Accounting for liabilities related to ecosystem degradation

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ABSTRACT

Introduction: A growing belief that accounting can and should play a role in halting and reversing degradation of ecosystems is leading to conceptual and methodological developments that recognize the cost of degradation, attribute the cost to the entities responsible and assure that entities can’t ignore the economic burden associated with it.

Outcome: Demonstration accounts prepared around a scenario where agricultural use of land includes an obligation to maintain ecosystem condition. The accounts are compliant and coherent with both the international accounting standards for individual entities and the United Nations’ System of Environmental-Economic Accounting.

Discussion: Accounting for liabilities for ecosystem degradation demonstrates that, where the liability reflects the lost economic value of the ecosystem, the accounts communicate a reduction in the total net worth of the economy and a redistribution of net worth away from the party responsible for the degradation. The inclusion of both liabilities for degradation and the cost of degradation does not lead to double-counting the economic impact of degradation.

Conclusion: Accounting principles and frameworks encourage greater accountability for entities responsible for ecosystem condition by providing greater visibility of the economic cost to individual entities, governments and nations.

Introduction

Land degradation caused by human activities is undermining the well-being of humanity and compromising achievement of the sustainable development goals (SDGs) (IPBES. 2018). While overall responsibility lies with national governments, the SDGs cannot be achieved without a concerted effort by business and other organizations through properly integrated reporting models (Adams 2017). A potential constraint on resolving issues of land degradation is that many of those who benefit from overexploitation of natural resources are among the least affected (IPBES. 2018) and while this situation persists, many potential restoration activities may remain unfunded making continued ecosystem decline almost inevitable.

To overcome this, businesses and governments are increasing investment in methods to adapt and apply accounting concepts to incorporate the condition of natural resources in decisions about optimal allocation of capital (ACCA, FFI, and KPMG 2012; Rapacioli et al. 2013; NCC 2015; UN 2014; Edens and Hein 2013; Obst, Hein, and Edens 2015).

Reflecting this investment, 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 (UN 2014). 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.

The SEEA-Experimental Ecosystem Accounting (SEEA-EEA) endorsed in 2013 provides a starting point for the development of ecosystem accounting at national and subnational levels to integrate complex biophysical data with socioeconomic data so that changes in ecosystems and biodiversity can be linked to changes to economic and other human activity.

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 (UN 2017) to support further development. 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 (UN 2017).

One aspect of this is integration to record values of ecosystem assets in monetary terms alongside other assets recorded in the standard macroeconomic balance sheet described in the SNA. However, 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 (i) 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 and Vardon, 2014; Obst, Hein, and Edens 2015 cited in UN 2017); (ii) determining whether liabilities should be recognized 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” (UN 2017, 138); and (iii) 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 recognized, 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 (UN 2017). To date, no integrated approach to accounting for liabilities in an ecosystem accounting context has been developed that responds to these challenges. This paper provides a way forward.

The starting point for establishing a national accounting solution is the recognition that accounting for environmental degradation-related liabilities has been part of International Accounting Standards (IAS) for years (IASB 2004). Further, governments and most corporations are required to prepare accounts according to the IAS. Under IAS, where these entities have obligations to restore ecosystem condition, for example to remediate polluted sites, they must report the related monetary amounts in their financial statements as liabilities (Ji and Deegan 2011).

The SNA 2008 states that it is desirable for national accountants to be aware of developments in IAS with a view to amending the SNA to follow new accounting standards when appropriate (UN 2008). Given this, the following research question arises: can the standards for accounting for liability in IAS assist SEEA to resolve the challenges it perceives in accounting for liabilities related to degradation of ecosystem assets?

The paper proceeds as follows. The next sections consider the research methods used. They provide: a summary of the key accounting concepts; a short introduction to the management and modeling of northern Australian rangelands for livestock grazing; a description of the scenario used; and explain the methods and values of the modeled data used in the accounts. The “Results” section presents simplified SEEA-based ecosystem accounts followed by capital statements summarizing the financial accounts for the government owner of the pastoral land and the pastoral entity leasing the land. Then, the relevant national accounts entries for the scenario are presented in a sequence of tables. Finally, the implications of the various accounting treatments are discussed before conclusions are drawn.

Methods

To explore the potential to account for liabilities for ecosystem degradation, the paper uses scenario analysis and modeling of a pastoral livestock operation that leases land in the northern rangelands of Western Australia. This activity has been chosen because 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 and 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 paper, 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 (Stoate 2012; Safstrom and Waddell 2013).

Key accounting concepts and treatments

There are five aspects of national and corporate accounting of most relevance in this paper, 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 have been applied using their current definition. They are introduced in this section and discussed further in the remainder of the paper.

Ecosystem accounting is described in the SEEA-EEA. In essence it involves four key steps:
- 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 type (e.g., a patch of forest) is considered an ecosystem asset;

- assessing the condition of each ecosystem asset, usually based on a range of ecological variables including species diversity;
- measuring the flow of ecosystem services generated by that asset (ecosystem services are generally considered to be provisioning services (e.g., for food, fiber, energy); regulating services (e.g., air and water purification, climate, and water regulation); or cultural services (e.g., use of ecosystems for recreation);
- assessing the relative value of the benefits obtained from those services.

With this range of information organized using standard national accounting principles, it is possible to integrate this ecosystem information with standard economic accounts for production, income, capital, and net worth.

The rangeland ecosystem assets used by agriculture are assumed in this paper to be equivalent to bearer plants under the recently published IAS interpretation and therefore to require the application AASB116 Property Plant and Equipment (IAS 2014a, para. BC60). This implies that the rangeland combination of soil and vegetation for grazing are considered an asset that produces forage for grazing animals, much as an orchard produces fruit. The concept of bearer plants is analogous to the SNA produced asset of cultivated biological resources (UN 2008, para. 10.11).

Under AASB116, bearer plants are assets subject to a regular impairment test (AASB 2015b; IAS 2014b). 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 (IAS 2014b, para. 40). (An elegant description 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 recognized immediately, via double-entry bookkeeping convention, in profit or loss as an impairment loss (AASB 2015b). 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 paper uses the term revaluation loss in keeping with common practice in corporate accounting.

Ecosystem degradation arises when the condition of an ecosystem asset declines over time as a result of economic and other human activity. This paper 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. Notwithstanding this choice, 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 (IAS 2014). 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.

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) (UN 2008; IASB 2010). A liability is recognized 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, under IAS, for an entity to recognize a liability to restore a degraded ecosystem, there must be an obligating event. This arises from the combination of a legal or constructive obligation to avoid degradation and evidence of degradation of the ecosystem where satisfying the obligation requires future sacrifices of economic benefit that can be reliably estimated. 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 and 53)

Further,

...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, 97)

Together, these treatments mean that there are a wide range of situations in which liabilities should be recognized 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 recognized in the national accounts.

Complementing the information in the accounts, the paper demonstrates the use of the concept of contingent liability and contingent assets (AASB 2015a; IASB 2016) so that stakeholders are informed of the possible consequences if ecosystem degradation cannot be reversed by the end of the lease.

Finally on accounting treatments, 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 (UN 2008, para. 17.310; IFRS 2016). In the corporate accounts, the operating lease is recognized 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.

**Overview of management of northern Australian rangelands for grazing**

The rangelands of northern Australia are comprised of many different ecosystems. Each pastoral property typically controls a combination of ecosystems either by freehold ownership of the property or ownership of a lease for grazing use. 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, Ash et al. 2011; Hodgkinson 1992; MacLeod and McIvor 2008; O’Reagain et al. 2014; Ash et al. 2015; Pettit 2011; Walsh and Cowley 2011; Abbott and Corfield 2012; Tongway and Hindley 2004). The characterization 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.

In keeping with the second step of ecosystem accounting under the SEEA-EEA (assessing the condition of each ecosystem asset) current Australian good practice for management of these ecosystems includes assessment and classification of its condition for grazing (its capacity to provide provisioning services for livestock) to A, B, C, or D depending on the quality and arrangement of vegetation. The ABCD land condition classifications for northern rangelands are designed in relation to flows of provisioning services for livestock (i.e., forage), and only provide an indication of regulating services such as soil retention services (to limit soil erosion) and habitat services (to support conservation of biodiversity) (Parsons et al. 2017). The condition measures are not designed to indicate the capacity for carbon storage (Bray et al. 2016) or cultural services. Nonetheless it would be expected that land in A and B condition under this classification system can be regarded as providing more regulating and cultural services than land in C or D condition. Modeling of changes to rangeland condition as part of the research in sustainable grazing of these landscapes indicates that land in A condition prior to livestock grazing will often decline to B condition but can return to A condition within a few years of livestock being removed. Land in C condition may return to A 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 modeling indicates that the land will most likely continue to decline in condition if heavy stocking rates continue. Improvements in condition from 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 (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 and 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 number 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 the annual forage budgets should approximate the long-term carrying capacity if land condition and grazing capacity are to be maintained. From these estimates and related models available in the industry, the monetary value of the long-term

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1 Referred to as “Land systems,” these are characteristic combinations of geology and vegetation that have differing qualities for grazing and differ in their ability to regenerate following disturbance.
carrying capacity can be estimated using lease or agistment rates for similar land in similar condition (Ogilvy and Vail 2018).

If the condition of an ecosystem declines (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 stocking rate reductions, prescribed burns, installation of brush packs, and increased rest from grazing during the growing season by reducing the number of livestock carried on the property (see, for example, Tongway and Ludwig 1996, 2011; Walsh and Cowley 2014a, 2014b).

These various interventions suggest 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 interventions.

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, the absence of disturbances that would interfere with recovery and probably some factors currently poorly understood by science.

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 in the event that a lessee causes ecosystem degradation.

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 and Novelty 2012)).

**Scenario analysis – pastoral company**

The scenario created for the paper draws on the rangeland science described in the previous section and uses modeled data described in the next section. It commences with the establishment of a contract for a pastoral entity – Hypothetical Pastoral Company (HPCo) – to lease a property for grazing use under the Western Australian (WA) Pastoral Land Act. Protective rights under AASB116 (AASB 2016) to maintain ecosystem condition at an agreed level are included in the lease agreement in accordance with the act. 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 2016), 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 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. In this scenario, 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 1* summarizes the key events in the scenario. Date 0 ($D_0$) is the commencement of the contract with HPCo. Date 1 ($D_1$) is the first revaluation of condition and Date 2 ($D_2$) is the end of the contract. The vertical axis is the number of AE cattle illustrating the long-term carrying capacity of the rangeland and number of livestock actually being carried. The horizontal axis shows the key accounting dates. The solid black horizontal line at 6660AE represents the ecosystem condition (in terms of long-term carrying capacity) that is required to be maintained by HPCo. The solid black curving line shows the decline of condition for the first accounting period $D_0$–$D_1$ and partial improvement in the second period ($D_1$–$D_2$). 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 modeled data is explained below.

**Modeled data**

The accounting entries for this scenario are based on modeled data. Extent and condition characteristics for the individual ecosystems that comprise the hypothetical pastoral lease area of 90,000 ha were simulated for the scenario in accordance with the second step of SEEA-EEA accounting processes (described earlier). 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, and Counsell 2014). The model allowed for changes to the area of rangeland ecosystems in each condition class (ABC or D) 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 modeled data in Figure 1 and Table 1.

**Results**

**Ecosystem accounts**

The ecosystem accounts for the scenario are presented in Table 2, for the period $D_0$–$D_1$, and Table 3, for the period $D_1$–$D_2$. These accounts report to the lessor and the lessee the condition of the ecosystem asset and indicate whether the lessee is using it sustainably. In the ecosystem condition accounts, the area of rangeland ecosystems in each condition class and the equivalent physical and monetary asset values of carrying capacity are presented. The value at $D_0$ represents the starting ecosystem condition which is also the condition the ecosystem must be in at the end of the lease.

The sustainable flow of ecosystem services (defined as the amount of forage that can be consumed by cattle without risking degradation of the ecosystem) reflects the long-term carrying capacity of the ecosystem in a similar manner to "Physical and monetary ecosystem services accounts for Europe: A case study for in-stream nitrogen retention" (La Notte et al. 2017). 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.

The actual flow of ecosystem services reflects the forage consumed by the livestock given the number of livestock on the property and is the amount that
Table 1. Modeled data used for accounting entries is based on a hypothetical pastoral lease of 90,000 ha in the Kimberley region of Western Australia.

| Accounting entry                                      | Value                     | Estimation basis and method                                                                                                                                                                                                 |
|-------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ecosystem asset capacity (physical, for grazing, for the property) | 6660AE at D₀, 4941AE at D₁, 5648 at D₂ | Derived from research by Northern Territory Department of Primary Industries and Resources based on the methodology described in Johnston, Mckeon, and Day (1996) that relates land types to carrying capacity per hectare at different land condition classifications. Long-term carrying capacity at condition A was modeled as 0.1AE/ha and discounted to 75%, 45%, and 25% at condition classes B, C, and D per current practice (Chilcott et al. 2005). |
| Sustainable ecosystem services generated               | 33,300 (AE/year): D₀ – D₁, 24,705 (AE/year): D₁ – D₂ | Five years of grazing based on long-term carrying capacity at condition at start of period.                                                                                                                                 |
| Ecosystem services harvested                           | 43,290 (AE/year): D₀ – D₁, 18,509 (AE/year): D₁ – D₂ | Modeled as a factor of 1.3 times sustainable carrying capacity (over-grazing) based on condition at D₀ in the first period and 0.75 times long-term carrying capacity (under-grazing) based on condition at D₁. |
| Ecosystem asset (monetary value)                       | 51,122,516 at D₀, 5832,786 at D₁, 951,863 at D₂ | Based on the net present value (NPV) at 6% 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 and Vail 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                | 5762,570 (5 years)        | Modeled on a lease rate of 5% commonly used in property leasing applied to the value of land and infrastructure per AE of $458 (McLean, Holmes, and Counsell 2014) and associated with its condition via long-term carrying capacity at the start of the lease. |
| Bearer biological asset                                | 51,100,684 at D₀, 5471,109 at D₁, 559,198 D₁ – D₂ | Estimated from experience with a similar scenario. Assumed to be purchased from the household sector.                                                                                                                          |
| Revenue from sale of progeny                           | 51,306,492 D₀ – D₁, 558,918 D₁ – D₂ | Target livestock number to facilitate ecosystem condition improvement modeled as a factor of 0.75 of the long-term carrying capacity based on ecosystem condition at D₀ and used to estimate the amount by which the breeding herd needed to be reduced. |
| Purchase of goods and services for ecosystem restoration between D₁ and D₂ (Liability 1) | 3,706AE D₁ – D₂ | Number of breeding cows sold (from above) multiplied by $53.89/AE (as for progeny sold).                                                                                                                                               |
| Reduction of bearer biological asset value (Liability 2) | 3,706AE D₁ – D₂ | Estimated from experience with a similar scenario. Assumed to be purchased from the household sector.                                                                                                                          |
| Revenue from sale of cows                              | 533,285,61 D₁ – D₂       | Number of breeding cows sold (from above) multiplied by $53.89/AE (as for progeny sold).                                                                                                                                               |
| Penalty for ecosystem degradation                      | 5643,676: contingent liability disclosed at D₁, 5379,128: Liability 3 recognized at D₂ | 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, we 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%. A period of 20 years for restoration to occur reflects the grazing land management research (Watson and Novelly 2012; Cowley and Walsh unpublished; Scanlan et al. 2014). |

*a* Operating leases in agriculture are treated as interest in EBIT calculations. The treatment of lease costs as expenses in the demonstration accounts do not reflect double-counting of the value of the ecosystem.

*b* Discount rates reflect the differing risk and return profiles of different classes of assets and investments.
would be recorded in supply–use tables for ecosystem services under SEEA. The accounts shown below for sustainable and actual flows of ecosystem services provide information about whether the sustainable use criterion has been satisfied and, together with the condition accounts for ecosystem assets, provide information about the change to condition. Table 2 shows that the area of ecosystems in each condition class has changed through the accounting period and this is reflected in a decline in the physical and monetary valuations of long-term carrying capacity. The net ecosystem services (sustainable less actual) of −9990AE in Table 2 provides 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 monetary value $289,731 of the degradation, equal to the decline in the value 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 the penalty for ecosystem degradation.

Table 3 shows the effect of reducing livestock numbers and other restoration interventions both on the estimated net ecosystem service flows and the improvement in condition. The ecosystem services accounts show a surplus of 6176AE of grazeable ecosystem biomass has been retained to rebuild ecosystem asset condition. The ecosystem asset accounts show condition of the ecosystem has improved with a net increase of 707AE of carrying capacity worth $119,078.

However, at D2, the long-term carrying capacity is still 1012AE below the starting point. The difference between long-term carrying capacity at D2 and D3 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.

**Capital statements following IAS**

The effects 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. 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.

**Government entity capital statements**

Table 4 shows capital statements reflecting the accounts of the model government entity for the 10-year period that its rangeland ecosystem is leased for use by HPCo.

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### Table 2. Ecosystem accounts D0–D1.

| Ecosystem services | D0 | Provisioning services: sustainable Inputs to livestock | Provisioning services harvested by livestock | D1 |
|--------------------|----|--------------------------------------------------------|---------------------------------------------|----|
| Sustainable flow of ecosystem services (AE/year): Date 0 to Date 1 (based on land condition at Date 0) | 33,300 | | |
| Actual flow of ecosystem services (AE/year): Date 0 to Date 1 (imputed from number of livestock) | 43,290 | | |
| Ecosystem assets | | | | |
| Ecosystem Condition: Area in A condition (ha) | 22,500 | Increases | 13,500 | 9000 |
| Ecosystem Condition: Area in B condition (ha) | 49,500 | | 28,800 | 20,700 |
| Ecosystem Condition: Area in C condition (ha) | 13,500 | 37,800 | | 51,300 |
| Ecosystem Condition: Area in D condition (ha) | 4500 | 4500 | | 9000 |
| Physical value: Carrying capacity for livestock | 6660 | | 1719 | 4941 |
| Monetary value: Carrying capacity for livestock | $1,122,516 | | $289,731 | $832,786 |

### Table 3. Ecosystem accounts D1–D2.

| Ecosystem services | D1 | Provisioning services: sustainable Inputs to livestock | Provisioning services harvested by livestock | D2 |
|--------------------|----|--------------------------------------------------------|---------------------------------------------|----|
| Sustainable flow of ecosystem services (AE/year): Date 1 to Date 2 (based on land condition at Date 0) | 24,705 | | |
| Actual flow of ecosystem services (AE/year): Date 1 to Date 2 (imputed from number of livestock) | 18,509 | | |
| Ecosystem assets | | | | |
| Ecosystem condition: area in A condition (ha) | 9000 | 4500 | | 13,500 |
| Ecosystem condition: area in B condition (ha) | 20,700 | 15,300 | | 36,000 |
| Ecosystem condition: area in C condition (ha) | 51,300 | 19,800 | | 31,500 |
| Ecosystem condition: area in D condition (ha) | 9000 | | | 9000 |
| Physical value: carrying capacity for livestock | 4941 | 707 | | 5648 |
| Monetary value: carrying capacity for livestock | $832,786 | $119,078 | | $951,864 |
They record the owner’s opening equity and how this changes in response to the income from the operating lease, the impairment of the ecosystem asset at D1, and a subsequent partial reversal of the impairment by D2. 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 $208,476 (8%) in owner’s equity over the course of the agreement providing them with resources available to invest in restoration of ecosystem condition.

**HPCo capital statements**

Table 5 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 is not shown in capital statements. The cash-at-bank entry for D1 reflects the net income from sale of progeny between D0 and D1 of $1,306,492 less rental expenses of $762,570 for the operating lease. At D2, the cash-at-bank reflects a reduced income of $559,198 from sale of progeny (due to the reduced number of breeding cows), but also reflects the income of $332,856 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).

The last row in Table 5 is not an entry in the accounts. It is a disclosure by HPCo to its stakeholders 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 $643,676 in accordance with AAS137 (AASB 2015a). When the final condition assessment is made at D2, and the penalty is unavoidable, the valuation is recognized as a liability (as an account payable) of $379,128, reflecting the improvement of ecosystem condition since D1.

The illustrative accounts show that the pastoral company experiences a $375,298 (34%) reduction in owner’s equity as a result of their inability to maintain ecosystem condition.

**National accounts tables**

The national accounts tables 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 recognized at D₀ 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 D₀ (Opening balance sheet Table 6) whose value will be unwound over the two accounting periods and entries for an accounts receivable/payable pair has been established in the financial accounts.

**Demonstration national accounts tables for D₀ to D₁**
The opening balance sheet (Table 6) shows the scenario entries for D₀.

In Table 7, output is equivalent to the revenue generated by both parties. 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 (Tables 6 and 7).

Table 8 shows other changes between D₀ and D₁ in capital and financial accounts covering changes in the ecosystem assets and in the financial assets. Table 9 shows the closing balance sheet at D₁ (Table 9).

**Demonstration national accounts tables D₁ to D₂**
The opening balance sheet for D₁ is the same as the closing balance for D₁ and is not separately shown. The first table shown for the scenario period D₁–D₂ is the production account. Table 10 records entries for the production account for the period D₁–D₂. In this period, the output of the pastoral sector reflects the reduced revenue resulting from the reduction of the breeding herd.

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**Table 6. Opening balance sheet at D₀**

|                   | Government | Pastoral sector | Households | Total economy |
|-------------------|------------|-----------------|------------|--------------|
|                   | Assets     | Liabilities/   | Assets     | Liabilities/ | Assets     | Liabilities/ |
|                   | net worth  | net worth       | net worth  | net worth    | net worth  | net worth    |
| Produced non-financial assets | 1,100,684 | 1,100,684       |            |              |            |              |
| Cultivated biological assets |            |                 |            |              |            |              |
| Non-produced non-financial assets | 1,122,516 | 1,122,516       |            |              |            |              |
| Rangeland ecosystem – pastoral use | 1,525,140 | 1,525,140       |            |              |            |              |
| Operating lease – pastoral ecosystem |          |                 |            |              |            |              |
| assets/liabilities |            |                 |            |              |            |              |
| Currency and deposits | 1,525,140 | 1,525,140       |            |              |            |              |
| Accounts receivable/payable |          |                 |            |              |            |              |
| **Net worth D₀** | 2,647,656 | 1,100,684       | 3,748,340  |              |

**Table 7. Production account for D₀–D₁**

|                   | Government | Pastoral sector | Households | Total economy |
|-------------------|------------|-----------------|------------|--------------|
|                   | Uses       | Resources       | Uses       | Resources    | Uses       | Resources    |
| Output            | 762,570    | 1,306,492       |            |              | 2,069,062  |              |
| Intermediate consumption | 762,570 | 1,306,492       |            |              | 2,069,062  |              |
| Value added, gross/gross domestic product | 762,570 | 543,922         |            |              | 1,306,492  |              |
| Consumption of fixed capital |          |                 |            |              | 1,306,492  |              |
| Value added, net/net domestic product | 762,570 | 543,922         |            |              | 1,306,492  |              |

**Table 8. Capital and financial accounts D₀–D₁**

| Changes during the period | Government | Pastoral sector | Households | Total economy |
|---------------------------|------------|-----------------|------------|--------------|
|                           | 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           | -289,731  | -289,731        |            |              | -289,731  | -289,731        |
| Other changes in volume account |          |                 |            |              | 1,306,492  |              |
| Economic disappearance of assets | -289,731  | -289,731        |            |              | -289,731  | -289,731        |
| Financial account         | 762,570   | 543,922         |            |              | 1,306,492  |              |
| Currency and deposits     | -762,570  | 722,570         | 40,000     |              | -722,570  | -722,570        |
| Accounts receivable/payable | -762,570  | 722,570         | 40,000     |              | -722,570  | -722,570        |

*There are no matching transaction for economic disappearance/appearance, except in goods and services (not shown).
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 11 shows the capital and financial accounts for the accounting period D1–D2. Key entries reflect the improved condition of the ecosystem asset ($119,078), the reduction in the breeding stock (−$629,575), 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 ($379,128).

The final table lists the changes to net worth for each of the participants in this scenario (Table 12).

Table 13 shows where change is derived from net worth at D2 less net worth at D0 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.

### Discussion

To explore the challenges in accounting for liabilities for ecosystem degradation described in the SEEA Tech. Rec., this paper 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 modeled data in the development of realistic physical and financial values to explore the accounting for related liabilities.
Table 12. Closing balance sheet for scenario D2

| Closing balance sheet: D2 | Government | Pastoral sector | Households | Total economy |
|--------------------------|------------|-----------------|------------|---------------|
|                         | Assets     | Liabilities/net worth | Assets     | Liabilities/net worth | Assets     | Liabilities/net worth |
| Produced non-financial assets | 2,856,132 | 725,386          | 40,000     | 379,128        | 3,621,518 | 379,128         |
| Cultivated biological assets | 375,298   | 130,822          | 126,822    | 3%             | 379,128   | 379,128         |
| Non-produced non-financial assets | - | -                | -          | -              | -         | -               |
| Rangeland ecosystem – pastoral use | - | -                | -          | -              | -         | -               |
| Operating lease – pastoral ecosystem | - | -                | -          | -              | -         | -               |
| Financial assets/liabilities | 3,748,340 | 3,621,518        | 471,109    | 471,109        | 3,748,340 | 3,621,518        |
| Currency and deposits | 1,525,140 | 633,406          | 3,621,518 | 379,128        | 3,748,340 | 3,621,518        |
| Accounts receivable/payable | 379,128   | 40,000           | 379,128   | 379,128        | 379,128   | 379,128         |

Table 13. Change in net worth between D2 and D3

| Change in net worth ($) | D2       | D3       | Change |
|-------------------------|----------|----------|--------|
| Government              | 2,647,656| 2,856,132| 208,476|
| Pastoral businesses     | 1,100,684| 725,386  | -375,298|
| Pastoral services sector| -        | 40,000   | 40,000 |
| Total “economy”         | 3,748,340| 3,621,518| -126,822 (3%)|

Finally, with respect to the challenge of avoiding double-counting in the derivation of net worth, the paper demonstrates this requires assessing two impacts of degradation; the decline in asset value and a value of economic loss while restoration occurs.

Ecosystem assets in this paper 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 net present value (NPV) of the ecosystem services (forage for grazing livestock) assuming a 10-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 and 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, we 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 paper to produce a demonstration of accounting for ecosystem degradation that showed the accounting transactions and the impact of degradation on the economy.

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. 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; Ogilvy and Vail 2018) and may prevent users of an ecosystem from overestimating its capacity to help them meet financial commitments.

Through the accounts presented in this paper, 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, 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 paper has demonstrated a current limitation in the SEEA-EEA with respect to recording sustainable flows of ecosystem services. 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 are not presently recorded in the SEEA-EEA it is recommended that guidance be developed to allow this issue to be handled.

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 paper 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 organizations 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 does not currently exist.
Conclusion

This paper demonstrates accounting, subject to the availability of reliable and just methods of defining ecosystem condition and attributing change in condition to human use, for ecosystem degradation that is consistent with IAS, AAS, SNA, and SEEA accounting frameworks. The explicit application of IAS and national accounting standards enables valuation of assets and liabilities that faithfully represent these concepts. The paper demonstrated that the application of rules of recognition under accrual accounting addresses the question of when liabilities should be recognized and confirmed that liabilities should be recognized 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 have demonstrated they can fulfill 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 financial accounts have demonstrated the timing of recognition of the liabilities and the related expenses in response to this obligating event.

This paper also demonstrates 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.

Further development of these accounting treatments is needed to incorporate the value of regulating and cultural services and to establish guidelines for discount rates and time periods for use in estimating the NPV of ecosystems. The implementation of ecosystem accounts to complement financial accounts would give sustainability-conscious corporations greater ability to influence development of markets for agricultural products that have better environmental performance. They would also assist governments enforce the ecological sustainable clauses of the current land acts and enable leading land managers to clearly demonstrate their environmental credentials in domestic and international markets.

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