CAPITALS COALITION

Time to take stock version 2.1

Improving corporate natural capital accounting with asset registers of stocks, ecological equivalency, double entry bookkeeping and statements of position and performance

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Working Paper

John Finisdore, Point Advisory, an ERM Group Company

Dr. Joël Houdet, Department of Business Management, University of Pretoria

Carl Obst, IDEEA Group

Ian Dickie, eftec

June 2022

Reviewers and designers

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Foreword

Born out of a desire to distinguish the most powerful natural capital accounting methods, this paper outlines a foundational approach for what we characterise as “corporate natural capital accounting” (CNCA). This approach draws from the full range of natural capital accounting thinking and practice to date. The approach applies to all natural capital work irrespective of the ecosystem type or natural capital assets (so long as it is defined by proper organizational boundaries), organisational sector (private, public, NGO), standard (e.g., BS8632, Biological Diversity Protocol), service providers involved or its analytical purpose.

To implement the approach, we define some core processes (“standardisations”) that we believe should underpin all CNCA work. These standardisations link the theory underpinning a natural capital approach to its application. We envisage this document can:

- Advance the understanding of the most powerful methods in use today.
- Support the implementation of existing standards (e.g., BS8632, Biological Diversity Protocol) and approaches (e.g., Natural Capital Protocol).
- Serve as input to forthcoming guidance (e.g., TNFD, Science Based Targets for nature) and future developments (e.g., ISSB project on biodiversity, ecosystems and ecosystem services; assurance of natural capital accounts).

Contents

Highlights

The main themes from this working paper are:

1. The natural capital community of practice aims to use corporate natural capital assessment and accounting methods to value natural capital assets, but in practice often falls short of adequately recognising and measuring the changes in the state of the underpinning biophysical assets.

2. Methods for measuring the changes in the state of natural capital assets exist but have never been adequately surveyed and described.

3. This working paper proposes a definition for corporate natural capital accounting (CNCA) that builds from the state of natural capital assets in biophysical terms: "Corporate natural capital accounting is the systematic process of identifying, measuring, recording, summarising and reporting the periodic and accumulated net changes to (a) the biophysical state of natural capital assets and (b) the associated values of natural capital to business and wider society."

4. This definition applies to any organisation along value chains, from suppliers to clients.

5. This working paper also defines a process by which CNCA is implemented using "seven CNCA standardisations" in a sequential manner.

6. CNCA complements existing natural capital assessment, accounting methods and efforts including: the Natural Capital Protocol, Science-Based Targets for nature, Global Reporting Initiative, CDSB Biodiversity Application Guidance, the Taskforce on Nature-related Financial Disclosures and British Standard 8632:2021 Natural Capital Accounting for Organisations.

7. Public and private sector guidance documents and case studies that explain and demonstrate the seven CNCA standardisations are available but more thorough analysis of how CNCA can be advanced is warranted, particularly in terms of complementing existing natural capital assessment methods and efforts.

01 Summary

The estimated USD 125 trillion of annual contribution that natural capital provides to the global economy (Kubiszewski et al., 2020) can only be managed with proper measurement. Despite being ranked consistently by the CEOs as one of the top 5 global risks (World Economic Forum, 2021), measuring the state of this natural capital remains a challenge (Lammerant et al., 2021). As a result, managers do not effectively integrate natural capital risks with their existing financial and non-financial analysis, risk assessments, operational procedures, product development systems and related business applications.

Recognising this challenge, governments and businesses have been working to address these issues. Among their efforts are The Economics of Ecosystems and Biodiversity (TEEB, 2010) whose lead, Pavan Sukhdev, described a simple aim, to make nature visible in decision making. Picking up on this mandate, the Natural Capital Protocol (Natural Capital Coalition, 2016) was developed to increase the use of natural capital thinking in business by an order of magnitude. To this end, it covered a broad range of potential approaches that can be used to conduct "natural capital assessments." About the same time, the paper Developing Corporate Natural Capital Accounts (eftec et al., 2015) drew from the accounting field, to increase the visibility of nature.

Now is the time to take stock of these efforts and begin working towards a clear, precise and pragmatic concept of "natural capital accounting," or "corporate natural capital accounting (CNCA)" when applied to business or public organisations.

This paper proposes a definition for CNCA that draws from financial accounting and ecology. It includes several requirements upon which the development of natural capital accounts depends. Failure to use them all or using them out of sequence violates this paper's definition of CNCA. The definition in this paper is one of many definitions and understandings of corporate natural capital accounting. We encourage discussion of the definition of CNCA leading to increased standardisation of processes and guidelines.

A sequence of seven steps necessary for undertaking CNCA. We call these steps "standardisations" to emphasise their necessity and structure. The research and discussion around some of these standardisations is more mature than others. We expect all to be the subject of ongoing debate and refinement. This paper notes some current best practices and highlights gaps that need to be addressed such that we can establish robust standards for each of these standardisations.

The seven CNCA standardisations help ensure that CNCA considers all natural capital assets, including ecosystem types (e.g., forests, wetlands, coral reefs) and their components (e.g., timber, soil, water, species, gases, chemicals). Because of the use of classification systems, the seven CNCA standardisations also ease measurement of both interactions among components within ecosystems as well as interactions among ecosystems. Moreover, when resources limit measurement to an incomplete set of components (e.g., soil, water), the standardisations provide a framework for incorporating additional data or improving methods at later dates. In total, the application of the seven CNCA standardisations will improve valuation, support better integration of risks into decision making, enhance opportunity identification and improve the interoperability of data.

While the methods that are applied to implement the seven CNCA standardisations are in growing use, the core thinking underpinning them has not been synthesised in a way that enables practitioners to recognise the benefits of CNCA nor to see how CNCA interfaces with existing natural capital efforts such as the Natural Capital Protocol, Science Based Targets for nature, CDSB's Biodiversity Application Guidance, British Standard 8632: Natural Capital Accounting by Organisations, and the Global Reporting Initiative. This paper provides the framing to address these gaps.

To date much of the work on natural capital assessment and accounting has emphasized monetary values rather than changes to state of natural capital assets themselves. Consequently, the distinct features and benefits of effectively measuring changes in natural capital assets are neither adequately surveyed nor widely known. This working paper aims to support the natural capital community of practice by capturing these features and benefits so they can best complement the ongoing natural capital efforts.

02

Corporate natural capital assessments

Efforts to help corporations better manage natural capital risks and opportunities date to at least 2008 (Hanson et al., 2008). These soon proliferated into scores of tools, approaches and guidance documents (Natural Capital Coalition, n.d.). In 2016, The Natural Capital Protocol (Natural Capital Coalition, 2016) began harmonizing a great deal of knowledge. In doing so, it explicitly used the term "assessment" to capture the broad array of methods being developed—from GHG footprinting to The Water Footprint method to Environmental Profit & Loss Statements. The Natural Capital Protocol quickly became a bedrock document particularly for managers with little prior experience with natural capital.

These natural capital assessment methods sometimes casually referred to as corporate natural capital accounting[1], have developed in an *ad hoc* manner to address various natural capital challenges and opportunities related to different business applications[2] (Table 1). Specific measurement (physical aspects of the environment) and valuation (i.e., qualitative, quantitative, monetary) methods (Natural Capital Coalition and eftec, 2019) are associated with different business applications. For example, the business application group "comparing options" contains "cost benefit analysis" methods. Carbon accounting methods may be used to measure emissions of greenhouse gases, business application number 5 in Table 1. Multicriteria analysis methods may be used to compare different stakeholders' perspectives on competing land use plans.

Business application group	Business application
Compliance with laws and regulations	1. Permitting related to the environment (e.g., water quality, endangered species) 2. Compensation for damages (e.g., loss of ability to fish or recreate)
External disclosures and assurance	3. Voluntary disclosures (e.g., GRI, CDSB, CDP) 4. IFRS or GAAP aligned financial disclosures (e.g., contingent liability from oil spill)
Assessing past, current and future corporate performance (a.k.a. net impact)	5. GHG emissions across sites and value chains 6. Environment profit & loss (e.g., net acres of crops in a product)
Tracking progress to targets	7. Carbon neutrality targets for direct operations 8. Net positive impacts on biodiversity for greenfield projects
Comparing options	9. Product, service or process design and development 10. Comparing risks at different greenfield sites 11. Comparing technical options (e.g., wetland vs. built wastewater treatment facility)
Certification or audit	12. Forest plantation certification (e.g., FSC) 13. Environmental management system (e.g., ISO 14001)
Third party engagement and rating	14. Comparative natural capital performance (e.g., CDP) 15. Databases and key performance indicators (e.g., Planet Tracker)
Product development	16. Efficiency of resources use/unit
Risk and opportunity assessments	17. Direct measurement of impacts and dependencies 18. Life cycle assessments (LCA), input-output modelling 19. Mass balance measures 20. Estimations or industry averages from literature or databases 21. Productivity modelling

[1] This paper uses "corporate natural capital accounting (CNCA)" to refer exclusively to methods that meet this paper's definition of CNCA defined in section 1 Summary.

[2] Business applications are the intended use of assessment results, and may include strategic or operational decisions relating to resource procurement, new product development, site selection, or project investment across the value chain, among many others (Natural Capital Coalition, 2016). However, public and community organisations also use these systems.

Table 1: Business applications[3]

Natural capital assessment methods can have different areas of focus (e.g., corporate sites, value chain, products), different target audiences (e.g., internal decision makers, external stakeholders); varying understandings of the relationships between corporations and natural capital (e.g., impact, dependence) and reflect contributions from experts from different disciplines (e.g., ecologists, economists).

This development process has led to an array of methods which use data and generate results that are not consistent, difficult to compare and challenging to integrate with one another.

For instance, to support permit applications, corporations may (1) measure impact drivers (e.g., emissions, effluents) and impacts (e.g., changes in ecosystem condition); (2) value ecosystem services used by the corporation or external stakeholders or (3) assess expenses and liabilities (e.g., wetland offset costs, emissions control equipment costs).

With respect to external disclosures, corporations use a range of methods. Some may choose the Global Reporting Initiative's (GRI) standard and be encouraged to disclose physical environmental measures (e.g., cubic meters of water consumed, tons of GHG emissions, protected species at a manufacturing site). By contrast, the Climate Disclosure Standards Board's (CDSB[4]) guidance focuses on financial implications (e.g., asset impairment, contingent liabilities) of specific physical environmental measures (e.g., GHG emissions). Comparing datasets and company performance with respect to natural capital from these two standards is thus challenging.

Natural capital assessment methods allow corporations to expand the range of environmental aspects included in risk analysis and corporate financials. They also enable some integration of data among methods either directly or through recalculations. However, natural capital assessment methods rarely treat stocks of natural capital as assets in a complete way nor do these methods have standardized rules such as those used in financial accounting. As a result, measures of the stocks are generally incomplete, methods inconsistent and results more difficult to compare and consolidate into a single statement for an organisation or business unit.

[3] Other lists of business applications are available such as the one found in the Natural Capital Protocol (Natural Capital Coalition, 2016).

[4] CDSB was consolidated into the International Financial Reporting Standards (IFRS) Foundation in November 2021.

03

Corporate natural capital accounting

To address gaps in corporate natural capital assessment methods, corporate natural capital accounting has been emerging. It rests on a key principle, making nature visible in decision making. This visibility is compromised when positive and negative impacts of different natural capital assets (e.g., forest, grasslands) are considered equivalent. It is also compromised when nature, which is a stock (Dasgupta, 2021), is indirectly measured, rather than being directly measured for the extent and quality of its stocks. Similarly, much is lost with an emphasis on annual monetary values over measuring changes to natural capital assets themselves.

These and other issues are grappled with in a spate of work released or commenced in 2021 that focused on public and private sector natural capital accounting. It includes:

- The United Nations System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) (UN, 2021)
- The Biological Diversity Protocol (BD Protocol) (Endangered Wildlife Trust, 2020)
- TRANSPARENT (Transparent, 2021) and Align (Align, 2021)
- The Taskforce on Nature-Related Financial Disclosures (Taskforce on Nature Related Financial Disclosures, 2021).

To build on and contribute to this body of work, the following definition of CNCA is proposed. It is applicable to all types of natural capital (e.g., ecosystems, gasses, water) and all public and private sectors and organisations. This definition applies to any organisation along value chains.

Definition of corporate natural capital accounting (CNCA)

CNCA is the systematic process of identifying, measuring, recording, summarising and reporting the periodic and accumulated net changes to (a) the biophysical state of natural capital assets and (b) the associated values of natural capital to business and wider society. CNCA requires:

A. An asset inventory recognising the biophysical properties and dynamics of each asset category

B. Measurement techniques that use spatially explicit data and apply the principle of ecological equivalency (like-for-like)

C. Recording rules based on double-entry bookkeeping from financial accounting

D. Asset-specific biophysical statements of performance and position

E. A defined scope according to organisational and value chain boundaries

This definition draws from:

- The Millennium Ecosystem Assessment (Reid et al., 2005) and the 2019 global assessment on biodiversity and ecosystem services (Brondizio et al., 2019) for requirements A and B
- The System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) (UN, 2021) for requirements A, B and D
- The GHG Protocol Corporate Accounting and Reporting Standard (WBCSD and WRI, 2012) and the Natural Capital Protocol (Natural Capital Coalition, 2016) for requirement E
- The Biological Diversity Protocol (Endangered Wildlife Trust, 2020) for requirements B, C, D and E

- Academic (Houdet et al., 2020) and position papers (Houdet et al., 2022, 2016) for requirements C and D; academic papers (Bezombes et al., 2017; Brondizio et al., 2019; Carton et al., 2021; Maseyk et al., 2016) for requirement B; academic papers (Dickie et al., 2020; Finisdore et al., 2020; Fu et al., 2011; Hancock, 2013; Hoffmann and Chamie, 1999; Overhage and Suico, 2001; Wu, 1999) for requirement A
- The IFRS Accounting Standards (IFRS Foundation, 2021) for requirement C

Undertaking CNCA based on this definition requires following seven sequential steps. We call these steps the "seven CNCA standardisations". We use the term standardisations to refer to "what" needs to be the focus of further standardisation work. As a result, we do not attempt to provide a definitive statement on "how" these steps should be standardised and simply call for an active and purposeful process to articulate standards in these areas. The seven CNCA standardisations are:

1. Defining the natural capital stock as an asset
2. Developing "natural capital asset registers of stocks" using classification systems
3. Measuring changes in the state of natural capital using appropriate methods specific to each asset category
4. Employing recording rules for accounting events and linked journal entries
5. Summarizing the biophysical state of natural capital with a statement of natural capital position
6. Summarizing net periodic biophysical changes in natural capital with a statement of natural capital performance
7. Using valuation or other analytical methods to link the stock-based accounts and integrated datasets with complementary value framing perspectives

CNCA requires sequentially following the seven CNCA standardisations. Moreover, CNCA standardisations 1—6 underpin implementation of standardisation seven (Figure 1). Without natural capital asset information, undertaking valuation can be counterproductive to its purported intent of showing the critical importance of natural capital for decision-makers.

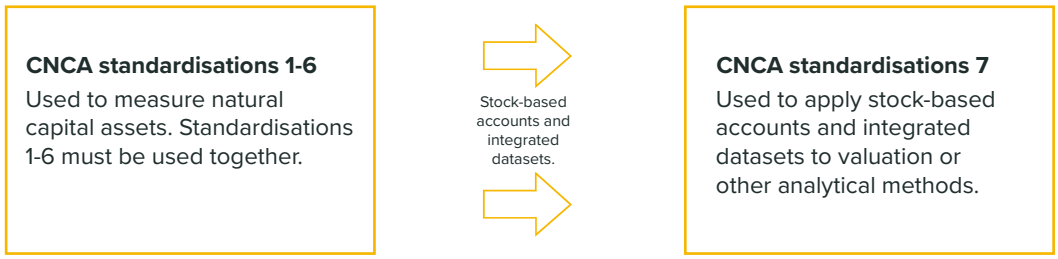


Figure 1: Sequential nature of the seven CNCA standardisations

For example, using CNCA standardisations 1-6 for a mountain forest would start by measuring and recording changes to the forest's extent and condition on a regular basis[5]. A change may be recorded to the forest's condition, for example, due to the spread of an invasive tree species. This species may increase the use of water in the forest, decreasing flows to a commercial timber plantation and communities downstream. With the asset accounts and integrated datasets complete, CNCA would turn to standardisation seven and value water flows to the plantation and communities.

[5] The frequency of the recording would be contingent to knowledge about the forest life cycle (e.g., average number of years for a tree to reach maturity), dynamics of its components and the occurrence of events that would trigger changes in its state (e.g., fire or storm).

Combined, the seven CNCA standardisations ensure that the measurement of natural capital assets recognizes the biophysical properties and dynamics of each asset category, is spatially explicit, applies the ecological equivalency principle, uses double-entry booking recording rules, compiles asset-specific biophysical statements of performance and position and distinguishes accounts according to value chain boundaries.

The seven CNCA standardisations are explained in more detail below. References to examples are provided as the end of this section.

1. Defining the natural capital stock as an asset
Consistent with the definition of the physical assets in corporations (e.g., manufacturing facilities, truck fleets), there are "natural capital assets" (eftec et al., 2015; UN, 2021). These include ecosystems (e.g., forests, agricultural, urban, mangroves) and individual components of the environment (e.g., species, soil, gases, chemicals). Accounting for these assets requires the use of biophysical measures relevant to the properties and dynamics of each natural capital asset category. This involves specifying how natural capital stocks are identified and recognised as asset accounts within a broader set of accounting rules (see CNCA standardisation 4). For instance, ecosystem asset accounts would be defined differently from greenhouse gas asset accounts.

2. Developing "natural capital asset registers of stocks" using classification systems
Natural capital asset inventories are created by identifying the physical elements of the environment using classification systems. In many cases, this involves identifying ecosystem types and various components of ecosystems (e.g., species, soil). For example, a site may have the ecosystem type boreal forests and grizzly bears may be a material species. These asset types (boreal forests and grizzly bears) form the basis of the accounting system through the development of asset registers, and their proper identification alone embodies a great deal of information about the site's biodiversity, functioning and related characteristics (Finisdore et al., 2020).

The proper identification rests on using classifications systems. Classification systems provide a common language that nests sub-groups in a hierarchy that is complete, mutually exclusive, consistent, and relevant to the practical needs of users (e.g., balanced among users' needs) and what they are defining and measuring stable through time and comparable to other classifications (Fu et al., 2011; Hancock, 2013; Hoffmann and Chamie, 1999; Overhage and Suico, 2001; Wu, 1999).

Classification systems are used to identify different types of natural capital assets such as:

- Ecosystems, using the Global Ecosystem Typology (Keith et al., 2020), FAO Landcover Classification System (Di Gregorio and Jansen, 2000) or equivalent national or subnational system such as the USGS National Land Cover Database (USGS, 2021)
- Species, using the Linnean taxonomy or PhyloCode (Bruno and Richmond, 2003)
- Greenhouse gases (Sanchez et al., 2006)
- Chemicals (MIYAGAWA, 2010)

The use of classification systems provides many benefits (Finisdore et al., 2020). Among them, are ensuring that the ecological equivalency principle is applied so that loss of one type of natural capital asset (e.g., a species or ecosystem type) is not associated with gains in another (Brondizio et al., 2019; Reid et al., 2005). Thus, boreal forests are measured independently from bottomland hardwood forests and wildebeests are distinct from elephants. Conversely, gains and losses among a single ecosystem type, Mesic Mixed Hardwood Forests for example, can be consolidated.

Finally, these natural capital asset inventories need to be developed according to organization and value chain boundaries. The Greenhouse Gas Protocol (WBCSD and WRI, 2012) and the Biological Diversity Protocol (Endangered Wildlife Trust, 2020) use similar methods to segment organizational boundaries and their value chains. These protocols discuss accounting for wholly and partially owned business units and assets. Therefore, all assets that relate to the selected organisational boundary are included in the accounts. This could be sites owned by an organisation (e.g., mining company), sites in a value chain (e.g., palm oil growing locations) or a portfolio of sites (e.g., sites in a global agriculture fund).

Natural capital asset inventories are important parts of most natural capital assessment methods, though they are not always built. The inventories are tangible resources from which value is derived, impacts and dependencies on natural capital are determined (Endangered Wildlife Trust, 2020) and natural capital targets defined and measured (Science Based Targets Network, 2020). Without the inventories, these measures and targets are, at best, less accurate, or at worst self-selected, providing an opportunity for greenwash. This is particularly relevant to determining future benefits from natural capital, as changes to stocks alter future flows of final ecosystem services.

3. Measuring changes in the state of natural capital using appropriate methods for each asset category

With the inventory complete, every natural capital asset category (e.g., species, ecosystem type) is measured periodically using the appropriate method.

For ecosystems, this is can be done using "quality hectares"[6] method (Houdet et al., 2020). The extent, or size, of an ecosystem type (e.g., hectares of forest, hectares of coral reef) is measured along with the condition of that ecosystem type. Typically, the condition is measured on a 100 point scale (e.g., 0.0-1.0)[7].The product of these two yield a quality hectare. For example, 100 hectares of boreal forest in pristine condition would be calculated as the product of an extent of 100 hectares by quality of 1 (100 X 1), or 100 quality hectares. This rating of 1.0 is the baseline reference condition for measuring change to the ecosystem. Should the quality of the forest degrade 10% because of an invasive tree species, the condition score might drop to 0.90 and the forest would now reflect 90 quality hectares (100 X 0.90).

There are a number of resources that practitioners can use to identify the appropriate condition rating method for their area (UN, 2021). They recognise that various condition rating methods are available for specific habitats (e.g., wetlands, soil, fauna) and geographic scales (e.g., global, regional). The method used should either (1) be cited or (2) if an appropriate method is not available, documented so it can be later refined and validated by a third party.

Condition rating methods, or any measurement method, must use the appropriate classification system. For example, the Ecosystem Condition Typology (Czúcz et al., 2021) classifies the characteristics of an ecosystem[8] that could be integrated into a condition rating method. Individual components also use classification systems. For example, species should be identified using the Linnean taxonomy or PhyloCode (Bruno and Richmond, 2003). Finally, the data for a condition rating method needs to follow best scientific practices in ecological monitoring and be spatially integrated, ideally with a single grid scale (e.g., 10m X 10m).

In some cases, it is appropriate to measure individual components (e.g., a material species, soil, greenhouse gases). The appropriate metrics for the component should be used to ensure that net changes can be measured over time. For instance, a soil quality index could be used to track soil condition across a landscape and be measured perhaps every two years. For greenhouse gases, all sources of emissions and withdrawals are converted into tons of CO_2 equivalents (Houdet et al., 2022b).

When measuring components, it must be recognized as providing a partial measure of natural capital assets. If the component measures are not integrated with a full accounting of the asset, decision making needs to explicitly mention the limitations of the measures.

Finally, these measures must ensure ecological equivalency. Ecological equivalency is the concept of "like-for-like" when recording losses and gains of different components of natural capital. For greenhouse gases this equivalency is found in different categories of gas: carbon dioxide, methane, nitrous oxide, etc. For ecosystems, this is generally ecosystem types or species, though examples can be found for categories using habitat or ecosystem community types and similar ecosystem properties (Quétier and Lavorel, 2011).

In CNCA, this is done by using the classification systems mentioned above and the recording rules and linked journal entries described below (CNCA standardisation 4). Combined, they ensure that positive and negative changes to an ecosystem type (e.g., boreal forest, mangrove) or component (e.g., a pine tree is not equivalent to an oak tree) are not equated with changes to a different asset type (Bezombes et al., 2017; Maseyk et al., 2016). When considering GHG emissions and removals, carbon dioxide reduction cannot be equated with methane increase (Carton et al., 2021). The same holds true for all types of natural capital.

[6] Quality hectares is also referred to as "surface area adjusted for condition," "quality adjusted hectare," "condition adjusted hectares", "hectares equivalents", "habitat hectares", "Econd™", among other terms.

[7] The condition score (e.g., 0.0-1.0) relies on high quality condition rating method, reference condition and data.

[8] Many condition methods available for various ecosystem types in the world that are based simple qualitative scoring systems. They are commonly used in environmental impact assessments. These systems may need to be adapted for integration with the more complex classification systems that are emerging.

Box 1 CNCA, embedded with iteration

The required sequential structure of the seven CNCA standardizations also has an iterative nature. This iteration takes place within standardizations and when restarting the whole process.

Within standardizations this may take place by iteratively introducing organisations to new subjects. A list of the ecosystem types may see overwhelming, and the organisation's expert advisors may first introduce common terms (e.g., forest, savanna) before adding more complexity (e.g., bottomland hardwood forests). Similarly, ecosystem services classification systems (e.g., NESCS Plus and CICES) may also seem daunting to those working with them for the first time. An expert advisory may introduce the SEEA EA reference list of some 30 commonly used ecosystem services (UN, 2021) as a first step and to broaden the conversation to ecosystem services the organisation may not be familiar with.

Iteration also occurs when restarting the whole CNCA process. Organizations may find it pragmatic to start with a subset of their operations or supply chain and expand overtime. As data is often challenging, the first iteration of accounts can serve to identify data gap that are later filled. This is particularly true with complex supply chains. Moreover, the organizations also need to undergo a conceptual change to understanding their boundaries of influence extending from the factory gate to the state of natural capital. The same shift is underway as companies integrate Science Based Targets for greenhouse gas emissions into their strategy, procedures and operations.

4. Employing recording rules for accounting events and linked journal entries

CNCA requires recording rules, adapted from double entry bookkeeping in financial accounting, to account for changes in natural capital. These changes could come from events such as land clearing, water abstraction, or the reintroduction of a keystone species. Each event needs to be recorded to facilitate derivation of measures of both periodic and accumulated net changes in natural capital. For each event, debit and credit journal entries are recorded, with the sum of debits always equalling the sum of credits (Ridoutt et al., 2021).

Using the asset inventory (CNCA standardisation 2) as a basis, recording rules:

A. Are specific to each natural capital asset category (e.g., ecosystems, species, greenhouse gases, water) that are identified using classification systems when developing the asset inventory

B. Are organised around two equations:
   a. One for recording periodic positive and negative changes to natural capital assets
   b. Another for recording accumulated positive and negative changes to natural capital assets

C. Enable the compilation of a statement of natural capital position (CNCA standardisation 5) and a statement of natural capital performance (CNCA standardisation 6)

When conducting national accounting, double entry bookkeeping is not used. Rather, quadruple entry bookkeeping is needed to capture the interactions between economic agents. SEEA EA uses quadruple entry bookkeeping and it applies various financial accounting conventions such as employing recording rules for accounting events and linked journal entries (OECD, 2017).

CNCA can be contrasted with the use of single-entry bookkeeping which merely add up negative or positive changes. For instance, most GHG footprint methods (Houdet et al., 2022b) and several biodiversity footprint assessment methods (e.g., Biodiversity Footprint Methodology, Biodiversity Footprint Calculator[9], modelling impacts using impact driver or economic data) only add up negative impacts over time.

[9] A review of biodiversity footprint methods, see Lammerant et al., 2021.

5. Summarizing the biophysical state of natural capital with a statement of natural capital position

At regular periods (e.g., 1 year, 3 years), corporations will summarize the total state of their natural capital in a "statement of natural capital position" (Houdet et al., 2016). Again, these statements are specific to each component of the natural capital asset inventory (CNCA standardisation 2). In the BD Protocol, the Statement of Biodiversity Position is used. In SEEA EA—used for national accounting—it is the opening and closing entries in the ecosystem extent and condition accounts. These statements present the accumulated net state of natural capital at a given point in time and incorporate or synthesise two sets of information:

- Outputs from the current statement of performance (CNCA standardisation 6) and
- The accumulated net state of natural capital from previous periods

Statements of natural capital position serve a role in CNCA similar to the role balance sheets (or statements of financial position) play in financial accounting.

6. Summarizing net periodic biophysical changes in natural capital with a statement of natural capital performance

These recording rules enable corporations to summarize changes to natural capital at regular periods (e.g., 1 year, 3 years, 7 years) with a "statement of natural capital performance." Here too, these statements are specific to each component of the natural capital asset inventory (CNCA standardisation 2). Techniques for developing these statements have various labels including the Statement of Biodiversity Performance from the BD Protocol and net changes in extent and condition in the ecosystem extent and condition accounts in the SEEA EA. These statements of performance will include:

- Additions or removals of natural capital assets from the sale or acquisition of new sites or engagement of new value chains[10]
- Conversion of an asset type into another (e.g., conversion of a coastal forest to a dune ecosystem through natural erosion processes)
- Changes in the condition of an ecosystem type (e.g., increased quality of soil on a farm, increased number of native species in a coastal marsh) relative to the reference condition

Statements of position and performance do not include all information necessary for measurement and management of an ecosystem nor the risks arising from them. A "stock-based integrated dataset" (integrated dataset) is generally maintained by site managers that contains other data (e.g., physical measures of the ecosystem needed to track ecological functions or final ecosystem services). The statements, however, provide a summary of key information for tracking performance that can be consolidated and used for a variety of other purposes (e.g., disclosure, financial analysis, risk assessments). In most situations, they represent the data needed for numerous business applications (Table 1 Business applications) that are addressed in standardization 7.

[10] For a discussion on what to include in a company's natural capital accounts, see the Biological Diversity Protocol.

7. Using valuation or other analytical methods to link the stock-based accounts and integrated datasets with complementary value framing perspectives
Once standardisations 1-6 are completed, complementary analytic and valuation methods can be applied to the biophysical statements of position and performance, often accompanied by other integrated data, to enhance decision making (UN, 2021). At least three key valuationframing perspectives should be mentioned: (i) natural capital targets; (ii) natural capital dependencies; and (iii) natural capital impacts. The potential of CNCA in relation to each of these areas of focus is described below.

i. Natural capital targets
The desired state of a natural capital asset is often the basis for ecosystem management. These targets can note the desired recovery of an ecosystem or the component of an ecosystem (Locke et al., 2021), quality hectares (Mappin et al., 2021) or the delivery of a final ecosystem service (Perrings et al., 2011). Examples include grey wolf recovery numbers, soil quality levels or number of quality hectares of an ecosystem. CNCA, because of its focus on the biophysical properties and dynamics of assets, enables these targets to be defined and measured against a baseline.

This gap between the baseline and target can be used to determine the financial cost restoration, offsets or a combination of the two. Depending on the business application (Table 1) this cost can represent a liability or simply the cost of reaching a target. Some of the business applications where this applies include:

1. Compliance with laws and regulations such as permits or compensation for environmental damages. A desired natural capital state can be determined (e.g., total maximum daily loads of effluents, state of environment before the environmental damages occurred) and then used to determine the costs to reaching the target.

2. Tracking progress to targets such as Science Based Targets for nature (Science Based Targets Network, 2020) or other corporate natural capital goal.

3. Comparing options for the environmental impact of developing different greenfield sites (e.g., for a palm oil plantation), installing industrial equipment (e.g., water quantity use) or the impacts of alternate products (e.g., timber versus concrete)

4. Certification or audit schemes, for example sustainable forestry certification, where change in forestry practices lead to a desired state of natural capital

These target-based measures can be integrated with dependence or impact analytic methods (discussed below). For example, a recent life cycle assessment (LCA) measured the impacts of food production in Australia relative to the planetary boundaries (Bradley G. Ridoutt et al., 2021). Data on the state of natural capital could be included in such analyses, as is shown by LCAs that include context specific information on freshwater (Ridoutt et al., 2009)

Targets can also shift corporate focus to natural capital assets, from measures of operational efficiency—for example—having significant influence on corporations. The state of the ecosystem itself becomes the focus of line managers, rather than just the efficient use of inputs. On the public sector side, there are also opportunities for CNCA to support target analytic methods. A recent study in Australia used CNCA to help estimate the cost of conserving 30% of its land (Mappin et al., 2021).

ii. Natural capital dependencies
Companies that depend on natural capital can improve the management of risks associated with these dependencies with CNCA. Because the state of natural capital is directly related to its ability to produce final ecosystem services, accurate measurement of the state of natural capital can improve dependency risk assessment. For example, food producers can measure farm yields, farm productivity, soil quantity and model scenarios based on changes in climate and farm management practices. The latter of these measures—soil and scenarios—are CNCA based and provide useful information about future risks.

Some of the business applications (Table 1) related to dependency-based risks and opportunities allow for the estimation of biophysical and monetary value of final ecosystem services. Continuing with the farm example, land rents can serve as a proxy measure of the degree to which the state of natural capital is being incorporated into market prices. But because markets can inaccurately price the true value of natural capital stocks, direct measurement can add value.

Another application is using the data from standardisations 1-6 to build accounts of the flows of final ecosystem services and their monetary values (Dickie et al., 2020; eftec et al., 2015; UN, 2021).

The flow accounts are the recording of the elements of nature that are directly used or appreciated by businesses, governments or households (Boyd and Banzhaf, 2007). These final ecosystem services are identified using a classification system (see "notes on valuation" later in this section) and are recorded as the supply and use of FES (UN, 2021).

The monetary valuation accounts, in turn, used FES supply and use data to identify the appropriate valuation methods to determine each FES' monetary value (UN, 2021).

iii. Natural capital impacts

Corporate impacts on natural capital also creates risks that need to be properly attributed and measured (Natural Capital Coalition, 2016). These can be measured using natural capital assets, for example, by using the change of quality hectares from a mining operation or development of a greenfield. Methods such as hybrid life cycle assessments (LCA) or mass balance measures (see Table 1 for examples of business applications) estimate the impacts of a production process on rivers, forests or other ecosystems and include the state of natural capital (Ridoutt et al., 2021; Ridoutt et al., 2009).

CNCA allows these types of indirect measures—measure of the flow of final ecosystem services or natural resources and their values—to be improved. First, natural capital assets can be identified using a classification system (see CNCA standardisation 2), helping shift these methods away from less accurate measures of flows (e.g., biodiversity, land use, livestock). Effectively, final ecosystem services can more accurately link the causal impacts to changes in the state of natural capital.

Moreover, many impact related business applications are based on regional averages. The impacts of climate change on waterflows or the impact of land clearing across a region on biodiversity, for example. Ultimate these impacts need to be linked to specific ecosystems, which CNCA enables. For example, global climate models can be downscaled and context specific measures on the state of natural capital used as basis for measuring change.

Notes on valuation

Because these three groups of analytic and valuation methods often involve final ecosystem services, they must be identified in a way that minimizes double counting, speeds data discovery and improves data interoperability (Finisdore et al., 2020). This requires using a classification system that is based on the concept of final ecosystem services (see NESCS Plus or CICES for definitions and examples). This process identifies the biophysical flows or environmental end products (e.g., water, soil, coastal storm mitigation) that are directly used by companies and encompasses both marketed, non-marketed, public and private flows. It produces clearly defined, mutually exclusive and consistent final ecosystem services that support the drawing of impact pathways to and from assets and corporations.

Three specific considerations are:

- Identify final ecosystem services, using NESCS Plus[11] (Johnson et al., 2020) or CICES (Haines-Young and Potschin, 2018). These are the only true classification systems that have been developed for ecosystem services. They distinguish between "final ecosystem services" and the more general term "ecosystem services" (Finisdore et al., 2020).

- Even when not engaging in an accounting exercise, NESCS Plus and CICES help ensure that the identification ecosystem services is correct. Two common errors include (1) mistaking an economic input for an ecosystem condition, process or function and (2) mistaking the flow between ecosystem as an ecosystem condition, process or function of the source ecosystem (Finisdore et al., 2020).

- Identify economic actors, using the North American Industrial Classification System (NAICS) (Ambler and Kristoff, 1998), the International Standard Industrial Classification of all Economic Activities of the United Nations (UNIDO, 2016), the Global Industry Classification Standard (GICS) Methodology (MSCI, 2020) or an equivalent national industrial classification system should be used to identify the users of the final ecosystem services.

[11] NESCS Plus has an embedded ecosystem type and industrial classification system.

Valuation is not without its challenges. Among them is capturing the diverse ways that nature is perceived and valued by people in different and often conflicting ways (Pascual et al., 2017). In addition, monetary valuation can be counterproductive to its own purpose of taking the economic worth of unpriced environmental goods and service into account (Farrell, 2007). These challenges helped spur recent research on the need for pluralistic valuation methods. These would require recognizing and addressing power relationships across stakeholder groups that hold different values on human nature relations and nature contributions to people (Pascual et al., 2017).

A final note on process. When determining which biophysical measure to collect (Standardisations 2 and 3), knowledge of the targets (e.g., final ecosystem services), risk or dependencies helps. Knowing the analytic or valuation method to be used can drive the biophysical metrics, collection method (e.g., eDNA sampling, transects) and data processing (e.g., processing of satellite data) that are most suitable. An iterative process is often used in practice.

While many of the examples of targets, dependencies and impact methods presented here use data about activities from the past, CNCA enables the building of scenarios to look at likely future risks and opportunities. Corporations may want to model the impacts of increased freshwater use in a catchment overtime combined with climate change. Investors may want to understand demand for timber products in the face of regulatory changes.

Examples using the seven CNCA standardisations

The seven CNCA standardisations, and the net measurement of natural capital stocks, have been embraced by ongoing efforts. The most prominent are the development of standards and guidance documents that codify and explain the standardisations. These include:

- Biological Diversity Protocol (BD Protocol), a guidance document to help corporations account for and consolidate an organization's impacts on ecosystems and material species (Endangered Wildlife Trust, 2020)

- UN System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA), a public sector standard focused on building national ecosystem accounts (UN, 2021)

There are growing number of case studies using these guidance documents and standards (Keith et al., 2017; Houdet et al. 2021; Warnell et al., 2020; Houdet, et al. 2022a). In addition, Science Based Targets for nature (SBTn), Taskforce of Nature-Related Financial Disclosures (TNFD) and the Convention on Biological Diversity (CBD) are exploring how they can apply the core standardisations—not in name—that are embodied in CNCA.

There may be other standards and examples. This paper draws from those best known by the authors and therefore focused on the BD Protocol, SEEA EA and the supporting literature.

04

Benefits of using CNCA

The use of CNCA organizes natural capital information in ways that increase its utility. These benefits stem from (1) the focus on biophysical measures of natural capital stocks and (2) the sequential use of seven CNCA standardizations.

Focus on measuring stocks
The focus of CNCA on biophysical measures of natural capital assets, development of natural capital asset registers of stocks combined with appropriate measurement method (e.g., quality hectares), ensures that a strong integrated dataset of ecosystem assets underpins all analysis. This shifts the focus to the management of natural capital assets, complementing measures of impacts, flows and benefits. These measures of assets not only serve as a basis for assessing sustainability but also encourage systems thinking.

More specifically, this focus on biophysical measures of natural capital assets:

1. **Improves precision of target, dependency and impact valuation methods**, by providing a strong base of biophysical measures, integrated datasets and properly identified final ecosystem services.

   Because the most accurate valuation methods require biophysical measures, CNCA supports development of context specific production functions (Kubiszewski et al., 2022; Pandeya et al., 2016). But benefit extend beyond just these most data intensive valuation techniques. For example, benefits transfer techniques are being pushed to include evermore physical measures to narrow their error ranges (Johnston et al., 2017). The inclusion of data on the different ecosystem types and their extent can improve the use of benefit transfer valuation techniques.

   Next, CNCA supports the development of integrated datasets of stock-based information. While data on ecosystem type, extent, condition and components are core, additional data can be included. For example, data needed to measure final ecosystem services. This inclusion provide value beyond just the biophysical measures. When using NESCS Plus, the uses and users are identified within the NESCS Plus classification system. In CICES, uses and users must be identified through other classification systems (e.g., International Standard Industrial Classification of all Economic Activities of the United Nations) (UNIDO, 2016). More importantly, having identified the final ecosystem services, use and users, the options for measure of (1) biophysical flows (e.g., litres of water), (2) use (e.g., manufacturing) and (3) valuation (e.g., risk weighted cost per litre) narrow. This narrowing, by default, drives harmonization of terms, methods and metrics (Finisdore et al., 2020).

2. **Serves to establish targets** for natural capital management, notably biodiversity conservation (Locke et al., 2021). In turn, distance from targets can be supported with analysis of the costs and benefits of restoration (Mappin et al., 2021) and efficiency gains needed at the product level (Ridoutt et al., 2021). Such analysis provides insights into ecological thresholds and that can be missed with a sole focus on flows and values.

3. **Helps integrate natural capital into risks and opportunity analysis** by creating a single measure of a stock, a quality hectare. This likely eases the consideration of both risks and opportunities by reflecting both the degradation and enhancement of natural capital stocks. Moreover, these quality hectares can be directly linked to flows.

4. **Supports direct engagement with managers of other assets** particularly produced and financial assets. CNCA is analogous to methods used in managing produced and financial assets and improves the ability to integrate natural capital information and sustainability considerations into core operational aspects of corporations. For example, the financial aspects of sustainability are often missed, and finance departments need to be directly engaged (Atz et al., 2019).

Use standard rules
CNCA places a focus on the importance of accounting rules. While these are not commonly used for non-financial data, CNCA improves the ability to integrate this information into decision making. Notably, the use of double entry bookkeeping rules from financial accounting builds more harmonized data across business units and companies and make corporate board and site level natural capital data more interoperable. In other words, it helps enable system thinking and analysis because it:

1. **Improves the interoperability of data** that support comparability of results across business units, sectors, geographies, scales and times. This should also support the ongoing efforts to improve data quality, harmonize CNCA methods and integrate measures of natural capital with produced, human and social capitals.

2. **Is likely to be more readily integrated with an array of business applications** (Table 1) including financial accounting methods. Because CNCA data is context specific, scalable, can be aggregated and disaggregated, a single CNCA account and integrated dataset are likely to have applicability in a broader range of methods across numerous business applications. For example, financial accounting rules enable a single dataset to be used for internal analysis, regulatory disclosures and investor relations.

3. **Eases the ability of nonexperts to engage** with natural capital. The seven CNCA standardisations provide a structure to allow complex, context specific data to be organized for discussion and broad use. This should also create opportunities to "mash" CNCA results with other data in ways that are difficult to predict (Clarke, 2018). The example of Google Maps is an example of effective mashing different data onto a digital map.

4. **Enables consolidation of disparate metrics for natural capital assets.** Corporations often have data collected from different experts using different methods. So long as that data either was collected using a geographically scalable technique (e.g., habitat hectares) or can be modified to be scalable (e.g., different ecosystem condition rating methods can be converted to a single condition adjusted surface area metric), they can be consolidated.

5. **Helps avoid recording errors (e.g., misstatements, imbalances) and inconsistencies (e.g., in measurement methods and assumptions).** This is enabled by double entry bookkeeping that requires the debits and credits balance out.

   Thus, CNCA provides direct support to the ongoing efforts to harmonize natural capital measurement and valuation methods and metrics. For example, CNCA continues to:

   - Bolster the role of accounting in establishing credible natural capital data that can be used in traditional accounting. For example, it could support the work of the International Sustainability Standards Board.

   - Strengthen the accounting rules and principles necessary for auditing and assurance of natural capital data. In particular, CNCA requires specific definitions, measurement boundaries and treatments necessary for these external reviews.

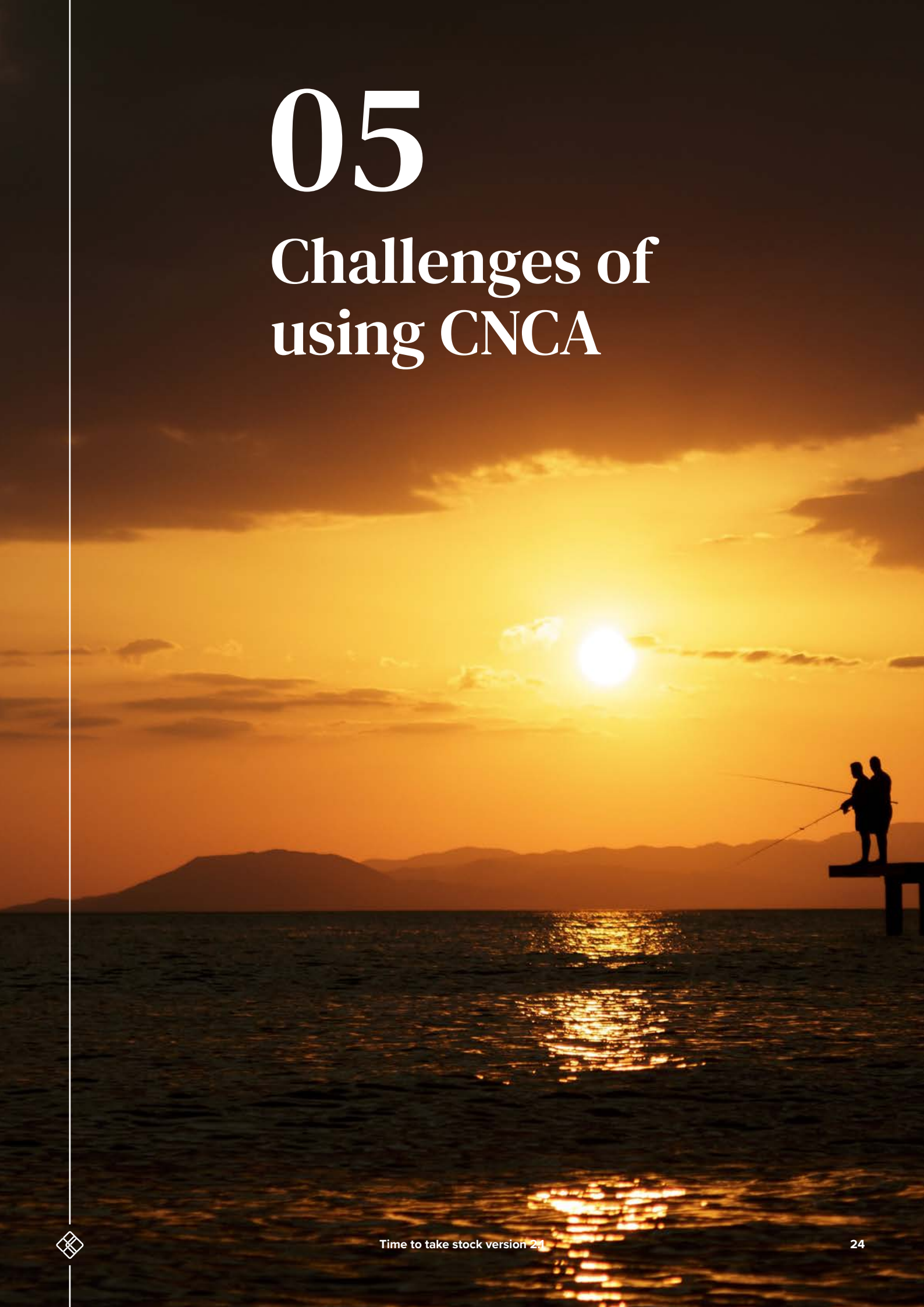
   - Drive a common language that can be a focus for exchanging experience, developing technology and building capacity. Overall, this should lower the barriers to entry, reduce transaction costs and support more rapid scaling of natural capital (Finisdore et al., 2019).

   - Leveraging public and private datasets by helping corporations use of public sector CNCA accounts and corporation providing select information to public sector CNCA efforts.

   This initial list of benefits suggests the need for a more thorough review. Such a review would be most valuable if it could identify specific suggestions on how CNCA can best complement and be broadly integrated into current CNCA methods and business applications.

05

Challenges of using CNCA



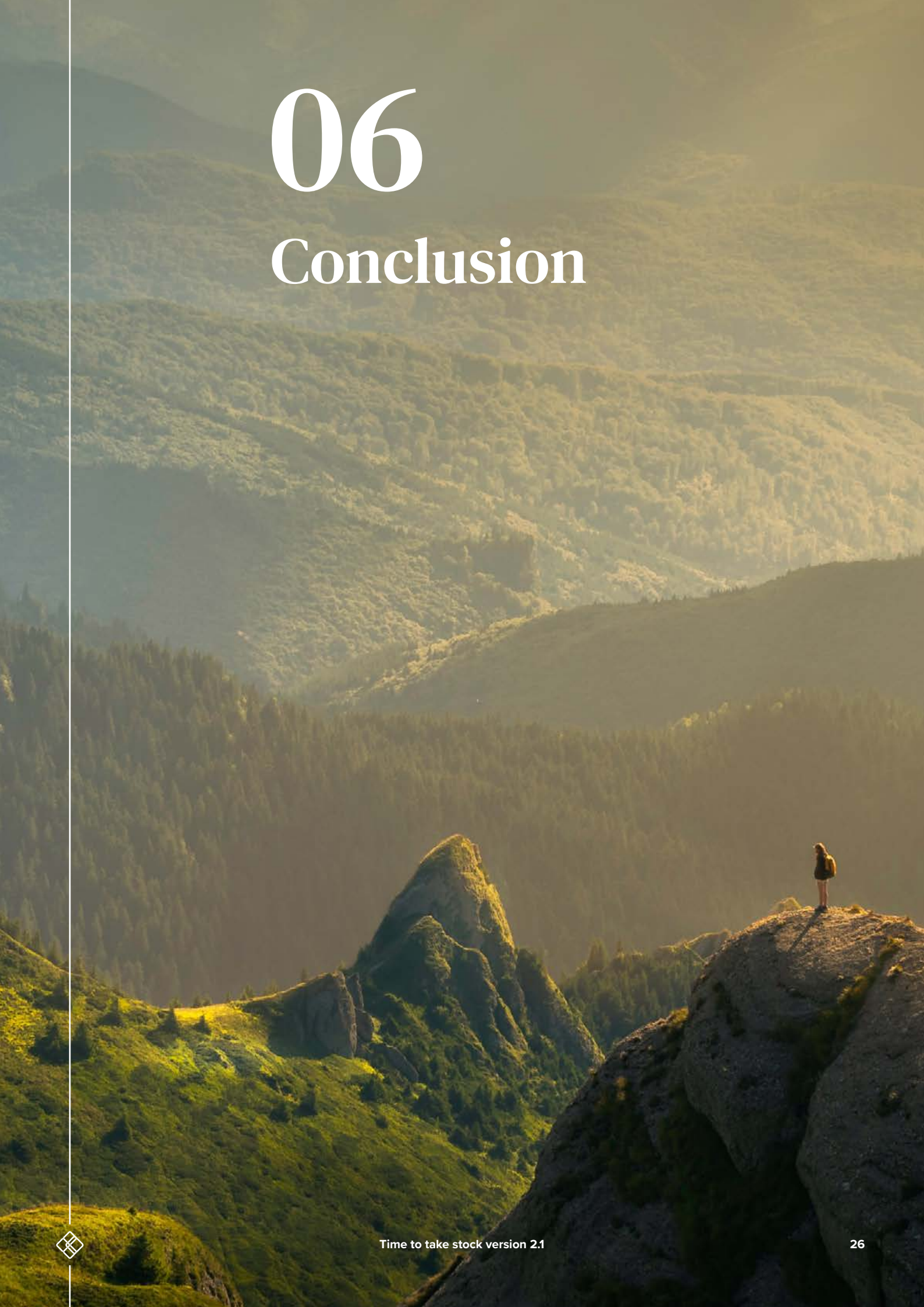
Although the techniques for implementing the various components of CNCA exist, their use collectively to record, report and analyse natural capital information is new and challenges in application and integration are many and varied. In broad terms, these challenges can be framed as concerning (I) consistency in methods, (II) digitalisation and data flows and (III) knowledge and skills gaps. Here three specific challenges across these areas are noted, recognising that efforts are being made in many places to find solutions and that case studies are being developed globally helping to spread expertise.

One challenge concerns condition rating methods is that there are some generic methods that have been applied globally but, unfortunately, these are not accurate nor precise enough to support many management decisions that require information that appropriately reflects local contexts.

Concerning data challenges, as more advanced methods are implemented globally, they often face data shortages. Some secondary data is usually available but demands for primary data collection generally expand with use of CNCA. There is also a data management and processing component to this, which is increasingly being automated with efforts such as Artificial Intelligence for Environment & Sustainability (ARIES).

Finally, the challenges of learning curves that need to be traversed by corporations and consultants are real. There are, however, numerous pilots of this work being led by the UN, Business Council for Sustainable Development Australia (a subsidiary of WBCSD) and various NGOs and consultants. Because the basic quality hectare techniques and traditional accounting methods are well known, many of the challenges lie in convincing corporations of the need for the change so that appropriate teams are built to implement CNCA.

06
Conclusion



Natural capital is an increasing part of corporate strategy. The proliferation of natural capital assessment methods is evidence of building demand for accurate and precise measures. This is being complemented by CNCA that improves corporate capacity to incorporate natural capital related risks and opportunities in decision making.

CNCA measures the net change in a company's impacts on natural capital over time. The data produced by CNCA creates context relevant measures of natural capital that are interoperable with numerous existing natural capital assessment methods, efforts and business applications. As a result, corporations using CNCA will be better able to integrate natural capital into their decision making. There are already expanding efforts to advance CNCA, SEEA EA, BD Protocol and Align (Align, 2021) among them.

However, the advantages of CNCA described here have not been adequately surveyed, nor are they widely known. Consequently, they may be generally considered as just another natural capital measurement method, rather than a different category of methods that grew from and complements existing methods. Finally, considering the ongoing efforts to improve data, build automated systems and harmonize natural capital assessment methods and rules, a thorough analysis of how CNCA contributes to the mix of natural capital tools, methods and approaches has merit. Such an analysis would support communication of the benefits of using CNCA and reveal how such use can best complement ongoing efforts of the natural capital community.

Issues for future development

All CNCA issues cannot be addressed within the scope of this paper. In addition, the existing standards (SEEA EA) and guidance documents (BD Protocol) will require regular updating. Some of the key issues that need development are:

1. Clarifying the definition and treatment of liabilities related to natural capital

2. Detailing how to iteratively engage with and choose among different classification system (e.g., ecosystem type, industrial type, ecosystem service)

3. Describing the spatial, temporal and legal boundaries of accounting

4. Describing the process for selecting the best methods for measuring different natural capital categories (e.g., ecosystem type) and components (e.g., trees, soil)

5. Exploring backward looking analysis of changes to natural capital and their causes. For example, a company may wish to explore the historic causes of the accumulative changes to natural capital that was caused by multiple actors.

6. Determining when species and other components of ecosystems should be included in accounts

7. Explaining when and to what extent should all spatial data used in accounts and integrated datasets be organized around a in a single grid scale (e.g., 5x5 m2)

8. Using the seven CNCA standardizations in formal standards (e.g., TNFD) with minimum requirements and a 'comply or explain' process

9. Detailing how the seven CNCA standardisations compare with and relate to other natural capital measurement method and frameworks (e.g., SBTN, TNFD) beyond the cursory treatment in the Annex to this paper

10. Determining how natural capital targets should be set

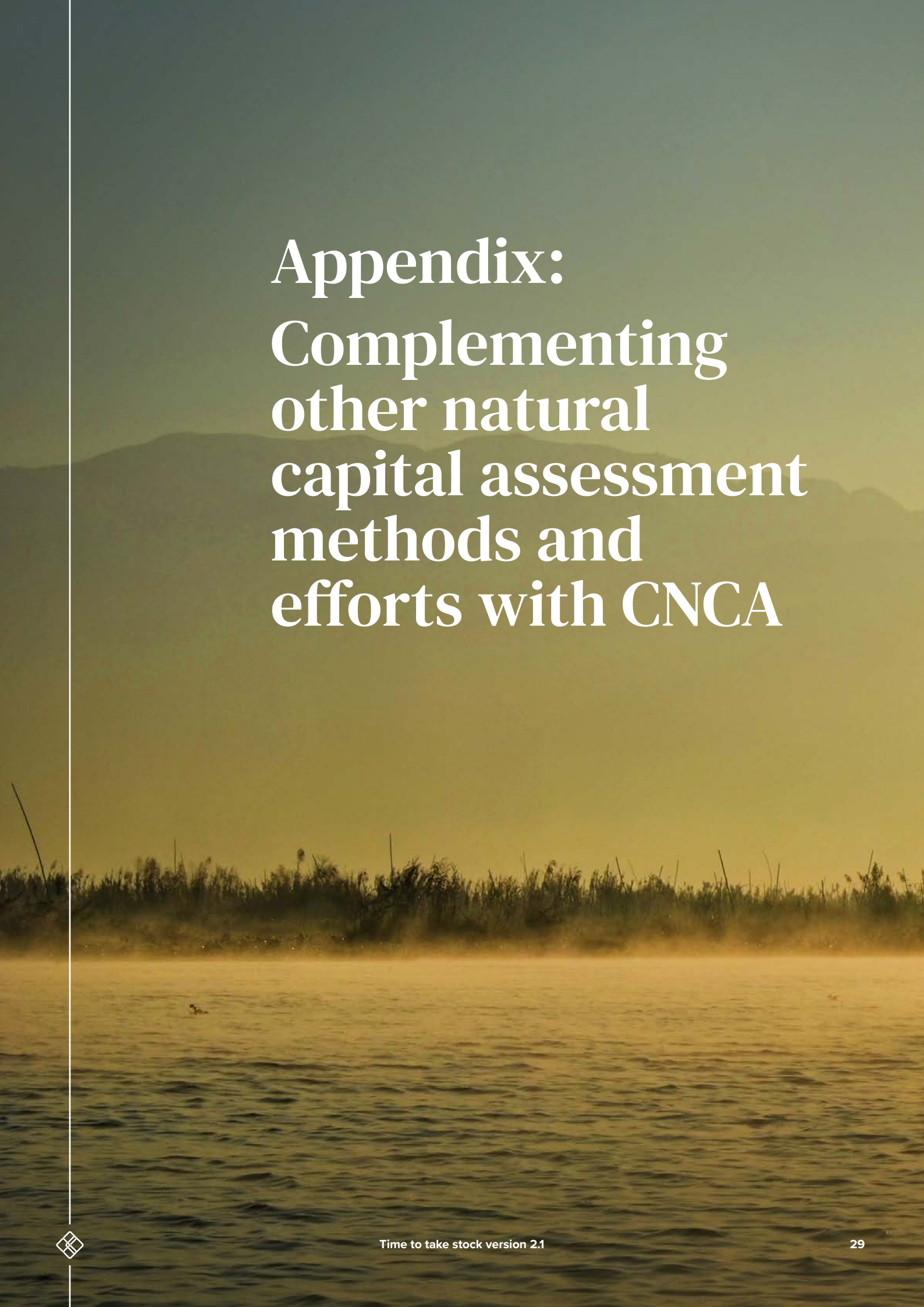
11. Developing quality standards for ecosystem condition rating systems

12. Using rules from financial accounting to ensure strong audit trails

13. Understanding the differences between public and private sector natural capital accounting. For example, what are the differences between double entry bookkeeping used by organisations and those used in national accounts such as the SEEA EA, how the charts of accounts differ as well as the underlying equations for negative and positive changes to natural capital.

These needed developments do not justify delaying implementation of CNCA. They are unlikely to affect the first few iterations of an organization's accounts. Should they affect accounts, simple clerical changes will likely address most items. More to the point, the challenges of advancing CNCA are related to overcoming complexity.

The iterative process described in Box 1 notes the efficacy and need for building accounts and organisational capacity overtime. The methods, data and support for beginning this journey are available today.



Appendix: Complementing other natural capital assessment methods and efforts with CNCA

Many existing natural capital assessment methods and efforts recognize natural capital stocks and are compatible with the inclusion of the seven CNCA standardisations. This compatibility and indeed complementarity is described for these high profile efforts: the Natural Capital Protocol, Science Based Targets for nature (SBTs for nature), the Global Reporting Initiative (GRI), Climate Disclosure Standards Board (CDSB) Biodiversity Application Guidance and, the Taskforce on Nature-Related Financial Disclosures (TNFD) and British Standard 8632:2021 Natural Capital Accounting for Organisations (BS:8632).

These are not standalone methods, but rather reenforce one another. Companies often start with the Natural Capital Protocol, for example, before moving on to the SBTs for nature to set targets and then back to the Natural Capital Protocol to understand the impact. Then they will go to the CDSB Biodiversity Application Guidance and the newly released TNFD to understand how to disclose this information, drawing on the BS:8632 for accounting guidance. Data information and knowledge flows among them, helping drive transformative change (Figure 2) (Capitals Coalition, 2022).

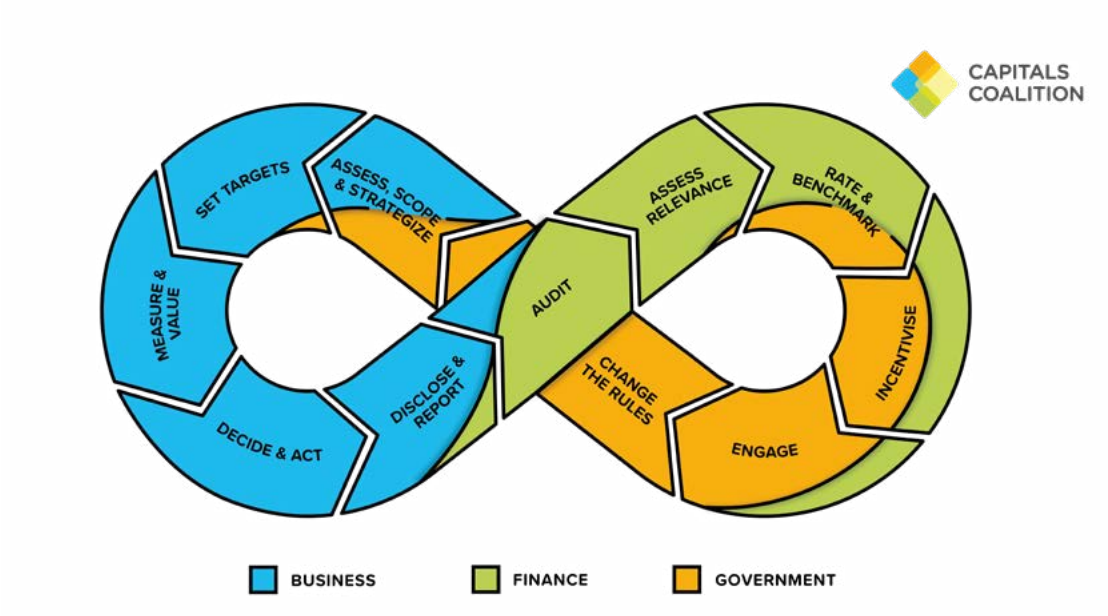


Figure 2: Capitals Coalition Infinity Loop (Capitals Coalition, 2022)

Many of methods and efforts described below are in development and the analysis here is based on limited information. In addition, these descriptions are a rapid analysis and warrant a thorough review of how integration can best be achieved. However, this analysis demonstrates that the seven CNCA standardisations can directly support these efforts.

Collectively, the six informal crosswalks described below demonstrate that some aspects of CNCA are already being applied. However, the richness and rigour of the CNCA method, its components and means of implementation to support the other natural capital methods and efforts listed here, have not been investigated. Broadening the use of the seven CNCA standardisations has the potential to increase their efficacy and coherence.

Natural Capital Protocol

The Natural Capital Protocol (Natural Capital Coalition, 2016) is arguably the most influential effort to support the integration of natural capital into corporate decision making. The Natural Capital Protocol directly recognizes stocks and calls for their measurement and management. In addition, it explores casual pathways among stocks, flows and value (Figure 3).

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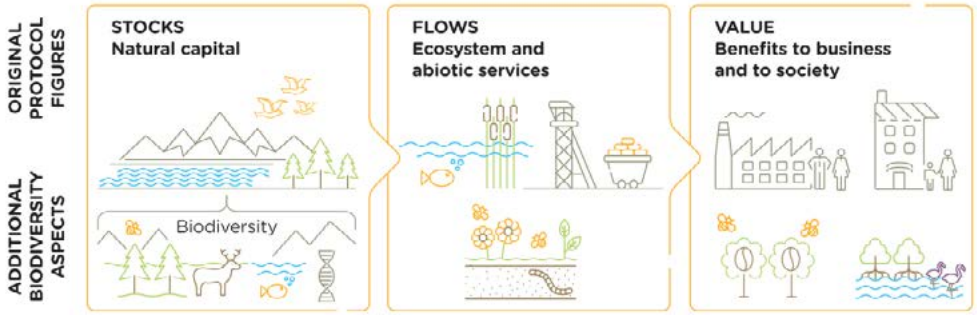

Figure 3: Natural capital stocks, flows and value (Capitals Coalition, 2020)

The Natural Capital Protocol also provides a four stage, nine step framework for helping managers identify, measure and manage their company's risks and opportunities related to natural capital (Natural Capital Coalition, 2016). Managers using Natural Capital Protocol can incorporate the seven CNCA standardisations into to appropriate stage (Figure 4). CNCA Standardisations 1-6 are implemented sequentially. CNCA standardisation 7 is implemented after completing CNCA standardisations 1-6. It requires returning to the scoping stage, identifying the final ecosystem services before using stock accounts to improve the flows or value measures or grounding flow or value measures in specific stocks.

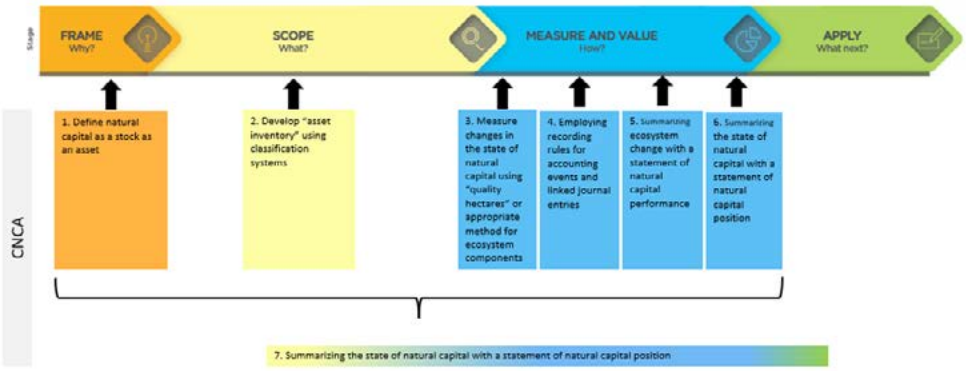

Figure 4: The Natural Capital Protocol Framework and CNCA (adopted from Natural Capital Coalition, 2016)

Science Based Targets for nature

The Science Based Targets for nature (SBTs for nature) is growing in popularity. A number of companies already engaged, drawn in part because of the popularity of its sister initiative, the Science Based Targets initiative (SBTi). SBTs are methods for determining a corporation's fair share of impact on climate (SBTi), water, land, biodiversity and oceans (SBTs for nature). They are aligned with targets from the planetary boundaries (Steffen et al., 2015) and also provide a process for defining, disclosing and taking action to meet targets (Figure 5)[12].

Figure 5: SBT for nature framework (Science Based Targets Network, 2021a)

This five step process is directly aligned with the Natural Capital Protocol and CNCA. In the first two steps, data on natural capital assets—their location, type, quantity and health (e.g., habitat hectares, water stress)—can be directly used to conduct a materiality assessment and identify key areas to take action. In the third step, the baseline data targets use CNCA data, or something very similar. Finally, in step 5, track, statements of performance and position provide the monitoring necessary for understanding progress and reporting on progress. Effectively, CNCA is consistent with SBTs for nature and by applying the seven CNCA standardisations should expand the utility of SBTs for nature efforts.

Global Reporting Initiative

The Global Reporting Initiative (GRI) is an independent, international organization that helps corporations and other organizations take responsibility for their impacts, by providing them with the global common language to communicate those impacts. The GRI Sustainability Reporting Standards (GRI Standards) are the most commonly used corporate sustainability reporting standard (Threlfall et al., 2020). They aim to help organizations report on their impacts on the economy, the environment and society.

CNCA has applicability to many parts of the GRI standard. For example, in the GRI 1-3: Universal Standard, CNCA can help with materiality assessments, governance and corporate strategy. However, a majority of the applicability is with GRI 304: Biodiversity. It provides biodiversity reporting requirements in four sections. They are:

- Disclosure 304-1 Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas
- Disclosure 304-2 Significant impacts of activities, products, and services on biodiversity
- Disclosure 304-3 Habitats protected or restored
- Disclosure 304-4 IUCN Red List species and national conservation list species with habitats in areas affected by operations

CNCA can be directly used within GRI 304: Biodiversity. Disclosure 304-4 requires listing of key species and habitats; these are defined the natural capital asset inventory with classification systems (CNCA standardisation 2). CNCA statements of performance and position create a monitoring mechanism for progress and the ability to provide a level of detail that, while it may not be required, is likely to improve risk management. In addition, they provide inputs from Disclosure 304-3. Effectively, this can help corporations move

[12] As targets and allocation methods are still being developed for some SBTs for nature, interim corporate targets have been released (Science Based Targets Network, 2021b) that some companies can use.

beyond qualitative, management approach-based disclosures (i.e., proximity of corporate sites to protected areas) (Addison et al., 2019; Bhattacharyya and Yang, 2019) and towards the target-setting and impact-focused reporting that the GRI Standards facilitates.

CDSB Biodiversity Application Guidance

Another sustainability reporting standard is the Climate Disclosure Standards Board's (CDSB) Framework[13] [14]. The CDSB Framework also provides an approach for identifying, measuring and reporting on environmental information (CDSB, 2015). As with the GRI Standard, CNCA can be used in the material, governance and strategy components of disclosures.

The CDSB Biodiversity Application Guidance was updated in November 2021. It arguably contained the most current natural capital disclosure guidance at the time this paper was written. It may be a harbinger of where corporate use of CNCA is headed.

For example, it directly incorporates thinking on classification systems (see CNCA standardisations 2 and 7), Statements of Biodiversity Position and Performance (in reference to the Biological Diversity Protocol; see CNCA standardisations 5 and 6), targets (see CNCA standardisation 7), the ecological equivalency principle (see CNCA standardisation 2 and 3) and the need to recognize the biophysical properties, dynamics and spatially explicit character of natural capital assets (see CNCA standardisation 1, 2 and 3). In addition, the CDSB biodiversity standard discussed the need to directly measure the actual impact for each ecosystem, the central theme of CNCA.

As with the GRI Standard, CNCA can be directly used to produce information for CDSB aligned disclosures. Perhaps more importantly, CDSB is now part of the International Sustainability Standards Board and the Taskforce on Nature-related Financial Disclosures (TNFD) has been launched. This CNCA thinking is likely to be advanced in these efforts.

Taskforce on Nature-related Financial Disclosures

The Taskforce on Nature-related Financial Disclosures (TNFD) launched its beta version to help corporations report and act on their "nature-related risks and opportunities" (Taskforce on Nature Related Financial Disclosures, 2021). It builds from the conceptual framework and definitions harmonized in the Natural Capital Protocol. TNFD seeks to draw from the Taskforce on Climate-related Financial Disclosures (TCFD) (TCFD, 2017) that has been successful (Kroener and Newman, 21AD; TNFD, 2021). The new taskforce has already garnered a great deal of interest and is expected to be widely implemented.

Figure 6: TNFD interim core elements (Taskforce on Nature Related Financial Disclosures, 2021)

[13] CDSB is now part of the Integrated Sustainability Standards Board.

[14] John Finisdore and Dr. Joël Houdet served on the on CDSB Technical Working Group on Biodiversity-related disclosures that helped develop this standard.

TNFD is structured similarly to the GRI and CDSB standards (Figure 6) and is moving toward categories largely repurposed from TCFD (Table 2). CNCA, as with GRI and CDSB, has direct applicability. Effectively, the more closely tied the governance, strategy, management and metrics are to measures based on CNCA, the more benefits will be realised (see section 4. Benefits of using CNCA).

Group		Risk	Opportunity
Transition	Policy and legal	• Extraction moratoria, lower quotas • Fines • Permit suspension or denial • Lawsuits	
	Technology	• Substitution of products with lower impact alternatives • Unsuccessful investment in new technology	• Increased efficiency • Low impact industrial processes
	Market	• Changes in customer preferance (public sector, private sector)	• New products or services • Markets for certified products • Markets for ecosystem services • New revenue streams from company owned or managed ecosystems
	Reputational	• Damage to brand or image • Challenge to social "license to operate"	
Physical	Acute	• Temporary increased scarcity or cost of inputs • Disruption to business operations	• Increased resilience to disruptions
	Chronic	• Gradual permanent increased scarcity or cost of inputs • Increasing number of disruptions to business operations	• Increased resilience to change
Systemic		• Natural system no longer functions properly (loss of one ecosystem function means others are not provided — e.g. overfishing of sardines and two El Niño events in the Northern Benguela ecosystem led to a systemic collapse and the ecosystem being dominated by jellyfish and pelagic bogy (Cochrane et al, 2009)	• Increased resilience to systemic risks

Table 2: TNFD interim risk groups[15]

British Standard 8632: Natural Capital Accounting by Organisations

British Standard 8632 (BS 8632) is an accounting standard designed to better integrate natural capital considerations into financial and other business analyses (British Standards Institution, 2021). It provides a framework for combining financial, environmental and socioeconomic information to reveal biophysical measures and values (e.g., qualitative, quantitative, monetary) that nature provides to both organizations and society. Its focus is to represent changes in the value of natural capital.

It is explicitly stock based: it requires production of a natural capital asset register as part of the account outputs; and the values calculated are dependent on changes in the stock of natural capital, use of final ecosystem services flowing from these stocks and the values people and organisations ascribed these flows.

The standard defines natural capital stocks as assets, consistent with CNCA standardisation 1. It implicitly calls for the use of appropriate methods for measuring the state of natural capital, CNCA standardisation 3. While they are focused on monetary values, BS 8632's Natural Capital Balance Sheet and Income Statement can hold biophysical values as CNCA standardisations 5 and 6 do. Also implicit in the standard is that through repeated development of the accounts, periodic changes in the state of natural capital, or its value, can be developed (CNCA standardisation 6).

CNCA makes a clear separation of the biophysical accounts and any valuation through CNCA standardisation 7. BS 8632 practitioners should first develop statements for biophysical measures before exploring the monetary values of natural capital assets. This would be further supported by the use of ecological equivalency (CNCA standardisation 3), double entry bookkeeping (CNCA standardisation 4) and classification systems (CNCA standardisation 2 and 7).

[15] Adopted from: Taskforce on Nature Related Financial Disclosures, 2021; TCFD, 2017

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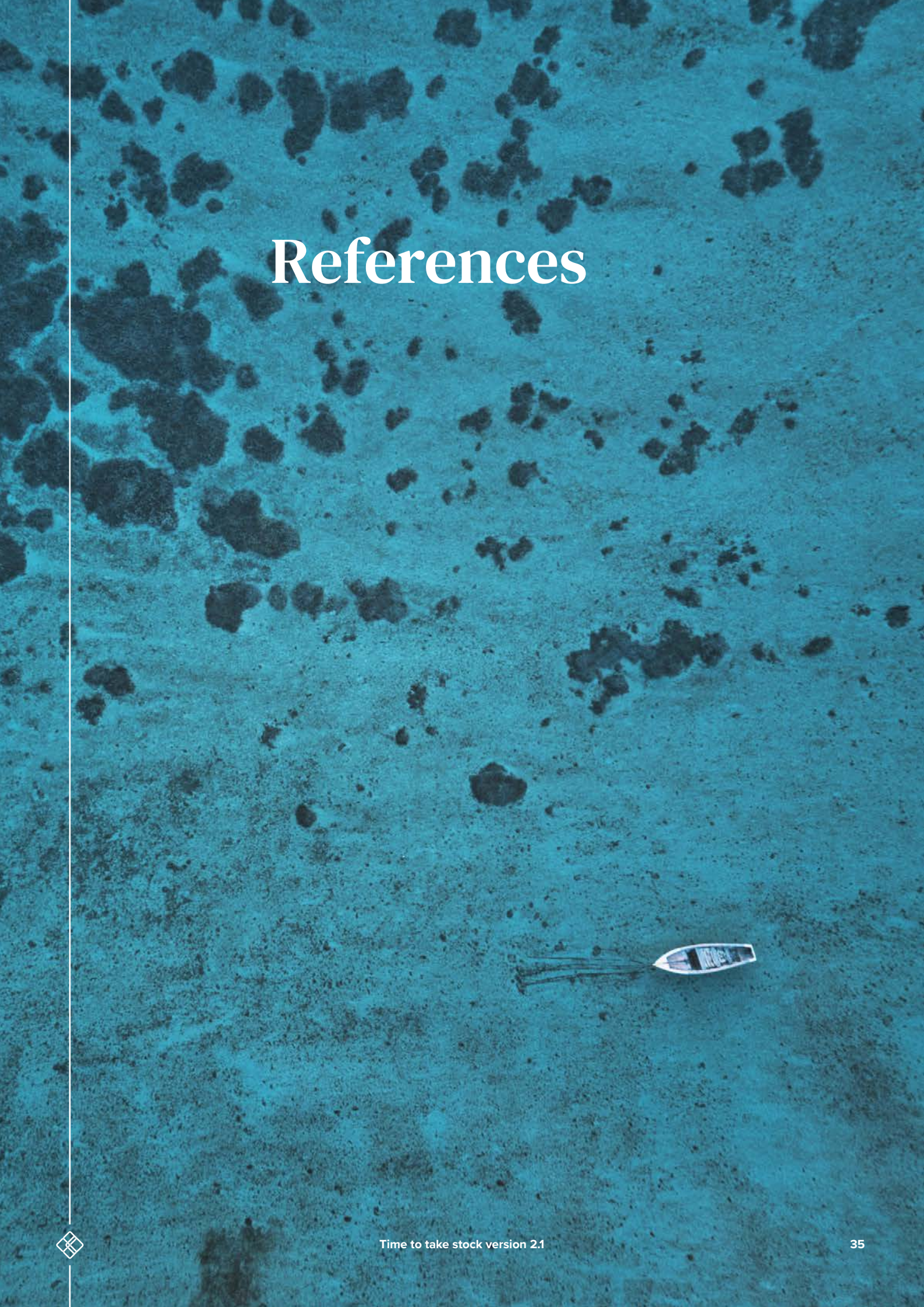

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