cattle). The property is comprised of ecosystems of different types and different conditions which have differing capacity for grazing. In addition to the area used for livestock grazing, there are two additional zones that are managed for biodiversity conservation and cultural amenity with no pastoral use. These comprise a 'Gouldian' zone (partly shown in the illustrative map (Figure 6)) that is an area managed to conserve habitat for the endangered Gouldian Finch (Erythrura *gouldiae*) and a Cultural zone (not shown in Figure 6) that is an area managed to conserve the geological forms, fauna and flora that are significant to the culture and ceremonies of the traditional owners of the land.

As assets under IAS 16 PPE, the ecosystems are revalued regularly. This is in accordance with best practice as change in rangeland condition due to grazing or other disturbance generally occurs gradually over multiple years and is difficult to detect on an annual basis. A 3 to 5 year rolling schedule monitoring high productivity and fragile areas is generally regarded by rangeland scientists to be useful (DAFF 2014; Ryan et al. 2013), and is compliant with IAS (discussed in Chapter 3). The scenario reflects this by separating the ecosystem asset revaluation dates and demonstration accounting periods D_1 and D_2 by five years. Due to the sensitivity of ecosystem condition to annual patterns of harvest of ecosystem services, measurements of provisioning services (for the ecosystems being used for livestock production) are performed annually. This study focuses on the

[22] The scenario with additional detail is also used in Chapter 6 to demonstrate accounting for liabilities related to degradation.

management of ecosystems used for production so in this scenario, the condition of the Gouldian and Cultural zones does not change.

During the first five-year period to Date 1 (D_1), the entity fails to consistently match the numbers of livestock carried on the pastoral ecosystems to the long-term carrying capacity and carries too many cows. The ecosystem is revalued at D_1 consistent with the requirements of IAS 16 for assets under this standard and found to have declined in condition. To restore the condition in the period D_1 to D_2, the pastoral entity identifies locations on the property where it expects that ecosystem condition improvement will be rapid in response to reductions of livestock grazing, particularly during the wet season. In response to this and other interventions, the condition of the property at the revaluation on Date 2 (D_2) shows improvement but hasn't been restored to the condition at the start of the period.

Figure 5 and Table 3 describe the rangeland scenario used to design and demonstrate the approach to the accounting adaptations.

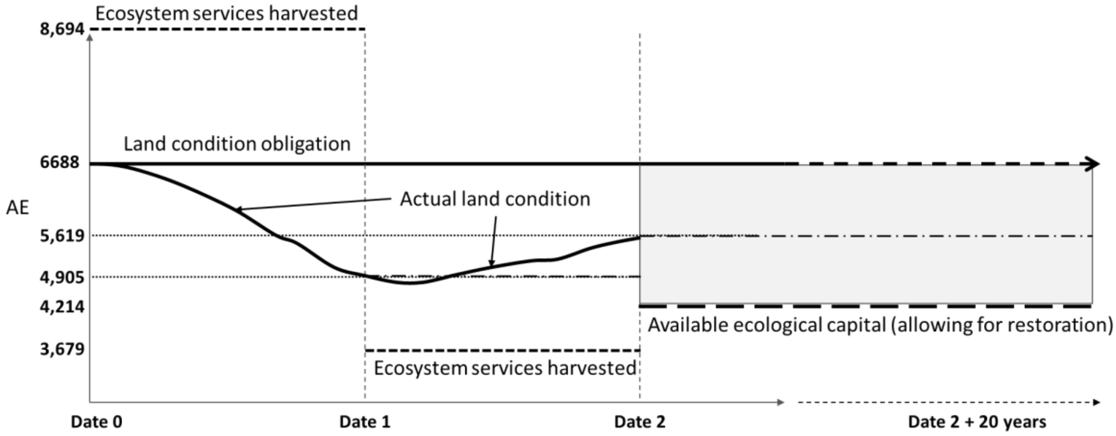

Figure 5: Illustration of scenario for demonstration accounts. Vertical axis shows the carrying capacity in Adult Equivalent Units (AE). The horizontal axis shows the key dates for the scenario.

Table 3: modelled data used for accounting entries is based on a hypothetical pastoral lease of 90,000ha in the Kimberley region of Western Australia.

Accounting entry	Value	Estimation basis & method
Ecosystem asset capacity (physical, for grazing, for the property)	6,688AE at D_0, 4,905AE at D_1 5,619AE at D_2.	Derived from research by the Department of Agriculture and Food Western Australia and CSIRO that relates land types to long-term sustainable carrying capacity per hectare at different land condition classifications (Chilcott et al. 2005; DAFWA 2013).
Sustainable ecosystem services generated	33,440 (AE.5.year): D_0, - D_1 24,525 (AE.5.year): D_1 - D_2.	Five years of grazing based on long-term carrying capacity at condition at start of period (simulated data based on land type and condition and seasonal conditions).
Ecosystem services harvested	43,472 (AE.5.year): D_0, - D_1 18,394 (AE.5.year): D_1 - D_2.	Modelled as a factor of 1.3 times sustainable carrying capacity (over-grazing) based on condition at D_0 in the first period and 0.75 times long-term carrying capacity (under-grazing) based on condition at D_1

4.4 Physical ecosystem accounts

Ecosystem accounts prepared in a SEEA-coherent manner record and communicate the type of ecosystem, its extent and condition at a point in time and how it changes between accounting periods. The capacity for the ecosystem service of interest at a point in time (in this study this is grazing) is calculated in physical and monetary terms to indicate where improvements (declines) of condition may result in increases (decreases) in economic benefit for the entity.

This section describes the data types and sources available for compilation of ecosystem accounts in rangelands being used for pastoral production and summarises the current practices for ecosystem condition assessments. It demonstrates the different types of physical accounts required to represent the stocks and flows identified by rangeland science for sustainable grazing of natural ecosystems. It starts with a brief summary of how different ecosystems in the northern rangelands are identified and mapped and how their condition is assessed. This is not a formal review and commentary of the relative merit of different methods, but a general overview to provide context for how the accounts are compiled. The first accounting tables demonstrated are the conceptual equivalent of an asset register[23] to show how this information might be displayed in an ecological accounting system. These example tables show the type, extent and condition of the ecosystems that make up the ecological capital at a point in time. Next, example tables are displayed that show the patterns of use of the ecosystem (the grazing accounts) so that stakeholders can detect whether the ecosystems are being used in an unsustainable manner. Following these, the chapter demonstrates the development of accounts that communicate changes between periods. Finally, a table communicating the net ecological position of the entity is shown; the statement of ecological capital.

4.4.1 Establishing the type and extent of ecosystems assets

Outlined in chapter 3, a wide range of different ecosystems are used for the grazing of livestock by pastoral enterprises. Each agricultural or pastoral enterprise typically controls a combination of ecosystems that differ from each other in grazing capacity and vulnerability to degradation caused by grazing. To facilitate livestock management,

[23] Commonly used in organisations to record the details of different types of assets and their current values.

pastoral-use properties are typically divided into different paddocks and artificial waters are added to assure reliable water for livestock. Livestock mainly graze within 4 kilometres of water points, with the most grazing pressure applied within 1km and so the availability and distribution of the waters and the amount of each type of ecosystem within watering range is important to the production capacity of the paddock (Ash et al. 2015; Petty et al. 2013; Walsh & Cowley 2014a).

In keeping with the first step of ecosystem accounting under the SEEA EEA, a foundation for the accounts for an individual entity are the spatial extents of different ecosystem types under their control. These are the ecosystem assets. To provide management-useful information about the relative production capacity of different areas of the property (paddocks), grazing enterprises in Australian rangelands may further describe the extent of each ecosystem, and access to water in each paddock.

It is relatively easy to compile the ecosystem extent accounts. Information about the type of land systems (ecosystems) in the Kimberley region of Western Australia, their grazing potential and vulnerability to grazing-related degradation is available from the Department of Agriculture and Food (DAFWA 2018a). Maps of them for the pastoral station may already have been developed for the pastoral station manager including information about the pasture type[24] and condition (DAFWA 2013). An illustrative example of a mapped output is shown in Figure 6. These sources of data combine to provide the information necessary to establish SEEA-compliant ecosystem asset accounts of the type of ecosystem and the extent that is accessible to livestock.

[24] A distinctive mix of plant species, soil type and position in the landscape

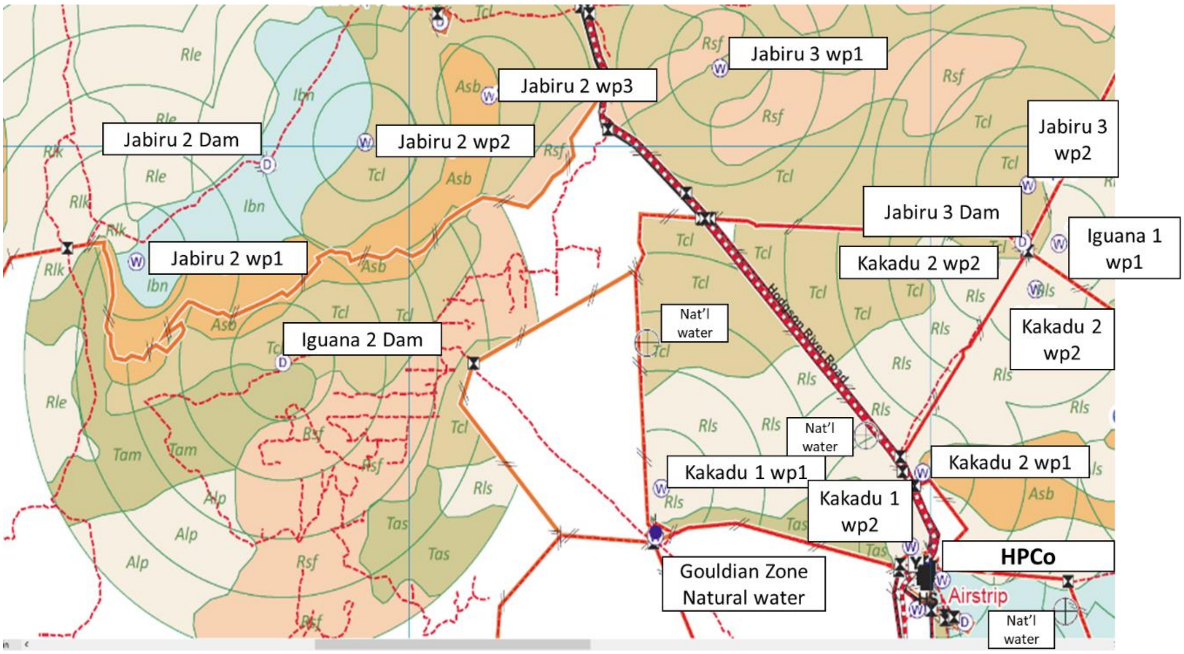

Figure 6: Illustrative map of land systems (different colours) and distance to reliable (artificial) waters (concentric circles) in each paddock (names Jabiru, Kakadu and Iguana). Artificial water points (wp), man-made dams (Dam) and ephemeral natural springs an and lagoons (Nat'l water) are noted. (Adapted for this thesis with permission from Australian Indigenous Agribusiness.)

As well as the type of ecosystem, its extent (and distance to water) the condition of the ecosystem governs its capacity to provide ecosystem services and ecosystem benefits.

In the demonstration accounting for this scenario, while the condition of the Gouldian Zone and the Cultural Zone is important, it is stable and is only reported at the highest accounting summary level. The more detailed accounting designs and compilations prioritise information about the ecosystem assets used to generate provisioning services of forage for livestock due to risk exposure for the enterprise[25]. Two main methods are used by pastoral station managers to monitor the condition of land systems in rangelands; on-ground monitoring of vegetation and remote sensing of light signals from satellite.

4.4.2 **Classifying the condition of ecosystems**

Like many government agencies, DAFWA provides detailed guidelines for the on-ground assessment of pasture condition in WA. The guidelines assist pasture assessors to collect and interpret detailed ecological data to categorise a pasture as Good, Fair or Poor condition. For the purpose of this study, these condition categories are equivalent to the

[25] In the scenario, the entity receives no income from biocarbon stored in the soil and embodied in the vegetation and so it is not material for the accounting processes.

ABC classes used in other parts of Australia. Whilst they have been designed for practical use, they comply with guidance for establishing an ecosystem condition account (Keith et al. 2019; UNSD 2017b Chapter 4) illustrated as indicators of condition I1, I2, I3, I4 in Figure 2.2 of SEEA EEA Discussion paper 2.1: Purpose and role of ecosystem condition accounting (Keith et al. 2019).

Illustrated in Figure 7, pastures in Good condition are dominated by the desirable local native perennial species (for that geological location) with small amounts of other desirable perennial (native) grasses. Annual grasses and herbs may occupy the small spaces between the perennial tussocks. Pastures in Good condition can be considered to reflect both a natural and a desired state as recommended for the SEEA EEA. Pastures in Fair condition are reduced in density and vigour of desirable local native perennial species compared to pastures in Good condition and increased in presence of the less desirable perennial species. Increased spaces between perennial tussocks are occupied with less desirable annual plants. Pastures in Poor condition have almost no desirable local native species and show significant bare ground. The pastures are dominated by undesirable perennial (weedy) species or by woody species (DAFWA 2018b; Ryan et al. 2013). This study has added an extra condition, Very Poor, to refer to a degraded condition which has lost most of its vegetation and soil.

These condition classes reflect the guidance for condition accounting recommended under SEEA EEA (Czücz et al. 2019; Keith et al. 2019; Maes et al. 2019; UNSD 2017b para. 4.31);

- They reflect the overall ecological condition of the ecosystem, the proximity to abrupt transitions (recommended in Maes et al. 2018) and are able to signal changes in condition;

- They are linked to measures of ecosystem services supply; they are easy to understand and interpret (and can easily be converted into a normalised index, or eConds (Sbrocchi, Davis, M., et al. 2015) if desired for reporting purposes);

- Data is available as part of good management practice, and measurements are scientifically coherent with the concepts of sustainability and productivity.

Condition classifications (or categorisations) are an elegant way of aggregating indicators of vegetation quality (for livestock as well as for habitat and conservation), soil erosion potential, biodiversity, and carbon for accounting purposes. While there is likely to be further development to fully meet the requirement of users preparing ecosystem accounts, it should be possible to usefully impute some values for biodiversity conservation and regulation (capture, storage and cycling, reduced emissions) of water and air-borne resources including avoidance of soil loss because they are already incorporated in these condition classes.

These condition classes also reflect the prospects for the ecological capital to be transmitted to future generations so they have the same resources as current generations. For example, pastures in Good condition are healthy, viable, resilient and sustainable as that ecosystem type. In addition to providing good quantities and qualities of pasture for livestock, they exhibit healthy biodiversity, regulating capacity and could be expected to provide cultural amenity. Good management, including use of sustainable use patterns (pasture utilisation rates), exclusion of grazing in the wet season and appropriate burning regimes will help to maintain it. Pastures in Fair condition have lower biodiversity indicators and exhibit fewer of the characteristics of the native ecosystem. They have reduced capacity to capture, store and cycle nutrients and soil-water and increased exposure to soil erosion. They are susceptible to a decline to Poor condition but can be managed back to Good condition within a season or two.

A return of pastures in Poor condition to Fair or better condition requires a major change in management over many sequential years. They are vulnerable to degradation to Very Poor condition and once in this condition, pastures are very unlikely to return to better condition in a commercially or socially acceptable timeframe (Ryan et al. 2013). The implication of this is that prevention of degradation is more economic than restoration and interventions should be prompt for landscapes falling into risk. Accounts providing evidence for good stewardship would demonstrate collection of information about ecosystems moving into Poor condition and the ability to identify where economically efficient interventions can be made to restore their condition. Such information is useful for analysis of the investment required to restore ecological capital for future generations.

Assessment of pasture condition is still currently reliant on on-ground monitoring which, for such large areas (e.g. 90,000ha of our scenario), is expensive. Statistical approaches to selection of representative areas and an appropriate number of replicates can be used to establish a reasonable estimate of the condition of ecosystems that would be acceptable for accounting purposes. On-ground monitoring can be supplemented with remotely-sensed reflectance data that have been correlated with on-ground characteristics such as bare ground, water, dry vegetation, and green vegetation and datasets are now available at fine-scale (approximately 25m x 25m) from Landsat. Interpretation of the results requires some skill as these datasets do not reliably identify species or soil surface stability and so cannot be used as a complete replacement for on-ground monitoring. They are useful as a complementary dataset and can corroborate on-ground monitoring or detect significant change over time as a mechanism for prioritising on-ground activities (Department of Agriculture and Food Western Australia 2017; Guerschman et al. 2015).

Confidence in the condition classification of a property, or part of a property, is dependent on the choices for sampling regimes and indicators of condition. Accordingly, users of accounts should be informed of the strength of evidence for the ecosystem condition being reported in accounts. The model developed for estimating and communicating the quality of evidence in conservation management practice (CMP) (Salafsky et al. 2019) and in preparation of the eCond (Sbrocchi, Davis, Grundy M., et al. 2015) may provide a suitable foundation for the development of guidelines appropriate for accounting.

Ribbon Grass pasture in Good condition

Ribbon Grass pasture in Fair condition

Ribbon Grass pasture in Poor condition

Figure 7: Ribbon Grass pasture in Good, Fair and Poor condition categories. Reproduced with permission from Pasture condition guide for the Kimberley DAFWA (2013).

4.4.3 Ecological Asset Register

A register of ecological assets[26] is a foundation of an ecological accounting system and is relatively easy to compile from existing maps and mapping technology and condition classifications discussed earlier. Three different views are demonstrated. Table 4 lists the types and extents of each ecosystem on the property being used for each primary purpose. Table 5 lists the types and extents of each ecosystem on the property that is used for livestock production and shows the area in each condition class. Table 6 illustrates a further breakdown of each ecosystem in each paddock. Table 7 demonstrates presentation of the ecosystem extent and condition at different distances to water. This information is essential for a faithful valuation of physical capacity for provisioning services for livestock and is required to help managers to identify the locations where interventions for changes to condition are required.

Table 4: Ecosystem extent-use register depicting the extent of each ecosystem in hectares (ha) under each type of use. (Numbers may not add up due to rounding.)

	Primary use (ha)		
Ecosystem (pasture) type	**Grazing Livestock**	**Gouldian Zone**	**Cultural Zone**
Annual Sorghum Hill Pastures	7,775	0	6
Black Speargrass Pastures	3,750	0	0
Bluegrass Alluvial Plain Pastures	12,388	10	0
Curly Spinifex Annual Sorghum Hill	0	0	12
Cockatoo Grass Pastures	0	0	0
Drainage Eucalypt and Acacia Pastures	0	50	25
Fringing pastures	0	0	0
Frontage Grass Pastures	16,986	40	0
Lovegrass Alluvial Plain Pastures	892	23	0
Mitchell Grass Alluvia Plain Pastures	12,568	23	0
Mitchell Grass Upland Pastures	7,418	0	0
Plum Sorghum Pastures	0	0	0
Ribbon Grass Alluvial Plain Pastures	2,280	5	0
Ribbon Grass Pastures	1,866	0	0
Samphire Pastures	0	0	45
Sandplain Spinifex Pastures	0	0	32
Treeawn Plain Pastures	0	0	0
Tippera Tall Grass Plain Pastures	14,093	0	0
White Grass Bundle-Bundle Pastures	9,985	0	58
Property total	**90,000**	**151**	**178**

[26] Conceptually similar to the asset registers kept by businesses as records of their current and non-current physical assets.

More detailed information is provided by a breakdown of the extent of each ecosystem in each condition class. This information may be used to assess the vulnerability of each ecosystem to degradation and the prospects for restoration as inputs to decisions about allocation of capital.

Table 5: Illustrative ecosystem extent-condition register showing the extent in hectares (ha) of each ecosystem (pasture) type that is used for livestock grazing on the subject property at D_0 in the scenario (Figure 5). It shows the area of each ecosystem in each condition class. (Numbers may not add up due to rounding.)

Ecosystem (pasture) type	**Condition class (ha)**				
	Good	**Fair**	**Poor**	**Very Poor**	**Total**
Annual Sorghum Hill Pastures	1,943.8	4,276.3	1,166.3	388.8	7,775
Black Speargrass Pastures	937.5	2,062.5	562.5	187.5	3,750
Bluegrass Alluvial Plain Pastures	3,096.9	6,813.1	1,858.1	619.4	12,388
Curly Spinifex Annual Sorghum Hill	-	-	-	-	0
Cockatoo Grass Pastures	-	-	-	-	0
Drainage Eucalypt and Acacia Pastures	-	-	-	-	0
Fringing pastures	-	-	-	-	0
Frontage Grass Pastures	4,246.5	9,342.3	2,547.9	849.3	16,986
Lovegrass Alluvial Plain Pastures	223.0	490.6	133.8	44.6	892
Mitchell Grass Alluvia Plain Pastures	3,142.0	6,912.4	1,885.2	628.4	12,568
Mitchell Grass Upland Pastures	1,854.4	4,079.6	1,112.6	370.9	7,418
Plum Sorghum Pastures	-	-	-	-	0
Ribbon Grass Alluvial Plain Pastures	570.0	1,254.0	342.0	114.0	2,280
Ribbon Grass Pastures	466.6	1,026.5	280.0	93.3	1,866
Samphire Pastures	-	-	-	-	0
Sandplain Spinifex Pastures	-	-	-	-	0
Treeawn Plain Pastures	-	-	-	-	0
Tippera Tall Grass Plain Pastures	3,523.2	7,750.9	2,113.9	704.6	14,093
White Grass Bundle-Bundle Pastures	2,496.3	5,491.8	1,497.8	499.3	9,985
Property total	22,500	49,500	13,500	4,500	90,000

Information about the area in each condition class provides information about the sustainability of these assets and the prospects for them to be available for future generations. Ecosystems in Good and Fair condition are likely to remain that way (subject to continued sustainable patterns of use), whereas investment is needed to return ecosystems in Poor condition to a productive state, and ecosystems in Very Poor condition may have been permanently eliminated as resources for future generations.

The example format for a condition account using disaggregated indicators as suggested in the technical recommendations in support of the SEEA EEA (UNSD 2017b Table 4.1) is judged to be impractical for the rangeland grazing system given that the condition categories capture this information. Subject to further development of condition categories, the information presented in Tables 4, 5 and 7 would be easily combined with information from other pastoral leases and freeholds, national parks and indigenous-managed areas to form a state-wide or national SEEA-compliant ecosystem account for this sector. This draws into focus the potential for evaluation of the extent and location of each ecosystem in each condition class to be measured against a condition target for the region in order to identify a future need for investment in ecosystem condition to allow sufficient ecological capital to be transmitted to meet the needs of future generations.

Table 6 shows this information presented on a paddock by paddock basis. This is unlikely to be of use to preparers of national and subnational accounts and is expected to be a compilation of ecological accounts used at the individual entity level.

Table 6: Illustrative ecosystem assets register (Level 2) type- extent (ha)-condition by paddock. At the date of reporting (D_0 in the scenario (Figure 5)). (Numbers may not add up due to rounding.)

Paddock	Ecosystem (pasture) type[27]	Condition-extent (ha)				Total (ha)
		Good	Fair	Poor	Very Poor	
Jabiru 1	Total					18,700
	Annual Sorghum Hill	1402.5	3085.5	841.5	280.5	5,610
	Frontage Grass	3272.5	7199.5	1963.5	654.5	13,090
Jabiru2	Total					8,920
	Mitchell Grass Upland	446.0	981.2	267.6	89.2	1,784
	Mitchell Grass Alluvia Plain	892.0	1962.4	535.2	178.4	3,568
	Lovegrass Alluvial Plain	223.0	490.6	133.8	44.6	892
	Frontage Grass	669.0	1471.8	401.4	133.8	2,676
Jabiru 3	Total					6,100
	Frontage Grass	305.0	671.0	183.0	61.0	1,220
	Tippera Tall Grass Plain	1220.0	2684.0	732.0	244.0	4,880
Jabiru 4	Total					9,250
	White Grass Bundle-Bundle	786.3	1729.8	471.8	157.3	3,145
	Bluegrass Alluvial Plain	346.9	763.1	208.1	69.4	1,388
	Tippera Tall Grass Plain	925.0	2035.0	555.0	185.0	3,700
	Mitchell Grass Upland	254.4	559.6	152.6	50.9	1,018
Kakadu 1	Total					15,000
	Bluegrass Alluvial Plain	1500.0	3300.0	900.0	300.0	6,000
	Mitchell Grass Alluvia Plain	2250.0	4950.0	1350.0	450.0	9,000
Kakadu 2	Total					12,500
	Bluegrass Alluvial Plain	1250.0	2750.0	750.0	250.0	5,000
	Black Speargrass	937.5	2062.5	562.5	187.5	3,750
	Mitchell Grass Upland	937.5	2062.5	562.5	187.5	3,750
Iguana 1	Total					15200
	White Grass Bundle-Bundle	1710.0	3762.0	1026.0	342.0	6,840
	Ribbon Grass Alluvial Plain	570.0	1254.0	342.0	114.0	2,280
	Tippera Tall Grass Plain	1140.0	2508.0	684.0	228.0	4,560
	Ribbon Grass	380.0	836.0	228.0	76.0	1,520
Iguana 2	Total					4,330
	Tippera Tall Grass Plain	238.2	523.9	142.9	47.6	953
	Annual Sorghum Hill	541.3	1190.8	324.8	108.3	2,165
	Ribbon Grass	86.6	190.5	52.0	17.3	346
	Mitchell Grass Upland	216.5	476.3	129.9	43.3	866
Property total		**22,500**	**49,500**	**13,500**	**4,500**	**90,000**

[27] Note – abbreviations are simulated for hypothetical scenario to match the mapping image and simplify the scenario.

Table 7 demonstrates a compilation of ecosystem assets at a finer scale of detail by showing the extent and condition of each ecosystem in each paddock at each distance to water. This provides a faithful representation of the extent of the ecosystem that is available for livestock grazing (that is, it is within 4km of permanent water) to avoid inadvertent overestimation of the capacity of the land to support livestock sustainably. It is also an important factor in assessing the impact of further development of rangelands for pastoral use. It is commonly expected (and accepted) that the condition of pastures that are within 1km of water are likely to be in poor or degraded condition due to the concentration of livestock at water points (Petty et al. 2013; Walsh & Cowley 2014a) and the further addition of watering points to develop a landscape is expected to increase the amount of degraded land used by the pastoral sector (TSCS 2013).

Table 7: Excerpt of ecosystem asset register (Level 3) showing ecosystem extent in hectares)ha) and its condition at each distance to water class.

Ecosystem Assets		**Dist-to-water**	**D_0 extent-condition**	
Paddock name	Ecosystem (pasture) type		Extent (ha)	Condition
Jabiru 3	Frontage Grass	0-1km	61	Very Poor
Jabiru 3	Frontage Grass	1-2km	183	Poor
Jabiru 3	Frontage Grass	1-2km	0	Very poor
Jabiru 3	Frontage Grass	2-3km	671	Fair
Jabiru 3	Frontage Grass	2-3km	0	Poor
Jabiru 3	Frontage Grass	3-4km	305	Good
Jabiru 3	Frontage Grass	3-4km	0	Fair
Jabiru 3	Tippera Tall Grass Plain	0-1km	244	Very Poor
Jabiru 3	Tippera Tall Grass Plain	1-2km	732	Poor
Jabiru 3	Tippera Tall Grass Plain	1-2km	0	Very poor
Jabiru 3	Tippera Tall Grass Plain	2-3km	2684	Fair
Jabiru 3	Tippera Tall Grass Plain	2-3km	0	Good
Jabiru 3	Tippera Tall Grass Plain	3-4km	1220	Good
Jabiru 4	White Grass Bundle-Bundle	0-1km	157	Very Poor
Jabiru 4	White Grass Bundle-Bundle	1-2km	472	Poor
Jabiru 4	White Grass Bundle-Bundle	1-2km	0	Very poor
Jabiru 4	White Grass Bundle-Bundle	2-3km	1730	Fair
Jabiru 4	White Grass Bundle-Bundle	2-3km	0	Poor
Jabiru 4	White Grass Bundle-Bundle	3-4km	786	Good
Jabiru 4	White Grass Bundle-Bundle	3-4km	0	Fair
….	….	….	….	….

4.4.4 Estimating the capacity for livestock production

Once the type, extent and condition of the ecosystems have been determined, their capacity to deliver the ecosystem service of interest can be estimated. The capacity of an ecosystem to provide forage (provisioning services) for livestock as a complement to an ecosystem condition account is reflected in the ecosystem service capacity indicators (ESC1, ESC2, ESC3 in Figure 2.2 of SEEA EEA Discussion paper 2.1: Purpose and role of ecosystem condition accounting (Keith et al. 2019)). Currently, estimations of carrying capacity for each rangeland ecosystem is provided by rangeland scientists as an output of research. In future it would be desirable for this to reflect the long term (sustainably managed) numbers of livestock of the property being assessed.

Estimates of long-term sustainable carrying capacity as the number of adult equivalents (AE) per square kilometre that can be carried for a year for the ecosystems in the scenario used this study (DAFWA 2018a; Ryan et al. 2013) are provided in Table 8.

This is consistent with the SEEA EEA which describes capacity as the ability to provide the ecosystem service of interest under current ecosystem condition and use at the maximum yield or use level that does not negatively affect the future supply of the same ecosystem service or other ecosystem service (Hein et al. 2016; La Notte, Vallecillo & Maes 2019; UNSD 2017b para. 7.35, 7.37, 7.42).

Lane (2016) observes that the quality of management is a very significant factor in the productivity of agricultural landscapes (Lane 2016) and it is possible that different station managers will achieve greater (or less) long-term sustainable carrying capacity observed in rangelands research. This might be due to their skill in identifying the most economically efficient patterns of use of the ecosystems which might take the form of using different methods of grazing (for example, using continuous numbers of stock in each paddock (set stocking), or moving animals from water to water or paddock to paddock (rotational grazing or cell grazing(McDonald et al. 2019)). If data about condition and carrying capacity were captured for each entity, it would be a more reliable indication of its prospects as well as a way of comparing management skill and quality of stewardship between entities. If ecosystem accounting as proposed in this study is widely adopted and contributes a richer dataset to agricultural resource economics research, it is possible that, over time, ecosystem accounts would communicate the relative skill of management teams and help stakeholders decide which livestock management method suits them best.

Table 8: Estimates of the number of adult equivalent cattle (AE) per kilometre squared that can be carried on each ecosystem (pasture type) over the long term, without risking degradation of the ecosystem, incorporating the effect of interannual seasonal variation. Information for a sample of ecosystem (pasture) types in the Kimberley WA including those used in the scenario of this study is provided.

	Carrying Capacity for livestock (AE)			
Pasture type	**Good**	**Fair**	**Poor**	**Very Poor**
Annual Sorghum Hill Pastures	10.67	8.00	4.80	1.07
Black Speargrass Pastures	8.00	6.00	3.60	0.80
Bluegrass Alluvial Plain Pastures	10.67	8.00	4.80	1.07
Curly Spinifex Annual Sorghum Hill Pastures	4.00	3.00	1.80	0.40
Cockatoo Grass Pastures	4.00	3.00	1.80	0.40
Drainage Eucalypt and Acacia Pastures	4.00	3.00	1.80	0.40
Fringing pastures	8.00	6.00	3.60	0.80
Frontage Grass Pastures	10.67	8.00	4.80	1.07
Lovegrass Alluvial Plain Pastures	8.00	6.00	3.60	0.80
Mitchell Grass Alluvia Plain Pastures	10.67	8.00	4.80	1.07
Mitchell Grass Upland Pastures	10.67	8.00	4.80	1.07
Plum Sorghum Pastures	4.00	3.00	1.80	0.40
Ribbon Grass Alluvial Plain Pastures	8.00	6.00	3.60	0.80
Ribbon Grass Pastures	8.00	6.00	3.60	0.80
Samphire Pastures	2.67	2.00	1.20	0.27
Sandplain Spinifex Pastures	4.00	3.00	1.80	0.40
Treeawn Plain Pastures	2.67	2.00	1.20	0.27
Tippera Tall Grass Plain Pastures	10.67	8.00	4.80	1.07
White Grass Bundle-Bundle Pastures	8.00	6.00	3.60	0.80

The carrying capacity by paddock by ecosystem can now be estimated. This is shown in Table 9.

Table 9: Estimates of carrying capacity for adult equivalent cattle (AE) at D_0 compiled by paddock and by ecosystem condition. (Numbers may not add up due to rounding.)

Paddock name	Ecosystem type	Condition-capacity AE/year) Good	Fair	Poor	Very Poor	Total
Jabiru 1	Total					1,466
	Annual Sorghum Hill	150	247	40	3	440
	Frontage Grass	349	576	94	7	1,026
Jabiru2	Total					682
	Mitchell Grass Upland	48	78	13	1	140
	Mitchell Grass Alluvia Plain	95	157	26	2	280
	Lovegrass Alluvial Plain	18	29	5	0	52
	Frontage Grass	71	118	19	1	210
Jabiru 3	Total					478
	Frontage Grass	33	54	9	1	96
	Tippera Tall Grass Plain	130	215	35	3	383
Jabiru 4	Total					664
	White Grass Bundle-Bundle	63	104	17	1	185
	Bluegrass Alluvial Plain	37	61	10	1	109
	Tippera Tall Grass Plain	99	163	27	2	290
	Mitchell Grass Upland	27	45	7	1	80
Kakadu 1	Total					1,176
	Bluegrass Alluvial Plain	160	264	43	3	470
	Mitchell Grass Alluvia Plain	240	396	65	5	706
Kakadu 2	Total					907
	Bluegrass Alluvial Plain	133	220	36	3	392
	Black Speargrass	75	124	20	2	221
	Mitchell Grass Upland	100	165	27	2	294
Iguana 1	Total					983
	White Grass Bundle-Bundle	137	226	37	3	402
	Ribbon Grass Alluvial Plain	46	75	12	1	134
	Tippera Tall Grass Plain	122	201	33	2	358
	Ribbon Grass	30	50	8	1	89
Iguana 2	Total					333
	Tippera Tall Grass Plain	25	42	7	1	75
	Annual Sorghum Hill	58	95	16	1	170
	Ribbon Grass	7	11	2	0	20
	Mitchell Grass Upland	23	38	6	0	68
Property total		**2,275**	**3,754**	**614**	**45**	**6,688**

This compilation allows a user to see the total long-term carrying capacity of the property (6,688AE) and how this is distributed amongst the paddocks, ecosystems and condition classes. This information is of analytical interest because it supports evaluation of the economic impact of decisions related to maintenance, investment, or consumption of ecological capital given current and forecast market prices for livestock and long-term forecasts for season quality.

The tables shown so far present ecosystem asset information at a point in time. The next section addresses the compilation and presentation of information over time to assess whether the ecosystems are being used sustainably and to record the changes to ecosystem assets between accounting periods.

4.4.5 Sustainable use (grazing accounts)

The Technical Recommendations in support of the SEEA EEA (2017) notes that recent research has suggested that further discussions on integrating the accounts for ecosystem services and capacity are required (UNSD 2017b para. 7.44). Hein et al., (2016) propose three concepts of the ecosystem's ability to generate ecosystem services; capacity, capability and potential supply, to encapsulate concepts of sustainable use and potential future ecosystem services in the measurement of ecosystem services (Hein et al. 2016). At a future time, these could also be tested with research that has assessed rangelands for different types and combinations of land use. For the current study, the definition and good practice of rangeland science is more consistent with that used by La Notte et al., (2017) where the sustainable flow corresponds to the amount of service flow that can be used by humans without impacting the condition of the ecosystem and the actual service flow corresponds with the total flow used by humans noting that this might impact the condition of the ecosystem (La Notte et al. 2017). The actual flow is what would be recorded in supply and use tables under SEEA and SNA (La Notte, Vallecillo & Maes 2019) and "mismatch accounts' would record overuse that in the medium to long term would lead to degradation (La Notte et al. 2017). While the best approach to accounting for ecosystem capacity and services is being resolved, the terms including ecosystem capacity, ecosystem supply and actual flow have multiple meanings. This study uses its own terms to avoid confusion.

In this study, the ecosystem services generated (sustainable use) correspond to the amount of forage that can be consumed by cattle without negatively impacting the condition and therefore future capacity of the ecosystem. The ecosystem services consumed reflects the forage consumed by the livestock given the number on the property. 'Grazing accounts' would indicate the sustainable (or otherwise) use of an ecosystem by livestock (and other herbivores) by measuring the flows of ecosystem services (in this case provisioning of forage for livestock) generated by the ecosystem in a year and the proportion that can be consumed without negatively affecting the condition of the ecosystem. This separation of information is consistent with the Ecosystem Services account: Supply/Use tables depicted in Figure 2.2 of SEEA EEA Discussion paper 2.1 (Keith et al. 2019).

The data source for ecosystem services generated is the forage budget prepared under the good practice for grazing management. Forage budgeting is performed at the end of the pasture growth period to estimate how much pasture has grown and therefore how many livestock can be sustainably carried in the coming year (Chilcott et al. 2005). The ecosystem services consumed are calculated from the forage requirements of the number of cattle actually carried in that year (data from livestock records in financial accounts per IAS 41).

If the condition of the ecosystem has declined and the grazing accounts demonstrate that overgrazing (unsustainable use) has occurred, then the decline in condition would match the definition of degradation used by the SEEA as condition decline caused by human use of an ecosystem. However, the condition of ecosystems can decline as a result of factors outside of management's immediate control (such as climate change[28], biosecurity threats, wildfire). Condition decline that is not caused by human use is not defined as degradation under the SEEA.

Table 10 demonstrates a possible presentation of accounting for ecosystem services generated separately from ecosystem services consumed to provide information about whether the sustainable use criterion has been satisfied. Together with the condition

[28] It is not clear whether condition decline due to climate change is considered degradation. This study distinguishes degradation is caused by the owner/controller of the use of the ecosystem, not by human-induced changes to weather patterns. A specific category for climate change-induced degradation would be useful.

accounts for ecosystem assets, these provide information about the likely future condition of the ecosystem or an explanation of a change to condition in the prior period. The ecosystem services accounts shown in Table 10 record the ecosystem services generated and ecosystem services consumed in each year of the 10-year scenario. The annual amounts of ecosystem services generated for the scenario are modelled using a simulated interannual variation of rainfall percentage of long-term average. A simulated annual variation in livestock numbers is incorporated into the ecosystem services consumed to allow a realistic reflection of the effect of these dual variations on ecosystem use patterns.

Table 10: Ecosystem services accounts showing the ecosystem services generated and the ecosystem services consumed in each year of the 10-year scenario. Ecosystem services are communicated in terms of the numbers of AE since this is a useful unit for station managers. The proportion of ecosystem services consumed to those generated is shown as a percentage to indicate over grazing (indicated in red text, first five years of the scenario), or retention of resources for ecosystem restoration (second five years). Quantification of retention of resources for ecosystem restoration provides a useful indication of the opportunity cost to the business of running lower numbers of livestock than can be sustainably carried given the condition of the land. (Numbers may not add up due to rounding.)

Ecosystem services accounts (AE/year)	**$D_{0.0}$ -$D_{0.1}$**	**$D_{0.1}$ -$D_{0.2}$**	**$D_{0.2}$ -$D_{0.3}$**	**$D_{0.3}$ -$D_{0.4}$**	**$D_{0.4}$ -$D_{1.0}$**	**$D_{1.0}$ - $D_{1.1}$**	**$D_{1.1}$ - $D_{1.2}$**	**$D_{1.2}$ - $D_{1.3}$**	**$D_{1.3}$ - $D_{1.4}$**	**D1.4 – $D_{2.0}$**
Ecosystem services generated (sustainable use)	6,889	6,889	7,289	6,354	6,019	5,052	5,348	5,052	4,659	4,414
Ecosystem services consumed	5,952	8,694	9,699	10,433	8,694	4,905	3,920	3,683	2,943	2,943
Consumption percent of sustainable use	86%	126%	133%	164%	144%	97%	73%	73%	63%	67%
Ecosystem services retained for condition regeneration	936					147	1,428	1,369	1,716	1,471
		Net D_0 to D_1		**-10,032**			**Net D_1 to D_2**		**6,131**	

These accounts show the annual amounts of ecosystem services available for sustainable consumption and the actual consumption. The relationships between these amounts indicate the likely trajectory of the condition of the ecosystem. In the first period of the scenario (D_0 to D_1), there were 33,440 AE of ecosystem services supplied (for sustainable consumption) by the ecosystem and 43,472 AE of ecosystem services were consumed by the livestock. The percent consumption (by livestock) of the sustainable use amount generated by the ecosystem indicates overgrazing years 2 to 5 of the scenario. The deficit of 10,032 AE indicates the amount of resources that were not retained by the ecosystem for its regeneration and indicates an increased chance that ecosystem degradation will occur.

In the second period of the scenario (D_1 to D_2), the impact of reduced livestock numbers is evident in the net retention for regeneration of a surplus of 6,131AE of resources resulting from consumption by livestock of only 18,394AE (an average of 75%) of the total 24,525AE generated by the ecosystem. This surplus of regeneration (above that needed for sustaining the current condition) indicates that the ecosystem condition may improve in future.

4.4.6 Ecosystem Asset Accounting

Ecosystem asset accounts present the changes to ecosystem condition identified by revaluation of the ecosystem assets at D_1 and D_2 and are presented in Table 11 and Table 13 respectively. These communicate information about areas on the property that have changed condition class since the last revaluation. The tables have been designed using a combination of the standard SEEA CF account presentation (United Nations et al. 2014a Table 5.13) to explain the net change (e.g. increases in condition), and a combination of the change matrix suggested in SEEA CF (United Nations et al. 2014a Table 5.14) and the double-entry bookkeeping concept[29] to further disaggregate the information to show the 'from' and 'to' classes of the change.

The opening balance is shown per accounting convention and displays ecosystem extent in each condition class with the total for the property in the right-hand column. The adaptation of double-entry concepts to the accounts shows that the addition of 420ha of land to the Good condition classification is matched by (came from) a removal (upgrade) of 420ha from the Fair condition classification: a portion of land has improved in condition. Likewise, the addition of 2700ha of land to the Poor condition class with the matching entry of a reduction of 2700 from the Good condition class indicates portions

[29] Where the addition of an amount to an account is matched by an equal entry subtracted from a related account is used to show the sources of changes to assets, liabilities and equity accounts.

of the property have declined in condition since the last valuation. These areas can be matched with more detailed accounts or other information, such as management records that might explain the reason for the decline in condition and indicate areas where interventions to improve condition or avoid further decline might be economically efficient.

Table 11 presents an ecosystem asset account designed to show the overall change to the extent of ecosystems in each condition class including information about the ‘from’ and ‘to’ classifications for land areas. These are highly aggregated but would be compiled from very detailed tables. They therefore provide information useful to on-ground management as well as external stakeholders. For example, they provide a way for a station manage to identify a particular paddock or watering point associated with a condition change (demonstrated in Table 12).

Table 11: Ecosystem asset (extent (ha)-condition) account D_0 to D_1. (Numbers may not add up due to rounding.)

Ecosystem Asset Account D_0 to D_1		**Good**	**Fair**	**Poor**	**V. Poor**	**Total**
Opening balance (ha)		**22,500**	**49,500**	**13,500**	**4,500**	**90,000**
Additions – reappraisals of condition	Good		9,870	2,700	1,350	
	Fair	420		32,515	5,735	
	Poor					
	V. Poor			2,585		
Sub-total Adds-condition		*420*	*9,870*	*37,800*	*7,085*	*55,175*
Reductions – reappraisals of condition	Good		420			
	Fair	9,870				
	Poor	2,700	32,515		2,585	
	V. Poor	1,350	5,735			
Sub-total Red'ns-condition		*13,920*	*38,670*	*0*	*2,585*	*55,175*
Closing balance (ha)		**9,000**	**20,700**	**51,300**	**9,000**	**90,000**

The closing balance of the account is the sum of the changes and indicates (in extent-condition terms) the ecological capital available for the next period. These show that there has been a significant decline in the condition of the property manifested in the increase in the extent of land in Poor condition which is now vulnerable to degradation. In response to this decline in condition of the ecological capital, management will need to identify interventions that will improve the condition. The detailed asset register demonstrated in this study can be a source of information to identify which portions of the property have been affected and now require greater periods of livestock exclusion or other interventions to encourage ecosystem recovery and condition improvement. This is demonstrated in Table 12. This table is an excerpt of a detailed asset register where changes to the condition of each portion of the landscape are recorded at each revaluation. An extent of Frontage Grass Pastures in Jabiru 3 is highlighted to indicate a portion of a paddock can be seen to have declined in condition. At D_0 671ha of this parcel of land was in Fair condition, but at D_1 249ha of it was assessed as Poor condition.

Table 12: Excerpt of Ecosystem Asset Register showing locations of change in extent-condition between D_0 to D_1 relative to artificial watering points in paddocks.

Ecosystem Assets			D_0 extent-condition		D_1 extent-condition	
Paddock name	Ecosystem (pasture) type	Dist-to-water	Extent(ha)	Condition	Extent(ha)	Condition
Jabiru 3	Frontage Grass pastures	0-1km	61	Very Poor	61	Very Poor
Jabiru 3	Frontage Grass pastures	1-2km	183	Poor	62	Poor
Jabiru 3	Frontage Grass pastures	1-2km	0	Very poor	121	Very Poor
Jabiru 3	Frontage Grass pastures	2-3km	671	Fair	422	Fair
Jabiru 3	Frontage Grass pastures	2-3km	0	Poor	249	Poor
Jabiru 3	Frontage Grass pastures	3-4km	305	Good	116	Good
Jabiru 3	Frontage Grass pastures	3-4km	0	Fair	189	Fair
Jabiru 3	Tippera Tall Grass Plain Pastures	0-1km	244	Very Poor	244	Very Poor
Jabiru 3	Tippera Tall Grass Plain Pastures	1-2km	732	Poor	681	Poor
Jabiru 3	Tippera Tall Grass Plain Pastures	1-2km	0	Very poor	51	Very Poor
Jabiru 3	Tippera Tall Grass Plain Pastures	2-3km	2684	Fair	2264	Fair
Jabiru 3	Tippera Tall Grass Plain Pastures	2-3km	0	Good	420	Good
Jabiru 3	Tippera Tall Grass Plain Pastures	3-4km	1220	Good	1220	Good
Jabiru 4	White Grass Bundle-Bundle Pastures	0-1km	157	Very Poor	157	Very Poor
Jabiru 4	White Grass Bundle-Bundle Pastures	1-2km	472	Poor	261	Poor
Jabiru 4	White Grass Bundle-Bundle Pastures	1-2km	0	Very poor	211	Very Poor
Jabiru 4	White Grass Bundle-Bundle Pastures	2-3km	1730	Fair	1252	Fair
Jabiru 4	White Grass Bundle-Bundle Pastures	2-3km	0	Poor	478	Poor
Jabiru 4	White Grass Bundle-Bundle Pastures	3-4km	786	Good	274	Good
Jabiru 4	White Grass Bundle-Bundle Pastures	3-4km	0	Fair	512	Fair
….	….	….	….	….	….	….

Table 13 presents the accounts of the revaluation of the ecosystems for the second period of the scenario, D_1 to D_2.

Table 13: Ecosystem asset (extent (ha)-condition) account D_1 to D_2. (Numbers may not add up due to rounding.)

Ecosystem asset account D_1 to D_2		Good	Fair	Poor	V. Poor	Total
Opening balance (ha)		**9,000**	**20,700**	**51,300**	**9,000**	**90,000**
Additions – reappraisals of condition	Good					
	Fair	2,700				
	Poor	1,800	18,000			
	V. Poor					
Sub-total Adds-condition		*4,500*	*18,000*	*0*	*0*	*22,500*
Reductions - reappraisals of condition	Good		2,700	1,800		
	Fair			18,000		
	Poor					
	V. Poor					
Sub-total Red'ns-condition		*0*	*2,700*	*19,800*	*0*	*22,500*
Closing balance (ha)		**13,500**	**36,000**	**31,500**	**9,000**	**90,000**

The accounts show that some portions of the land have been upgraded from Fair to Good condition and a significant portion has been upgraded from Poor to Fair. These changes are associated with the reduction in livestock numbers during the second period, indicating that this strategy is working effectively.

Another way of assisting users of the accounts to interpret these results is to communicate how these condition changes have affected the carrying capacity. This information would also indicate the economic implications of condition change in a single number. This is demonstrated in Table 14 with the presentation of ecosystem asset accounts, but this time in terms of livestock carrying capacity. While the tables communicate the change to carrying capacity, the explanation of the change (in the left most column) is still a reappraisal of ecosystem condition. This allows changes to carrying capacity due to additional land (i.e. by adding watering infrastructure or converting conservation areas to production areas) to be distinguished from changes due to condition change.

Table 14: Ecosystem asset (carrying capacity (AE)) account D_0 to D_1. (Numbers may not add up due to rounding.)

Ecosystem Asset Account D_0 to D_1		Good	Fair	Poor	V. Poor	Total
Opening balance (AE) (Carrying capacity terms)		**2,275**	**3,754**	**614**	**45**	**6,688**
Additions - reappraisals of condition	Good		687	108	13	
	Fair	41		1,295	55	
	Poor					
	V. Poor			103		
Sub-total Adds-condition		*41*	*687*	*1,550*	*68*	*2,302*
Reductions - reappraisals of condition	Good		29			
	Fair	970				
	Poor	265	2,264		25	
	V. Poor	133	399			
Sub-total Red'ns-condition		*1,368*	*2,692*	*0*	*25*	*4,085*
Closing balance (AE)		**948**	**1,749**	**2,120**	**88**	**4,905**

Note that when changes to carrying capacity are communicated using the double-entry/change matrix design for extent-condition, that the increases to carrying capacity are not matched by decreases to carrying capacity. This is because when a piece of land improves (declines) in condition, its carrying capacity increases (decreases). For example, the 420ha listed in the extent-condition account (Table 11) that changed from Fair to Good condition in the period D_0 to D_1 had a carrying capacity of 29AE when in Fair Condition and in its D_1 Good condition has a carrying capacity of 41AE and when 9,870ha of land declined in condition from Good to Fair, it's carrying capacity declined from 970AE to 687AE. So, while the extent is matched per double-entry convention when it changes condition, the carrying capacity demonstrates the gain (loss) of economic benefit resulting from the condition change. Table 14 also communicates that during the period, a net loss from 6,688 to 4,905 carrying capacity occurred. Table 15 presents the carrying capacity changes during D_1 to D_2.

Table 15: Ecosystem asset (carrying capacity (AE)) account D_1 to D_2. (Numbers may not add up due to rounding.)

Ecosystem asset account D_1 to D_2		Good	Fair	Poor	V. Poor	Total
Opening balance (AE) (Carrying capacity terms)		**948**	**1,749**	**2,120**	**88**	**4,905**
Additions - reappraisals of condition	Good					
	Fair	265				
	Poor	177	1,253			
	V. Poor					
Sub-total Adds-condition		*442*	*1,253*	*0*	*0*	*1,695*
Reductions - reappraisals of condition	Good		188	72		
	Fair			721		
	Poor					
	V. Poor					
Sub-total Red'ns-condition		*0*	*188*	*793*	*0*	*981*
Closing balance (AE)		**1,390**	**2,814**	**1,327**	**88**	**5,619**

These changes reflect the increase of condition of some parts of the property to show a net increase in carrying capacity. These tables provide useful information for management analysis but are perhaps too complex and detailed for external stakeholders who may prefer summaries that are easier to read. Alternative presentations that meet these needs are provided in the next section.

4.4.7 Ecosystem asset accounts

Ecosystem asset accounts in physical terms should communicate changes to the extent-condition and capacity of the ecological capital of the entity between accounting periods. As demonstrated, ecosystem asset accounts can be prepared at different levels of detail to provide information at the right level of aggregation given the purpose. The next set of tables have been prepared to combine the communication of condition change between periods and the economic implications of these changes (via the change in carrying capacity). For completeness, the table design includes a row for additions or reductions in the area available for grazing. While not included in this scenario, as discussed earlier some entities might find it necessary to communicate additions (reductions) of extent of ecosystems for grazing due to the addition of water, or the removal of ecosystems from use in livestock grazing. The design also presents the condition and carrying capacity that the entity is obligated to maintain. Table 16 presents the combined version of ecosystem asset accounts for D_0 to D_1. Table 15 presents the accounts for D_1 to D_2.

Table 16: Ecosystem asset accounts for D_0 to D_1 (combined presentation of extent (ha)-condition and capacity (AE)). (Numbers may not add up due to rounding.)

	Extent-condition (ha)					Conservation (ha)	
	Good	**Fair**	**Poor**	**V. Poor**	**Capacity (AE)**	**Gouldian**	**Cultural**
Opening Balance @ D_0	**22,500**	**49,500**	**13,500**	**4,500**	**6,688**	**151**	**178**
Additions to extent (e.g. development for grazing)	-	-	-	-	-	-	-
Additions - reappraisals of condition	420	9,870	37,800	7,085	2,302	-	-
Total Additions to Grazing Operation Asset base	420	9,870	37,800	7,085	2,302	-	-
Removals of extent (e.g.removal from grazing use)	-	-	-	-	-	-	-
Reductions - reappraisals of condition	13,920	38,670	-	2,585	4,085	-	-
Total Reductions to Grazing Operation Asset base	13,920	38,670	-	2,585	4,085	-	-
Closing Balance @ D_1	**9,000**	**20,700**	**51,300**	**9.000**	**4,905**	**151**	**178**
Accumulated ecological capital formation (consumption)					(1,783)		

Table 16 combines the information about the area of ecosystems in each condition class that has changed through the accounting period and reflects the economic implications of the change in a net decline in the physical valuation of long-term carrying capacity of

1,783AE. The net ecosystem services (sustainable less actual) of -10,032AE in the grazing accounts (Table 10) provided evidence that the lessee has not been using the ecosystem sustainably. The combination of evidence for unsustainable use and reduced asset condition means that ecosystem degradation, as defined in SEEA EEA, has occurred.

The value of 1,783AE of degradation, representing the decline in the physical value of the long-term carrying capacity, reflects the physical value of the reduction of economic benefit (the economic loss) in carrying capacity terms. Discussed in Chapter 6, the physical measure of lost economic capacity provides a basis for the estimation of a financial penalty for ecosystem degradation.

These accounts enable valuation of the materially important ecosystem services and assets for the entity. Since the condition classes only indicate (rather than directly measure) biodiversity, regulation or carbon storage capacity of the ecosystems, these ecosystem services cannot be estimated. However, it should not be forgotten that because the condition classifications indicate biodiversity, regulating services and carbon storage, the decline in condition also indicates loss of these public benefits and may increase reputational and regulatory risks (and financial risks discussed in Chapter 6) related to the decline of ecosystem condition.

Table 17 shows changes to condition between D_1 and D_2. The condition of the ecosystem has improved with a net increase of 714AE of carrying capacity and the net accumulated amounts of ecological capital formation (consumption) under this entity's management is a net consumption (loss) of 1,069AE over the ten-year period.

Table 17: Ecosystem accounts D_1 to D_2 (combined presentation of extent (ha)-condition and capacity (AE)). (Numbers may not add up due to rounding.)

	Grazing extent-condition (ha)					Conservation (ha)	
	Good	Fair	Poor	V. Poor	Capacity (AE)	Gouldian	Cultural
Opening Balance (D_1)	**9,000**	**20,700**	**51,300**	**9,000**	**4,905**	**151**	**178**
Additions to extent (e.g. development for grazing)	-	-	-	-	-	-	-
Additions - reappraisals of condition	4,500	18,000	-	-	1,695	-	-
Total Additions to Grazing Operation Asset base	*4,500*	*18,000*	-	-	*1,695*	-	-
Removals of extent (e.g. removal from grazing use)	-	-	-	-	-	-	-
Removals - reappraisals of condition	-	2,700	19,800	-	981	-	-
Total Reductions to Grazing Operation Asset base	-	*2,700*	*19,800*	-	*981*	-	-
Closing Balance @ D_2	**13,500**	**36,000**	**31,500**	**9,000**	**5,619**	**151**	**178**
Accumulated ecological capital formation (consumption) D_0 to D_2.					**(1,069)**		

The presentation of these accounts is also missing a piece of material information related to the reduced ecosystem condition – the need to reduce the amount of livestock in order to allow the ecosystem an opportunity to regenerate (to satisfy the obligations under the lease contract). Without this information, users of accounts may overestimate the income-earning capacity of the entity or underestimate its future liabilities. Discussed in Chapter 6, an additional financial liability (as defined in IAS) may emerge if a monetary penalty needs to be paid to compensate the lessor for the reduced land condition.

Described in Chapter 3, GLM research has found that to create the conditions necessary to improve ecosystem condition, a pastoral company would have to run stock numbers at a rate below the current carrying capacity for an extended period. Conceptually this is the same as removing an amount of carrying capacity (ecological capital) from the budget for stock numbers for the coming year. The amount of 'foregone production' would be chosen using professional judgement and would have an economic impact by reducing the livestock yield from the property.

The use of condition categories in accounting to communicate the area of land in each condition category is useful for analytical purposes but may not be the best way to communicate whether the property is improving or declining overall. It may therefore be useful to supplement the extent-condition information with a normalised index that represents the 'overall condition' as a percentage (following the Wentworth Group's concept of eCond (Sbrocchi, Davis, Grundy M., et al. 2015; Steinfeld & Cosier 2018)). A normalised index would be conceptually consistent with the 'rules of thumb' of different carrying capacities at different condition classes already used in the pastoral sector. These are that a pasture in Good condition represents 100% of the carrying capacity of that ecosystem type, Fair condition is thought to be around 75%, Poor condition is expected to be at 40% and Very Poor is expected to be at 10% of the potential carrying capacity (Chilcott et al. 2005). The normalised index is demonstrated in the Statement of ecological position (Table 18). It is calculated by multiplying the area (extent) of ecosystem in each condition category with the 'rule of thumb' percentage of carrying capacity.

A statement of ecological performance has been prepared to illustrate the communication of the existence of any 'obligation to under graze' in order to restore land condition. It also demonstrates the use of a condition index to communicate the ecosystem condition (in physical terms) as well as the carrying capacity. It may be valuable to users of accounts to communicate the management decisions that may affect current and prospective returns on investment in the entity and the current income-earning potential of the ecological capital.

4.4.8 Statements of ecological performance

Under IAS, a financial statement presents a complete picture of what is owned and what is owed by a company at a point in time so that stakeholders can assess its financial health and sustainability (IASB 2010). One of the priorities for ecological capital accounting identified in the literature review is to include information about improvements to condition 'owed' to parties as part of an obligation to maintain condition, for example lessors as in this scenario. To provide equivalent ecological information, this study adapts the concept of the financial statement to include information about the quality of the ecological capital of the entity as well as its obligations to improve land condition.

This experimental (physical) statement of ecological performance (Table 18) provides information about the ecological position and performance of the entity over the two scenario periods. It shows the long-term carrying capacity at the start of the lease (6,688AE), that must be maintained. This reflects the condition of the ecosystems (in physical terms) and is represented by a Condition Index (Cond Index) of 73 (compared to a reference condition if every ecosystem was in Good condition). It shows the formation or consumption of ecological capital between periods (-1,783AE and 714AE respectively) and the current ecological capital (4,905AE and 5,619AE respectively). The changes to the condition of the ecological capital for the two periods is also reflected in the Cond Index for each point in time (51 and 60 respectively). The entity needed to restore condition in the second period, and this required reduced stock numbers. The opportunity cost of this livestock reduction was subtracted from the ecological capital amount to communicate the amount of ecological capital available for the entity's use in production over the next period consistent with good prospects for ecosystem recovery. Users of the accounts can combine this information with other types of information, for example market forecasts, to estimate the income-earning potential of the ecological capital and whether this is adequate to meet the organisation's financial commitments.

Table 18: Statement of ecological performance D_0 to D_2.

Grazed ecosystems (pastoral use)	**D_0**	**D_1**	**D_2**
Ecological Capital Required (AE)	6,688	6,688	6,688
Ecological Capital Required (Cond Index)	73	73	73
Ecological capital formed (consumed) by lessee in the previous period (AE)	na	(1,783)	714
Ecological Capital (AE)	na	4,905	5,619
Ecological Capital (Cond Index)	73	51	60
Opportunity cost of reduced grazing to restore ecosystem condition[30] (AE)	na	(1,226)	(1,405)
Available Ecological Capital (pastoral use) (AE)	**na**	**3,679**	**4,214**

Ecosystems for conservation and cultural use	**D_0**	**D_1**	**D_2**
Gouldian Zone (ha) Extent of habitat in good condition for conservation of Gouldian Finch	151	151	151
Ecological capital formed (consumed) by lessee in the previous period	-	-	-
Cultural Zone (ha) Extent of country preserved and managed for cultural heritage	178	178	178
Ecological capital formed (consumed) by lessee in the previous period	-	-	-

[30] The amount of under grazing (the number of AE not carried) to allow the ecosystem to improve in condition is a management decision. This study has applied a factor of 75% to Ecological Capital to demonstrate the concept of the Available Ecological Capital (the amount of capital effectively available for production given the need to under graze to restore the land to the condition required).

4.5 Adjustments to the national accounts

As discussed earlier, the SEEA already acknowledges the usefulness of physical values and recommends the compilation of physical accounts at a national or subnational level (United Nations et al. 2014b; UNSD 2017b). However, as discussed in Chapter 2, it does not suggest preparation of accounts of ecological capital that should be transmitted to future generations as an input to measuring sustainability. The concept of 'ecological capital required' used in this scenario specifies the type of ecosystem, its area, condition and carrying capacity that should be maintained under economic use as one of the capitals employed by the pastoral industry. If statements of ecological position for each individual pastoral entity demonstrated in this chapter were to be aggregated to a national level, it would allow accounting for the following elements;

- The extent, condition and carrying capacity of all ecosystems required to be maintained for future use in the pastoral sector and the current values for these characteristics.

- The shortfall or surplus of pastoral ecological capital from the perspective of future generations.

- The consumption (condition decline and degradation) or formation (condition improvement and restoration) of ecosystems condition and carrying capacity since the previous period and the accumulated amount of consumption/formation since initial recognition of ecosystems as assets.

- The amount of under-grazing that is being applied to allow ecological capital to be restored to required levels (if in deficit).

4.6 Conclusion

In the design of physical ecosystem accounts for individual entities, this chapter focused on three issues of materiality at the entity level;

1. The magnitude and nature of the ecosystems' contribution towards the income-earning potential of the entity.

2. Whether its condition could trigger extra or unexpected expenditure in response to regulation or challenges to the entity's social licence to operate.

3. Whether its condition could result in extra income from being able to secure advantageous contracts.

It presented compilations of ecosystem asset accounts and ecosystem services accounts in physical terms and demonstrated a possible partial ecological capital statement. These demonstrated that the compilation of SEEA-compliant and IAS-aligned physical ecosystem accounts is relatively easy from data captured and used under good management practice for pastoral use of Australian rangelands. The accounting designs demonstrated the potential to capture and communicate management-useful information as well as convey summary information for external stakeholders. The chapter also demonstrated the potential for a statement of ecological position of an entity (in physical terms) to assist stakeholders to assess whether the ecological capital had the physical capacity that, under current and expected market conditions, it can meet the financial and social commitments of the entity.

The existing methods of classifications for condition of Australia's northern rangelands demonstrate that, whilst some further development is needed, they incorporate biodiversity and regulatory capacity quite well already and should be able to be modified to also reasonably estimate biocarbon storage. The asset accounts demonstrate that changes to condition classifications of ecosystems can inform stakeholders of the potential for future expenditure related to management of reputational or regulatory risk. The explicit information for condition class changes indicate if biodiversity is being threatened or restored, or whether the landscape is producing dust storms (wind borne soil erosion) or water pollution (water borne soil erosion) and negative externalities that impact its social licence to operate.

The accounts also demonstrate the capacity to communicate accumulated formation (consumption) of ecological capital such that entities in the value chain can assess their own exposure to reputational and financial risk related to the dependability and social acceptability of the ecological capital performance of the primary producer. While the scenario used in this chapter is situated in the rangelands, the concepts and techniques are applicable to other biomes.

Chapter 5 explores techniques to complement the physical values with estimates of monetary valuations for ecosystems separately to the real estate value of the land.

5 Monetary valuation of ecological assets

Monetary values of ecosystems as assets separately from land can provide important insights into the financial and environmental sustainability of their use. While the SEEA EEA aims to provide guidance for accounting valuations for ecosystems, methods are still an area of active research requiring further discussion and testing (Barton et al. 2019). Further difficulties with ecosystem valuation arise from the intrinsic and non-market values of ecosystems and fears that applications of monetary values for them will in fact cause them to be de-valued (Bartelmus 2014, 2015; Barton et al. 2019; Fenichel & Obst 2019; Keith et al. 2019; Maynard, James & Davidson 2014).

This chapter describes and demonstrates methods of estimating the monetary value of ecosystem assets that are coherent with IAS and SEEA valuation principles. It applies principles of asset valuation and revaluation of assets described in IAS 13, IAS 16 and IAS 36 (IASB 2011, 2014a, 2014b) and in the SEEA EEA (Barton et al. 2019; Fenichel & Obst 2019).

The chapter begins with a brief discussion of common valuation approaches presently used to obtain market values for agricultural properties and to estimate return on investment in them. Summaries of the valuation approaches required under IAS 13 Fair Value and SEEA EEA are followed by a brief recap from previous chapters of the drivers of economic flows from ecosystems in pastoral operations and the principles for reliability of fair value measurement. Five approaches that explicitly apply IAS fair value and SEEA EEA are demonstrated to represent the economic value of ecosystems in pastoral operations via a case study of an economically and environmentally sustainable pastoral operation. The observed values and their implications are discussed.

5.1 Common valuation approaches of the pastoral industry

Properties intended for pastoral use are commonly valued using two methods; the comparative value method, and a production capacity-based method referred to as Walk-in, Walk-out (WIWO). The comparative method is consistent with the market approach using Level 1 inputs to valuation. It compares the property of interest to other similar properties sold at about the same time (within the last six months) to weigh up the comparative advantages and disadvantages and hence to set a price (Lane 2016). But the method raises two issues - the reliability of property values in agriculture and the value of the ecosystem separately from the other values associated with the property (Ogilvy, S. & Vail, M. 2018).

The comparative value method is regarded as more of an art than a science for agricultural investments because the sample size of similar properties being concurrently sold is too small for reliable comparison purposes (Lane 2016). As well, in addition to income-earning potential, a range of factors are involved with property valuation. Landscape amenity, distance to schools or the possibility of future development may affect the purchase price of a property relative to a value based on its income-earning potential (Lane 2016). In consequence, even if similar properties are available for comparison, the purchase price of a property may not be a good indicator of its income-earning potential. This is reflected in the observation that *"the top 25% of beef producers in Northern Australia don't seem to be located on the "best" or the most expensive country"* (McLean, Holmes & Counsell 2014 pg. 47).

The WIWO method values a property as a going concern, with all things necessary for a pastoral operation. It is oriented to an income approach in that it applies financial models based on estimates of the sustainable stocking rate (SSR) [31] to obtain a price at which an investment would generate the desired returns from livestock production over a period given the variability of seasons and markets (Vail 2014).

To discover whether pastoral operations had developed methods to value ecosystems separately from land, publicly available annual reports for Australian publicly listed agricultural corporations[32] (grazing or pastoral enterprises) were reviewed. Only one company, Australian Agricultural Company (AACo) Ltd (AACo), was identified that related the value of the land to the type and condition of ecosystems being used for livestock production. AACo applies a bespoke method of land valuation they call the productive unit approach. This uses the type and condition of the land as an input to

[31] The SSR means the area (in acres or hectares) required to sustainably carry one beast (adult bovine).
[32] Many agricultural companies in Australia are not corporations under the Corporations Act and therefore do not have to produce reports according to AAS.

estimation of its value as an asset used for generating income from livestock production (AACo 2016a).

The productive unit approach takes into consideration the different types and the condition of land being used for production, and the availability of water, fencing, and structural improvements. It addresses the question of whether the asset is being used sustainably by incorporating estimates of sustainable carrying capacity (SCC) [33] developed under rangeland research programs to estimate the number of adult equivalent livestock (AE)[34] that can be carried on the property. In compliance with AAS, AACo applies AAS 141 - Agriculture (AASB 2015d) to estimate the fair value of commercial and stud livestock. This is used to calculate an average value per animal which is multiplied by the SCC to put a monetary value on the agricultural ecosystems. The estimates of SCC and value of dollar per AE are disclosed as level 3 inputs to valuation in the financial statements (AACo 2016a).

Ecosystem asset valuations obtained by this approach may not be a reliable representation of the asset value for pastoral production. The SCC estimates are derived from models produced by rangeland science rather than the entity's own data. While these models have been established in scientific studies, the use of modelled rather than the entity's own data is a potentially misleading indication of the quality of management of the entity. The carrying capacity of a pastoral property may differ from rangeland models due to differences in the local climate, management history of the property and the quality of the current station manager (Walsh & Cowley 2016).

The productive unit approach may overstate the value of the ecosystem by using the fair value of the livestock instead of net income (including the cost of production). The qualities of the ecosystem contribute to the degree of reliance on fodder and supplements, and the efficiency of labour for animal management. These can be significant factors in the gross margin of livestock operations, but in the productive unit method, are not

[33] The long-term average number of livestock that can be carried on a property without degrading its condition. SSC usually refers to the number of livestock (AE) that can be carried on a property. The sustainable stocking rate (SSR) refers to the number of hectares that will be required to sustainably carry one head of livestock.

[34] Adult equivalent (AE) is a standard unit of size of a bovine generally based on its daily nutritional requirements. Some animals, such as bulls or lactating cows are more than one AE. Young animals are less than one AE.

removed from the fair value of livestock. Further, by failing to fully isolate the contribution of labour and produced assets, the productive unit method may not be compliant with the SEEA EEA because of the potential for overstating the value of the ecosystem services produced (United Nations et al. 2014b; UNSD 2017b).

5.2 Accounting standards for measurement of monetary value

This study has argued that ecosystems can be accounted for as non-financial assets acquired as part of a property purchase. Under IAS, the valuation premise of non-financial assets is that they are used in combination with other assets or on a stand-alone basis to provide maximum value to market participants (IASB 2011). The ecosystem, together with the fences that confine livestock to particular locations and the natural or artificial watering infrastructure, can be conceptualised as cash generating units (CGU) defined in IAS as *"the smallest identifiable group of assets that generates cash inflows that are largely independent of the case inflows of other assets or groups of assets"* (AASB 2015e; IASB 2014b).

Under a concept of ecological capital maintenance described in the framework (Chapter 3), in order to determine how to measure a profit, pastoral enterprises would measure the monetary value of the operating capacity of their ecological capital assets at current cost. This would reflect the present cost to acquire the services or operating capacity of the ecosystem asset and should reflect its fair value.

The output of the ecosystem is forage for livestock. While this is an intermediate step in a production process, active markets for livestock forage exist. This satisfies the requirement under IAS that active markets for the outputs of CGUs must exist (IASB 2011). However, the carrying amount (the value recognised in the accounts) should be the recoverable amount of a CGU which is the higher of the CGU's fair value less costs of disposal and its value in use [35] (AASB 2015e; IASB 2014b). Because of the inseparability of the ecosystem from the land, a recoverable amount is difficult to estimate.

[35] Value in use is the present value of cash flows expected to be derived from an asset or cash generating unit.

For this reason and because of the nature of the ecosystem asset, value in use is likely to be a more useful basis for valuation.

To measure fair value (and value in use), entities should use one or more of the following valuation techniques; the market approach, the cost approach and the income approach (IASB 2011). In some cases, including when measuring assets in a CGU, IAS suggests that it is appropriate to use multiple valuation techniques to provide a range of values. The fair value of the asset is the point within the range of values that is most representative of fair value in the circumstances (IASB 2011).

The next sections briefly summarise the cost approach, the income approach, and an approach suggested in the SEEA EEA of valuing an ecosystem as a residual.

5.2.1 **Cost approach**

The cost approach "*is a valuation technique that reflects the amount that would be required currently to replace the service capacity of an asset*" (IASB 2011 pg. A619). The service capacity of a pastoral ecosystem asset is reflected in its capacity to produce forage for livestock. Under the cost approach, the ecosystem would be valued using the expected cost to replace this service capacity.

There are two methods commonly used in agriculture to replace or supplement the capacity of an ecosystem to produce forage for livestock:

1. estimating the cost to graze livestock on other land;

2. estimating the cost of substituting fodder (hay and grain).

The access to land for grazing livestock is referred to as agistment. It is a transaction familiar to livestock managers and is conceptually similar to the cost of leasing land for production. The cost to lease resources such as land is considered by the SEEA to be a good reflection of its potential to produce goods for market (United Nations et al. 2014b). There is enough activity in pastoral regions to claim the existence of a market for agistment services and professional station managers are expected to be able to form a reliable estimate of its value. Sustainable use of the ecosystem is also incorporated in agistment contracts, usually by limitations of the number of animals that can be grazed and the length of the contract (Marsh 2018, pers. comm.).

The agistment rate is dependent on a range of factors including the quality of the forage and shelter, distance to markets, and the inclusion of animal husbandry services (such as paddock moves and inspection of herds and waters). Although agistment rates are advertised via industry websites, ecosystems are never identical and agistment rates are negotiated between parties and not publicly available. Consequently, they are level 2 or 3 inputs to valuation[36] of an ecosystem.

In practice, the agistment rate would reflect the professional judgement of the quality of the forage available and its capacity to deliver live-weight gain of livestock. Estimates of agistment value based on these methods are expected to reflect what a well-informed person in a free exchange would be prepared to pay to receive the benefits produced by the ecosystem.

The cost of substituting the forage generated by the ecosystem with purchased feed is easily estimated by multiplying the numbers of livestock with the amount (usually in tonnes) of feed required and the cost per tonne of purchasing, transporting and distributing the feed. This strategy is typically used to fill temporary shortfalls in feed supply, for example in drought or flood situations.

5.2.2 **Income approach**

In IAS, the income approach is *"a valuation technique that converts future amounts (for example cash flows or income and expenses) to a single current amount. The fair value is determined on the basis of the value indicated by current market expectations about these future amounts*" (IASB 2011 pg. A619). The income approach in IAS is conceptually similar to the methods recommended by Fenichel and Obst (2019) for the update to the SEEA EEA that, where assets (such as ecosystems) are not exchanged in markets, that changes in net present value of real incomes are an appropriate method of imputing asset values (Fenichel & Obst 2019). Reflecting this principle, advice from experts working towards the next update of the SEEA EEA recommend that the

[36] The hierarchy of inputs to valuation is described in Chapter 3.

ecosystem services associated with harvested and cultivated terrestrial resources are valued using gross income less certain expenses. Examples include farm-gate prices less production costs and subsidies, leases paid for productive land or replacement costs (Barton et al. 2019).

The income approach under IAS is rarely, if ever used in agriculture (Lane 2016). Valuers involved with agricultural property often have limited access to farm performance information for preparation of estimates of discounted cash flows and successful litigation against valuers who have used the income approach has greatly limited the property valuations based on this method (Henry 2016; Lane 2016). As a surrogate for an income approach, agricultural property valuations can be based on productive capacity, but this is difficult to estimate and annual operating returns in agriculture are heavily reliant on the capacity and capability of the individual farm manager (Henry 2016; Lane 2016; Vail 2014, 2015a, 2015b).

However, estimations of the income-earning potential of a pastoral property that incorporate its present combination of other forms of capital and management and the quality of the ecosystems may be useful for economic decisions about the business. These should be developed using the entity’s own data (IASB 2011).

5.2.3 **Estimating the value of ecosystems as a residual**

The SEEA describes ways in which the value of ecosystems being used to provide food, fibre, or other marketable goods can be estimated as a residual (United Nations et al. 2014b; UNSD 2017b). It suggests that, subject to several important assumptions, estimates of ecosystem services value can be obtained by deducting the cost of human inputs, for example labour and produced assets, from the value of marketed goods. This approach is referred to as Unit Resource Rent (URR) and can be interpreted as an indication of the economic benefits obtained from exploitation (use) of an ecosystem or other natural resource using the production technologies currently available to the operator. URR is proposed for use in ecosystem accounting to value annual ecosystems services flows in agriculture, forestry and fishing industries where there are limited possibilities to use land leases and prices (United Nations et al. 2014b).

Where URR is used to estimate the annual value of ecosystem services under SEEA EEA, the implicit assumption is that the ecosystem services (in this case forage production for livestock) are being extracted sustainably (United Nations et al. 2014b). The question of whether a landscape is being used sustainably is important to corporations and nations and so URR should be accompanied by information that confirms sustainable use. If not, the URR should include estimates of the monetary value of ecosystem degradation (consumption of ecological capital).

5.3 Drivers of ecosystem asset value

As discussed in Chapters 2, 3 and 4, research by ecologists and pastoral production scientists confirms that the type (land-system), extent and condition of ecosystems governs their capacity to provide inputs such as forage, shelter, and pest-predation to livestock production enterprises, and that this influences the profitability and sustainability of the enterprise. The amounts and qualities of these services and the cost to produce them is affected by management decisions related to grazing and to operational policies such as use of fertiliser and pasture sowing. Consequently, the amount of economic benefit flowing from the ecosystem and therefore the value of the ecosystem asset is affected by these choices.

5.4 The reliability of fair value measurements

The IAS (and AAS) regards information as reliable when it is complete, neutral, and free from error (AASB 2016b; IASB 2011). The fair value of an asset is reliably measurable if the variability in the range of fair value measurements is not significant for that asset and the probability of the various estimates within the range can be reasonably assessed (AASB 2014a; IASB 2011). The standards do not prescribe an acceptable range of variation. The fair value measurement is the point within that range that is the most representative of fair value in the circumstances (AASB 2015b). In some cases, multiple valuation techniques should be used to measure fair value. If multiple valuation techniques are used, users of the valuations shall consider the reasonableness of the range of valuations indicated by the results.

5.5 Methods

To demonstrate multiple valuation techniques to produce a range of values for ecosystem assets required by IAS 13 (IASB 2011), the study used case study data from a sustainable pastoral operation. The case study enterprise is 45,000 acres near Blackall, Queensland. Its SCC is judged to be 2248 head (AE) of cattle. It sells on average 900AE per year and its (ten-year rolling) average annual earnings before interest and tax (EBIT) is $449,483. The enterprise uses sustainable stocking rates (SSR) on natural grasslands with no 'improved'[37] pastures. There is no evidence of decline in ecosystem condition on the property, so it is judged to be environmentally sustainable at the average stock numbers of 2248AE. The estimated WIWO valuation is $4,545,832.

In addition to livestock, the enterprise has a contract to sequester carbon in vegetation via the Human Induced Regeneration (HIR) program (DotEE 2015). The ecosystem service of carbon sequestration is defined as the removal of carbon from the atmosphere by ecosystems, by storing it in carbon pools (other than the atmosphere) for more than a year (Edens, Elsasser & Ivanov 2019). The generates a net income of $3,183 annually for the enterprise.

The details of the long-term average of the underlying operational activities of the enterprise that make up the revenues and the variable and fixed costs are documented in Table 19 designed to resemble a profit and loss statement. Data for long-term (ten year) averages of income and expenses for the operation was judged to represent likely future income and expenses given the variability of markets and seasons. These were used to provide inputs to five different valuations for the pastoral ecosystem asset. The methods demonstrated in this chapter include the productive unit method used by AACo (AACo 2016a), two methods to demonstrate application of the cost approach and one method to demonstrate the residual approach. To enable estimates of future amounts of income to be apportioned to the ecosystem separately from other asset, an Income Approach method, the Direct Apportionment Method (DAM), was developed for this study. In Table 19, column four (DAM) communicates the assignment of the accounting elements to the

[37] Pastures that are cleared, cultivated, fertilised and sown with exotic plants.

equation for this income approach method. Column five (URR) communicates the assignment of the accounting elements to the equation for the residual method.

The income approach (IASB 2011 para. B10, B11) and the residual value approach recommended by SEEA (United Nations et al. 2014b; UNSD 2017b) were demonstrated using income and expenses (level 3) inputs derived from the case study data for the model enterprise. The cost approach estimates the value of forage provision for the livestock operation using the livestock numbers of the case study multiplied by estimates of agistment rates and supplementary feed costs provided by a suitably qualified person.

The approaches to valuation are presented in the following order:

1. Productive unit approach used by AACo to measure the fair valuation of land and improvements (AACo 2016a).

2. Cost approach

    - Agistment cost (cost to replace, compliant with IAS 13 and SEEA EEA)

    - Fodder (cost to replace compliant with IAS 13 and SEEA EEA).

3. Direct Apportionment Method (DAM)

4. URR adapted from SEEA- Experimental Ecosystem Accounts (SEEA EEA) (United Nations et al. 2014b).

Table 19 presents the case study data. The assignment of elements to the DAM and URR calculations are indicated in column 4 and column 5 respectively. The role of these elements as parameters in equations 1, 2, 3 and 4 for valuation estimates using the DAM is illustrated in Figure 8, described in Table 20 and demonstrated in Table 21. The use of the parameters in the URR calculations are described in Equation 5 and demonstrated in Table 22.

5.5.1 **Model enterprise**

Table 19: Case study enterprise data used for ecosystem asset valuation. The equation parameters for income and expenses for the DAM and URR calculations are indicated in column 4 and column 5 respectively. The use of these parameters in DAM calculations is described in Tables 20 and 21 and illustrated in Figure 8. For URR, explanations of parameter use are provided in Eq 5 and demonstrated in Table 22.

(model[38]) Profit and Loss Statement				
	Rate	**Total ($)**	**DAM**	**URR**
Livestock Sales (per head, Net Farm Gate Price)	$1,215	1,120,230	a	TR
Carbon sequestration (tonne per ha per year)	$14	3,183	b	TR
Total Income (Revenue)		1,123,413		
	Rate	**Total**		
Contractors (per person, per day)	$300	33,000	c	CoE
Horses (per head, per year)	$6,000	12,000	c	IC
Dips & Drenches (per head, per day)	$2.00	4,496	d	IC
Fodder & Supplements (per head, 122 days/year)	$0.50	137,128	e	IC
Freight and/or Droving (per head, per kilometre	$0.25	18,440	c	IC
Saddlery and Harness (total)	$5,000	5,000	c	IC
Sales Commission percent of total income	1.5%	16,803	c	IC
Veterinary and Animal Husbandry	$20,000	20,000	c	IC
Pasture improvements, soil amendments (per acre)	$400	-	e	IC
Weed, sucker and pest control (per acre)	$11	13,200	e	IC
Purchase of Growers (per head, price per head)	$400	-	g	IC
Purchase of Bulls (per head, price per head)	$20,000	40,000	g	IC
Total Variable Costs		*300,067*		
	Rate	**Total**		
Administration	$15,000	15,000	f	IC
Insurance	$10,000	10,000	f	IC
Motor Vehicle (per vehicle, per week)	$400	20,800	f	IC
Repairs and Maintenance (estimated weekly rate)	$300	15,600	f	IC
Staff Stores (per person, per day)	$33	50,820	f	IC
Superannuation (Gross Salary, rate)	10%	22,484	f	CoE
Wages	$224,845	224,845	f	CoE
Work Cover percent of salary	4.5%	11,130	f	CoE
Total Fixed Costs		*370,679*		
Total Costs		**670,746**		
EBIT (Operating Profit)		***452,667***		**π**
Produced Capital (replacement value)		898,731		K
Consumption of produced capital (annual)[39]		44,937		CoPC
Estimated useful life (mean) for produced capital		20 years		

[38] Representative of ten-year average of income and expenses items.

[39] Estimated as 4% of Gross Revenue (Vail pers comm)

Opportunity cost of capital in URR estimate	5%	r

5.5.2 Valuation using the Productive Unit Approach

In the productive unit approach used by AACo, the SCC is multiplied by an estimate of the dollar per AE. AACo estimate the fair value of livestock carried to vary over time between $900/head and $3748/head for different types of cattle with the long-term average price per head stated as $1,215/head (AACo 2016a). The estimations presented in this paper used the SCC of 2,248AE of the model enterprise and multiplied this with the value of livestock ($1,215/AE) from the AACo estimate.

5.5.3 Valuation using the Cost approach

The cost approach was explored using the two different premises for the replacement of the service capacity of a livestock grazing ecosystem. The first premise is that the service capacity of the ecosystem can be replaced by access to an equivalent ecosystem for grazing. This has been labelled Replacement cost (agistment). The second premise is that the service capacity of the ecosystem can be replaced with supplementary feed. This has been labelled Replacement cost (fodder and supplements).

1. Replacement cost (agistment) - This estimates the cost to replace the present ecosystem service capacity (conceptualised as the capacity for provisioning of forage for livestock) and is coherent with AASB 13 and SEEA EEA. The valuation of agistment rate for the case study enterprise was judged to be $1.85 per head per week for grass and water (excluding services for livestock husbandry). This is a 10-year average of agistment rates that reflect the quality of the ecosystem and the variability in demand for agistment and quality of markets for beef cattle. For this case study, the replacement cost of provisioning services for livestock for a year using annual agistment estimates is calculated as 2248AE (SSC) x $1.85 per head per week.

2. Replacement cost (fodder and supplements) – This estimates the replacement cost of the ecosystem services via the cost of purchasing comparable fodder and supplements. This case study uses a conservative estimate of $0.05/kg[40] to

[40] A producer purchasing small volumes in a normal season would pay $80 each for a round bale of good hay weighing about 400kg ($0.20/kg).

incorporate volume discounts for large purchases. The estimate of the replacement cost (fodder and supplements) of $182.63 per head per year is based on a rule of thumb that an AE will eat 10kg of feed per day. Annual supplementary feed cost is 2248AE (SSC) x $182.63 per head.

5.5.4 Valuation using the Income approach - Direct Apportionment Method (DAM)

The DAM was developed in this study as a potential method to estimate the contribution the ecosystem makes to enterprise profits separately from the contribution made by livestock. The premise of the DAM is that the contribution the ecosystem makes to enterprise profit is analogous to the contribution to net profit that one internal business division (or production unit) makes to another as part of a production process. This is also coherent with the concept of expansion of the SNA production boundary to account for the contribution of ecosystems to the economy (described in Eigenraam & Obst 2018) and the SEEA EEA (Barton et al. 2019; United Nations et al. 2014b). Accordingly, the EBIT attributable to the pastoral ecosystem is based, in principle, on its contribution to net profit of livestock production.

As discussed earlier in this study and illustrated in Figure 8 the capacity of an ecosystem to provide forage for livestock is a function of ecosystem type, extent and condition. If the ecosystem has low capacity, the ecosystem services it can supply may not be enough to support the numbers of livestock required to produce the livestock sales desired by management. If this is the case, management may need to purchase inputs to bring the capacity of the ecosystem up to the level desired by management. This may involve inputs of soil amendments to increase the forage production capacity of the ecosystem or purchases of supplementary feed to make up for a shortfall in the ecosystem's capacity to meet livestock requirements. Likewise, management may need to purchase inputs and undertake activities to bring the livestock to a condition desired by management. The need for some of these inputs may be driven by insufficiencies in the supply of services from the ecosystem to the livestock. Some activities apply to both the ecosystem and the livestock and should be attributed to both.

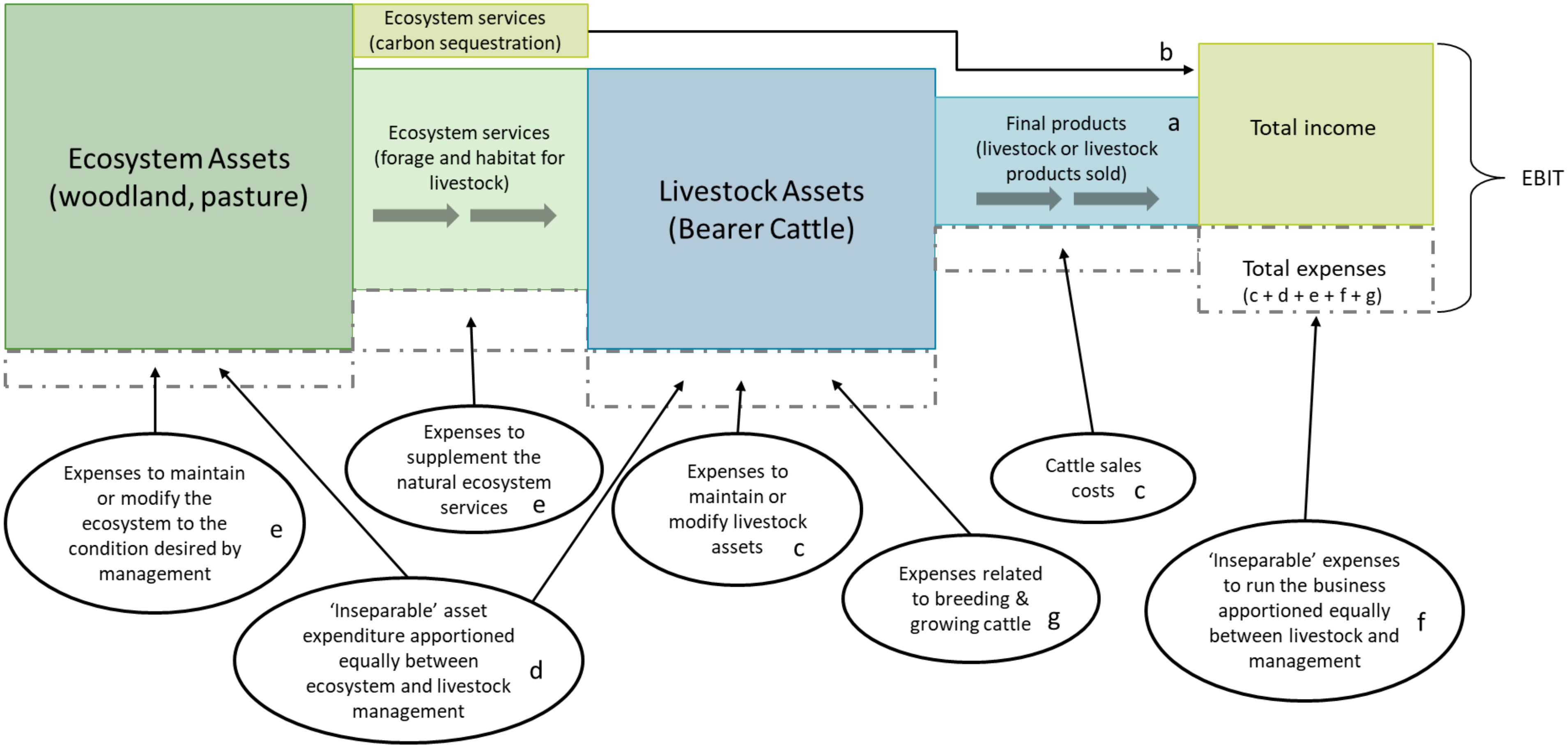

Figure 8: Conceptual illustration of the relationship between ecosystem and livestock assets and operational expenses used by a pastoral enterprise to generate economic benefits. Economic inputs used to change the characteristics of the Ecosystem Assets and supplement the Ecosystem services or prepare produce (livestock) for market are circled. These are parameters of the DAM (Equations 2, 3 & 4) and are explained further in Table 20

The DAM reflects the value of the ecosystem via the costs of inputs and activities necessary to increase or maintain the condition of the ecosystem or supplement the ecosystem services to achieve the levels desired by management. It draws the expenses related to these inputs and activities from the profit and loss statement of the enterprise per IAS 13 (and AAS13) (AASB 2015b; IASB 2011). These are level 3 inputs for ecosystem asset valuation and must be disclosed to users of the accounts (IASB 2011).

To demonstrate the potential for the DAM as one of the methods used to estimate a fair value for an ecosystem, the sources of income and purposes of expenditure were drawn from the case study scenario, analysed, and classified according to whether they were related to livestock or the ecosystem or whether they related equally to both. The explanations of the purposes of expenditure and their apportionment are explained in Table 20. Calculation details are presented in Table 21:

Table 20: apportionment (allocation) of expenses to increasing or supplementing the capacity of ecosystem or livestock to meet the levels required by management

Code	Description	Comment
a	**Revenues from livestock sales**	With the treatment of the ecosystem as an 'internal business unit' supplying 'components' to final production processes, there is no apportionment of income from livestock sales to either the livestock assets or ecosystem. They are considered inseparable factors of production of extensive grazing systems. Described in Chapter 2, breeder productivity and live-weight gain of progeny are emergent properties of the quality of the ecosystem (the nutritional and regenerative capacity) and the patterns of management.
b	**Revenues from ecosystem services (without livestock sales)**	The enterprise sells carbon sequestration services (under the HIR program). The income from this is apportioned only to the ecosystem. This situation would also apply to sales of agistment services or payments for environmental stewardship
c	**Expenses Livestock specific - husbandry**	In this example, some expenses are allocated purely to the livestock. These expenses are generally regarded as necessary to bringing the stock to the condition required for sale. They include marking (ear tagging), castrating and spaying (desexing), mustering, droving and sales commissions.

d	**Expenses Ecosystem – equally apportioned between livestock and ecosystem**	In this study, parasite treatment expenses have been apportioned to equally to both livestock and ecosystem. The logic for this is that the genetic factors of livestock can make them more vulnerable to pests and parasites but an insufficiency of the capacity of the ecosystem to supply pest and parasite predation services (for example Colloff, Lindsay & Cook 2013; Landis, Wratten & Gurr 2000) can also impact livestock productivity. Allocation of the expense to livestock only would also be reasonable. The choice should be disclosed to users of the information.
e	**Expenses Ecosystem specific**	These include expenses associated with inputs or activities to increase or maintain the condition of the ecosystem or supplement the ecosystem services to achieve the amounts desired by management. They include expenses for fodder & supplements, pasture Improvements, weed and pest management. They provide a monetary valuation of a shortfall of sufficiency with respect to the livestock requirement for quality and quantity of forage, landscape function and livestock habitat. This approach also provides an empirical basis for estimating the monetary value of any appreciation (depreciation) of the ecosystem (per Condition-based Depreciation AASB 2014b).
f	**Shared expenses for running the business**	Expenses such as vehicles are apportioned (in this case on a 50:50 basis) as the activities necessary to running the enterprise including monitoring and managing the condition of the ecosystem and the livestock. An activity-based study would provide an empirical basis for the apportionment, but the professional judgement of appropriately skilled personnel is likely to able to develop a reliable and useful estimate.
g	**Expenses Livestock specific – breeding and trading**	These livestock-specific expenses have been separately classified from generally husbandry expenses because of their different operational purpose. Purchase of replacement bulls or young stock for growing out is considered in this study to be a business policy choice rather than an expense related to the qualities of the underlying resource base.

The annual value of ecosystem services is estimated as the proportion of the total earnings before interest and tax (EBIT) that was generated by the ecosystem asset (as distinct from the livestock, human or produced assets). The equations using the parameters indicated in Table 19 illustrated in Figure 8 and described in Table 20 are listed and explained below. The apportionment is demonstrated explicitly in Table 21.

$$EBIT_{Ecosystem} = (EBIT_{Livestock} * (1-\%Expenses_{Ecosystem})) + b \quad \text{Eq 1}$$

$$Expenses_{Total} = c + d + e + f + g \quad \text{Eq 2}$$

$$Expenses_{Ecosystem} = (e + d/2 + f/2) \quad \text{Eq 3}$$

$$\%Expenses_{Ecosystem} = (e + d/2 + f/2)/(c + d + e + f + g)*100 \quad \text{Eq 4}$$

Where:

- $EBIT_{Total} = a + b - Expenses_{Total}$
- $EBIT_{Ecosystem}$ is the EBIT attributed to the ecosystem
- $EBIT_{Livestock}$ is the EBIT generated by the livestock enterprise
- $Expenses_{Ecosystem}$ are the expenses applied to keep the ecosystem in the desired condition or supplement ecosystem services
- $Expenses_{Total}$ is the total expenses for the operation.
- $\%Expenses_{Ecosystem} = Expenses_{Ecosystem}/Expenses_{Total} * 100$

To reflect the additional economic benefits the ecosystem is generating for the enterprise through the Carbon sequestration services under HIR, the net income from these services is added to $EBIT_{Ecosystem}$.

Table 21: Demonstrated analysis and calculation for DAM method of estimating ecosystem asset value (income approach)

Direct Apportionment Method: Analysis and Calculation Details				
Apportionment	***Code***	***Inseparable***	***Livestock***	***Ecosystem***
Revenues				
Revenues from livestock sales	a	1,120,230		
Revenues from Carbon sequestration	b			3,183
Expenses				
Variable Expenses				
Contractors	c		33,000	
Horses	c		12,000	
Dips & Drenches	d		2,248	2,248
Fodder & Supplements	e			137,128
Freight and/or Droving	c		18,440	
Saddlery and Harness	c		5,000	
Sales Commission	c		16,803	
Veterinary and Animal Husbandry	c		20,000	
Pasture improvement, soil amendment	e			
Weed, sucker and pest control	e			13,200
Purchase of Growers	g			
Purchase of Bulls	g		40,000	
Total Variable Expenses			**147,491**	**152,576**
Fixed Expenses				
Administration	f		7,500	7,500
Insurance	f		5,000	5,000
Motor Vehicle	f		10,400	10,400
Repairs and Maintenance	f		7,800	7,800
Staff Stores	f		25,410	25,410
Superannuation	f		11,242	11,242
Wages	f		112,423	112,423
Work Cover percent of salary	f		5,565	5,565
Total Fixed Expenses			**185,340**	**185,340**
Total Expenses			**332,831**	**337,916**
Total Expenses (%)			49.621%	50.379%
Apportioned EBIT (Livestock enterprise, not including Carbon Sequestration Services)			***226,445***	***223,038***
Apportioned EBIT (including Carbon Sequestration Service Income)			***226,445***	***226,221***

5.5.5 Valuation using the URR

URR is defined in the SEEA as the supply (sales) of extracted environmental assets at basic prices less taxes on products plus subsidies on products, less operating costs comprised of intermediate consumption (input costs of goods and services), compensation of employees and other taxes on production, less specific subsidies on extraction, plus specific taxes on extraction less user costs of produced assets (including consumption of fixed capital (depreciation)) and a return to produced assets (United Nations et al. 2014a, 2014b).

For this study, URR has been adapted for application to a pastoral enterprise. It is calculated using the inputs to valuation (Table 19) using equation 5. The URR has been further adjusted to remove livestock from the residual (estimated by a pastoral investment valuer to be 20% of the URR calculated (Vail 2017 pers. comm.)). Calculation details are demonstrated in Table 22

$$URR = TR - (IC + CoE + CoPC + (K^*r)) \qquad \text{Eq 5}$$

Where:

- TR is total revenue (equivalent to Supply or Output in the SEEA)
- IC is intermediate consumption which refers to the costs of goods and services used in production. In this case, this refers to all the items classified as fixed and variable costs
- CoE is Compensation of Employees and includes contractors, wages, superannuation, work-cover
- Consumption of produced capital[41] (CoPC) is equivalent to depreciation in corporate accounting. Since the case study relies on natural pastures, it does not have significant equipment (tractors and cultivation equipment) and so CoPC reflects the depreciation of produced capital in the CGU - fences, watering infrastructure, cattle yards, and vehicles

[41] Produced capital refers to fences, waters, vehicles, and other manufactured assets.

- K is the value of produced capital

- r the opportunity cost of capital (see below)

The SEEA requirement that the ecosystem asset is being used sustainably (United Nations et al. 2014b) is assured by the use of SCC as the management policy underpinning the model enterprise.

Table 22: Calculation details for URR

URR	*Code*	*Livestock*
Revenues		
Revenues from livestock sales	TR	1,120,230
Revenues from Carbon sequestration	TR	3,183
Total Revenues	TR	**1,123,413**
Compensation of Employees		
Contractors	CoE	33,000
Superannuation	CoE	22,485
Wages	CoE	224,845
Work Cover percent of salary	CoE	11,130
Total Compensation of Employees	**CoE**	**291,460**
Intermediate Consumption		
Horses	IC	12,000
Dips & Drenches	IC	4,496
Fodder & Supplements	IC	137,128
Freight and/or Droving	IC	18,440
Saddlery and Harness	IC	5,000
Sales Commission	IC	16,803
Veterinary and Animal Husbandry	IC	20,000
Pasture improvement, soil amendment	IC	-
Weed, sucker and pest control	IC	13,200
Purchase of Growers	IC	-
Purchase of Bulls	IC	40,000
Administration	IC	15,000
Insurance	IC	10,000
Motor Vehicle	IC	20,800
Repairs and Maintenance	IC	15,600
Staff Stores	IC	50,820
Total Intermediate Consumption	**IC**	**379,287**
Consumption of produced capital (annual)	CoPC	44,937
Produced Capital (replacement value)	K	898,731
Opportunity cost of capital in URR estimate	r	5%
URR = TR – (IC + CoE + CoPC + (K*r))		362,794
URR adjusted to represent the proportion of the residual attributable just to the ecosystem (without the contribution of human management or livestock assets)		**290,235**
Proportion of calculated URR attributable to ecosystem asset (expert opinion)		80%

5.5.6 Deriving ecosystem asset values from ecosystem services values

Per IAS (IASB 2011) and SEEA (Barton et al. 2019; Fenichel & Obst 2019), ecosystem asset values were derived as the present value (PV) of the ecosystem services values (except for the productive unit approach which is a direct asset valuation). Australian pastoral enterprises are subject to significant inter-annual and decadal variability in the quality of seasons and livestock markets. These combine to have a significant effect on pastoral ecosystem productivity and the probability that the ecosystem asset will produce positive economic benefits. The case study data prepared rolling average estimates for the model enterprise as inputs to the valuations, so PV estimates were prepared using Method 2 IAS13 Fair Value Measurement which uses expected cash flows that are not risk-adjusted, and a discount rate adjusted to include the risk premium that market participants require[42] (IASB 2011). The period for PV was ten years reflecting a useful planning horizon.

A discount rate that appropriately reflects this variability and that accommodates climate change could not be identified in the grazing land management literature. It was judged that a discount rate of 14% would be consistent with an industry estimate of Weighted Average Cost of Capital (WACC) (Vail pers. comm. 2017) as a useful proxy to reflect the risk in the estimation of PV.

The challenges related to choice of discount rates and time periods for use of PV or expected value (EV) techniques to derive asset valuations from annual flows are covered extensively in accounting, economics and ecological economics literature and summarised in SEEA EEA (United Nations et al. 2014b). Since it is relatively easy to explore the sensitivity of the results to different discount rates and time periods on the asset valuation, the analysis focused on the reliability and usefulness of the estimations of the annual ecosystem services.

[42] Method 1 of the expected present value technique uses risk-adjusted expected cash flows and a risk-free rate.

5.6 Findings and discussion

Table 23 presents the results of the five methods of empirical valuation of production ecosystems applied to the model enterprise. As the productive unit approach is an asset valuation approach and does not estimate an annual ecosystem services estimate, an ecosystem services value was derived by solving for annual amounts using the discount rate and period used in the PV estimates.

Table 23: Results - five different methods of empirical valuation of production ecosystems. Asset valuations use a present valuation of annual ecosystem services

	Annual Ecosystem Services Values	Ecosystem Asset Values
Productive Unit Approach	$523,631[43]	$2,731,320
Direct Apportionment of EBIT (DAM)	$226,221	$1,179,997
Unit Resource Rent (URR)	$290,234	$1,513,898
Replacement cost (agistment)	$216,258	$1,128,025
Replacement cost (fodder and supplements)	$410,541	$2,141,429

When the valuation premise is examined, two methods (the Productive Unit Approach and the Replacement cost (fodder and supplements) would be likely rejected as not compliant with SEEA and not reflecting fair value of the income-earning potential of the asset under IAS. The SEEA requires that provisioning services are valued using gross income less costs such as production costs and resource rent (Barton et al. 2019). The Productive Unit Approach only incorporates gross income (net farm gate price) for livestock. Similarly, Fair Value under IAS 13 reflects the income received from the sale of the asset less costs to sell (IASB 2011). Values obtained by the Productive Unit Approach are likely to overestimate the income-earning potential of the ecosystem.

The Replacement cost (based on substitution of fodder and supplements for forage) includes a significant contribution of human and produced capital as well as consumables (energy and fertiliser). In addition, the satisfaction of the full nutritional needs of livestock

[43] This value of the annual ecosystem services was derived from the asset value to allow a comparison to be made to the results of the other methods.

for multiple years with purchased fodder is an unrealistic scenario[44]. It would not be applied in practice and is not discussed further for these reasons.

The estimates for asset values and annual ecosystem services value produced by the DAM, URR and replacement cost (agistment) are shown in (Table 24) and (Table 25). They demonstrate a reasonable range of fair values as required by AAS13 (AASB 2015b).

Table 24: the relationship of each asset value to the average of values

Asset valuation method	Average of values	Ecosystem Asset Value
Direct Apportionment of EBIT (DAM)	$1,273,973	$1,179,997
Unit Resource Rent		$1,513,898
Replacement Cost (Agistment)		$1,128,025

Table 25: the relationship of annual values of ecosystem services to the average of values

Annual ecosystem services value	Average of values	Relationship to average
Direct Apportionment of EBIT (DAM)	$244,238	Lower by $18,017 (8%)
Unit Resource Rent (URR)		Higher by $45,997 (16%)
Replacement cost (Agistment)		Lower by $27,980 (13%)

The average asset value produced by the three methods is $1,273,973 and the average ecosystem services value across all methods is $244,238. This might suggest to Directors of the enterprise that the best representation of the value of the ecosystem is $1,273,973.

The calculation details demonstrate the simplicity and practicality of measurement and the capacity of the measures to reflect the different valuation premises. The cost approach that uses the agistment rate demonstrates simplicity and practicality as a method of estimating the replacement cost of the ecosystem services being generated in the pastoral

[44] Confined Animal Feeding Operations (CAFO) do use this system and tightly control the operating parameters such as livestock genetics, space per animal, and feed supply logistics in order to make it economical.

landscape. As a familiar transaction in this industry, it should be inexpensive to produce useful values.

The DAM is simple to apply and demonstrates the possibility that use of the enterprise's own data to estimate the value of ecosystem services provides users with insights into the adequacy of the ecosystem for livestock production given their unique combination of production processes and other forms of capital. When applied to the environmentally and economically sustainable model enterprise, the ecosystem services valuation obtained by this method is within a reasonable range of the values obtained by the URR and the replacement cost (agistment) methods.

If applied to a loss-making enterprise (where EBIT is negative), the DAM would estimate that the ecosystem services have a negative value which would infer that the ecosystem is a store of negative economic benefits – the ecosystem asset has a negative value. Under IAS (and AAS), a consistent outflow of economic benefit without a clear strategy to create other assets for the enterprise would suggest that the going concern assumption, an important factor in IAS fair value measurement, is not reasonable. Through its alignment to the functions and processes of the operation, the DAM may provide information which may help users identify and eliminate possible causes of losses and to assess strategies to reduce or eliminate them.

The use of the entity's own financial data in the URR means it derives the value the organisation obtains from its use of the ecosystem by using values of its unique combination of capital, systems, and skills in production. When applied to the model enterprise, it produced an estimate of ecosystem services that varied slightly from the others (except the productive unit approach). Like the DAM, if the URR was applied to a loss-making enterprise, it would also produce negative values for the ecosystem services and would be interpreted as indicative of resources that are uneconomic to exploit.

Under the circumstance of a loss-making entity, a range of results obtained from the four methods would demonstrate a wide range of variation in the value of ecosystem services. Asset valuations that use an expected negative cash flow would not generate an estimate of the recoverable amount of the CGU but would quantify negative economic benefits being experienced by the enterprise. This would provide stakeholders with information about the timing and amount that must be drawn from other assets for the operation to be a going concern. Estimates indicating negative economic benefits do not mean that the methods are unreliable but can give users of accounts information which may help them achieve the highest value from the use of the asset.

If users of the accounts were to have access to an asset valuation obtained by the replacement cost (agistment) method and one (or both) of the DAM or URR, they may have information that would help them to assess whether the highest value use for the asset would be obtained by their own operation, or if it were used by an enterprise with a different combination of capital and skill. Establishing the probability of the benefits from an asset being realised is an important part of assessing the reliability of asset valuations. The use of PV provides some insights into the probability that the entity compiling the accounts can realise these benefits. As observed in Ogilvy (2015), a rolling average of estimates of annual ecosystem services could be obtained over time to derive the probability, based on past performance, of different cash flows in response to the variability of seasons or markets in the estimates (Ogilvy 2015). Asset values based on long-term averages of past financial performance, risk-adjusted for future volatility of cash flows, should be a reasonable reflection of probability. The use of Method 2 under IAS13 reflects this approach for an individual entity.

Given the variability of economic performance of pastoral enterprises under season and market variability, PV estimates of asset values using risk-adjusted expected cash flows and a risk-free rate (Method 1 under IAS13) may be more satisfactory but would require development of a risk-adjusted discount rate. The large dataset and statistical analysis required to do this is judged to be beyond the capacity of an individual enterprise. National accounting under the SEEA takes an economy-wide view and SEEA-compliant ecosystem accounts, compiled for the pastoral industry may support the collection and production of national statistics that could provide insights into the probability of economic outcomes under different seasonal and market conditions. This may allow the development of a suitable risk-adjusted discount rate to be derived to improve the reliability of valuation of ecosystem assets used in the pastoral industry.

5.7 Conclusion

The accounting standards relating to valuation of assets described in IAS and SEEA EEA can be applied to privately-owned and controlled ecosystems used to produce livestock in the pastoral industry. This means that Australian pastoral enterprises that wish to include ecosystems on a voluntary and informal basis as a class of asset under IAS 16 can do so. The methods tested here demonstrate their ability to provide useful insights into the economic benefits that a pastoral enterprise might realise through its use of the ecosystem. The replacement cost (agistment) method is compliant with both IAS and SEEA EEA for annual ecosystem services and ecosystem asset valuations obtained by the EV of this method would provide a satisfactory and easily interpreted value of the recoverable amount of a pastoral CGU.

An important purpose of corporate and national accounting is to provide information that helps people compare the performance of companies and countries and to judge the effectiveness of management teams and governments. The ability of the URR and the DAM to use the entity’s own data to isolate the contribution of the ecosystem from the other forms of capital was demonstrated. When applied to the model enterprise, these methods provided reasonable agreement with the valuation achieved by the replacement cost (agistment) method indicating that the methods are reliable. Their use of the entity’s own data to estimate the economic benefit being generated by the ecosystem means that these methods will expose situations where the ecosystem is uneconomic to exploit given the enterprise’s current combination of management skill and other forms of capital, an important object of comparison.

The aim of providing valuations using multiple techniques is to provide users of accounts with a range of reasonable estimates from which a point can be derived that, in the opinion of the directors, is most representative of the value of future economic benefits given the circumstances (IASB 2011). As discussed in the earlier sections, ecological capital values (separately from land) do not necessarily represent the market value or the exit value for the asset. Additionally, economic benefits from ecosystems are affected by variation in seasons and markets. It may be appropriate for valuations of the economic benefits from ecosystems to be represented by (simplified) descriptive statistics to inform users of the accounts of the range and likelihood of economic benefits under predictions of future seasons and markets.

Support for pastoralists to apply a range of valuations to their ecosystems and assistance with understanding the risk of climate and market variation to their enterprise may provide the additional benefit of informing management decisions, a role that accounting should serve (Otley 2008). A more realistic understanding of the expected flow of economic benefits from an ecosystem should also prevent further environmental degradation being driven by financial imperatives and address the difficulties reported by McLean and Holmes (2014) of pastoralists struggling to achieve or demonstrate economic and environmental sustainability (McLean, Holmes & Counsell 2014).

Emerging from their underlying valuation logic, the valuation methods described in this chapter can be expected to describe upper and lower boundaries for valuation as well as a mid-point. That is, the productive unit method can be expected to provide the upper most value estimate for the future economic benefit that will flow to the enterprise, while the direct apportionment and URR provide a lower boundary, particularly where the enterprise has marginal or negative profit. In an economically sustainable enterprise, the agistment rate is expected to sit alongside the URR and direct apportionment estimates. For marginally profitable or loss-making enterprises, the replacement cost (agistment) might indicate the economic benefit the landowner might realise by offering agistment rather than running a livestock operation.

Estimations of monetary value of privately-owned and controlled ecosystems can be combined with information about the ecosystem type, extent, and condition to produce ecosystem asset accounts that could be aggregated into a set of national ecosystem accounts. The use of administrative data, rangeland science and quasi-markets (for agistment services) indicates the possibility that a large collection of financial statistics that would form the basis of national SEEA accounts for this industry would be possible. With a sufficiently large dataset this information could be combined with information about the quality of seasons and markets to provide useful estimates of the impacts of ecosystem type and condition as well as future climate and markets on the financial performance of pastoralists. This may allow the empirical derivation of risk-adjusted discount rates that managers, investors, and bankers can use for ecosystem asset valuations.

The SEEA and IAS are international standards so the methods described in this paper are likely to be generalisable to enterprises grazing low-rainfall rangelands in other countries. However, their ability to appropriately accommodate the extensive modifications to ecosystems caused by cultivation and fertilisation needs to be examined before they are applied to grazing operations in high-rainfall areas or other forms of agriculture such as cropping or horticulture.

6 Accounting for liabilities for ecosystem degradation

6.1 Introduction

Ensuring that entities responsible for maintaining the condition of ecosystems are held accountable is an important part of assuring cooperation and collaboration along the value chain. Under IAS, a mechanism for this is via the accounting for liabilities. The Technical Recommendations in support of the system of environmental-economic accounting (UNSD 2017b) takes a relatively negative position on the prospects of accounting for liabilities for ecosystem degradation and describes three challenges to be overcome (Ogilvy et al. 2018).

The first challenge involves estimating the value of degradation - in particular finding an alternative to the proposed use of the unpaid cost of restoration of an ecosystem as a valuation of the degradation because it is not conceptually consistent with the methods used to value depreciation or consumption of fixed capital (Obst, Hein & Edens 2015; Obst & Vardon 2014). The second challenge is related to determining whether liabilities should be recognised. The SEEA EEA Tech. Rec. notes that *"…if there is no expectation that the restoration will take place then, at least for accounting purposes, no liability should be recognised*." (UNSD 2017b pg. 138). Finally, addressing the concern that if a liability reflecting the degradation of the asset is recognised, then the fall in asset values and an increase in liabilities for the same event would reflect double-counting in terms of its impact on net wealth and fail to ensure a coherent and balanced set of national accounting entries (UNSD 2017b). To date, no integrated approach to accounting for liabilities in an ecosystem accounting context has been developed that responds to these challenges.

This chapter explores the solution of these challenges and the accounting for liabilities that is coherent with IAS and SNA (SEEA) frameworks (Ogilvy et al. 2018). The framework in Chapter 3 described accounting standards for liabilities to satisfy obligations to other entities and outlined where these could be adopted or adapted to provide accountability for ecosystem degradation. This chapter describes a case study approach to demonstrating accounting for ecosystem degradation.

6.2 Methods

To demonstrate the potential to account for liabilities for ecosystem degradation, this chapter uses scenario analysis and modelling of a pastoral livestock operation that leases land in the northern rangelands of Western Australia. A significant proportion of the West Australian land mass is leased from the Crown for livestock grazing and is reported to be declining in ecological condition (Watson & Thomas 2016).

Under the Acts that govern the use of these lands, owners of pastoral leases have a legal obligation for ecological sustainability and are required to not exceed the sustainable carrying capacity of the land (WA Government 1997 para. 111). Other states in Australia have similar legislation. Many of the lease owners are companies that, in accordance with the Corporations Act must apply Australian Accounting Standards (AAS) which, for the purposes of this chapter, can be regarded as the same as IAS. However, despite having obligations to maintain the ecological condition of the land, activities to prevent or remediate degradation are not uniformly enforced (Safstrom & Waddell 2013; Stoate 2012).

6.2.1 Key accounting concepts and treatments

There are five aspects of national and corporate accounting of most relevance in this chapter, namely ecosystem accounting, the treatment of bearer plants / cultivated biological resources, the concept of ecosystem degradation, the definition of liabilities and the treatment of operating leases. The accounting concepts for each of these aspects introduced in Chapter 3 are summarised here for convenience. They have been applied using their current definition.

The rangeland ecosystem assets used by agriculture are argued (in Chapter 3) to be a class of asset under IAS 16 Property Plant and Equipment (IAS 2014). The concept of the ecosystem is argued also to be analogous to non-financial non-produced (non-cultivated) biological resources (UN 2008 para. 10.15).

Under IAS 16 (and AAS 16), assets are subject to a regular impairment test (AASB 2015e; IASB 2014a). If there is an indication that assets are impaired at the reporting date, the entity is required to estimate the recoverable amount of the asset or its value in use (IASB 2014a para. 40). (An elegant demonstration of asset impairment accounting is available in “Planetary Boundaries: implications for asset impairment” (Linnenluecke et al. 2015). Any reduction in value of the ecosystem asset is recognised immediately, via double-entry bookkeeping convention, in profit or loss as an impairment loss (AASB 2015e; IASB 2014a). This system preserves the information about the original value of the asset whilst simultaneously communicating the reduction in its value as an outflow of economic benefit. This chapter uses the term revaluation loss in keeping with common practice in IAS.

Ecosystem degradation arises when the condition of an ecosystem asset declines over time as a result of economic and other human activity. This study does not apply the treatment of consumption of capital (or depreciation) to ecosystems as proposed in Chapter 8 of the SEEA Tech. Rec. where the cost associated with ecosystem degradation is deducted from income earned from production. Rather, ecosystem degradation is treated as an unexpected cost reflecting the fact that the ecosystem assets are renewable and that it should be possible to maintain their condition. Consequently, treatment of ecosystem degradation as analogous to depreciation or consumption of capital, as under IAS and SNA, is not considered appropriate. The result is that ecosystem degradation is recorded as a change in the value of assets on the balance sheet with the change being recorded as an Other change in volume of assets in the SNA (UN 2008) and as a revaluation loss under IAS (IASB 2014b). It is also noted that the logic of the recording presented here could readily be adapted to record ecosystem degradation and associated liabilities as a direct cost against income from production.

Also explored in Chapter 3, under both corporate and national accounting frameworks, liabilities arise when there is an obligation that needs to be satisfied. Obliging events exist where the settlement of the obligation can be enforced by law (legal obligations) or where the event (which may be an action of the entity) creates valid expectations in other parties that the entity will discharge the obligation (constructive obligations) (IASB 2010; UN 2008). A liability is recognised in the accounts when satisfaction of the obligation is expected to result in either a financial claim on the entity or an outflow of resources embodying economic benefits.

More specifically, the obliging event under IAS for an entity to recognise a liability to restore a degraded ecosystem arises from the combination of a legal or constructive obligation to avoid degradation and evidence of degradation of the ecosystem. The liability is recognised when it is realised that satisfying the obligation requires unavoidable future sacrifices of economic benefit that can be reliably estimated.

Since it is possible to reliably estimate land (ecosystem) condition, the capacity for grazing and therefore the monetary value of the ecosystem asset for pastoral use, there is a basis for estimating the reduced economic value of a degraded ecosystem. This allows design of a proportionate and effective penalty for ecosystem degradation to be incorporated into a lease agreement to be applied if a lessee causes ecosystem degradation.

Complementing the information in the accounts, this chapter demonstrates the disclosure of a contingent liability (AASB 2015c; IASB 2016) so that stakeholders are informed of the possible consequences if ecosystem degradation cannot be reversed by the end of the lease.

Finally, the lease of the ecosystem for pastoral use is considered an operating lease rather than a financial lease and hence the underlying resource (in this case the rangeland ecosystem asset) continues to be recorded on the balance sheet of the lessor even though it is used by the lessee (IFRS 2016; UN 2008 para. 17.310). In the corporate accounts, the operating lease is recognised or disclosed by both parties as an asset that either depreciates over time (for the government) or is matched (in the corporate accounts) with a liability (to pay the rent). In the national accounts, the fees for the lease are recorded as intermediate consumption of the pastoral entity and in accounts receivable for the government owner of the asset.

The accounts prepared for the scenario have been designed to explicitly distinguish between the obligation to restore condition and the value of the liabilities that satisfy the obligation (noting that there is a possibility, that even though the liabilities are paid, the condition may not ever be restored (Watson & Novelly 2012)).

6.3 Scenario – pastoral company

The scenario created for the chapter draws on the rangeland science introduced in Chapter 3 and uses modelled data described in the next section (Table 26). It commences with the establishment of a contract for a pastoral entity - Hypothetikal Pastoral Company (HPCo), a corporation under the definition of the Corporations Act (Attorney-General's & Treasury 2018) - to lease a property for grazing use under the Western Australian (WA) Pastoral Land Act. Protective rights under AASB116 are terms and conditions designed to protect a supplier's interest in the asset and may specify the maximum use or require a customer to follow particular operating practices (AASB 2016a). The lease agreement includes protective rights, consistent with the Pastoral Land Act that require the pastoral lessee to maintain ecosystem condition at an agreed level. These rights specify that HPCo must use the property sustainably and, if the condition at the end of the lease was below the condition required under the protective rights, HPCo would be required to compensate the WA government for the full costs of restoration. In addition to this legal obligation to maintain condition, like many publicly-owned pastoral companies (see for example AACo 2016b), HPCo also expresses its public commitment to assuring the ecological sustainability of its grazing operations. This commitment creates a constructive obligation to maintain the condition of the rangeland ecosystem assets.

In this scenario, it is assumed that HPCo overestimates the provisioning services generated by the ecosystem, fails to consistently stock at the level of the long-term carrying capacity and carries too many breeding cows. Thus, when the ecosystem asset is revalued at the end of the first accounting period, it becomes apparent that HPCo is not satisfying its obligation to maintain ecosystem condition and must undertake restorative activities during the next accounting period. A reduction in stock numbers and expenditure for restoration activities to satisfy the obligation is unavoidable. These actions are somewhat effective, but the condition of the ecosystem is not fully restored by the end of the contract. In response, HPCo cannot avoid the penalty negotiated at the start of the contract to compensate the asset owner for its future economic loss associated with degradation of the ecosystem.

Figure 9 illustrates the key events in the scenario. Date 0 (D_0) is the commencement of the contract with HPCo[45]. Date 1 (D_1) is the first revaluation of condition and Date 2 (D_2) is the end of the contract. The vertical axis shows the number of adult equivalent cattle (AE) representing the long-term carrying capacity of the rangeland and number of cattle actually being carried. The horizontal axis shows the key accounting dates. The solid black horizontal line at 6,688AE on Date 0 represents the ecosystem condition (in terms of long-term carrying capacity) that is required to be maintained by HPCo. (This is an example of a prescribed value or legislated quality measure described as desirable for ecosystem condition accounting under the SEEA EEA (Keith et al. 2019).) The solid black curving line shows the decline of condition for the first accounting period D_0 to D_1 and partial improvement in the second period (D_1 to D_2). Liability 1 is triggered by the decision at D_1 to purchase services during the second accounting period to facilitate ecosystem condition improvement. Liability 2 reflects the decision at D_1 to reduce numbers of breeding cattle to facilitate ecosystem condition improvement. Liability 3 is the valuation of the penalty related to ecosystem degradation at the end of the contract. It is considered a contingent liability at D_1 but an actual liability at D_2. The modelled data is explained in Table 26.

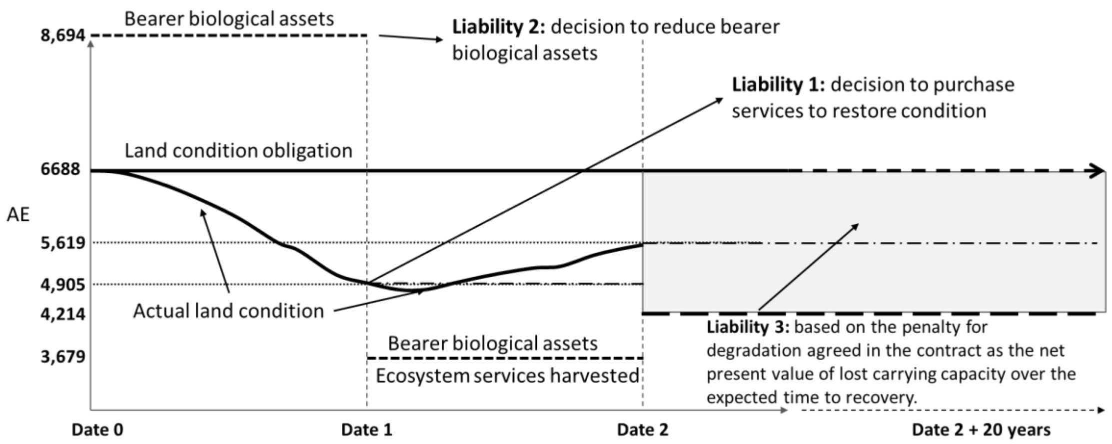

Figure 9: Illustration of scenario

[45] It is important to note that D_0 is not the date of initial development of the ecosystem for livestock grazing so it is not the date at which the ecosystem might have been in its pristine or reference condition prior to development for pastoral use. D_0 is simply the commencement of the lease contract with HPCo.

6.4 Modelled data

The accounting entries for this scenario are based on modelled data. Extent and condition characteristics for the individual ecosystems that comprise the hypothetical pastoral lease area of 90,000ha were simulated for the scenario in accordance with the SEEA EEA accounting processes (described in Chapter 3). Estimates of long-term carrying capacity in physical terms (i.e. in AE units) were based on rangeland ecosystem research and provide estimates of ecosystem services in accordance with the third step of SEEA EEA accounting processes. Asset valuations in monetary terms reflect the relevant time horizons and the risk profile of asset returns. To generate different values helpful for the accounting examples, different assumptions for the valuation of ecosystem assets and the costs to restore the ecosystem have been used. Monetary values for the accounts were drawn from an analysis of beef producers in the Kimberley region of Western Australia (McLean, Holmes & Counsell 2014). The model allowed for changes to the area of rangeland ecosystems in each condition class to be related to corresponding changes in long-term carrying capacity. The scenario and the timing of the liabilities is illustrated with some of the modelled data in Figure 9.

Note that operating leases in agricultural economic analyses are customarily treated as interest in EBIT calculations (Holmes Sackett 2018). The treatment of lease costs as expenses in the demonstration accounts do not reflect double-counting of the value of the ecosystem. The discount rates used in this analysis reflect the differing risk and return profiles of different classes of assets and investments.

Table 26: modelled data used for accounting entries is based on a hypothetical pastoral lease of 90,000ha in the Kimberley region of Western Australia. (Physical ecosystem service values repeated from Chapter 4)

Accounting entry	**Value**	**Estimation basis & method**
Ecosystem asset capacity (physical, for grazing, for the property)	6,688AE at D_0, 4,905AE at D_1 5,619AE at D_2.	Derived from research by the Department of Agriculture and Food Western Australia and CSIRO that relates land types to carrying capacity per hectare at different land condition classifications (Chilcott et al. 2005; DAFWA 2013).
Sustainable ecosystem services generated	33,440 (AE.5.year): D_0, - D_1 24,525 (AE.5.year): D_1 - D_2.	Five years of grazing based on long-term carrying capacity at condition at start of period (simulated data based on land type and condition and seasonal conditions).
Ecosystem services harvested	43,472 (AE.5.year): D_0, - D_1 18,394 (AE.5.year): D_1 - D_2.	Modelled as a factor of 1.3 times sustainable carrying capacity (over-grazing) based on condition at D_0 in the first period and 0.75 times long-term carrying capacity (under-grazing) based on condition at D_1
Ecosystem asset (monetary value)	$1,127,236 at D_0, $826,718 at D_1 $947,060 at D_2.	Based on the net present value (NPV) at 6 percent reflecting the weighted average cost of capital for 10 years using the annual operating lease value as a reflection of the market value of its capacity to produce forage for livestock (replacement cost approach) (following Ogilvy, Sue & Vail, Michael 2018). To allow the monetary value of the ecosystem asset to reflect the changes to condition and carrying capacity, the model multiplied the condition-based carrying capacity by the value of the operating lease per head of livestock derived from the scenario.
Operating lease asset and expense value	$765,776 (five years) $1,531,552 (ten years)	Modelled on a lease rate of 5 percent commonly used in property leasing applied to the value of land and infrastructure per AE of $458 (McLean, Holmes & Counsell 2014) and associated with its condition via long-term carrying capacity at the start of the lease.
Bearer biological asset	$1,105,312 at D_0, $467,676 at D_2.	Earnings before interest and tax (EBIT) per head of breeding cows of $30.18 (McLean, Holmes & Counsell 2014) multiplied by the number of head carried
Revenue from sale of progeny	$1,311,985 D_0, - D_1 $555,123 D_1 - D_2.	Based on EBIT per head of $30.18/AE sold and a reproductive rate of 56 percent (McLean, Holmes & Counsell 2014) multiplied by the ecosystem services harvested which represents the number of livestock carried.
Liability 1	$40,000	Purchase of goods and services for ecosystem restoration between D_1 and D_2 Estimated from experience with a similar scenario. Assumed to be purchased from the household sector.
Target bearer biological asset value (Physical terms, Liability 2)	3,679AE D_1 - D_2.	Target livestock number to facilitate ecosystem condition improvement modelled as a factor of 0.75 of the long-term carrying capacity based on ecosystem condition at D_1 and used to estimate the amount by which the breeding herd needed to be reduced.
Liability 2	$151,372	Reduction of biological assets Number of breeding cows sold (from above) multiplied by $30.18/AE (as for progeny sold) to reduce future stock numbers
Liability 3 Penalty for ecosystem degradation	$667,640: contingent liability disclosed at D_1 $400,285: liability 3 recognised at D_2.	The penalty for ecosystem degradation was designed as compensation for the economic loss suffered by the lessor. To do this, the valuation is proportionate to value of the lost carrying capacity including the opportunity cost of under-stocking and other investments in restoration to facilitate restoration. For the NPV, this study judged that the risk profile of the investment was similar to availability-based social infrastructure described in guidelines for discount rates for National Public Private Partnerships (DPIRD 2016) and applied a discount rate of 2 percent[46]. A period of 20 years for restoration to occur reflects the grazing land management research (Cowley & Walsh unpublished; Scanlan et al. 2014; Watson & Novelly 2012).

6.5 Results

6.5.1 Ecosystem asset accounts

Ecosystem asset accounts communicate changes between accounting periods to the extent-condition and capacity of the ecological capital of the entity. They can be prepared at different levels of detail to provide information at the right level of aggregation given the purpose. As in Chapter 4, the table has been designed to reflect the standard SEEA CF account presentation (United Nations et al. 2014a Table 5.13) and explain the net change (e.g. increases in condition). Table 27 presents the ecosystem asset accounts for D_0 to D_1 for the scenario and Table 28 presents the accounts for D_1 to D_2.

Table 27: Ecosystem asset accounts for D_0 to D_1 for the scenario (physical values summarised from Chapter 4, monetary values from model presented in this chapter)

Ecosystem Asset Accounts	Extent-condition of land (ha)				Carrying Capacity	
	Good	Fair	Poor	Very Poor	AE	$
Opening Balance (D_0)	**22,500**	**49,500**	**13,500**	**4,500**	**6,688**	**1,127,236**
Increases in area (development)	-	-	-	-		
Improvements in condition	420	9,870	37,800	7,085	2,302	
Total Additions to Grazing Operation Asset base	*420*	*9,870*	*37,800*	*7,085*	*2,302*	
Decreases in area (removal from grazing use)	-	-	-	-	-	
Declines in condition	13,920	38,670	-	2,585	4,085	
Total Reductions to Grazing Operation Asset base	*13,920*	*38,670*	*-*	*2,585*	*4,085*	
Closing Balance @ D_1	**9,000**	**20,700**	**51,300**	**9,000**	**4,905**	**826,718**
Accumulated natural capital formation (consumption)	(13,500)				(1,783)	(300,518)
Natural capital required to meet lease conditions	22,500	49,500	13,500	4,500	6,688	1,227,236

Table 27 shows that the area of ecosystems in each condition class has changed through the first accounting period and this is reflected in a net decline in the physical valuation of long-term carrying capacity of 1,783AE. The net ecosystem services (sustainable less actual) of -

10,032AE in the grazing accounts (Table 10 in chapter 4) provided evidence that the lessee has not been using the ecosystem sustainably. The combination of evidence for unsustainable use and reduced asset condition means that ecosystem degradation, as defined in SEEA EEA, has occurred. The estimated monetary value $300,518 of the degradation, based on the reduction of the long-term carrying capacity, reflects the annual value of the economic disadvantage the ecosystem owner will experience and provides a basis for the estimation of a penalty for ecosystem degradation.

Table 28: Ecosystem accounts D1 to D2

Ecosystem Asset Accounts	Extent-condition of land (ha)				Carrying Capacity	
	Good	Fair	Poor	Very Poor	AE	$
Opening Balance (D_1)	**9,000**	**20,700**	**51,300**	**9,000**	**4,905**	**826,718**
Increases in area (development)	-	-	-	-		
Improvements in condition	4,500	18,000	-	-	1,695	
Total Additions to Grazing Operation Asset base	*4,500*	*18,000*	-	-	*1,695*	
Decreases in area (removal from grazing use)	-	-	-	-	-	
Declines in condition	-	2,700	19,800	-	981	
Total Reductions to Grazing Operation Asset base	-	*2,700*	*19,800*	-	*981*	
Closing Balance @ D_2	**13,500**	**36,000**	**31,500**	**9,000**	**5,619**	**947,060**
Accumulated natural capital formation (consumption)	(9,000)				(1,069)	(180,176)
Natural capital required to meet lease conditions	22,500	49,500	13,500	4,500	6,688	1,227,236

Table 28 shows changes to condition between D_1 and D_2. The condition of the ecosystem has improved with a net increase of 714AE of carrying capacity (worth $120,342).

However, at D_2, the long-term carrying capacity is still 1,069AE below the condition at D_0. The monetary value of this ‘lost’ capacity is $180,176. The difference between long-term carrying capacity at D_0 and D_2 can now be used to estimate the value of the penalty that the lessee must pay the lessor to reflect its failure to satisfy its obligation to maintain the condition of the rangeland.

6.5.2 Accounts following IAS

The effect of ecosystem condition change on the financial performance of the asset owner and the lessee are shown in capital statements following IAS principles for each entity. Financial capital statements are derived from financial accounts and serve as a connecting link between the balance sheet and the profit and loss statement to explain the changes to owner's equity (net worth) during the accounting period. They are used here to communicate the changes to assets and liabilities of the scenario and demonstrate how IAS accounting conventions maintain visibility of accumulating impairments of asset values.

6.5.3 Government entity capital statements

Table 29 shows capital statements reflecting the accounts of the model government entity (the lessor) for the 10-year period that its rangeland ecosystem is leased for use by HPCo. They record the owner's opening equity and how it changes in response to the income from the operating lease, the impairment of the ecosystem asset at D_1 and a subsequent partial reversal of the impairment by D_2. The entry for accounts receivable matches the liability of HPCo concerning the penalty payment for the ecosystem degradation. Note that the change in value of the operating lease asset is matched by an increase in cash-at-bank reflecting the receipt of lease payments from HPCo.

The capital statements reveal that the rangeland ecosystem asset has declined in value and that despite this, due to the penalty for degradation included in the operating lease, the government owner of this ecosystem has experienced a net increase of $220,109 (8%) in owner's equity over the course of the agreement providing them with resources available to invest in restoration of ecosystem condition.

Table 29: Illustrative capital statements for the government lessor of an ecosystem for pastoral use.

Model government capital statement			
Assets	**D_0**	**D_1**	**D_2**
Cash-at-bank	-	765,776	1,531,552
Ecosystem assets - Rangeland	1,127,236	826,718	947,060
Operating lease - Rangeland ecosystem	1,531,552	765,776	-
Accounts receivable			400,285
Total assets	**2,658,788**	**2,358,270**	**2,878,897**
Liabilities			
Accounts payable			
Total Liabilities	**-**	**-**	**-**
Opening Equity	2,658,788	2,658,788	2,658,788
Retained earnings			400,285
Revaluation of Rangeland ecosystem		-300,518	-180,176
Total Equity	**2,658,788**	**2,358,270**	**2,878,897**

6.5.4 HPCo capital statements

Table 30 shows illustrative capital statements for HPCo. The pastoral entity does not own the ecosystem asset and so does not include it in its asset accounts. Revenue from production in each period are not shown in capital statements. The cash-at-bank entry for D_1 reflects the net income from sale of progeny between D_0 and D_1 of $1,311,985 less rental expenses of $765,776 for the operating lease. At D_2, the cash-at-bank reflects a reduced income of $555,123 from sale of progeny (due to the reduced number of breeding cows), but also reflects the income of $160,844 from sale of breeding cows. In addition to the operating lease expense for this period, the net income is reduced by the expenditure for the ecosystem restoration activities ($40,000).

Table 30: Illustrative capital statements for the corporate lessee of an ecosystem for pastoral use

Table 5: HPCo capital statement			
Assets	**D_0**	**D_1**	**D_2**
Cash-at-bank	-	546,209	456,400
Livestock assets - breeding herd	1,105,312	1,105,312	467,676
Operating lease	765,776	765,776	
Accounts receivable			
Total assets	**1,871,088**	**2,417,297**	**924,077**
Liabilities			
Accounts payable	765,776	805,776	400,285
Livestock assets - Reduction in breeding herd		637,635	
Total Liabilities	**765,776**	**1,443,411**	**400,285**
Opening Equity	1,105,312	1,105,312	1,105,312
Retained earnings		-131,426	46,644
Revaluation of Livestock assets - breeding herd			-637,635
Total Equity	**1,105,312**	**973,886**	**514,321**
Contingent liability		667,640	

The last row in Table 30 is not an entry in the accounts. It is a disclosure by HPCo that, due to the protective rights clause in the contract, HPCo may be required to pay a penalty to compensate for the economic loss caused by degradation. Because this is not yet certain, it is disclosed as a contingent liability of $637,635 in accordance with AAS137 (AASB 2015c). When the final condition assessment is made at D_2, and the penalty is unavoidable, the valuation is recognised as a liability (as an account payable) of $400,285, reflecting the improvement of ecosystem condition since D_1.

The illustrative accounts show that the pastoral company experiences a $590,992 (53%) reduction in owner's equity as result of their inability to maintain ecosystem condition.

6.6 National accounts tables

The national accounts tables (Tables 31 to 34) show where the transactions demonstrated in the capital statements of the individual government and pastoral entity would appear in the sequence of national accounts based on both SNA and SEEA principles. Only transaction types and account types relevant to the scenario are shown. A normal difference from the capital statements compiled following the IAS is that, in the SNA the value of future cash payments to be received under the operating lease would not be recognised at D_0 unless the lease itself had a transferable value in its own right. Instead, the national accounts generally record only the flows of cash associated with the lease payments as they occur. However, to support comparison to the estimates of net worth in the IAS capital statements a non-produced, non-financial operating lease asset has been established for the pastoral sector in D_0. The value will be unwound over the two accounting periods and entries for an accounts receivable/payable pair has been established in the financial accounts.

6.6.1 Demonstration national accounts tables for D_0 to D_1

Table 31: Opening Balance Sheet at D_0 showing the scenario values at D_0.

	Government		Pastoral Sector		Households		Total economy	
Opening Balance Sheet: D_0	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**
Produced non-financial assets								
Cultivated biological assets			1,105,312				1,105,312	
Non-produced non-financial assets								
Rangeland ecosystem – pastoral use	1,127,236						1,127,236	
Operating lease – pastoral ecosystem			1,531,552				1,531,552	
Financial assets/liabilities								
Currency and deposits								
Accounts receivable/payable	1,531,552			1,531,552			1,531,552	1,531,552
Net worth D_0		**2,658,788**		**1,105,312**				**3,764,100**

Table 32: Production account for D_0 to D_1. In SNA, output is equivalent to revenue under IAS.

	Government		Pastoral Sector		Households		Total economy	
Production account	**Uses**	**Resources**	**Uses**	**Resources**	**Uses**	**Resources**	**Uses**	**Resources**
Output		765,776		1,311,985				2,077,761
Intermediate consumption			765,776				765,776	
Value added, gross /Gross Domestic Product	765,776		546,209				1,311,985	
Consumption of fixed capital								
Value added, net /Net Domestic Product	765,776		**546,209**				**1,311,985**	

Note that the treatment of the lease payments as output is consistent with the SEEA EEA where the flow reflects the value of ecosystem services. This is different from the SNA where the lease payments are treated as payments of rent (property income). This different treatment does not affect the capital or financial accounts entries. The output of ecosystem services is matched by an entry of intermediate consumption for the pastoral sector. The changes between D_0 and D_1 to the different classes of assets in the scenario are shown in capital and financial accounts (Table 33) and communicate changes in the ecosystem assets and in the financial assets of the ‘economy’ of the scenario.

Table 33: Capital and financial accounts D_0 to D_1

	Government		**Pastoral Sector**		**Households**		**Total economy**	
Changes during the period	**Changes in assets**	**Changes in liabilities/ net worth**	**Changes in assets**	**Changes in liabilities/ net worth**	**Changes in assets**	**Changes in liabilities/ net worth**	**Changes in assets**	**Changes in liabilities/ net worth**
Capital account								
Acquisitions less disposals of bearer biological								
Other changes in volume account								
Economic appearance or disappearance of assets – increases or decreases in Rangeland ecosystem condition	-300,518[47]						-300,518	
Financial account								
Currency and deposits	765,776			546,209			1,311,985	
Accounts receivable/payable[48]	-765,776			-725,776	40,000		-725,776	-725,776

[47] Note that there is no matching transaction for economic disappearance/appearance.

[48] Note in these simplified adjustment tables that an increase (decrease) to accounts receivable and payable is noted with a + (-) sign.

The balance sheet at D_1 communicates the net position at this date.

Table 34: Closing Balance Sheet at D_1

	Government		Pastoral Sector		Households		Total economy	
Closing Balance Sheet: D_1	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**
Produced non-financial assets								
Cultivated biological assets			1,105,312				1,105,312	
Non-produced non-financial assets								
Rangeland ecosystem – pastoral use	826,718						826,718	
Operating lease – pastoral ecosystem			765,776				765,776	
Financial assets/liabilities								
Currency and deposits	765,776		546,209				1,311,985	
Accounts receivable/payable	765,776			805,776	40,000		805,776	805,776
Net worth D_1		**2,358,270**		**1,611,521**		**40,000**		**4,009,791**

6.6.2 **Demonstration national accounts tables D_1 to D_2**

The opening balance sheet for D_1 is the same as the closing balance for D_1 and is not separately shown. Therefore, the first table shown for the scenario period D_1 to D_2 is the production account.

Like Table 32: D_0 to D_1 Production accounts, Table 35 records entries for the production account for period D_1 to D_2. In this period the output of the pastoral sector reflects the reduced revenue resulting from the reduction of the breeding herd. The intermediate consumption of the pastoral sector includes the cost of both the operating lease and the expenditure on goods and services to restore the ecosystem. These are reflected in reduced value added of the sector in this period.

Table 35: Production account for D_1 to D_2

	Government		Pastoral Sector		Households		Total economy	
Production account	**Uses**	**Resources**	**Uses**	**Resources**	**Uses**	**Resources**	**Uses**	**Resources**
Output		765,776		715,967		40,000		1,521,743
Intermediate consumption			805,776				805,776	
Value added, gross /Gross Domestic Product	765,776		-99,280		40,000		706,496	
Consumption of fixed capital								
Value added, net /Net Domestic Product	**765,776**		**-99,280**		**40,000**		**706,496**	

Table 36 shows the capital and financial accounts for the accounting period D_1 to D_2. Key entries reflect the improved condition of the ecosystem asset ($120,342), the reduction in the breeding stock (-$637,635), and the establishment of an account receivable/payable in relation to the penalty to be paid by the pastoral sector for the loss of ecosystem condition ($400,285). The entry for Pastoral Sector Liabilities of $423,442 is the sum of $400,285 and $40,000 which represents the future expenditure on goods and service to the service providers (classified as Households) of the planned interventions (brush packs and so forth).

Table 36: Capital and financial accounts D_1 to D_2.

	Government		Pastoral Sector		Households		Total economy	
Changes during the period	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**
Capital account entries								
Acquisitions less disposals of bearer biological			-637,635				-637,635	
The other changes in volume account entries								
Economic appearance or disappearance of assets –increases or decreases in Rangeland ecosystem condition	120,342						120,342	
Financial account entries								
Currency and deposits	765,776		-99,280		40,000		706,496	
Accounts receivable/payable	-365,491[49]			-325,491[50]	-40,000		-325,491	-325,491

[49] Government Accounts receivable/payable: -765,776 + 400,285 = -365,491 (Removing lease payment from receivables and adding penalty payment)

[50] Pastoral sector Accounts receivable/payable: -765,776 + 40,000 + 400,285 = -325,491 (Removing lease payment from payables and adding payment for services and penalty payment)

The net position at D2 is shown in the closing balance sheet (Table 37). Note that, unlike the capital statements prepared under IAS that have a revaluation account that records the accumulated loss of ecosystem service capacity over time, this information is not presented in the SNA. As noted by Stiglitz et al, (2010), this potentially conceals the economic implication of ecosystem degradation and makes it hard for policy makers to analyse the economic implications of ecological unsustainability and to detect and avoid it. Potential supplements to the SNA that may address this problem are explored in Chapter 7 – Discussion.

Table 37: Closing Balance Sheet for D_2

	Government		**Pastoral Sector**		**Households**		**Total economy**	
Closing Balance Sheet: D2	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**	**Assets**	**Liabilities/ net worth**
Produced non-financial assets								
Cultivated biological assets			476,676				476,676	
Non-produced non-financial assets								
Rangeland ecosystem – pastoral use	947,060						947,060	
Operating lease – pastoral ecosystem			-				-	
Financial assets/liabilities								
Currency and deposits	1,531,552		446,929		40,000		2,018,481	
Accounts receivable/payable	400,285			400,285			400,285	400,285
Net worth D_2		**2,878,897**		**514,320**		**40,000**		**3,433,217**

The final table (Table 38) lists the changes to net worth for each of the participants in this scenario.

Table 38 shows where change is derived from net worth at D_2 less net worth at D_0 for each 'sector' and the total 'economy' of the scenario. It shows that the net worth of the economy has declined in response to the reduction in ecosystem condition and net worth for the government increased as a result of the transfer of money from the pastoral sector via the liability for ecosystem degradation.

Table 38: Change in net worth between D_0 and D_2

Change in net worth ($)	D_0	D_2	Change
Government	2,658,788	2,878,897	245,691 (8%)
Pastoral businesses	1,105,312	514,320	- 590,991 (53%)
Pastoral services sector	-	40,000	40,000
Total 'economy'	3,764,100	3,433,217	-330,882 (9%)

6.7 Discussion

To explore the challenges in accounting for liabilities for ecosystem degradation described in the SEEA Tech. Rec. this chapter has applied formal accounting frameworks of IAS and the national accounts to a scientifically coherent and realistic scenario involving ownership and lease of ecosystems for pastoral use. The scenario described the degradation of an ecosystem through overuse (a common cause of degradation) and used modelled data in the development of realistic physical and financial values to explore the accounting for related liabilities.

In exposing the details of the definition of concepts of liability under IAS and SEEA (SNA) and the existence of legal requirements concerning land management, the chapter explained how legal and constructive obligations to maintain ecosystem condition can be defined. The IAS based capital statements and analogous national accounts tables demonstrated the timing of the obligating event under accrual accounting as the date when the ecosystem is revalued and found to be degraded. The accounts demonstrated the recognition of the liability at the end of the lease when the lessee cannot avoid the penalty related to its legal and constructive obligation to avoid degradation. While liabilities for ecosystem degradation will not exist if there is no legal or constructive obligation to maintain ecosystem condition (as assumed in the SEEA Tech. Rec.), the realistic scenario described in this chapter suggests that such obligations may well be present and consistent with IAS requirements.

With respect to the challenge of using restoration cost as a measure of the cost of ecosystem degradation the chapter recognised that, in practical terms, the strategies for restoration of ecosystems with respect to grazing land commonly rely on exclusion from use for some period plus activities to manage invasive species and wildfire. The amount of expenditure is minimal compared to the economic loss associated with the exclusion from use. The chapter demonstrates a realistic approach to measuring the total economic cost that is consistent with the concept of constructed assets and the approach to valuation of bearer plants under IAS.

Finally, with respect to the challenge of avoiding double counting in the derivation of net worth, the chapter demonstrates this requires assessing two impacts of degradation: the decline in asset value and a value for the liability.

Ecosystem assets in this chapter were valued by their capacity for grazing. Capacity for grazing is governed by the condition of the ecosystem and the monetary value of the ecosystem is estimated at its current condition. The decline in the physical and monetary value of the ecosystem reflects its degradation and affects the net worth of the entity that owns it. The monetary value of the ecosystem asset was estimated as the NPV of the ecosystem services (forage for grazing livestock) assuming a ten-year resource planning horizon and an appropriate weighted average cost of capital to reflect the alternative investment opportunities.

The calculation of the penalty valuation and resulting liability in the accounts is a policy choice. Different jurisdictions and sectors will make different choices. Depending on the choices, the liability may or may not reflect the lost asset value or compensate for the full cost of restoration. Where it does not, entities responsible for degradation may avoid the cost of degradation. The capacity for ecosystem accounting to assist with the valuation of ecosystem assets and associated estimates of the economic loss related to degradation should assist in future with policy design that can generate more socially desirable outcomes.

In the scenario presented, the approach used to estimate compensation of the lessor (that became the liability for the lessee) serves two purposes. Firstly, in allowing the liability value to be different from the value of the ecosystem asset reduction (the value of degradation), this study aimed to help readers more easily see where the transactions appear in the corporate and national accounts. Secondly, the penalty represents the difference between what the government owner of the ecosystem would have earned (from lease contracts) had the ecosystem condition been maintained and what they can earn after degradation. This allowed the chapter to produce a demonstration of accounting for ecosystem degradation that valued the economic burden of degradation.

The resulting tables demonstrate that the liability related to degradation appears in HPCo accounts because it is the obligated party under the terms of the lease. The matched asset is held by the government. Inspection of the effect of these entries in the analogous national accounts tables demonstrates that the effect on the net worth of the economy of matched asset/liability pair is zero and the effect of recording liabilities for ecosystem degradation does not double-count the impact on the economy’s net worth.

The separate valuation of the ecosystem as a subclass of land and a natural resource owned and managed by government allows valuations and changes to valuations based on ecosystem services capacity to be distinguished from value changes arising from other reasons, for example changes to demand for real estate. The compilation of physical ecosystem accounts provides more complete information about the capacity of the system to generate ecosystem services. These may be useful for governments aiming to assure sufficiency of primary production as well as regulatory and cultural services. As discussed in Chapter 5 of this study and noted in the SNA (2008), the ability to distinguish the value of the ecosystem (natural capital) asset based on the ecosystem services it generates from the value of the land based on its location and extent allows the value of the capital services (ecosystem services) to determine whether the use of the asset is cost effective (UN 2008 para. 20.41) and may prevent users of an ecosystem from overestimating its capacity to help them meet financial commitments.

In addition, the recording of ecosystem degradation either as consumption of capital or economic disappearance of assets allows changes to GDP related that the degradation to be explained. As the accounting demonstrates, GDP for the scenario reduces because of the lower output due to reduced stock numbers in response to the degradation. Without the entry for the change to the value of the ecosystem recorded in appropriate asset accounts, the change to GDP is not explained.

Through the accounts presented in this chapter various choices have been taken in determining the entries required. Some alternative choices may have been taken, for example in terms of the choice to treat the degradation of rangeland ecosystems used for grazing of livestock as an impairment event, rather than as ‘wear and tear’; or with respect to the recording of the operating lease in the national accounts tables. Further discussion on the most appropriate accounting treatments and recording options that help to bridge the differences between IAS, SNA and SEEA based accounts would be beneficial.

With respect to recording ecosystem degradation as an impairment event and not depreciation, while this choice has no impact on the changes in net worth, there are situations in which the type of agricultural use would be expected to steadily degrade the ecosystem. For example, some agricultural uses in some landscapes cause continued loss of carbon, encroachment of salinity and soil erosion. In this case, ecology and soil science could be used to establish an expected rate of degradation, so the concept of regular wear and tear would apply and hence entries for depreciation or consumption of capital could be recorded.

The chapter has demonstrated a current limitation in the SEEA EEA with respect to recording sustainable flows of ecosystem services and in the SNA for recording the accumulated monetary loss associated with degradation of ecosystems. The scenario was founded on the science of grazing land management which recommends managers estimate the sustainable flows of ecosystem services and distinguish these from the estimates of actual ecosystem services consumed so that unsustainable patterns of use can be detected, and ecosystem degradation avoided. Since these flows and accumulated changes to ecosystem capacity are not presently recorded in the SEEA EEA or the SNA, it is recommended that guidance be developed to allow this issue to be handled.

The second observed limitation is with respect to recording of monetary loss associated with degradation of ecosystems. Under the quadruple entry system of the SNA and SEEA, in the absence of a transaction with another institution there is no matching transaction in the SNA or SEEA for an economic disappearance of a natural resource. This means there is presently no record of accumulating amounts of negative quality changes of natural economic assets apart from periodic balancing items to reduce net worth of the entity associated with the degradation.

Under the SNA system, change to ecosystem capacity is the change between sequential accounting periods (usually one year). There is no visibility of the accumulated loss of ecosystem service capacity and no means of associating these accumulating amounts with the financial performance of the economic owner of the asset, or the health of the economy. This is the issue observed by Stiglitz et al., (2010) where current consumption may be at the expense of future consumption (Stiglitz, Sen & Fitoussi 2010). This chapter demonstrates that the national accounting systems fail to indicate the total amount of loss and fail to provide the data for analysis of the economic implications of loss possibly resulting in an ill-informed policy response to address the issue. The design of the IAS to capture this information indicates that in future, should entities begin to record revaluations of ecosystem assets, it should be able to be retrieved from the GPFR of individual entities, including governments. Chapter 7 discusses some possible approaches.

A further development that environmental-economic accounting must address in future is the question of justice in attribution of causes of degradation. While the accounting for degradation is simple; the owner and user of the ecosystem is clear, and the degradation can be measured, difficulties remain in attribution of condition decline or improvement. Reliable methods for attributing condition change to lessee management, or exogenous factors such as climate change, invasive species or wildfire are essential. Ecosystem services accounts that distinguish sustainable service flows from actual service flows may provide empirical evidence to allow appropriate attribution of condition decline or improvement. A socially desirable outcome would be for such recording to allow identification of the performance of highly skilled managers who can perform beyond the expectations of current best practice. This could be a basis for design of contracts to motivate them to improve the ecosystem condition beyond expectations.

The accounting demonstrated in this chapter has also revealed some opportunities for entities further along the value chain to gain information that may allow them take greater responsibility for condition of ecosystems that underpin primary production. Most environmental degradation and other social costs are external to organisations but increased consumer awareness of ecosystem degradation has led many companies to invest to improve their understanding of their impact and dependence on ecosystems (natural capital) (NCC 2015) and to disclose their environmental management policies. If pastoral entities were regularly revaluing and communicating the condition of ecosystems and the changes to equity resulting from change to ecosystem condition, investors, lenders, and other creditors would have improved information on which to base decisions about continued association. However, a consideration for such companies is whether this would create a constructive obligation for them that doesn't currently exist.

6.8 Conclusion

Subject to the availability of reliable and just methods of defining ecosystem condition and attributing change in condition to human use, this study demonstrated accounting (accounts and disclosures) for ecosystem degradation that is coherent with IAS, AAS, SNA and SEEA accounting frameworks. The explicit application of IAS and national accounting standards enabled valuations of assets and liabilities that faithfully represented these concepts. The study demonstrated that the application of rules of recognition under accrual accounting addresses the question of when liabilities should be recognised and confirmed that liabilities should be recognised when there is a legal or constructive obligation to be satisfied. If there is no legal or constructive obligation for restoration, then the question of liabilities is not relevant.

The ecosystem accounts demonstrated they can fulfil their purpose of providing useful information about the condition and capacity of the ecosystem, support asset revaluation in the financial accounts and provide evidence for the discovery of degradation as an obligating event. The capital statements demonstrated the timing of recognition of the liabilities and the related expenses in response to this obligating event.

This chapter also demonstrated that, where the economic value of ecosystem degradation is estimated and an obligation to avoid degradation carries a proportionate penalty, then the effect of ecosystem degradation would be reflected in the net worth of the economy but would not be double counted. For this simplified scenario, the accounting demonstrates that the total net wealth of the 'economy' (as comprised of these three entities) has decreased between the commencement of the pastoral lease contract and the end of the contract due to the decline in ecosystem condition. The SEEA tables also demonstrate the distribution of net worth from the pastoral entity responsible for the degradation to the government and the pastoral services sector.

7 Synthesis and Discussion

7.1 Introduction

The foundation for analysis (Chapter 2) exposed the need for companies in the agricultural value chain and governments to have information about the ecological capital of agricultural businesses. Lenders, creditors, investors and customers in the agricultural value chain need to know the quality of the ecological resource base used by an agricultural entity. Governments need information about the aggregated amounts of ecological capital managed by agriculture. They need to assess these amounts against those needed to satisfy international and domestic obligations related to environmental protection and biodiversity conservation. They need to understand relationships between environmental resources and financial performance to manage regulation and markets to generate sustainable economic prosperity.

This chapter explores methods for compilation of information from accounts of individual entities to aggregations for government use and for use in supply chain management. It illustrates these via a statement of ecological position for a pastoral entity that has been synthesised from the concepts, accounts and values developed in Chapters 3, 4, 5 and 6. The possibilities for this information to support public and private accountability for resources to be transmitted to future generations are discussed. The chapter concludes with a discussion of how to encourage adoption of entity-level environmental-economic accounting and some of the issues that need to be resolved for these approaches to be implemented.

7.2 Compilation of national environmental-economic statistics from entity-level accounts

Described in Chapter 2, agricultural entities (including farming families) have a unique practical authority over ecosystems. They may also have an exposure to implied, but potentially onerous contracts for ecosystem condition and biodiversity conservation (AITHER 2018; NFF 2018, 2019). Consequently, it is desirable to have information about ecosystems owned and controlled by agricultural entities as an input to macroeconomic analysis and policy design for the sector.

This context is potentially analogous to the reason for the special accounting arrangements for government. Governments exercise unique legislative and regulatory authority over other institutional units in the economy and as a result of this authority an expanded set of information about the activities of all Australian Governments is made available to citizens (ABS 2015). Each government in Australia prepares financial statements according to the same AAS as used by other corporations with some exceptions specified by AASB 1049 Whole of Government and General Government Sector financial reporting (AASB 2016c). In addition to the information normally provided under AAS and IAS, financial statements prepared by governments in accordance with AASB1049 provide users with information about the performance of government related to its functions such as defence, public order and safety, health, education, transport and environmental protection. (AASB 2016c).

To facilitate assessment of the macroeconomic impact of each government and its sectors, the additional information to be collected and communicated by governments is defined in the government finance statistics (GFS) system managed by the Australian Bureau of Statistics (ABS) (ABS 2015). GFS provide information about transactions and other economic flows that involve governments (ABS 2015). To compile GFS, governments use an identifying code to record accounting elements such as income and expenditure related to different activities. (ABS 2015 Table A1C.2). Non-financial assets of governments are classified to the GFS balance sheet by using a type of asset and liability classification (TALC) and a unique code. For example, land is coded as ETF 8311 and non-cultivated biological resources as ETF 8313. These identify the type of asset within an asset class (ABS 2015 para. 8.118). For example, environmental protection (code 05) is one of the functions of government included in these classifications. It is further classified with functions including protection of biodiversity and landscape and research and development for environmental protection

7.3 Adaptations to current practice for Government Financial Statistics

As part of consideration of development of a future accounting standard for ecological capital in agriculture, it would be desirable to design it to accommodate methods of compilation of agricultural environmental-economic statistics. This would greatly facilitate the preparation of national accounts for these assets.

In addition to capturing amounts of resources being transmitted to future generations, a system of capturing agricultural environmental statistics could also enable analysis of agricultural 'defensive expenditures' (Stiglitz, Sen & Fitoussi 2010) such as management of biosecurity, wildfire or other externalities. Information about these expenditures, are of analytical interest to policy makers seeking to improve resource use efficiency or operationalise the polluter pays principle via market or regulatory design (EC 2012). For example, a classification of expenditures (obtained from conventional financial statements) that are used for environmental protection would potentially facilitate compilation of Environmental Protection Expenditure accounts and communicate agriculture's contribution to environmental protection (United Nations et al. 2014a).

The GFS system is presently silent on the classification of ecosystems, but the system points to a practical mechanism to capture statistics about the relationship of ecosystems to the economy. The resulting statistics have the potential for communicating the efficiency and effectiveness of the agricultural sectors' stewardship of environmental resources and its supply and use of positive and negative public environmental benefits. They may also contribute to better understanding at the entity level of the economic contribution of ecological capital and provide information to help assess the returns in investment in ecological capacity and improve the capacity for external stakeholders to influence management decisions.

7.3.1 Classifications of agricultural ecological capital

The potential for a system of classifications to support compilation of selected 'Agricultural Environmental Economic Statistics' (AEES) for selected areas of analytical interest is demonstrated in the following section (7.4) via a statement of ecological performance for the hypothetical entity used in this study. Adaptations of the concept of GFS to allow environmental-economic information to be extracted from the annual reports of entities requires a system of classification of different types of information about ecological capital (in addition to the classification of ecosystem types and conditions for use in SEEA described in Chapters 3 and 4) that reflect the multiple ecosystem services and full range of benefits being generated.

The areas of analytical interest chosen for this demonstration reflect the views of the Australian National Farmers' Federation (NFF) 2030 Road Map (NFF 2019) and the NFF submission to the review of the EPBC Act. These suggest that the economic contributions made by landholders to sustainable management of production landscapes and to biodiversity conservation is currently not well understood. AEES compiled from entity-level environmental-economic accounts would improve understanding. The use of classifications to enable these to be compiled are discussed as part of the demonstration of a ‘statement of ecological performance for agriculture.

To illustrate the potential solution, it is assumed that most if not all land currently zoned for agriculture represents stocks of ecosystems that are managed alongside or as part of production. It also acknowledged that agricultural entities commonly also manage zones of ecosystems that are dedicated to conservation or cultural heritage. These assets can be distinguished via a code that communicates the type of ecosystem and the predominant use.

For this illustration, a code designating resources such as Native Pasture Obligations: Provisioning (NPOG) would communicate the amount of native pasture that current generations (i.e. the current entity) are presently obligated to transmit to future generations. An additional qualifier to classify their predominant economic use: for provisioning services (P) or Regulating services (R), and cultural services (C) would prove useful information for economic planning.

These can be further disaggregated to indicate the types of native pastures by using the abbreviations presently in practice (demonstrated in Table 43). Provisioning services might be further disaggregated to indicate whether they are forage for livestock, annual cropping, natural forests for timber or zones for plantation timber etc. Regulating services might be disaggregated into emissions to air (carbon storage, or air filtration), or emissions to water (filtration services provided to reduce agricultural runoff to waterways). Cultural services might be disaggregated into conservation (e.g. the Gouldian finch zone in the scenario) or amenity (spiritual or recreational).

A demonstration of how these classifications could be applied to the ecological accounting statements of individual entities is presented in the next section.

7.4 Demonstration statement of ecological position

The following tables and text provide a plausible form of a statement of ecological position for the illustrative scenario of the rangeland ecosystem[51] owned by the Western Australian Government and leased by the hypothetical pastoral company in the scenario used for chapters 4, 5 and 6. This statement communicates to stakeholders of the lessee (including the lessor) the condition of the ecological capital, how it has changed between periods. They also indicate whether the lessee is using it sustainably.

This illustrative "Statement of Ecological Performance" including a summary of significant matters pertaining to Ecological Performance emulates the general format of an IAS-compliant financial statement (drawn from AACo (AACo 2016a) from the point of view of the lessee HPCo. A coding system as introduced above is used to classify the elements of the ecological position statement to allow AEES to be compiled from the accounts of individual entities. These have been incorporated into the statement to illustrate these concepts.

If the ecosystem is an asset for the lessor under IAS, the monetary value of the effect on equity of the reduced value of the ecological capital would be recorded in a statement of consolidated income (not shown). In these reports, the lessee communicates changes to ecological capital including information about the obligation to restore ecosystem condition. This is presented in physical and monetary terms. It also communicates values (in physical and monetary terms) of the investment to restore condition. The ecological capital that is available to the entity for economic use is also enumerated in physical and monetary terms. While the threats to the conservation ecosystems can be quantified in physical terms (numbers and types of weeds and feral animals, numbers of ill-behaved tourists), defensive expenditures in this illustration are only presented in monetary terms.

7.4.1 Supplementary notes to the financial statements – Ecological performance

In its supplementary notes to the financial statements, an entity may report a series of significant matters including relevant legislation and material issues such as regulatory

[51] It is envisaged that the ecosystem accounts are the same for both the lessee and lessor whereas the financial accounts are different for each party.

risk and challenges to the social licence to operate. It would also describe the significant accounting policies it has used to prepare these notes and the ecological statement. The following should be read as a demonstration of supplementary notes for an agricultural entity that owns or controls ecosystems[52].

HPCo Statement of Ecological Performance

7.4.1.1 X1 Significant matters

7.4.1.1.1 Pastoral Land Act

The company owns pastoral leases under the Pastoral Land Act of Western Australia. The Act obliges the company to maintain the condition of the land, including the capacity of the land to sustain pastoral productivity. In addition, as a result of public statements of its commitment to ecologically sustainable management, HPCo has a constructive obligation to do so.

At D_1, the company became aware of degradation of condition of the ecological assets of the pastoral lease due to overgrazing. It developed and implemented a remedial plan, including reduction of livestock numbers, to rehabilitate the land. At D_2, the revaluation of the ecosystem indicated that it had not been restored to the required condition by the end of the lease term. The company accordingly has recognised a liability of $400,285 in the financial statements[53].

7.4.1.1.2 Social Licence

The company addresses the increasing sustainability-consciousness of its investors, bankers, and supply chain by supplementing its General-Purpose Financial Statements with information about its ecological asset base. This information provides stakeholders with a way to judge whether the company meets their environmental management expectations. Land systems maintained in Good or Fair condition reflect sustainable ecological health and conservation of biodiversity.

Based on the standards for good management practice in the Kimberley (Ryan et al. 2013), management policy is to minimise risk to land condition by maintaining long-term average utilisation rate that is sustainable for the land types in production.

7.4.1.1.3 Climate Change

The company is addressing the potential of increased atmospheric carbon to increase the variability of seasons and the range of extremes of drought and wet seasons. To avoid this variability producing a detrimental impact on the dependability of livestock production and income from ecosystem services, the ecological asset base is being managed to provide resilience to extremes of weather by maintaining or restoring ecosystem condition.

7.4.1.1.4 Accounting policies – ecological capital

The financial statements of HPCo are supplemented by experimental environmental-economic accounts for the ecosystems that underpin its operations. These have been prepared by applying and adapting Accounting Standards and Accounting Concepts defined by AASB (and

[52] A different font has been used to distinguish this illustrative narrative from the body of the thesis.
[53] Drawn from the accounting for liabilities described in Chapter 6.

IASB) and the United Nations (UN) endorsed System of Environmental-Economic Accounts (SEEA) (United Nations et al. 2014b).

7.4.1.1.5 Ecological capital maintenance

To reflect its commitment to sustainable management of rangelands, the company has chosen to apply a concept of ecological capital maintenance[54] measured as the type, extent and condition its ecosystem assets and presented in terms of capacity for livestock grazing (per United Nations et al. 2014b). This adaptation is to provide a point of reference for the purposes of distinguishing consumption of the service potential (degradation) of these assets, from inflows of economic benefit produced from them. Changes in the measurement of the physical and monetary values of productive capacity of the entity are treated as part of equity and not as profit (consistent with AASB 2016b para. 109; IASB 2010).

7.4.1.1.6 Fair value

The choice of ecological capital maintenance has been judged to impose the use of current cost to replace the service capacity (AASB 2016b para. 106; IASB 2010). The fair value of the ecological assets is estimated based on its capacity to provide the ecosystem services of interest. In line with guidance under IAS 13 and AASB 13 Fair Value measurement and SEEA EEA (AASB 2015b; IASB 2010; United Nations et al. 2014b)[55], HPCo estimates a range of values using multiple methods including the expected value of cash flows from the asset and the current replacement cost of the services provided by the asset. Its directors selects the value that is most representative of fair value.

7.4.1.1.7 Revaluation policy

Due to the materiality of information about ecosystem condition and the prospect for ecosystems to change condition in response to management or factors beyond the control of management, two accounting policies are applied. 1) HPCo records and presents information about its patterns of use of the ecosystem in grazing accounts. These accounts communicate whether the company is using the resource sustainably. 2) HPCo employs an independent qualified ecologist to evaluate the condition of the production ecosystems. A rolling 5-year program of valuations ensures representative and regular assessment of ecosystem condition.

7.4.1.2 X2 Ecological Assets

7.4.1.2.1 Class of property, plant and equipment

Financial reports must present a “Faithful representation” of economic phenomena - a depiction that is complete, neutral and free from error (AASB 2016b QC12 & QC13). The type and condition of land systems used for production has economic significance and is judged to be material. The company has chosen to account for the ecological assets as an asset under IAS (AAS) 16 Property, Plant and Equipment. Due to the timing and method of ecosystem fair valuation being different to that of land (which is a market valuation), to provide a faithful, neutral and complete representation of the assets of the company, ecosystems assets are a presented in these supplements to the financial accounts as a separate class of asset.

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[54] discussed in Chapters 2 and 3.

[55] Note that, to be coherent with the simple scenario used in this thesis, the monetary value in this illustrative example are related to the value of the ecosystem as an operating lease of assets for livestock grazing. The paragraph describing the approach to Fair Value represents a more correct treatment.

7.4.1.2.2 Biodiversity Conservation and Cultural Heritage

Some ecosystems have significance to biodiversity conservation and cultural heritage and their use in production is judged to be incompatible with preservation of this heritage. These are accounted for separately to the ecosystems used for livestock grazing. Their extent remains unchanged and they have been maintained in good condition. Monetary valuations under the AS and SEEA are not relevant to these areas. The entries in the statement of ecological position (monetary terms) is annual expenditure on maintenance of these ecosystems.

7.4.1.2.3 Supporting compilation of national accounts

HPCo supports the compilation of national environmental-economic accounts from entity-level accounts. It classifies significant items of its statement of ecological position to facilitate compilation of individual entity accounts into AEES using the adaptation to GFS recommended for this purpose.

7.4.1.2.4 Statement of ecological position

The statements of ecological position for the last two periods are presented. Table 1 presents the statement in physical terms; Table 2 presents the statement in monetary terms[56]. Column one lists the (summary of) ecosystem assets in capacity terms. Column two provides the AEES code for that element. The physical asset value for ecological capital is provided in terms of provisioning service capacity. This is indicated by the number of adult equivalent cattle (AE) that can be sustainably carried at each accounting period (D_1 and D_2) given the condition of the ecosystems at that date. The value of conservation and cultural ecosystems is indicated by the extent in hectares[57].

In response to the detection of ecosystem degradation, HPCo acted to enable the ecosystem to restore. This included reducing stock numbers to 75% of the estimated sustainable carrying capacity of the property (given its condition). The opportunity cost representing foregone livestock production and the estimate of the resultant ecological capital available for production are presented in physical and monetary terms in the statement of ecological position.

7.4.1.2.5 Disclosure of significant externalities

HPCo is exposed to positive and negative externalities from neighbouring ecosystems. The company benefits from significant overland flows of water from a neighbouring property that has poor water infiltration capacity. This enables the property to capture and store fresh water for distribution to livestock throughout the property. The benefit is valued at $90,000 using a replacement cost approach - the cost of replacing this water source with groundwater should management change on the neighbouring property increase its water infiltration capacity.

Threats of feral animals (cats) is a significant negative externality that affects the Gouldian zone. Trespassing represents a significant negative externality of threats of vandalism of the Cultural zone. The expenditures noted in the statement of environmental performance are defensive expenditures to reduce these threats.

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[56] Valuation as described in Chapter 6

[57] In this simplified scenario, these ecosystems are maintained in good condition and extent is the most useful unit. If this was not the case, then a 'capacity' for conservation measure such as the eCond, or another unit would be useful. These are under development.

Tables communicating the ecological performance of HPCo over the last two periods are presented on the next page. Table 39 presents performance in physical terms. Table 40 presents performance in monetary in terms. Notes explaining the AEES classifications follow (Table 41).

Table 39: Statement of ecological performance (physical terms)

Grazed ecosystems (pastoral, AE carrying capacity, physical terms)	**AEES**	**D_1**	**D_2**
Patterns of use: Sustainable (unsustainable)	NPGUse	(10,032)	6,126
Ecological Capital Required (AE)	NPOP	6,688	6,688
Ecological Capital Required (Cond Index)	73	73	73
Ecological capital (consumed) formed (AE)	NPCFP	(1,783)	715
Ecological Capital (AE)	NPAP	4,905	5,619
Ecological Capital (Cond Index)	73	51	60
Opportunity cost to restore ecosystem (AE)	NPSP	(1,226)	(1,405)
Available Ecological Capital (pastoral use) (AE)	*NPCGP*	*3,679*	*4,214*
Ecosystems for conservation and cultural use	**AEES**	**D_1**	**D_2**
Gouldian Zone Habitat for Gouldian Finch (ha)	NPCB	151	151
Habitat formed (consumed) (ha)	NPCFCB	-	-
Cultural Zone Country managed for Cultural Heritage (ha)	EOFGST	178	178
Cultural Country formed (consumed) (ha)	EPCFST	-	-

Table 40: Statement of ecological position (monetary terms)

Grazed ecosystems (pastoral, monetary terms)	**AEES**	**D1**	**D2**
Ecological Capital Required	NPOP	1,127,236	1,127,236
Ecological capital formed (consumed) ($)	NPCFP	(300,518)	120,342
Ecological Capital	NPAP	826,718	947,060
Opportunity cost to restore ecosystem ($)	NPSP	(330,431)	(378,530)
Available Ecological Capital (pastoral use)	*NPCGP*	*620,039*	*710,295*
Ecosystems for conservation, cultural use Valuation basis: cost to maintain[58]	**AEES**	**D_1**	**D_2**
Gouldian Zone Defensive expenditure: Gouldian Finch	DEFXCC	20,000	20,000
Cultural Zone Defensive expenditure: Cultural Heritage	DEFXST	17,000	17,000

[58] Illustrative amounts of expenditure by current generations on management of threats such as weeds, feral animals, wildfires etc so that these ecosystems and species are maintained for future generations.

Table 41: Notes describing the system of classification for AEES presented in the statement of ecological position.

Classification code	**Classification description**
NPGUse	*Native Pasture Grazing Use*: Patterns of use of the native pasture (NP) ecosystem for grazing of livestock. To communicate sustainable (unsustainable) use.
NPOP	*Native Pasture Obligation: Provisioning services*. The quantity of native pastures (ecological capital) for provisioning services that current generations are obliged to maintain. ‘
NPCFP	*Native Pasture assets (Consumed) Formed: Provisioning services.* The performance of current generations as managers of the ecological capital in the last accounting period. ‘Consumption’ or degradation of ecological capital is indicated a number in brackets.
NPCFCB	*Native Pasture assets (Consumed) Formed: Habitat services.* The performance of current generations as managers of ecological capital for bird conservation in the last accounting period. ‘Consumption’ or degradation of ecological capital is indicated a number in brackets.
EPCFST	*Native Pasture assets (Consumed) Formed: Spiritual-Traditional.* The performance of current generations as managers of ecological capital for spiritual-traditional use in the last accounting period. ‘Consumption’ or degradation of ecological capital is indicated a number in brackets.
NPAP	*Native Pasture Available: Provisioning services.* The actual amount of ecological capital (for provisioning services) at the current date
NPSP	*Native Pasture Satisfaction investment: provisioning services*. Where a reduction in ecological capital is being addressed by a reduction in use (as in the grazing scenario), this amount records the investment by current generations to satisfy their obligations to restore the ecological capital to the amount designated (NPOP).
NPCGP	*Native Pasture for Current Generations: Provisioning*. Where current generations are underutilising ecosystems (for provisioning services) as part of the obligation to restore condition, this is the quantity (in physical capacity terms) that they have available for their current operation.
NPCB	*Native Pasture: Conservation of Birds.* This communicates the extent of native pasture that is providing habitat for birds (specifically the Gouldian Finch).
EOST	*Ecological Obligation: Spiritual and Traditional use.* This quantifies the ecological capital to be maintained for spiritual and traditional purposes.
EPCFST	*Ecological capital (Consumed) Formed Spiritual and Traditional use.* This quantifies the performance in the last accounting period of current generations as managers of the ecological capital for cultural purposes. ‘Consumption’ or degradation of ecological capital is indicated a number in brackets.
DEFXCC	DEFXCC Bird Conservation.
DEFXST	DEFXST: Spiritual and Traditional land use

7.5 Accounting for obligations to future generations

This study demonstrated, via a scenario and case study, accounting for a reduction of ecological capital due to degradation. Amounts of degraded ecological capital can be interpreted as resources not being transmitted to future generations. Chapter 6 [59] demonstrated the recording of monetary value of this in the SNA as an economic disappearance of assets in the Other Changes in Volume Account. In Chapter 6, it was noted that, in the present SNA and SEEA there is no matching asset-liability pair for monetary value of this disappearance and, unlike in IAS, there is no way of recording accumulated values of these events. The proposed addition of a new producing unit – the environment – in the SNA (Eigenraam & Obst 2018) may provide a resolution. Entries in the national accounts for this unit would be compiled from entity-level accounts.

To assist with accountability for resource transmission to future generations, an account design is proposed. This design aims to communicate the aggregate performance of the pastoral sector of a region in physical and monetary terms[60]. The design objective is to:

1. record the ecosystem assets that current generations are obliged to transmitted to future generations (i.e. the native pasture ecosystems types and condition that must be maintained (NPOP))

2. to record the resources being transmitted at a date (NPAP),

3. record the consumption or formation of ecosystems assets during the period (NPFCP)

4. record investments being made by the current economic users to satisfy obligations (NPSP)

5. record the environmental protection expenditure (or defensive expenditures to protect areas of conservation or cultural significance),

[59] Table33 Capital and financial accounts D_0 to D_1

[60] To illustrate the concept, it uses the values from the scenario used the study.

Table 42 demonstrates compilation of information about ecological capital presently being transmitted to future generations (in physical and monetary terms).

Table 42: Illustration of accounting elements for understanding the characteristics of resources being transmitted to future generations between D_0 and D_1. This table illustrates the presentation of a compilation of all pastoral entities in a region using values for the scenario in this study.

	Pastoral sector Physical terms (AE)	**Pastoral Sector Monetary terms ($)**
Native Pasture Obligation: Provisioning NPOP)	**6,688**	**1,127,236**
Native Pasture Available: Provisioning (NPAP) Opening balance D_0	**6,688**	**1,127,236**
Additions		
Due to restoration		
Reductions		
Due to decline⁺		
Due to degradation (NPCFP)*	(1,783)*	300,518
Catastrophic loss⁺		
Native Pasture Available: Provisioning (NPAP) Closing balance D_1	**4,905**	**826,718**
Native Pasture Obligation Satisfaction (NPSP)^	(1,226)^	330,431
Native Pasture for Current Generations: Provisioning (NPCGP)	***3,679***	***620,039***
Environmental protection expenditure		
Defensive expenditure for the Gouldian Finch (DEFXCC)	-	20,000
Defensive expenditure for Cultural Heritage protection (DEFXST)	-	20,000
Total D_0 to D_1	-	**40,000**

*This entry records the ecological capital consumed by the pastoral entity during the period. It is the physical analogue of the transaction in the Other Changes in Volume account (Chapter 6) of $300,518 for the economic disappearance of rangeland ecosystem.

+This type of entry would be used for reductions in capital due to circumstances (e.g. climate change) that are beyond the pastoral sector's control.

^ This entry records the 'opportunity cost' accepted by the current economic user to invest in ecosystem condition.

A simple example of how classifications of ecological capital could facilitate compilation of subnational (and national) ecosystem accounts for the scenario region of this study is demonstrated using simulated values. Table 43 below shows the ecosystem (native pasture) types used in the study scenario along with the abbreviations for these pasture types. The simulated figures demonstrate the compilation of this information from the accounts of several pastoral operations in the region. They communicate the total amounts of each native pasture ecosystem being used for grazing, conservation and cultural use at Date X. If fine-scale accounts for condition are also available, these compilations could communicate information about regions that have become degraded or are vulnerable to degradation.

Table 43: Illustration of ecosystem asset accounts compiled to predominant use from entity-level accounts in a pastoral region. Extent simulated to illustrate concepts. NP: Native Pasture, Pasture Abbreviations, P: Provisioning (Livestock), CB: Conservation of Birds, ST: Spiritual and Traditional use.

Ecosystem (pasture) type [NP] @ Date X	Primary use			
	Pasture type abbr.n	Grazing Livestock [P] km²	Gouldian Zone [CB] km²	Cultural Zone [ST] km²
Annual Sorghum Hill Pastures	ASHP	777	0	75
Black Speargrass Pastures	BSGP	375	0	0
Bluegrass Alluvial Plain Pastures	BGAP	1,238	890	0
Curly Spinifex Annual Sorghum Hill	CAHP	990	0	8
Cockatoo Grass Pastures	COGP	980	0	0
Drainage Eucalypt and Acacia Pastures	DEAW	1,230	50	19
Fringing pastures	FRIP	1.290	90	0
Frontage Grass Pastures	FRGP	1,698	123	0
Lovegrass Alluvial Plain Pastures	LGAP	8,921	560	0
Mitchell Grass Alluvia Plain Pastures	MGAP	1,256	13	0
Mitchell Grass Upland Pastures	MPUP	418	0	61
Plum Sorghum Pastures	PLSP	560	11	0
Ribbon Grass Alluvial Plain Pastures	RAPP	280	12	0
Ribbon Grass Pastures	RGRP	186	62	0
Samphire Pastures	SMPP	320	0	85
Sandplain Spinifex Pastures	SSSG	331	0	112
Treeawn Plain Pastures	TAPP	1,245	0	58
Tippera Tall Grass Plain Pastures	TTGP	1,409	0	21
White Grass Bundle-Bundle Pastures	WGBP	998	51	123
Region total		**23,213**	**1862**	**562**

The aggregate information presented in these two illustrative examples shows the potential for reporting of the amount of different types of resources being used and managed by the pastoral sector. For example, compared to modified and nutrient-enriched pastures, native pasture 'uses' less of the NOx budget proposed under science-based targets for planetary boundaries and supports greater levels of biodiversity (Willett et al. 2019). Consequently, the information in these tables communicates the quality and quantity of these resources being used and managed by the Australian pastoral sector and the economic implications of this.

7.6 Consolidated ecological statements

This section addresses the question of how to support the private sector to analyse and assure the quality and sustainability of ecological capital in its supply chain.

The concept of a supply chain entity (Burritt & Schaltegger 2014) or the notion of sustainability control (suggested in Antonini & Larrinaga 2017) may provide ways for companies to consider the environmental performance of agricultural producers in their supply chains. The four themes described in chapter 2 can be broadly categorised into two types. The first type actively considers environmental attributes of agricultural products in sourcing decisions. This involves selecting or avoiding producers based on the condition of their land. By demonstrating an explicit preference for environmental performance, a company may influence the ecological capital qualities in the supply chain. The second type passively reports the environmental externalities resulting from producers in the supply chain. These are not selected for environmental attributes, but for the qualities of the agricultural products - livestock or wool being sold.

An example of the first type - selective sourcing based on environmental attributes is provided by Patagonia (a leading apparel firm) which required its sheep graziers (in Patagonia) to measure and communicate the condition of their grassland ecosystems compared to a defined ecological standard (Crooke 2009; Patagonia 2014). For an 'active' manager like Patagonia, a concept of sustainability control may consider the degree of control it has over the condition of ecological capital of its wool producers.

An example of the second (passive) type that selects on product quality and then estimates the externalities resulting this is provided by Kering. Kering doesn't (presently) require its producers to measure or meet environmental standards. It estimates its annual EP&L from its purchases of agricultural commodities (estimated from industry performance) in that year (Kering 2014, 2017, 2019). Consequently, the notion of sustainability control for Kering is conceptualised as control only over which producers it purchases from rather than control over their environmental performance. The EP&L emerges passively as a result of its producers' choices.

Investors may have a positive perception of both approaches as evidence of a capacity to detect and avoid environmental related risk to their businesses and may incorporate this information when making decisions about investment or debt financing of these firms. It might be possible to meet investors (and other users) needs for information about the ecosystems assets in a company's supply chain by adapting the concept of Consolidated Financial Statements IASB 10 (and AASB 10) (AASB 2015a; IFRS 2011) to allow the presentation of aggregations of supplier statements of ecological position as supplements to GPFR. Adaptations would provide guidance for preparers of the accounts of the final retailer of transformed ecosystem goods to communicate information about the characteristics of the ecosystems of the supply chain it depends on.

This may be operationalised in a voluntary way by members of the agricultural value chain including a consolidated ecological statement representing the consolidated ecosystem assets of the primary producers in their supply chain. If agricultural suppliers prepared statements of ecological position in a standardised way such as demonstrated in this chapter, a net ecological position for the entity that depends on these suppliers could be estimated from the net of ecological positions of individual suppliers. This may allow entities such as Patagonia and Kering to report the condition and trends of ecological assets underpinning their operations and whether the business had been associated with a net consumption or formation of ecological capital in the last accounting period.

Where a company purchases from commodity markets and cannot identify its suppliers, it could use the average of the environmental performance of the sector to report on the performance of the ecological capital in its supply chain.

Chapter 3 identified that the present requirement for consolidated financial statements to include all aspects of financial performance of the entities within the reporting boundary may be a constraint on getting useful information about the ecological performance of the supply chain. It noted that the capacity to report only the environmental-economic information material to production, regulatory or social risk in the supply chain may be a useful approach. The approach to describing a statement of environmental performance is aligned with these adaptations and provides a mechanism for companies to communicate their management of environmental performance in their supply chains.

7.7 So how do you 'make them do it'?

As for financial performance information, measurement and reporting of environment or sustainability performance is largely driven by regulation or by user demand for information (Bartels et al. 2016; Hoogervorst 2019). Research suggests that public participation in framing of policies related to environment and sustainability issues is important, particularly so when it is desirable to draw particular expertise or information into the policy process (Dovers & Hussey 2013 Ch. 9). This suggests that methods for accounting for ecological capital in agriculture is likely to make the most rapid progress if those who believe they can use it to improve their performance or gain competitive advantage are supported to implement it in an experimental manner on a voluntary basis.

It is expected that some agricultural entities (including family farms) and brands will be interested in exploring the use of ecosystem accounting to create competitive advantage in sustainability-conscious markets. Involving these leaders in the evolution and development of this field would help them to design something that helps them to demonstrate the quality of their ecological assets and their management and to communicate any flow on advantages to the value chain such as greater dependability of quality and quantity of primary produce.

Taking such an approach would emulate the path to successful adoption of accrual accounting by Australian governments who initially demonstrated significant resistance in response to the proposal to move from cash (budget) accounting to accrual accounting in 1992 (McPhee 2006). Recognising that there were unresolved issues and a lack of acceptance of the benefits of accrual accounting among agencies, the (then) Department of Finance adopted an incremental approach to expansion of disclosure requirements and in this way conditioned public sector agencies to a more comprehensive basis of reporting. Under this approach, agencies were allowed several years to produce their first set of accounts including a two year trial when unaudited financial statements were published (McPhee 2006).

Voluntary involvement of willing and able participants with good quality ecosystems is likely to generate useful insights and accelerate development of accounting methods (including those explored in this study) based on good agro-ecological literacy. Willing and well-informed participants are likely to bring useful visions of the economic and societal benefits of accounting and accountability for ecosystem condition and adoption by leading agricultural producers will provide a positive role model and a practice template for others less visionary or capable to follow.

Presently, preparing farm-level environmental-economic accounts is a relatively expensive exercise and the benefit of the information to the individual farm business may not exceed the cost of compilation. However, looking beyond the farm gate, the potential benefits to governments, preparers of agricultural economic statistics, the financial services industry and entities dependent on agricultural products of environmental-economic information from property-level accounts seem considerable. This suggests that these entities may have a justification for supporting farm businesses to compile and communicate property-level accounts.

7.8 Discussion

The system of classification of ecosystem assets, related monetary values and expenditures to maintain environmental condition has the potential to provide a foundation of measurement and communication of environmental economic performance of individual entities, regions and nations. It demonstrates the potential to provide information that is coherent from management scale to policy scale, including the potential support science-based targets for resource use and biodiversity management. By providing this information, it supports the design and implementation of enabling frameworks and stewardship incentives across all levels of the agricultural sector to accelerate resolution of the issues of land degradation. However, to be effective, it would have to be supported with appropriate macroeconomic analysis and policy to define the allocation of resources and align market or taxation instruments accordingly.

An opportunity exists for conservation entities including national parks operators such as the Great Barrier Reef Marine Park Authority to also classify their activities and functions so that the expenditures they make to maintain the productive capacity of a grazed ecosystem or for conservation to reduce threats (e.g. of feral animals and invasive weeds) can be included in analysis of economic activity and of whether the activities should be supported by society.

The approach demonstrates the potential for companies in the agricultural supply chain to aggregate information about the ecological capital (in physical terms) and environmental protection expenditure of all its agricultural suppliers. Consistent compilation and classification of ecological capital stocks and patterns of use may also enable entities in the agricultural value chain to positively influence environmental performance in agriculture. To realise this potential, preparers of accounts will need guidance about how to apply a concept of sustainability control or to define a supply chain entity. The Natural Capital Protocol (NCC 2015) provides useful guidance for further exploration of this issue.

The use of the statement of ecological position in monetary terms communicates the present monetary value of the ecosystems being used for production in terms of income-earning potential presents these amounts separately to the value of the land as real estate. The monetary information related to the ecosystems identified as having cultural value conveys important information about expenditure for the period on management activities to preserve them. The SEEA observes the usefulness of such information is valuable in national accounting as a way to assess current attitudes towards environmental protection (United Nations et al. 2014a). Accordingly, it may be possible to interpret an entity's expenditure on environmental protection, as a method to estimate an entity's expenditure to maintain its social licence to operate.

Finally, the demonstrated tables present the highest level of aggregation only, but codes such as these could be applied to these assets all the way down to the register level. A code design that would describe additional information available at fine scale (such as the type of ecosystem) would enable accounting for the quantity and quality of ecosystems and provide information for assessment of environmental agencies achievement of their aims.

8 Conclusion

Measurement and communication of environmental-economic performance at all levels of the agricultural sector is regarded as a necessary foundation for transforming the economic relationships that lead to land degradation and biodiversity loss associated with agricultural practices. As the most widely used economic information standard in the world, IAS can provide this foundation by adapting and extending current theory and practice so that ecological capital can be incorporated into financial reports prepared under IAS.

This study focused on the use of rangeland ecosystems for livestock grazing by pastoral entities in Australia. It concluded that incorporation of ecological capital would improve the capacity of IAS to provide useful information to people making decisions about their economic involvement with a pastoral entity and that extending the IAS to include ecological capital is incremental rather than revolutionary. However, it might be best if information about ecological capital was presented in supplementary statements of ecological performance rather than integrated with the financial statements.

IAS acknowledges the importance users place on information about biophysical quantities and qualities of biological assets. Prior to this study, a significant barrier to incorporating ecological capital under IAS was the absence of measurement methods that satisfy IAS criteria for recognition of accounting elements. This barrier can be overcome by drawing on concepts and methods developed by rangeland science to help pastoral operations measure the productivity and sustainability of their ecological assets and to support good practice sustainable management of them. These concepts and methods can be represented in accounting tables that are coherent with concepts and principles in IAS and the SEEA EEA. This will enable pastoral operations who apply the good management practice for sustainable management of rangeland ecosystems to use formal, standardised and internationally accepted accounting frameworks to communicate this to customers, investors, lenders and citizens.

The incorporation of information about non-financial assets in physical terms is not revolutionary. IAS doesn't presently require information to be presented in currency terms and extending IAS with the additional concepts and account types emerging from rangeland science and from the SEEA EEA for the compilation and presentation of accounts in physical terms should, in principle, be relatively easy.

Along with values in physical terms, users need information about the contribution ecological capital makes to the prospects for net cash inflows to the entity. Estimation of monetary valuations of ecological capital separately from land, can be accomplished using the present guidance of IAS Fair Value Measurement for valuation of non-financial assets of a cash generating unit. Subject to the availability of accounts that detect ecosystem degradation (in physical terms), accounting for liabilities related to ecosystem degradation is demonstrated in this study to be coherent with present IAS concepts and standards.

Entities that use ecological capital need to ensure that their estimates of profit do not include inflows of cash resulting from depreciation or degradation of these assets. To enable this, the existing concept of physical capital maintenance in IAS should be adapted to create a concept of ecological capital maintenance. This would provide a measurement basis for entities that use ecological capital to ensure that their estimates of net cash inflows are excess of amounts needed to maintain ecological capital and therefore may be regarded as profit and a return on capital.

Ecosystem services are generally an intermediate factor of production in the value chain of a pastoral enterprise. The purpose of information about ecological capital is to assess its contribution to future net cash flows to the entity and to understand management’s stewardship of them. Accounts and statements of ecological performance presented as supplements to the financial statements would provide this information without requiring significant alterations to standards and conventions for financial accounting. This approach is conceptually consistent with the extension of the production boundary of the SNA to accommodate ecosystems.

The availability of robust, standardised and auditable information about ecological capital in supplementary statements of ecological performance of individual entities would enable decisions about economic involvement with them to incorporate considerations of the entity’s stewardship of these resources. Adaptation of the concept of consolidated financial statements could enable an entity to communicate the current condition and prospects for ecological capital underpinning its supply chain. Environmental-economic statistics can be compiled from the individual entities by adapting the present system for preparing government financial statistics. This would enable preparation of environmental-economic statistics for macroeconomic analysis of the pastoral sector for input to policies that create motivation and information for private and public investment in land condition.

8.1 Contributions

As the first study exploring how ecological capital can be incorporated as assets under IAS, this study contributed to theory and practice in several ways.

It provided an explicit description of the nature of ecological capital in agriculture and its role in generating private economic benefit for agricultural enterprises. The exposition of ecological capital and its management provided a science-based and pragmatic foundation for useful and relevant information in ecosystem accounting. The normative foundation describing the information needs of users at all levels of the agricultural sector, including governments, enabled analysis of the present IAS to identify where adaptations and additions are required to meet these needs. A practical framework demonstrated an approach to accommodating the unique characteristics and sustainable management of ecosystems assets under IAS. This contributes to the future development of a conceptual framework, or standard accounting concept for ecological capital accounting.

The study demonstrated how contemporary rangeland science-based good practice could be reflected in environmental-economic accounting practice thereby aligning the microeconomic and macroeconomic information systems. This included demonstrating how methods for assessing the condition of pasture ecosystems and whether they are being managed sustainably can be reflected in account presentations suggested by the SEEA EEA. It demonstrated practical approaches to physical valuations of ecological capital under IAS including possible presentations of a physical ‘balance sheet’ for ecological condition and a statement of ecological position.

This study built an IAS-coherent approach to valuation of ecological capital, separately from land to provide users of accounts with more complete information about an investment or loan. It demonstrated accounting for liabilities that is coherent with IAS and SNA (SEEA) frameworks. Finally, the research demonstrated a practical approach to compiling entity-level ecological accounts into statements of ecological performance and how these can be used by the agricultural supply chain to communicate their exposure to and management of risks related to the condition of agricultural ecological capital. It described and illustrated adaptation of GFS for the compilation of agricultural environmental-economic statistics for macroeconomic analysis and planning by governments.

8.2 Future research

8.2.1 General applicability

This study applied international standards for accounting for individual entities and for national accounts preparation, with a focus on accounting for pastoral entities in the Australian rangelands. Its scope addressed unmodified (natural or native) landscapes. While many of the principles and methods will apply to grazing enterprises in other countries some, such as the condition classifications, will need to be adapted. Additional research is required to test whether an approach including condition classification is applicable to extensive cropping (wheat, lentils, canola, soy etc) or horticulture (orchards and timber plantations, or market gardens).

8.2.2 Monetary valuations of ecosystems separately from land

This study demonstrated the potential to use the entity's own data to estimate the value of its ecological capital. It was limited by its scope to a case study approach to explore methods. Future research should test these valuation methods on a larger dataset and evaluate their reliability and ability to faithfully represent the economic flows to the entity.

8.2.3 Consultation with stakeholders of agricultural entities

IASB relies on extensive consultation with investors, managers and other stakeholders when considering changes to accounting standards or the introduction of new standard accounting concepts. The approaches proposed in this study provide a resource for a consultation process about incorporating ecosystems as assets of individual entities preparing GBFR and financial statements under IAS. In addition to consideration of the approaches used in this study, future research by accounting standards bodies should contribute to development of a standard accounting concept for ecological capital.

8.2.4 Consultation with sustainability-conscious firms

Leaders amongst apparel and food brands and the finance industry are designing and implementing strategies that enable them to gain greater visibility of the environmental (and animal welfare) attributes of suppliers and to selectively source from the better performers. Future research should experimentally implement the statements of ecological performance demonstrated in this study and the suggestion for adapting the concept of consolidated financial statements and assess its practicality and usefulness.

8.2.5 Consultation with national statistical organisations

This study proposes methods for ecosystem accounting that use condition classifications and concepts already in use under good practice management of rangeland ecosystems for livestock grazing and for conservation. It has suggested that the resulting accounts could provide information about private sector ecological management to national accounts and statistics via adaptation of the GFS used to obtain information about government financial management. Future research by national statistical organisations should test this approach for its potential to contribute to the implementation of the UN SEEA EEA.

8.2.6 Condition classifications

The approach to ecosystems accounting in this study incorporated the condition classifications developed by rangeland scientists to support good management practice. The classifications represent groups of ecological characteristics associated with different properties of ecosystems including sustainability, productivity, soil stability, biodiversity and conservation value suggested in the technical recommendations for SEEA EEA.

Designed to be practical for management monitoring and decision-making, they simplify and improve the usefulness of condition accounts without eliminating detailed information about the characteristics of the ecosystem. Condition classes for different ecosystems can be disaggregated into the individual characteristics at any point if information is required about the performance of a single characteristic of an ecosystem, for example in thematic accounts such as biocarbon and soil stability (regulating services).

However, current rangeland condition classifications used in this thesis were designed primarily to provide indications of quality of grazing for livestock and focus on vegetation (grass) cover, productivity for livestock and soil stability. They do not currently indicate carbon storage or native biodiversity of the overstory and in modified pastures. However, this appears to be a question of purpose (and resources) not a limitation on the concept. It should be relatively simple to modify them in future research, so they also provide information about biocarbon and biodiversity.

Ideally, future methods for condition accounting would incorporate information about the size and connectedness of an ecosystem to provide an indication of its prospects for the future (its sustainability) and to distinguish ecosystem condition changes due to connectivity change from condition changes due to local management activities. There is also a need to ensure that the amenity features of some assets (as opposed to their provisioning services) need to be accounted for.

Through the considerable expected impact of climate change on the composition and structure of ecosystems, it may be impossible to preserve them in their current state. Research is needed to develop measures and accounting techniques that distinguish ecosystem condition declines due to climate from declines due to management practice so that land managers are not unjustly accused of causing ecosystem degradation.

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