

# LESSONS, GAPS AND RECOMMENDATIONS

NATURAL CAPITAL ACCOUNTING  
IN THE MINING SECTOR

Beenup Site Pilot Case Study  
Technical Advisory Group



**Report initiated by:**

# BHP

**Report prepared by:**



#### CITATION

WABSI. (2023). *Lessons, gaps and recommendations*. The Western Australian Biodiversity Science Institute, Perth, Western Australia.

ISBN: 978-0-646-88087-7

May 2024

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FRONT COVER IMAGES: BHP



## THE TECHNICAL ADVISORY GROUP

WABSI played an integral role on the Beenup Natural Capital Accounting Technical Advisory Group for BHP's Beenup Site Pilot Case Study.

This report is a reflection on the lessons learnt, the gaps and recommendations from the work undertaken during this project.

The full case study, published by BHP, can be accessed here: [Beenup Site Pilot Case Study](#) (ISBN: 978-0-6456956-0-1)

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We acknowledge the contributions of Kathy Meney (Syrinx Environmental) in the preparation of this report.

### Acknowledgement of Country

We acknowledge the traditional custodians throughout Australia and their continuing connection to, and deep knowledge of, the land and waters. We pay our respects to Elders both past and present.

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# 1. EXECUTIVE SUMMARY

BHP has flagged a desire to develop natural capital accounting as part of its 2030 social value scorecard. BHP's closed Australian mineral asset site (Beenup Titanium Project) has provided an ideal opportunity for a pilot case study to trial the application of natural capital accounting within the mining sector. The terms Environmental Economic Accounting (EEA) and Natural Capital Accounting (NCA) are often used interchangeably and are conceptually similar. In practice, EEA tends to be used more within the context of policy making and regional and/or national accounting whereas NCA is being more widely used in the context of the private sector. Regardless, they share a common purpose to better understand the environmental inputs into economy.

Despite the concept of NCA being around for many years, there has been a marked uptick in interest in its application in the last five years, particularly amongst the private sector. Drivers for this are many, but at its core it has been driven by a need to transition to a more sustainable economy and growing calls for greater transparency and disclosure of environmental impacts and dependencies. Despite this, capability in both the compilation and interpretation of NCA is still relatively low and there are important barriers to adoption that need to be addressed if mainstreaming of the practice is to be achieved. From this perspective, the Beenup pilot case study has provided useful insights into the process. The example natural capital accounts developed as part of the pilot case study seek to present a picture of the changes in natural capital under management prior to and during mine operations and throughout the post operations restoration phase. They show an approach to illustrating, using ecosystem accounting processes, net gains in a number of aspects of nature over the 30+ years of management. At the time of writing this report, the example accounts have not been reviewed extensively externally and ultimately this will be an important test of their utility.

As a data driven exercise, the Beenup pilot case study was well positioned for the development of example accounts given the considerable investment into monitoring over the life of the project. As such, the Beenup example accounts were well-developed and addressed the main thematic areas of: extent, condition and ecosystem services, with only limited additional data collection required. While individual asset accounts will be useful, the integration to an organisational scale will be important to provide a more complete picture of BHP's management of natural capital. At the broader

organisational scale, a challenge will be developing consistent approaches to classification, mapping and condition assessment across the various assets and jurisdictions. Future adoption of natural capital accounting should consider this carefully as Australia does not currently have consistent approaches to these challenges. Similarly, quantification and valuation of ecosystem services is likely to vary significantly across assets, although some ecosystem services may be somewhat generic. Identifying ecosystem services that the company considers to be important to its environmental and social objectives (materiality assessment) would be useful to inform a common approach of assessment across all operated assets. For example, quantification of global climate regulation services and its role in achieving net zero greenhouse gas emissions. If pursued, it is also recommended that in house capacity and expertise be developed to support consistency across assets in the quantification and valuation.

Valuation of ecosystem services and the underlying ecosystem assets is an area that is continuing to develop. Noting that there are potentially many approaches to the valuation problem, The United Nations Statistical Commission's System of Environmental and Economic Accounting framework for Ecosystem Accounts (SEEA-EA) has a focus on monetisation, particularly exchange values. The monetisation approach to valuation is often applied but can be easily mis-interpreted. Care should be taken in doing so and we recommend that accounts that contain both physical and monetary values are preferable to accounts where valuations are only expressed in monetary terms. This may be particularly important in the resources sector where monetisation may be viewed by some as commodification of nature, even though this is often not the purpose of the valuation. This may be further complicated by presenting accounts in a format similar to financial statements such as the profit and loss statement or balance sheet.

Regardless of this conceptual challenge, an important goal of natural capital accounting is to better integrate financial and natural capital information, and it is recommended that presentation of accounts in formats similar to the Profit & Loss statements and balance sheets should be pursued, particularly from the perspective of summarising quite complex data and concepts. One caveat is that this presentation format is still in its infancy and its utility should be tested with a range of internal and external stakeholders. Furthermore, ultimately should natural capital accounting become a more mainstream process,

auditing and assurance of natural capital accounts will also mature as a mechanism to give users of the accounts' confidence.

The compilation of natural capital accounts is achievable within BHP, but broader adoption still has a number of relatively high entry barriers, including cost, efficiency and an understanding of the utility of the information. From this perspective, the Beenup pilot case study has contributed to building capability both within and outside of the organisation and thus has been a valuable exercise with some important lessons learnt. Broader adoption will need to address these challenges. The field is emerging quickly, and standards are likely to emerge and will be accelerated by initiatives such as the TCFD and the TNFD. This will address some of the challenges, but the broader utility of natural capital accounts remains to be tested. Ultimately the value of natural capital accounts will be their utility internally in driving the management of the organisation's ecosystem assets and the organisation's disclosure of its environmental performance to the broader market.

Natural capital accounting is likely to continue to attract significant interest. To the best of our knowledge, the Beenup pilot case study represents one of the first attempts at NCA in the mining sector. As a case study, it has demonstrated that NCA is achievable within the mining sector, noting that this case study was undertaken at a relatively small project site where data availability is good, and the growing sophistication of data service providers should enhance this capacity. Key conceptual challenges remain around the reporting and disclosure of natural capital data, valuation of ecosystems and ecosystem services, integration with financial accounts and an understanding of the utility of natural capital accounts to meet organisational requirements as well as driving efficiencies in sustainability disclosure reporting requirements.



## 2. BACKGROUND

BHP's 'Beenup' Titanium Minerals Project is a 700-ha site located 16 km northeast of Augusta, in south west Western Australia. Prior to acquisition, the site was used primarily for dairy operations. The mineral sands operation was explored by BHP in the 1980s and 1990s with mining operations commencing in 1997, having an expected operating life of 20 years. However, due to operational and/or technical reasons, the mine was decommissioned shortly after commencement and has since been subject to rehabilitation in line with the WA legislation. At the time of mine closure, approximately 355 ha of land had been disturbed including the development of a 40 ha dam and 2.1 km dredge pond.<sup>1</sup> Post completion of the operational mining phase, in consultation with community, BHP developed a restoration plan that was primarily focused on:

- Establishing permanent wetlands and native vegetation that develops a link with the Scott National Park to the south, where the wetlands receive, filter and provide water for rivers and creeks downstream of the site.

Restoration activities commenced in 1997 and were monitored until completion criteria were met in 2018, although some monitoring of spillways and other engineered structures is ongoing. The site's restoration is considered to be an example of world's best practice.<sup>2</sup> A timeline summarising the operations at the Beenup site is shown in Figure 1 and an aerial view of the project site is shown in Figure 2.



FIGURE 2. BHP Beenup Titanium Minerals Project

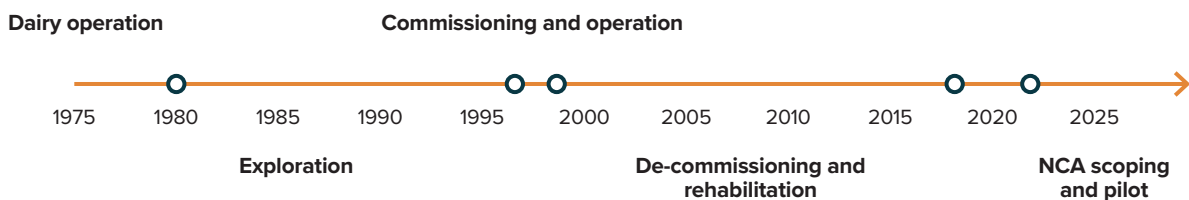


FIGURE 1. Timeline of the Beenup Titanium Minerals Project in SW Western Australia

<sup>1</sup> <https://www.bhp.com/news/case-studies/2018/08/closure-and-water-management-at-beenup>

<sup>2</sup> <https://www.mindat.org/loc-272647.html#:~:text=The%20Beenup%20mineral%20sands%20mine,two%20years%20in%20April%201999>



Due to BHP’s history with the site during the exploration, mining and restoration phases, the project provided an ideal opportunity to pilot the application of natural capital accounting in the mining sector as:

- the project has a long history of data collection and monitoring over the life cycle of changing land use from farming to operating mine site, to ecological restoration;
- the project retains significant corporate memory, including long-standing relationships with the site’s operational staff, consultants and community stakeholders; and
- the attention to detail in the ecological restoration and clearly defined community expectations focussed on achieving what would today be termed ‘nature positive’<sup>3</sup> outcomes provide a unique opportunity to test the application of emerging environmental accounting approaches to meet the rising demand for increased reporting and disclosure of environmental performance.

## 2.1 Objectives of the Natural Capital Accounting for the Mining Sector: Beenup Site Pilot Case Study

The primary objectives of the Natural capital accounting for the mining sector — Beenup site pilot case study were to:

- trial the application of the United Nations System of Environmental-Economic Accounting, Ecosystem Accounting (United Nations 2021);
- support BHP’s commitments to the Taskforce on Nature-related Financial Disclosure (TNFD) Forum, of which it is a member;
- identify the challenges and data requirements associated with integrating natural capital into company operations more widely; and
- support the development of NCA capability within the mining sector.

The development of the example accounts was led by Director of Syrinx Environmental, Kathy Meney and team. The project was overseen by a Technical Advisory Group charged with the purpose of providing project oversight and advice to the Syrinx team. The main outcome from the project is a set of example natural capital accounts for the Beenup Titanium Project:

*BHP (2023). Natural Capital Accounting for the Mining Sector: Beenup Site Pilot Case Study. Perth, Western Australia, pp 120*

Members of the Technical Advisory Group (TAG) are shown in Table 1.

**TABLE 1. Membership of the Beenup Natural Capital Accounting Technical Advisory Group**

Name	Organisation	Role
Anthony O’Grady	CSIRO	Chair, TAG
Graham Oborn	BHP	BHP representative
Tim Cooper	BHP	BHP representative
Stephen White	BHP	BHP representative
Bryan Maybee	Curtin University/CRC TiME	Mining engineer/Environmental accountant
Ram Pandit	UWA	Environmental economist
Owen Nevin	WABSI	Chief Executive Officer
Renee Young	WABSI	Program Director, Conservation and Restoration

<sup>3</sup> A high-level goal and concept describing a future state of nature (e.g. biodiversity, ecosystem services and natural capital) which is greater than the current state. This definition comes from the Taskforce on Nature-related Financial Disclosures (TNFD) Framework – Beta release v0.1.

## 2.2 The role of TAG and the purpose of this report

One of the roles of the TAG was to provide a summary of the lessons learnt associated with the natural capital journey in the Beenup Titanium Project pilot case study. These lessons could then be used to inform future expansion of natural capital accounting in the organisation, as well as more broadly across the mining industry globally.

In essence, the TAG evolved into a multidisciplinary forum for debate on key concepts, challenges, and approaches for addressing these challenges. As the field evolves, multi-disciplinary forums such as the TAG will play an important part in the role out of natural capital accounts, as they provide a forum to rapidly address challenges and disseminate learnings.

The TAG met at least weekly throughout the pilot case study's life and acted as a forum to discuss the many technical and conceptual challenges faced by the pilot case study. Throughout the pilot case study life TAG meetings were minuted, and these have formed the basis for a summary of the issues encountered, lessons learnt and the data gaps that were identified. These have formed the basis of this report, which sets out that summary of the lessons learnt and high-level recommendations.



# 3. SUMMARY OF LESSONS LEARNT AND HIGH-LEVEL RECOMMENDATIONS

High-level insights and lessons learnt during this process are summarised here. More detail is presented in Section 4 of this report. The lessons and recommendations are summarised into four themes:

- Concepts
- Data requirements
- Frameworks
- Reporting and disclosure

Under each theme, key issues associated with the natural capital accounting pilot case study are identified, and lessons learnt, and recommendations are made for future pilots or applications.

## 3.1 Concepts

Natural capital accounting within enterprises sits at the intersection of a number of concepts that are widely used and often confused when considering broader corporate environmental accounting and disclosure requirements. Historically, environmental accounting was developed to support better understanding of the environmental inputs into the economy and was designed to be compatible with the System of National Accounts (SNA)-at a national scale. As more corporate organisations trial the application of environmental accounting at the enterprise scale, there is growing recognition that the principles within SEEA can be applied at the scale of enterprises, particularly those that manage or own natural capital. Specifically, ecosystem accounting (United Nations 2021) provides a useful framing of nature's inputs, ecosystem services, into production that is currently lacking in corporate accounting. Existing accounting practices will already incorporate many environmental commodities, such as the mineral resource that are more formally incorporated in the SEEA Central Framework (United Nations 2014) and it probably doesn't make sense to try and recast this. The ecosystem accounting perspective, however, provides a framing that is currently missing in enterprise accounting and explicitly recognises the unique role that ecosystems play in providing a range of provisioning, regulating and cultural ecosystem services that the business and society more broadly are more or less dependent on or potentially impact. Indeed, it is the recognition that the invisibility of these impacts and dependencies has contributed to the ongoing degradation of nature's

assets, the associated loss of ecosystem services and has potential to create material risks for business that has become the focus of initiatives such as the Natural Capital Protocol (Coalition 2016) and the Taskforce on Nature-related Financial Disclosures (TNFD). Given the growing calls for disclosure of these impacts and dependencies on ecosystems, ecosystem accounting concepts of the United Nations SEEA-EA provide a useful framework that is readily translated into this space.

**RECOMMENDATION:** *That the mining sector continues trialling application of the United Nations System of Environmental Economic Accounting-Ecosystem Accounting as the underlying statistical approach for the future development of natural capital accounts.*

## 3.2 Data requirements

The development of natural capital accounts is a data intensive exercise. The ecosystem accounting perspective requires data on the extent and condition of underlying ecosystem assets, and an understanding of the flows of the ecosystem services generated by the assets to facilitate the valuation of those ecosystems (Hein et al. 2016). The Beenup pilot case study was data rich, and although the Beenup Titanium Project has not been operational for many years, there was an excellent knowledge of the underlying data and monitoring programs to facilitate the development of natural capital accounts. This bodes well for other sector assets. However, mining assets occupy a broad range of ecosystem types across a number of Australian and global jurisdictions. This will create challenges for individual organisations and the sector more broadly as it looks to scale learnings across the country. For example, Australia does not have a nationally agreed ecosystem classification typology, noting that progress towards a national aquatic ecosystems classification is further advanced than for terrestrial or marine ecosystems. Furthermore SEEA-EA, recommends that ecosystem reporting be consistent with the IUCN Global Ecosystem Typology (Keith et al. 2020).

**RECOMMENDATION:** *Develop nationally consistent framework of ecosystem classifications that conforms to the IUCN Global Ecosystem Typology (Keith et al. 2020) with approaches for adaptation to local scales. Moving towards an agreed organisational typology and methodology for mapping ecosystem assets will be important for consistency in data collection and organisation wide accounts. There will be opportunities to collaborate with other organisations that are currently facing similar challenges.*

Estimating condition of ecosystem assets is an important component of ecosystem accounting for which standardised practice is yet to emerge. Although SEEA-EA provides guidance on the framing of condition indicators it does not prescribe approaches to condition assessment. As for ecosystem mapping, states and territories have adopted a range of approaches for classifying ecosystem condition and these are not necessarily consistent across jurisdictions, although there are similarities in approaches. A consistent ecosystem typology should improve the efficiency of ecosystem condition assessment. The Beenup pilot case study developed an ecosystem condition methodology that links the SEEA EA condition approaches, with data likely to be widely available within the mining sector and linked with the Standards for Ecological Restoration (Young et al. 2022). The ecosystem condition approach from SEEA-EA provides the objective data to support the assignment of the SER scales, and hence can be a powerful way to standardise ecosystem assessments and reduce the level of subjectivity currently inherent in the way the SER is being applied. There also are a number of approaches emerging in Australia to address this gap including the Accounting for Nature ECond (Wentworth Group 2008) and the Australian Ecosystem Models Framework (Richards et al. 2020).

**RECOMMENDATION:** *Building on the development of a consistent ecosystem typology across assets, develop a nationally consistent approach to condition assessment to facilitate efficiency in ecosystem mapping and condition accounting across assets and facilitate organisation wide reporting.*

Recommendation: Develop a ‘calibration and validation’ approach to asset condition assessment. The scale of mining operations across the globe will necessitate, wherever possible, the utilisation of remote sensing data and associated models that will require validation. It will not be feasible, in the long-term, to comprehensively measure the condition of ecosystem assets using on ground measures. However, the extent of monitoring could provide very useful inputs to validate models of ecosystem condition. To some extent this is already happening and so this field will advance quickly, and future remote sensing approaches validated with existing on ground data collection will provide a powerful approach to future account compilation.

**RECOMMENDATION:** *Look to develop standards for the validation of on ground and remotely sensed data, with associated approaches for defining confidence.*

There are large number of ecosystem services that could potentially be measured and addressed. For example, the Common International Classification of Ecosystem Services for Environmental and Economic Accounting (CICES V 5.1) categorises 67 biotic and 31 abiotic ecosystem services. The SEEA framework clearly defines the concept of final ecosystem goods and services (and adopts CICES as the recommended typology), and this is important because of its relationship with the SNA. However strictly adhering to the concept of final ecosystem goods and services at a corporate (or management) level risks missing important information on ecosystem functioning. There is ongoing work on approaches to accounting for ‘intermediate’ ecosystem services and this is likely to develop more in coming years. Regardless, it will not be feasible to tackle quantification and valuation of all identified ecosystems services as these are often data poor even though they may be well parameterised. Where models do exist, they may represent steady state concepts or be poorly calibrated to local conditions, impacting their utility in accounts.

**RECOMMENDATION:** *Organisations in the mining sector should conduct a ‘materiality’ assessment of the ecosystem services that it wants to address through natural capital accounting. Effort should be focussed on quantifying and valuing a few ecosystem services well rather than many partially. Global imperatives such as net zero greenhouse gas emissions and the emerging Nature Positive agenda and how these align with organisations’ own objectives and social values statements will provide context for identifying this subset of ecosystem services (e.g. global climate regulation). At local scales, acknowledgement of important ecosystem services may necessitate new data collection.*

### 3.3 Frameworks

SEEA-EA accounting concepts are well suited to natural capital accounting at an enterprise scale. There is ongoing development of its application to enterprise accounting within the United Nations and the Beenup pilot case study will be of great interest to this working group. SEEA-EA has arrived at an international consensus that will most likely form the basis of future standards in natural capital accounting.

There is considerable rhetoric associated with natural capital in the market at the moment. The Beenup pilot case study has assisted in developing an understanding of the different purposes and approaches to natural capital accounting and natural capital assessment. It is

also one of the few attempts at integrating both natural capital accounting and the impacts and dependencies thinking associated with natural capital assessment. It was also the first attempt at populating the frameworks developed by Smith et al. (2022) which are designed to strike a balance between practical applicability and consistency with the SEEA framework, while also being broadly consistent with international financial accounting standards. Driving efficiency and consistency in reporting will be an important component of the value proposition for broader uptake of natural capital accounting and assessment, particularly in light of developments in relation to TCFD, TNFD and emerging standards for sustainability accounting. The project was not able to fully explore this integration, however there remains a need to present to market an integrated natural capital account and assessment.

**RECOMMENDATION:** *Continue to explore the potential to build and develop this integrated reporting approach. This will be advanced through the Department of Climate Change Energy the Environment and Water (DCCEEW) mining sector project and the Beenup pilot case study is well advanced down this path. Further development should include testing with both internal and external stakeholders.*

### 3.4 Reporting and disclosure

Presenting the wealth of ecosystem information contained in natural capital accounts in a readily digestible format represents a significant challenge. Across the four thematic areas of extent, condition, ecosystem services and benefits, ecosystem accounts are rich with spatially and temporally explicit data. The presentation and interpretation of this data which is normally presented as tables, charts and maps can be overwhelming, especially during the early phases of adoption where readers of the accounts may not be completely familiar or comfortable with the information. To address this, the Beenup pilot case study trialled the application of ecosystem equivalents of the financial profit and loss statement and balance sheet.

Similarly, the concept of ecosystems as assets is well established in SEEA-EA (Hein et al. 2016). However, incorporation of these assets into extended balance sheets of a corporate entity remains in its infancy. This created a number of conceptual challenges for the team. In contrast to assets normally owned, controlled and reported on by an entity, ecosystem assets represent a potential store of future value to both the enterprise and broader society. In many cases, particularly in the mining sector the 'value' associated with flows of

ecosystem services from these assets is typically greater to society than to the business (hence their historical consideration as externalities). Given this limited internal benefit flow, many ecosystem assets may fail materiality criteria for incorporation into an organisation's balance sheet. This perpetuates the treatment of the ecosystems as externalities, a framing that has contributed to the degradation of environment. As a general observation, the presentation and summary of the underlying accounts into conceptualised profit and loss and balance statements is appealing to organisations as they are already familiar with the financial equivalents of this presentation. The Beenup pilot case study has helped to indicate that natural capital accounts are amenable to this presentation format, although there remain conceptual challenges and the underlying standards and concepts are still developing and will continue to evolve.

**RECOMMENDATION:** *Continue to support/develop this format of reporting, ultimately aiming for more formal integration of the financial and natural capital statements. While some of this will be progressed as part of ongoing work through DCCEEW funded projects and the Pathway to Nature Positive<sup>4</sup> project and an early standard has been developed (British Standards Institution 2021), there is good potential for the mining industry to contribute to future developments.*

**RECOMMENDATION:** *This form of presentation should be tested further with internal and external stakeholders to ensure that it meets their needs for environmental disclosure.*

#### A note on valuation

The monetisation of ecosystem assets and their associated services has a long history in the ecosystem services literature. Throughout this journey, the debate has shifted from a utility primarily focussed on driving conservation outcomes to one focused on the commodification of ecosystem services through the development of markets or market-based instruments (Gómez-Baggethun et al. 2010). The prospect of monetising ecosystem services has been an important driver for the adoption of natural capital accounts in the private sector (van Putten et al. 2021). However, the concept that nature is being commodified is one that has attracted and will continue to attract debate and criticism (Matulis 2014, Masood 2022). Used thoughtfully, valuation through monetisation can be a powerful tool. Careful consideration of the purpose of the monetisation and the associated approaches to valuation are required if this path is to be pursued, particularly in the resources sector where the potential for monetary valuations to be misinterpreted is high. It is important to note that valuation does not necessarily require that ecosystem services be monetised (i.e., there can be

<sup>4</sup> The Pathway to Nature Positive project is a collaboration between BHP and CSIRO looking at approaches to developing nature-positive plans for landscapes that BHP operate in.



socio-cultural approach to valuation), and monetisation does not necessarily imply a commodification of nature, although this nuance is not widely appreciated. There was considerable debate on this particular topic within the TAG and Beenup pilot case study teams. For example, a key insight was that debates about the choice of appropriate discount rates used to calculate the net present values of ecosystem service flows quickly distracted from the quantum of the ecosystem service and the purpose of the valuation. To address this, the ecosystem services were presented in both physical and monetary terms.

It is important to note that valuation is not about the commodification of nature but can be useful in a number of ways. These include, for example, understanding the importance of natural assets for all the socio-economic outcomes they support (market and non-market), supporting decision makers allocating capital resources; giving a monetary value can help ensure the conservation/restoration of nature is valued commensurately to other capital projects for which there are existing monetary/market values.

The valuation and reporting of these values associated with nature is likely to develop considerably during the next decade. The SEEA-EA considers the exchange values but not the welfare values which is being estimated by valuation methods. Both conceptual and methodological challenges remain in valuing intangibles or non-use values (option, existence etc.) of biodiversity/ecosystems and ecosystem service flows.

**RECOMMENDATION:** *Avoid presenting profit and loss and balance sheets as only monetary values of ecosystem services or their underlying assets. Where possible, use a mix of both physical and monetary values, but where contentious or there is a high degree of uncertainty in the valuation process use only the physical. Continue to build literacy in the purpose of valuation, approaches to valuation and methodological expertise.*



# 4. LESSONS LEARNT

## 4.1 Concepts

Natural capital refers to the stocks of renewable and non-renewable resources (water, minerals, timber, ecosystems etc.) that combine to produce flows of benefits to humanity. In this framing of nature as capital, all of humanity and its institutions are dependent on natural capital to some extent. Associated with the rise of natural capital has been a proliferation of concepts, frameworks and initiatives that have created considerable confusion within the global community. While there is general agreement on the term natural capital, noting that the framing of nature as capital does have its critics, the relationships between natural capital, natural capital accounting, natural capital assessment and natural capital risk assessment are not always clear.

Natural capital accounting has been defined as: the process of compiling consistent, comparable and regularly produced data on natural capital and the flow of services generated in physical and monetary terms (Lammerant 2019).

Natural capital assessment refers to: the systematic process of identifying, measuring and valuing relevant natural capital and its impacts and/or dependencies (Lammerant 2019). This differs from natural capital

accounting as the focus is on impacts and dependencies rather than stocks and flows. i.e. a natural capital account might support a natural capital assessment, but natural capital accounts are not necessarily a precursor for a natural capital assessment.

Natural capital risk assessment is defined as the process of identifying, measuring and evaluating material risks associated with an organisation's impacts and dependencies on natural capital (Lammerant 2019). Here the concept of 'materiality' is similar to the concept of financial materiality. In natural capital assessments and risk assessments, materiality is interpreted as anything that has reasonable potential to significantly alter decisions (Smith et al. 2020).

Natural capital reporting and disclosure involves the communication of natural capital related information to stakeholders internal and external to an organisation. Natural capital reporting and disclosure may be via standalone reports or be part of a broader disclosure regime through initiatives such the Global Reporting Initiative or the Taskforce on Nature related Financial Disclosures.

**TABLE 2. Detailed lessons associated with key concepts in Natural Capital**

Area	Lesson/Issue	Recommendation
EEA/NCA	Environmental Economic Accounting is conceptually similar to Natural Capital Accounting. Use of the latter is largely focused on environmental accounting in the private sector, for management, risk assessment and disclosure while the former is primarily focused at policy development.	<ul style="list-style-type: none"> <li>Recognise that there is considerable overlap in intent and purpose of NCA and EEA, noting that presentation and reporting of NCA will vary from the presentation of EEA.</li> </ul>

(Table 2 continued following page)

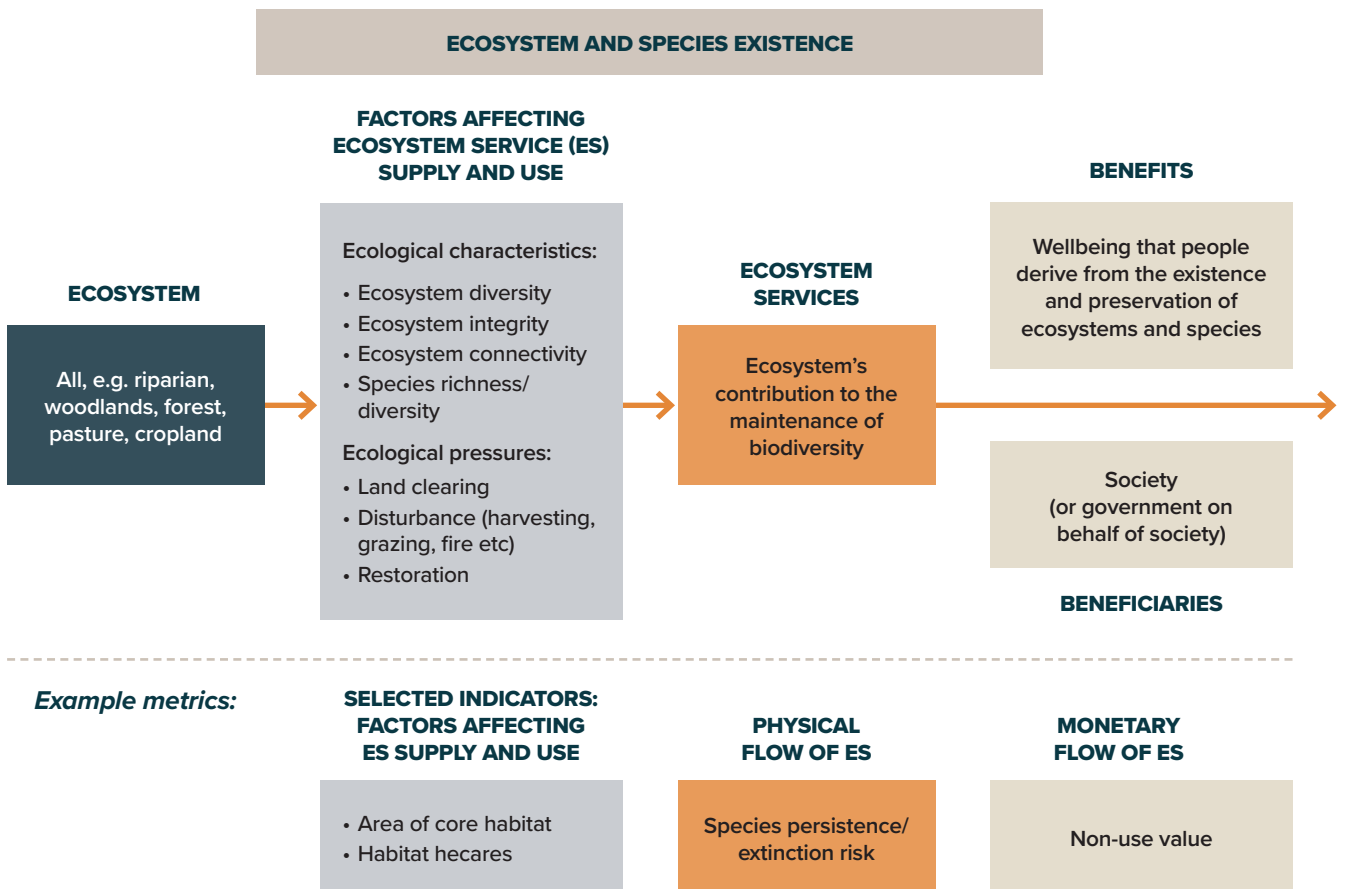
Area	Lesson/Issue	Recommendation
SEEA	<p>The SEEA is primarily designed to support the system of national accounts (SNA). Application of SEEA at corporate scales remains in its infancy, and thus strict compliance with the statistical standards is not always useful at a corporate level.</p> <p>Many of the environmental accounting concepts are directly relevant to the management, risk and disclosure requirements of organisations.</p>	<ul style="list-style-type: none"> <li>Continue to use and trial the application of SEEA principles in organisations.</li> </ul>
	<p>SEEA has created a working group to contribute to the harmonisation of public and private accounting, and to develop collaboration between the public and private sectors on natural capital data and accounting.</p>	<ul style="list-style-type: none"> <li>Consider exploring the potential of using this mechanism as a forum to promote the Beenup pilot case study and other work that BHP is doing in this area.</li> <li>Promote the Beenup pilot case study within the TNFD Forum to test utility of ecosystem accounts within the LEAP framework.</li> </ul>
SEEA framing	<p>Environmental accounting in SEEA encompasses two perspectives on the environment:</p> <ul style="list-style-type: none"> <li>Environmental resources</li> <li>Ecosystems</li> </ul>	<ul style="list-style-type: none"> <li>The incorporation of the un-mined mineral resource into a broader set of Natural Capital Accounts provides a unique and more holistic view of natural capital, however the consideration of mineral resource within Natural Capital Accounts is yet to be fully developed.</li> <li>Future natural capital accounting should focus on ecosystem accounting to support the broader nature positive agenda emerging as part of the Global Goal for Nature.</li> <li>Linking environmental and ecosystem assets together in one natural capital report will create a range of challenges that need deeper exploration.</li> </ul>
	<p>While benefits and beneficiaries are well defined in SEEA, recognition of the distribution of benefit across private benefit and social benefit for presentation within a corporate accounting context remains unresolved.</p> <p>The distinction of private benefits and societal benefits provides useful perspective on natural capital management.</p>	<ul style="list-style-type: none"> <li>Work with accounting standards to develop approaches to the reporting and disclosure of natural capital from a private benefit and benefit to society perspective.</li> </ul>
Ecosystem Accounting area	<p><b>UN definition:</b> The ecosystem accounting area is the geographical territory for which an ecosystem account is compiled.</p> <p><b>Suggested business definition:</b> The area, including the full suite of terrestrial, marine or aquatic ecosystems in modified and natural states owned or controlled (e.g. leased) by an entity for the purpose of running a business.</p> <p>Within a mining context the area of tenure under management is likely to change with changing operational context and will have implications for the framing of a net natural capital position.</p>	<ul style="list-style-type: none"> <li>Use the organisation's tenure boundaries to define the Ecosystem Accounting Area.</li> <li>Establish, <i>a priori</i>, the maximum extent to be considered within the life of the project as this will impact reporting as areas enter and leave ownership/control.</li> <li>Explore a range of accounting processes to accommodate the dynamic nature of tenures within profit and loss and balance sheets.</li> <li>Moving beyond SEEA reporting, the geographic extent on which impacts and dependencies are considered may be even broader than the assets owned or controlled by the entity considering those impacts and dependencies.</li> </ul>

(Table 2 continued following page)

Area	Lesson/Issue	Recommendation
<b>Ecosystem Classification</b>	SEEA-EA recommends the adoption of the IUCN Global Ecosystem Typology. However, Australia does not have nationally accepted ecosystem classification and associated typology, and the existing UN typology is potentially too coarse for operational use in Australia.	Resource companies typically have mineral assets across various Australian (and global) jurisdictions. To better facilitate the adoption of organisational environmental accounts, the sector should: <ul style="list-style-type: none"> <li>• Promote the adoption of a nationally agreed ecosystem typology aligned to the global classification.</li> <li>• Or consider investing in the development of a nationally consistent approach to ecosystem mapping across the reporting entity's operated assets that is consistent with the IUCN GET.</li> <li>• Where required, land use classifications should align with the Australian Land Use and Management Classification.</li> <li>• Classification of aquatic ecosystems should align the Interim Australian National Aquatic Ecosystems framework.</li> </ul>
<b>Ecosystem assets</b>	<b>UN definition:</b> Ecosystem assets are contiguous spaces of a specific ecosystem type characterised by a distinct set of biotic and abiotic components <b>Operational definition:</b> Areas of specific ecosystem types in a relatively similar condition used for a designated purpose.	<ul style="list-style-type: none"> <li>• Consider the development of an ecosystem asset register across operated assets.</li> <li>• Moderately and highly modified systems are considered ecosystem assets in modified states.</li> </ul>
<b>Ecosystem condition</b>	<b>UN definition:</b> The quality of an ecosystem in terms of abiotic and biotic characteristics Condition remains a difficult conceptual challenge in ecosystem accounting. Condition should be framed within the context of the supporting ecosystem services, although mechanistic linkages to ecosystem services are rare.	<ul style="list-style-type: none"> <li>• Clearly identify the management objectives associated with classes of ecosystem assets – this becomes an attribute of the asset itself in the asset register and focuses the condition assessment.</li> <li>• Establish measurement method, aligned to management objectives that is transparent and repeatable.</li> </ul>
<b>Ecosystem services</b>	<b>UN definitions:</b> The contributions that ecosystems make to human wellbeing. The potential of the site to generate future ecosystem goods and services should be considered as part of a natural capital assessment but is not within scope of the balance sheet accounts. Ecosystem accounting requires clear definition of final ecosystem goods and services. In contrast, effective management of natural capital may require identification of intermediate ecosystem services.	<ul style="list-style-type: none"> <li>• Consider both final and intermediate ecosystem goods and services when scoping future accounts.</li> <li>• Use CICES V5 to classify ecosystem services.</li> <li>• Identify high priority ecosystem services, i.e. final ecosystem services likely to be somewhat generic across the organisation (e.g. climate regulation) to target investment in quantification.</li> <li>• Develop a library of logic chains to increase the literacy within the organisation of ecosystem services (e.g. see example Figure 3).</li> </ul>

(Table 2 continued following page)

Area	Lesson/Issue	Recommendation
<b>Biodiversity</b>	<p><b>CBD definition:</b> Biological diversity is the variability among living organisms from among all sources including inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems.</p> <p>Biodiversity is not an additive concept. Quantifying and determining a net biodiversity position is an area of active research.</p> <p>Biodiversity presents a unique problem in ecosystem accounting as biodiversity can be considered as both an attribute of an ecosystem or an asset in it owns right. Existing guidance is weak. The challenge of biodiversity accounting is yet to be resolved.</p> <p>Valuation of biodiversity is growing traction, but it is difficult. It is also an issue fraught with conceptual and ethical challenges.</p>	<ul style="list-style-type: none"> <li>BHP is already conducting work on this problem as part of the Pathways to Nature Positive Project.</li> <li>Recommendations for biodiversity accounting are leaning towards specific thematic accounts that consist of ecosystem extent, condition and measures of biodiversity persistence.</li> </ul>
<b>Collaboration</b>	The compilation of ecosystem accounts involves a multidisciplinary effort and is emerging rapidly.	<ul style="list-style-type: none"> <li>Continue to build an inhouse capability.</li> </ul>



**FIGURE 3.** An example of an ecosystem service logic chain. Here the logic chain outlines the pathway from an ecosystem to the benefits that humans receive



## 4.2 Data requirements

Natural capital accounts are data intensive exercises. While natural capital case studies provide some insights into the challenges associated with compiling accounts, future mainstreaming of natural capital accounting should be preceded by a comprehensive review of the

data requirements and strategies for streamlining data collection, interpretation and synthesis. The use of monitoring data routinely collected by organisations should be explored for its potential to calibrate and validate existing modelling approaches that would enable scaling of point-based data to area-based metrics required in accounting to drive efficiency in data collection.

**TABLE 3. Detailed lessons associated with data requirements for natural capital accounts**

Area	Lesson/Issue	Recommendation
<b>Extent accounts</b>	High quality ecosystem extent mapping is foundational data for any ecosystem accounting exercise. However, data availability and reliability is highly variable across jurisdictions and across organisational assets.	<ul style="list-style-type: none"> <li>• Consider the development of an organisation wide ecosystem typology that is consistent with IUCN GET.</li> <li>• Explore use/training of existing high resolution remote sensing products (e.g. (Brown et al. 2022) Assist in informing the development of standards for data acquisition, accuracy and reporting of natural capital assets.</li> <li>• Explore opportunities to collaborate or outsource these data sourcing/training and maintenance requirements.</li> </ul>
	Organisation is data rich however, not all data is digitised. The capacity to recover data could be enhanced through employees' knowledge of assets and projects.	<ul style="list-style-type: none"> <li>• Develop a comprehensive data management plan with explicit consideration of the needs for historical data sources (e.g consider baseline requirements etc.).</li> <li>• Review corporate stewardship of data assets and capacity to maintain into the long term.</li> </ul>
<b>Condition accounting</b>	Condition assessment is conceptually and technically challenging. SEEA-EA recommends approaches to aggregation of condition metrics but does not prescribe an approach.	<ul style="list-style-type: none"> <li>• Develop protocols for ecosystem condition accounting to drive standardisation in condition accounting across organisations. The Beenup pilot case study provides a useful foundation for this further development.</li> <li>• Review approaches to condition assessment across other natural capital accounting initiatives, e.g Accounting for Nature, Farming for the Future, AusEco models framework.</li> <li>• Consider the development of rapid assessment and remote sensing technologies to support condition assessment.</li> <li>• Address the data collection strategy through a calibration and validation lens to increase data coverage.</li> <li>• Integrate with the International Standards for ecological restoration (Gann et al. 2019; Young et al 2022).</li> </ul>

(Table 3 continued following page)

Area	Lesson/Issue	Recommendation
<b>Ecosystem services</b>	<p>The type, quantity and quality of ecosystem service flows will vary temporally and among assets.</p> <p>Some ecosystem services are likely to be generally applied across sites (e.g. ES associated with climate regulation and biodiversity).</p>	<ul style="list-style-type: none"> <li>• Consider a scoping study to identify and prioritise ecosystem services across an organisation's assets.</li> <li>• Work to develop a co-ordinated approach to biodiversity and carbon accounts across the Australian assets (Note: the P2NP project is addressing biodiversity).</li> <li>• Validate existing carbon accounting approaches e.g. FullCAM/Flintpro to streamline carbon accounting across the organisation, particularly for data poor areas.</li> <li>• Work towards an organisational approach to mapping ecosystem services related to water provisioning and water quality.</li> </ul>
<b>Ecosystem accounts</b>	<p>There is a need to provide estimates of the confidence in the ecosystem accounts. While this was not done in the Beenup pilot case study, best practice would include a confidence assessment for accounts.</p>	<ul style="list-style-type: none"> <li>• Consider the development of an objective confidence assessment to assist readers of accounts to gauge their quality, particularly if the services are to be traded in potential future markets.</li> <li>• Develop standardised protocols to assist in potential auditing of future accounts.</li> <li>• Consider how to support the establishment of an accounts accreditation body to provide independent reviews of accounts.</li> <li>• Maintain decision registers and workflows for account development.</li> </ul>
<b>Valuation</b>	<p>Valuation of ecosystem service flows is complex. It is an active area of research that spans the existence of and interaction between private and public goods. Inevitably, the data required for monetary valuation is limited or incomplete, and these monetary valuations may not provide broad enough or in some cases useful information for decision making, e.g. monetisation could result in undesirable decisions where the commercial activities have a higher monetary value than the monetised environmental value, because the valuation is incomplete, uses inappropriate value concepts or does not take a broad enough valuation concept.</p> <p>In many cases the concepts of valuation are not well understood or easily interpreted.</p> <p>Communicating the valuation purpose, contexts, and the process clearly (to relevant stakeholders) is important to develop clarity and usefulness of valuation concepts in decision making.</p>	<ul style="list-style-type: none"> <li>• Improve literacy around valuation concepts and metrics, particularly their purpose and function in areas where monetary valuation does not add useful information.</li> <li>• Focus short term efforts on improving the quality of the measurement or modelling of the physical flows of ecosystem services.</li> <li>• Investigate valuation methods used by other sectors to place monetary values on tough-to-quantify assets or those that are shared by multiple entities (i.e. non-market-based valuation, transfer pricing methodologies, etc.).</li> <li>• Ensure the purpose of the valuation process is clearly articulated. Valuation is more than monetisation and monetisation is not necessarily commodification. i.e. valuation is not equivalent to commodification of nature.</li> <li>• The valuation of biodiversity is complex and needs active development if it is to be implemented. Simple valuations based on benefit transfer approaches may well be inappropriate.</li> <li>• Develop a data base of valuation approaches that includes contextual information on use constraints and recommended use.</li> </ul>
<b>Collaboration</b>	<p>The compilation of ecosystem accounts involves a multidisciplinary effort and is emerging rapidly. A range of data providers are stepping into the field.</p>	<ul style="list-style-type: none"> <li>• Continue to build an inhouse capability.</li> <li>• Work within collaborative initiatives to drive efficiency in data collation and analysis.</li> </ul>

### 4.3 Frameworks

Natural capital accounting and natural capital assessment are not the same thing, although they may be aligned and support each other. While natural capital accounting has been evolving over a long period (Åkerman 2005, Barker 2019), all Australian governments have adopted the United Nations System of Environmental Economic Accounting as the statistical standard for environmental accounting (Australian Government 2018). There is also growing interest in the adoption of SEEA accounting in private enterprise. There has also been a proliferation of natural capital assessment frameworks in recent years (e.g. NCC, 2021, TNFD, 2022, WBCSD, 2021), although these may have different focus, where some are concerned with the identification and valuation (through quantification in physical and or monetary terms), while others focus on an organisation’s impacts and dependencies. The integration of these complementary approaches to natural capital accounting and assessment is rarely addressed. This was partly attempted in the Beenup pilot case study but should be explored deeper to drive more efficient and comprehensive reporting and disclosure.

### 4.4 Reporting and disclosure

Comprehensive natural capital accounting collates a considerable amount of spatially and temporally explicit data on ecosystems. As a result, natural capital accounts can be dense and difficult to interpret by those other than the compilers of the accounts. While some of this will be addressed by increased familiarity that develops as accounts become more common (Bagstad et al. 2021), clear and concise presentation of natural capital accounts can be challenging. The Beenup pilot case study trialled the application of the financial equivalents of the natural capital balance sheet and profit and loss statement. There is considerable appetite for aligning the reporting of natural capital with financial reporting precedents (Ogilvy 2018) (Forico 2020) (Afonso et al. 2022), and we recommend that this approach continues to be pursued. Furthermore, (Smith et al. 2022) developed an approach for integrating natural capital assessment into the accounts to provide an integrated natural capital reporting framework that could meet the needs of reporting the current states and trends of natural capital under management as well as responding to the growing requirements for broader natural capital impact and dependency disclosures. While not fully tested in this pilot, this framework has yet to be fully implemented, and there is an opportunity to do so that highlights the efficiency of this systematic thinking.

**TABLE 4. Detailed lessons associated with existing frameworks for natural capital accounts**

Area	Lesson/Issue	Recommendation
<b>Natural capital accounting/ natural capital assessment</b>	Recent years have seen a proliferation of natural capital ‘frameworks’ and initiatives.	<ul style="list-style-type: none"> <li>Identify a strategy for regular reporting of natural capital through the development of natural capital accounts.</li> </ul>
	Natural capital accounting is the process of calculating and valuing the stocks and flows of natural resources and ecosystem services in a given region at regular time intervals that enables the quantification and valuation of NC through time.	<ul style="list-style-type: none"> <li>Continue to trial natural capital accounting-ongoing work with DCCEEW and other sector partners.</li> <li>Adopt SEEA as the statistical standard for BHP’s natural capital accounting.</li> </ul>
	Natural capital assessment is the systematic assessment of an organisation’s impacts and dependencies on natural capital, and the risks and opportunities associated with those impacts and dependencies.  The Beenup pilot case study attempted to integrate accounting and assessment, although the exercise was incomplete.	<ul style="list-style-type: none"> <li>The integration of natural capital accounting and assessment will be of great interest to the international community. Continue to work towards an integrated reporting framework.</li> <li>The end goal, which is some way off, is genuine integration of financial and natural capital reports.</li> </ul>

**TABLE 5. Detailed lessons associated with the compilation and presentation of natural capital data**

Area	Lesson/Issue	Recommendation
<b>Accounts</b>	The presentation of natural capital data in the form of profit and loss statements and balance sheets is still conceptually challenging.	<ul style="list-style-type: none"> <li>As much as possible, align to existing accounting standards as these are generally flexible and can potentially already accommodate natural capital.</li> <li>Test the Beenup pilot case study with an organisation’s stakeholders (internally and externally): do the example accounts contain useful information?</li> </ul>
	Recognition of ecosystems as ‘assets’ on the balance sheet. Technically only assets that are generating a flow of benefits to the business would be recognised on the balance sheet.	<ul style="list-style-type: none"> <li>Persist with this approach; current disclosure requirements are looking for information on the extent and condition of ecosystems under management. These are thus potentially material issues and can be demonstrated using ‘balance sheet’ concepts.</li> <li>Consider an approach which broadens the balance sheet but differentiates between private and external value.</li> <li>Test utility with stakeholders.</li> </ul>
	Delineation of benefits to the business and benefits to society. A purpose of ecosystem accounting is to ‘recognise’ ecosystems as assets. However, existing standards have most ecosystem assets being invisible as the benefits flow predominantly to society, not to the business.	<ul style="list-style-type: none"> <li>Persist with the benefit to business and benefit to society approach</li> <li>This could be potentially misleading and overrepresent the value of the business assets of benefits flowing externally.</li> <li>Test with stakeholders.</li> </ul>
	When looking at ecosystems as assets to a business, some may provide a regular, continuing contribution to the business operations, while others will only provide benefits/costs at sparse time intervals. It may be important to differentiate assets along these lines as part of NC reporting processes.	<ul style="list-style-type: none"> <li>Investigate the use of typical above the line/below the line reporting as a means of differentiating the importance of assets to the operations (where the ‘line’ refers to gross profit).</li> </ul>
<b>Valuation</b>	The incorporation of values other than exchange values in the balance sheet remains problematic and existing subjective valuation techniques have limited utility.	<ul style="list-style-type: none"> <li>Explore existing accounting standards (i.e. accounting for intangibles or non-use values, benefit transfer pricing methodologies, etc.) to develop approaches for incorporating a more diverse set of valuation concepts.</li> </ul>
	Monetary valuation can distract readers of accounts from the key message i.e. what is the state and trend of the underlying ecosystem asset.	<ul style="list-style-type: none"> <li>Avoid presenting monetary values without the associated physical variables.</li> </ul>
	Valuation is an area of ongoing research, and will develop quickly, particularly if the demand is driven by the emergence of more natural capital accounts.	<ul style="list-style-type: none"> <li>Maintain a strong focus on getting good physical valuations and flexible frameworks to support monetary valuation concepts as they emerge.</li> </ul>
	What does a monetary value for an ecosystem asset actually mean? What does a dollar of natural capital actually represent? It has been noted that many of the valuation concepts being used were not designed for this purpose.	<ul style="list-style-type: none"> <li>Continue to investigate alternative metrics/ concepts/methods for representing the ‘value’ of ecosystem assets that align with financial accounting frameworks.</li> <li>These may not be ‘monetary’ but should move beyond simple physical flows.</li> </ul>

# 5. CONCLUSIONS

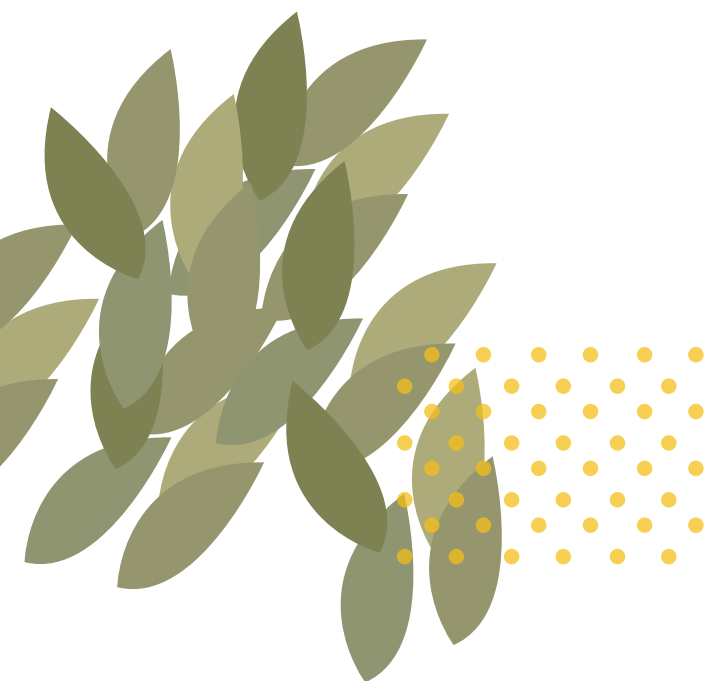
The Natural Capital Accounting for the Mining Sector: Beenup site pilot case study has provided an important insight into the process and challenges associated with natural capital accounting in the private sector. It has demonstrated that operational accounts are achievable for organisations, but broader adoption still has a number of relatively high entry barriers, including cost, efficiency and an understanding of the utility of the information. Broader adoption across organisations will need to consider the challenges associated with developing consistent and transparent methods and approaches to ecosystem classification, mapping and condition assessment across assets and jurisdictions. There is considerable scope for sector wide collaboration on this front.

Valuation of ecosystem assets and services is still emerging. Monetisation, in particular, as a valuation approach is widely adopted, even recommended, but should be used cautiously and with clear caveats around its purpose and limitations as monetary valuations can be easily misinterpreted. Regardless, there is a considerable body of research underway aimed at developing a range of approaches to valuation that consider a broader range of valuation perspectives.

The presentation of natural capital accounts in formats similar to financial statements is promising and future development of this approach will be required if the ultimate aim of natural capital accounting is to be achieved, i.e. the integration of financial and natural capital accounting. The Beenup pilot case study has made good progress on this front.

The capability development and collaboration associated with the pilot case study has made an important contribution to mainstreaming natural capital accounting in Australia. There has been significant collaboration enduring beyond the Beenup pilot case study. There remain some important conceptual challenges to address and the industry and research provider model utilised in the Beenup pilot case study provides a useful example of how to drive solutions to these challenges.

Ultimately, determining the utility of the Beenup pilot case study and the example accounts requires broader stakeholder testing and evaluation. The example accounts will make a useful contribution to deliberations around the Taskforce on Nature-related Financial Disclosures. Developing a process to provide assurances on natural capital accounts will be an important component to consider in this testing and evaluation phase, but many precedents for this process already exist in the financial accounting space.

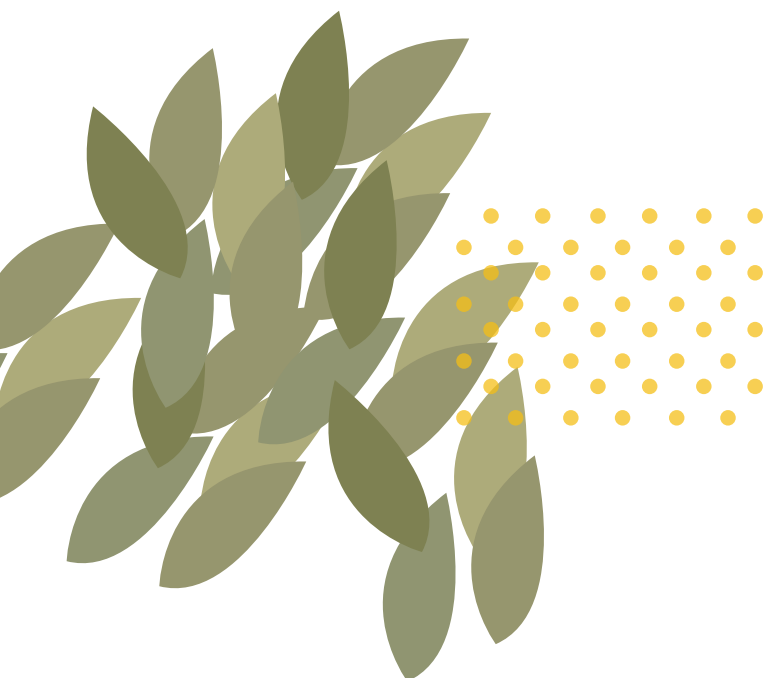




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