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The Forestry Natural Capital Handbook A practical guide to corporate natural capital accounting, assessment, risk assessment and reporting

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NATIONAL INSTITUTE FOR
FOREST PRODUCTS INNOVATION
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The Forestry Natural Capital Handbook

A practical guide to corporate natural capital accounting, assessment, risk assessment and reporting

Prepared for

National Institute for Forest Products Innovation

Launceston

by

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Executive Summary

This handbook provides guidance on natural capital accounting, impact and dependency assessment, risk assessment, and reporting for organisations (private, public, and non-profit). It does not seek to replicate guidance that is already published elsewhere, but to provide a practical 'how-to' guide which points towards other resources and helps to make sense of occasional differences in interpretation between different sources, so that organisations can make informed decisions about what approach will best suit their own needs.

*The natural capital approach extends the economic notion of capital (resources that enable economic production) to the natural environment. The term '**natural capital**' conceptualises nature as assets: stocks of resources such as clean air, water, soil and living things which produce flows of **ecosystem services** that have value because they **benefit** humans (households or firms).*

The guidance in this handbook is applicable to organisations of different size and types (private, public and non-profit organisations). The main intended audiences are organisations that own or control natural capital (such as forestry organisations) that are seeking to prepare natural capital accounts or natural capital impact, dependency, and risk assessments. The natural capital accounts and assessments aim to provide useful information for managers of organisations and their stakeholders such as investors, lenders, certification bodies, regulators, and the general public.

Although aimed at organisations, the concepts and principles in this report could be applied at different scales, such as regional or sector level accounts or assessments. The natural capital accounting guidance in this handbook is designed to be consistent with national-level accounting under the UN System of Environmental-Economic Accounting (SEEA) but has been simplified and streamlined for organisational level application.

While there is guidance available for each of these activities in isolation, what has been missing until now is guidance that covers all these different activities and explains how they relate to each other. The key features of this handbook are:

- **Clear differentiation** between **natural capital accounting** for organisations (which is principally relevant to organisations that own or control natural capital assets) and **natural capital impact, dependency and risk assessment** (which any organisation can use to understand and report their interactions with natural capital, regardless of ownership or location of that natural capital);
- Acknowledgement of a **central role for natural capital risk assessment**, which applies to all organisations and builds on the core elements common to any natural capital assessment (i.e. assessment of impacts and dependencies);
- Identification of **five key disclosure statements** that together can form a complete picture of an organisation's interactions with natural capital:
    - 1) a **natural capital balance sheet** and 2) associated **natural capital income statement** (principally applicable to organisations that own or control natural capital assets); and

- 3) a **natural capital impact statement**, 4) **natural capital dependency statement** and 5) **natural capital risk statement** (applicable to any organisation).

- **Alignment with existing corporate reporting**: the natural capital balance sheet and income statement are closely aligned with their financial equivalents (i.e. the balance sheet or statement of financial position as at the end of the period, and the income statement or statement of profit or loss and other comprehensive income for the period), while the natural capital risk statement is aligned with the corporate risk statement, and the impact and dependency statements are aligned with sustainability disclosures. Importantly, the natural capital income statement as defined here explains all changes reported in the natural capital balance sheet, in the same way that the financial income statement explains changes reported in the financial balance sheet.

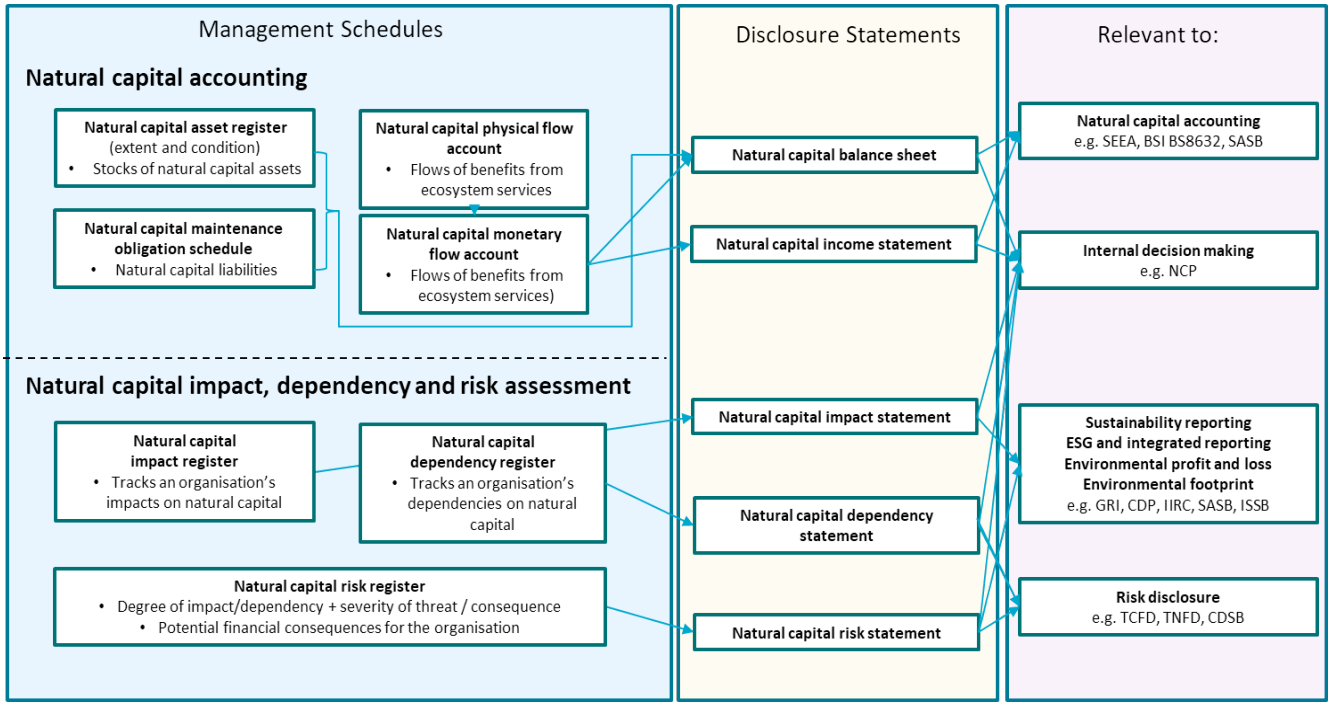

Figure 1 Corporate natural capital accounting, assessment, risk assessment and reporting

What are natural capital accounts, and natural capital impact, dependency and risk assessments?

Natural capital accounting identifies and records consistent and comparable information on natural capital assets and the services provided to the organisation and other users (e.g. society). It includes information on the state (quantity and quality, or extent and condition) of natural capital assets, the flows of ecosystem services that these assets provide, and associated monetary values (if desired, and where it is feasible to identify such values). For organisations, natural capital accounting can be seen as a logical extension of management and financial accounts, bringing the structure and rigour to natural capital that is already applied to manufactured and financial capital. Unlike financial accounting frameworks—which are well established and often mandatory—natural capital accounting is currently a voluntary and flexible process for organisations. An international standard, the System of Environmental-Economic Accounting (SEEA) exists for natural capital accounting at a national government level [(United Nations, 2021, United Nations et al., 2012), but its application at local or organisational scale is still at an early stage (Barker 2019). This handbook adopts SEEA-compatible concepts and approaches wherever possible in order to promote consistency between environmental-economic accounting and reporting at different scales.

A standard for natural capital accounting for organisations has recently been released by the British Standards Institution (BSI, 2021). The BSI standard offers useful guidance on the process of preparing natural capital accounts for organisations but has some disadvantages insofar as it combines aspects of natural capital accounting with impact and dependency assessment without clear separation between the two. In this handbook we attempt to reconcile these differences by referencing relevant sections of the BSI standard in relation to these two separate activities.

Natural capital impact and dependency assessment identifies and records consistent and comparable information on the organisation's relevant (material) impacts and dependencies on natural capital (whether those natural capital assets are owned/controlled by the organisation, or not). **Natural capital impacts** include negative impacts, such as land degradation, emissions or pollution, and positive impacts, such as carbon sequestration or ecological rehabilitation.[1] **Natural capital dependencies** include any material reliance on or use of natural capital, such as reliance on adequate rainfall or groundwater resources, or the services provided by insect pollinators. In some cases, the relevant dependency might be the *absence* of conditions that would otherwise be unfavourable (such as extreme weather or pests and diseases). Relevant existing guidance includes the **Natural Capital Protocol** (Natural Capital Coalition, 2016). The Natural Capital Protocol provides a generic framework for organisations to identify their natural capital impacts and dependencies, and then to measure and value what is relevant, without prescribing how such measurement or valuation should be done or how it should be used or disclosed.

Natural capital risk assessment identifies and records consistent and comparable information on the material risks to the organisation arising from their natural capital impacts and dependencies and how these are projected to change in the future (e.g. through management changes, climate change or changes in social preferences and regulation). Broadly speaking, physical changes such as climate change or habitat loss that affect natural capital dependencies can be thought of as 'physical risks', while changes in social responses to natural capital impact are often driven by society's transition towards a lower-impact state, hence 'transition risks'. However, in principle, transitions can also affect natural capital dependencies (e.g. by increasing demand for some forms of natural capital and reducing demand for others), while physical risks can also affect the context and social consequences of impacts (e.g. climate change may increase water scarcity in a region, hence increasing the impacts of water consumption, which may lead to greater regulation or higher pricing).

Relevant existing guidance includes the **Natural Capital Finance Alliance (NCFA)** methods and tools for portfolio-level natural capital risk assessment (NCFA and PwC, 2018, NCFA and UN Environment World Conservation Monitoring Centre, 2018) and individual asset-level risk assessment in agriculture (Ascui and Cojoianu, 2019). In addition, a natural capital risk materiality assessment has been undertaken for Australian forestry (Smith et al., 2021b, Smith et al., 2021a).

Why conduct natural capital accounting?

Natural capital accounts are principally **relevant for organisations that own or control natural capital assets**, e.g. forest growers, farmers, government, and non-governmental organisations with substantial landholdings. They provide information for internal decision-making (similar to

[1] In this handbook we use the terms 'positive' and 'negative' for impacts that generally improve or degrade natural capital, respectively. However, this is a complex topic and impacts could be positive for some aspects of natural capital and negative for others, and/or viewed differently from different value perspectives or by different stakeholders. It is up to the organisation to clarify the basis on which any distinction between 'positive' and 'negative' impacts is made, particularly if using these concepts to report 'net' impacts.

conventional management accounting information) and external reporting/disclosure (aligned with financial or annual reporting).

Natural capital accounting: measure and report on owned or controlled natural capital assets:
Step 1: Develop natural capital accounts for internal management use:
- Natural capital asset register (including extent and condition accounts)
- Natural capital obligation schedule
- Natural capital physical flow account (including a schedule of projected future flows)
- Natural capital monetary flow schedule (including a schedule of projected future flows)

Step 2: Develop natural capital accounting statements for external reporting:
- Natural capital balance sheet
- Natural capital income statement

Step 3: Synthesise in a natural capital report or integrate alongside financial accounts.

Why conduct natural capital impact, dependency, and risk assessments?

Natural capital impact, dependency and risk assessments are **relevant for all organisations**.

Natural capital impact and dependency assessments provide information for external reporting/disclosure, aligned with the organisation's sustainability reporting (which may take the form of environmental, social, and governance (ESG) reporting, Sustainable Development Goals (SDG) reporting or integrated reporting). They can also inform how organisations manage their operations, configure their supply chains, identify strategic opportunities and risks and make investment decisions.

Natural capital risk assessments provide a structured and consistent way for organisations to integrate natural capital risk management into their decision-making and risk reporting, aligned with the organisation's corporate risk reporting, and with disclosure frameworks such as the Task Force on Climate-Related Financial Disclosures (TCFD) and Task Force on Nature-Related Financial Disclosures (TNFD). Changes in the availability of natural capital and the ecosystem services that an organisation depends on can threaten the productivity, profitability or even viability of the organisation. Natural capital impacts can also affect the financial position of an organisation, for example when society responds to natural capital impacts through regulation (such as fines) or changes in consumer acceptance (such as restricted access to certain markets in the absence of sustainability certification).

Natural capital impact, dependency, and risk assessment: measure and report on natural capital impacts, dependencies and risks:
Step 1: Develop natural capital impact, dependency and risk registers for internal management use:
- Natural capital impact register
- Natural capital dependency register
- Natural capital risk register (including materiality assessment)

Step 3: Develop natural capital impact, dependency and risk statements for external reporting:
- Natural capital impact statement
- Natural capital dependency statement
- Natural capital risk statement

Step 4: Synthesise in a natural capital report or integrate into non-financial/sustainability reporting or into corporate risk statements.

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Acronyms

AASB	Australian Accounting Standards Board
BSI	British Standards Institution
CDSB	Climate Disclosure Standards Board
CICES	Common International Classification of Ecosystem Services
ESG	Environmental, Social and Governance
GRI	Global Reporting Initiative
IAS	International Accounting Standards
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
IIRC	International Integrated Reporting Council
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IUCN-GET	IUCN Global Ecosystem Typology
NCFA	Natural Capital Finance Alliance
NCP	Natural Capital Protocol
NPV	Net Present Value
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
SEEA	UN System of Environmental-Economic Accounting
SEEA-CF	SEEA – Central Framework
SEEA-EA	SEEA – Ecosystem Accounting
SNA	System of National Accounts
TCFD	Task Force on Climate-related Financial Disclosures
TNFD	Task Force on Nature-related Financial Disclosures
TEEB	The Economics of Ecosystems and Biodiversity

Introduction

This handbook provides guidance on natural capital accounting, impact and dependency assessment, risk assessment, and reporting, particularly (but not exclusively) for organisations that own or control natural capital assets, such as forestry organisations. It does not seek to replicate guidance that is already published elsewhere, but to provide a practical 'how-to' guide which points the user towards other resources and helps to make sense of occasional differences in interpretation between different sources, so that users can make informed decisions about what approach will best suit their own needs.

The guidance in this handbook is applicable to organisations of different size and types (private, public and non-profit organisations). The main intended audiences are organisations that own or control natural capital (such as forestry organisations) that are seeking to prepare natural capital accounts or natural capital impact, dependency, and risk assessments. The natural capital accounts and assessments aim to provide useful information for managers of organisations and their stakeholders such as investors, lenders, certification bodies, regulators, and the general public.

Although aimed at organisations, the concepts and principles in this report could be applied at different scales, such as regional or sector level accounts or assessments. The natural capital accounting guidance in this handbook is designed to be consistent with national-level accounting under the UN System of Environmental-Economic Accounting (SEEA) but has been simplified and streamlined for organisational level application.

The major natural-capital-related accounting, impact, dependency and risk assessment and reporting activities relevant to organisations are the following:

- **Natural capital accounting** has been defined as "the process of compiling consistent, comparable and regularly produced data using an accounting approach on natural capital and the flow of services generated in physical and monetary terms" (Lammerant, 2019 p6). The most well-developed framework for natural capital accounting is the System of Environmental-Economic Accounting (SEEA), which is a United Nations standard guiding the preparation of natural capital accounts at the national level (United Nations, 2021, United Nations et al., 2012). However, various approaches have also been developed for natural capital accounting at the corporate level (Eftec et al., 2015, BSI, 2021).
- **Natural capital impact and dependency assessment** is a much broader concept, which has been defined as "the process of identifying, measuring and valuing relevant ("material") natural capital impacts and/ or dependencies, using appropriate methods" (Lammerant, 2019 p6). Although this sounds similar to natural capital accounting, the focus on impacts and dependencies (i.e., chains of cause and effect) is fundamentally different to natural capital accounting's focus on stocks and flows (even though they may occasionally overlap). Natural capital impact and dependency assessment may encompass a range of activities such as options appraisal, performance assessment and risk assessment. The Natural Capital Protocol (NCP) (Natural Capital Coalition, 2016) provides a generic framework for organisations to identify, measure and value their natural capital impacts and dependencies, without prescribing how such measurement and valuation should be done nor how it should be used or disclosed.
- **Natural capital risk assessment** (NCRA) can be defined as the process of identifying, measuring and evaluating relevant ("material") risks arising from an entity's impacts and/or dependencies on natural capital. The Natural Capital Finance Alliance (NCFA) has developed methods and tools for portfolio-level natural capital risk assessment (NCFA and PwC, 2018,

NCFA and UN Environment World Conservation Monitoring Centre, 2018) and individual asset-level risk assessment (Ascui and Cojoianu, 2019), the latter of which is consistent with the NCP.

- **Natural capital reporting** or disclosure involves the communication of natural-capital-related information to external stakeholders, such as shareholders, regulators, and civil society. A number of different voluntary standards and guidance have covered the disclosure of various aspects of natural-capital-related information by organisations, published by organisations including the Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), Climate Disclosure Standards Board (CDSB), International Integrated Reporting Council (IIRC) and the Taskforce on Climate-related Financial Disclosures (TCFD) (TCFD, 2017, CDSB, 2019, CDP et al., 2020, GRI, 2011). In November 2021, a new International Sustainability Standards Board (ISSB) was formed by the International Financial Reporting Standards (IFRS) Foundation, which also oversees the International Accounting Standards Board (IASB) which sets corporate financial accounting standards. The ISSB will set standards for disclosure of sustainability-related information that is material to company value, building on the existing SASB, CDSB, IIRC and TCFD standards and guidance and consistent with IASB standards, while the GRI will likely continue to provide a framework for voluntary reporting of sustainability-related information that is more broadly relevant to society. IFRS standards are not, in themselves, mandatory, but they have been adopted into mandatory reporting requirements for listed companies in 144 jurisdictions (including Australia), and they are often followed voluntarily by companies not subject to these requirements. Therefore, while natural capital reporting has been entirely voluntary in the past, reporting of natural capital information that is material to company value is likely to become increasingly expected, if not mandatory, for many organisations in the near future.

While there is guidance available for each of these activities in isolation, what has been missing until now is an integrated framework that provides guidance across all these different activities and explains how they relate to each other, specifically for corporate or other organisational users. Figure 1 sets out such an integrated framework. The key features of the framework, implemented in this handbook, are:

- **Clear differentiation** between **natural capital accounting** for organisations (which is principally relevant to organisations that own or control natural capital assets) and **natural capital impact, dependency and risk assessment** (which any organisation can use to understand and report their interactions with natural capital, regardless of ownership or location of that natural capital);
- Acknowledgement of a **central role for natural capital risk assessment**, which applies to all organisations and builds on the core elements common to any natural capital assessment (i.e. assessment of impacts and dependencies);
- Identification of **five key disclosure statements** that together can form a complete picture of an organisation's interactions with natural capital:
    - 1) a **natural capital balance sheet** and 2) associated **natural capital income statement** (principally applicable to organisations that own or control natural capital assets); and
    - 3) a **natural capital impact statement**, 4) **natural capital dependency statement** and 5) **natural capital risk statement** (applicable to any organisation).
- **Alignment with existing corporate reporting**: the natural capital balance sheet and income statement are closely aligned with their financial equivalents (i.e. the balance sheet or statement of financial position as at the end of the period, and the income statement or statement of profit or loss and other comprehensive income for the period), while the natural capital risk statement is aligned with the corporate risk statement, and the impact and dependency statements are aligned with sustainability disclosures. Importantly, the natural capital income statement as defined here explains all changes reported in the natural capital balance sheet, in the same way that the financial income statement explains changes reported in the financial balance sheet. Of the five statements, the natural capital balance sheet and natural capital impact statements are relatively

well established, with many other examples of reporting practice, some of which we refer to in this handbook. Natural capital income statements, dependency statements and risk statements, on the other hand, are less well developed, and we have therefore given our own hypothetical examples.

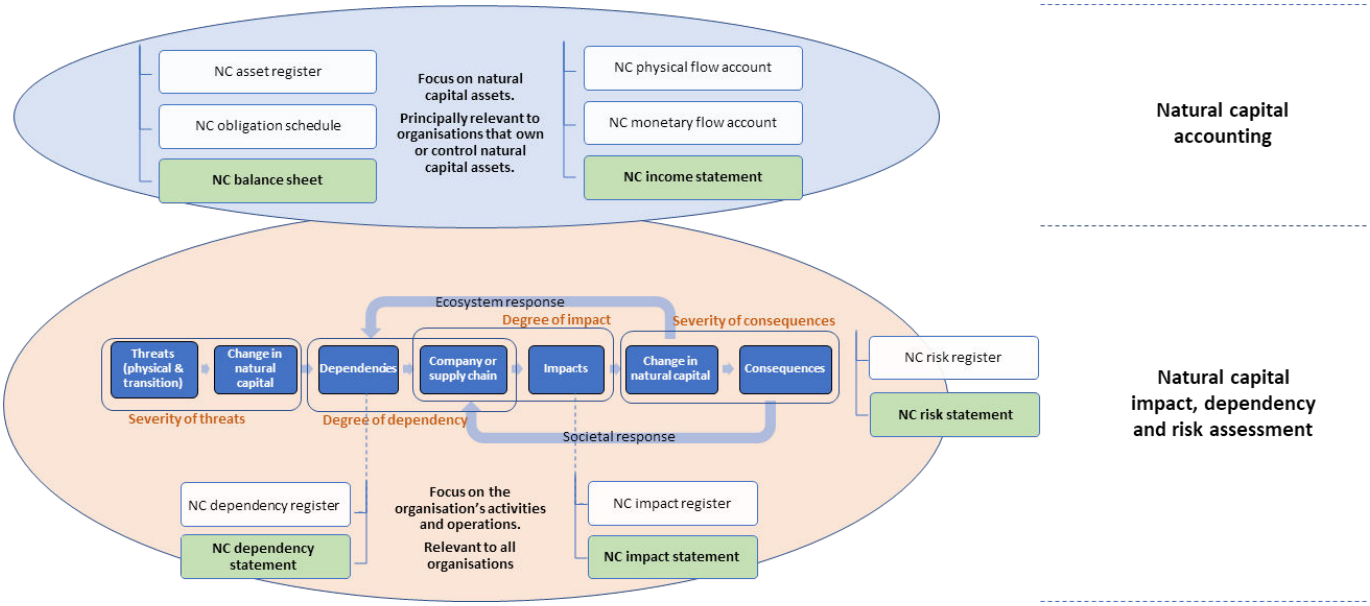


Figure 2 Integrated framework for natural capital accounting, assessment, risk assessment and reporting.

While this integrated framework is broadly consistent with existing guidance, it also highlights some inevitable inconsistencies. One key source of confusion arises from the fact that different natural capital activities are relevant for different types of organisations. Natural capital accounting is principally relevant to organisations that own or control natural capital assets (for example, forestry or agriculture) and has a focus on these natural capital assets. Natural capital impact and dependency assessments and natural capital risk assessments are relevant for all organisations, because virtually all organisations impact on and depend on natural capital to some degree, and these impacts and dependencies can result in exposure to natural capital risks. These activities therefore have a focus on the organisation's activities and operations.

Clarifying differences in viewpoint: the natural capital income statement

Differences in viewpoint have in the past led to the term 'environmental profit and loss' (PUMA, 2011, Kering, 2020) being used for what is essentially a natural capital impact statement, as opposed to a statement of comprehensive income from owned/controlled natural capital assets. Similarly, the BS8632:2021 standard (BSI, 2021) adopts the term 'natural capital income statement' for a statement of the organisation's impacts on (any) natural capital. A major disadvantage of this approach is that it breaks the fundamental relationship that exists in financial accounting between the balance sheet and the income statement, where the income statement should explain the changes in the balance sheet over the reporting period – and which therefore should focus only on changes in the *same* set of natural capital assets, i.e. those that the organisation owns or controls. We therefore propose that the term 'natural capital income statement' is reserved for a statement of the comprehensive (positive and negative) flows of benefits from natural capital assets that an organisation owns or controls, while the term 'natural capital impact statement' is used for any statement of the organisation's impacts (positive and negative) on natural capital in general. Viewed in this way, natural capital balance sheets and income statements have the organisation's natural capital *assets* as their focus; whereas natural capital impact and dependency statements have the *organisation's* wider relationship with natural capital as their focus.

What to expect in this handbook?

This handbook

- Delivers practical guidance on how to undertake natural capital accounting, impact and dependency assessment, risk assessment, and reporting; particularly (but not exclusively) for organisations that own or control natural capital assets, such as forestry organisations.

Structured into two main parts

- Part 1: Natural capital accounting
- Part 2: Natural capital impact, dependency, and risk assessment
- Each part is in turn divided into a separate section for each account, register or schedule (oriented towards internal users) and each associated statement (oriented towards external users).

Additional detail

- Further details on key concepts related to natural capital assets and ecosystem services are contained in the Appendix.

Companion workbooks are also provided in separate Excel files which have expanded worked examples and additional indicators and data which may be relevant for the forestry sector.

- Companion workbook - Natural capital accounting: Forestry
- Companion workbook - Natural capital impact, dependency, and risk assessment: Forestry

An emerging area of science

- It is important to emphasise that, because this is still an emerging area of science, the guidance provided in this handbook should be viewed as a starting point and is subject to change as new evidence, approaches and standards emerge.

How to use this guide

- The main body of text in the handbook provides, for each natural capital account, register, schedule or statement, a summary of **what** it is, **why** it is relevant to an organisation, and a step-by-step explanation for **how** the account, register, schedule or statement is constructed. This is followed by simplified worked examples, which are expanded on in the companion workbook.

The sidebars

- Provide brief summaries of key concepts that may be useful to understand alongside the main text and example accounts, registers, schedules and statements. The sidebars also provide cross-references to existing standards and guidance and provide commentary where guidance from different sources is conflicting.

Steps for natural capital accounting, assessment, risk assessment and reporting

The generic steps for undertaking and reporting on natural capital accounting, impact and dependency assessments and risk assessments are shown here and illustrated in Figure 2.

Natural capital accounting: measure and report on owned or controlled natural capital assets:

Step 1: Develop natural capital accounts for internal use:

- Natural capital asset register (including extent and condition accounts)
- Natural capital obligation schedule
- Natural capital physical flow account (including estimating changes to future flows)
- Natural capital monetary flow account (including estimating changes to future flows)

Step 2: Develop natural capital accounting statements for external reporting:

- Natural capital balance sheet
- Natural capital income statement

Step 3: Synthesise in a natural capital report or integrate alongside financial accounts.

Natural capital impact, dependency and risk assessment: measure and report on natural capital impacts, dependencies and risks:

Step 1: Develop natural capital impact, dependency and risk registers for internal management use:

- Natural capital impact register
- Natural capital dependency register
- Natural capital risk register

Step 2: Develop natural capital impact, dependency and risk statements for external reporting:

- Natural capital impact statement
- Natural capital dependency statement
- Natural capital risk statement

Step 4: Synthesise in a natural capital report or integrate into non-financial/sustainability reporting or into corporate risk statements.

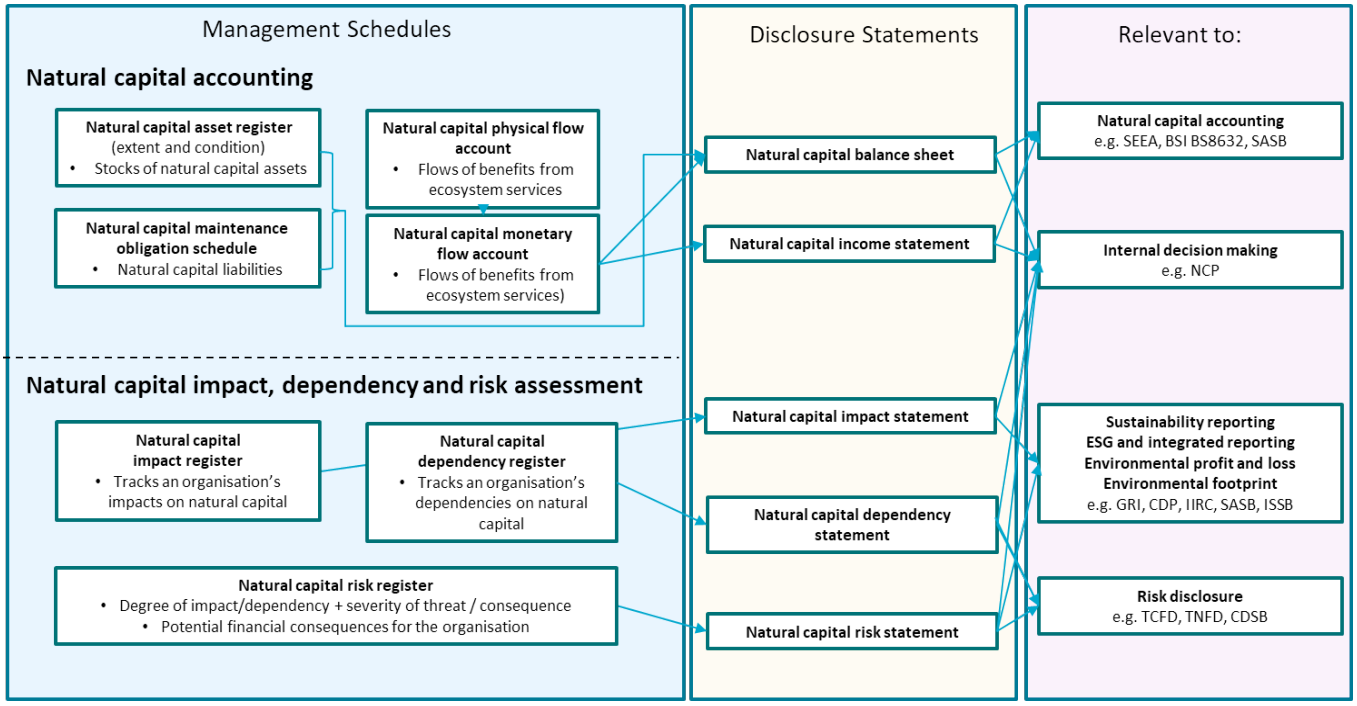


Figure 3 Corporate natural capital accounting, assessment, risk assessment and reporting.

1. Natural Capital Accounting

What?

- **Natural capital accounting** identifies and records consistent and comparable information on **natural capital assets and the ecosystem services provided to the organisation and other users** (e.g. society).
- **Natural capital** assets are the stock of natural resources, e.g., plants, animals, air, water, soils, minerals (NCP 2016 p. 2)
- **Ecosystem services** are the contributions of ecosystems to the benefits that are used in economic and other human activity SEEA-EA 2021, s. 6.9, p. 121). Ecosystem services provided by forests include timber and wood fibre, food such as fungi, plants, habitat for a variety of fauna, climate regulation through absorbing carbon dioxide, and recreation and cultural opportunities.
- Natural capital accounting focuses on the natural capital assets that the organisation owns or controls.
- **If an organisation does not own or control any natural capital assets, they should turn to p. 32, 'Natural capital impact, dependency and risk assessment'.**

Why?

- Natural capital accounting is principally relevant for organisations that own or control natural capital assets, for example, forest growers, farmers, government, and non-government organisations.
- It provides information relevant for internal decision-making and external reporting/disclosure, aligned with financial and annual reporting.

How?

The natural capital accounts consist of four supporting schedules:

- **Natural capital asset register (including extent and condition accounts)**
- **Natural capital obligation schedule**
- **Natural capital physical flow account**
- **Natural capital monetary flow account**

Which are used to produce two reporting statements:

- **Natural capital balance sheet**

Concepts

Natural capital accounting

There are two branches of natural capital accounting, one more closely connected to governmental System of National Accounts, and the other to the financial and management accounts of organisations:

National natural capital accounting has yielded internationally adopted frameworks such as the United Nations System of Environmental and Economic Accounting (SEEA) Central Framework and SEEA- Ecosystem Accounts. The scale typically ranges from regional to national.

Corporate natural capital accounting has yielded different assessment frameworks aimed at the integration of natural capital concerns into corporate decision-making. The scale typically ranges from local to regional.

Natural capital asset recognition

Similar to other assets, natural capital assets should be recognised in an organisation's accounts when the asset is a resource controlled by the entity as a result of past events and from which future economic benefits are expected to flow to the entity (AASB, 2019).

Consistency with financial statements

The two natural capital statements are inspired by two key financial statements:

a) **the balance sheet** – which reports an organisation's assets, liabilities, and shareholders' equity at a specific point in time; and

b) **the income statement** – which reports an organisation's revenues and expenses over a specified accounting period, usually a year. It presents the flows from economic activity of the organisation.

- **Natural capital income statement**

We show how to organise natural capital information in the subsequent example accounts and statements. Additional detail is provided in the companion workbook 'Natural capital accounting workbook: forestry'.

Before starting a natural capital accounting exercise, it is recommended to identify the purpose of the exercise, and any applicable legal or voluntary requirements. For example, if the purpose is to produce natural capital accounting data that is consistent with national accounting, then it is advisable to follow SEEA guidelines, for example, using **exchange values** rather than **welfare values** when it comes to monetary valuation.

Natural capital accounting: value

- When calculated using market-based monetary values, the value to the organisation presented in the natural capital balance sheet and natural capital income statement should be consistent with values already reported in the organisation's financial balance sheet and income statement, but with clearer allocation to the natural capital assets (e.g. the value of ecosystem assets on a piece of land can be reported separately to the market value of that land).
- The additional value to society of the organisation's natural capital assets can also be reported separately to their value to the organisation. These values may accrue to other specific actors, or society in general. If markets exist for these values to society (e.g. the value of mushrooms harvested from the organisation's forest and sold to local restaurants), then market prices may be used, or exchange values may be inferred using market price proxies. SEEA accounts use exchange values only.
- However, in some cases, exchange values may be considered inappropriate (e.g. for cultural value), or insufficient to represent the true value of something to society, i.e. its welfare value. An example is the social cost of carbon, which is much higher than carbon prices in existing carbon markets. If both exchange values and welfare values are used in natural capital accounting, they should be clearly identified as such, kept separate and never added together to avoid issues with inconsistent measurement and double counting. See Appendix A1 for further information.

Values

Exchange values represent the contribution of an asset or service to the market economy, regardless of their impact on human welfare. **Welfare values** reflect the contribution of an asset or service to human welfare, regardless of their contribution to the market economy.

For most market goods, exchange values are readily available. However, for natural capital and ecosystem services, most of which are not traded in the market, it is impossible to observe an exchange value and instead exchange values need to be imputed. Identifying exchange values for ecosystem services is conceptually challenging. Since exchange values don't capture the full welfare value, for some services, exchange values are likely to be significantly smaller than welfare values.

Existing guidance

The example natural capital accounts proposed here are broadly consistent with the approach of SEEA EA (United Nations, 2021).

BS8632:2021 for natural capital accounting (BSI, 2021) has different definitions of the natural capital balance sheet and natural capital income statement. BS8632:2021 defines a natural capital balance sheet as an account of "the dependencies of the organization and its value chain on natural capital assets" and a natural capital income statement as an account of "the positive and negative impacts of the operations of the organization and its value chain on natural capital assets". We recommend that these definitions are taken instead as appropriate definitions of the natural capital dependency statement and natural capital impact statement, respectively.

Example scenario used in the following example natural capital accounting accounts and statements:

For the example natural capital accounts and statements presented in this document the following natural capital assets and ecosystem services are used throughout:

- NC Asset: Plantation Forest.
  Priority ecosystem services covered: Provisions of timber and carbon sequestration.
- NC Asset: Native Forest.
  Priority ecosystem services covered: Provisions of seeds and plants.
- NC Asset: Upland streams.
  Priority ecosystem services covered. Recreational Fishing.

1.1 Natural Capital Asset Register (Extent and Condition Accounts)

What?

- A natural capital asset register is a list of the natural capital assets that the organisation owns or controls.
- The SEEA standards draw a distinction between **ecosystem assets** (areas of specific ecosystem types, covered in SEEA-EA) and other **environmental assets** such as mineral deposits, land, water and energy resources (covered in the SEEA-CF). As most environmental assets are generally already considered as assets within corporate financial accounting standards,[2] the remainder of this handbook will focus on ecosystem assets. Where there is overlap (e.g. areas of land or water resources can be both environmental assets and ecosystem assets) then the value of each type of asset should be reported separately to avoid double-counting, e.g. the market value of land based on *IAS 16 Property, Plant and Equipment* as the environmental asset value and the net present value of ecosystem services as the ecosystem asset value (see natural capital monetary flow account).
- Natural capital extent and condition accounts track the quantity and quality of ecosystem assets owned or controlled by an organisation.

Why?

- A natural capital extent and condition account provides information for tracking trends in the extent and ecological condition of ecosystem assets and understanding the outcomes of management activities. An asset's extent and condition are factors determining the asset's capacity to provide flows of ecosystem services.

How?

Step 1: Identify and list all relevant natural capital assets, divided into environmental and ecosystem assets. Ecosystem assets are contiguous areas of a given ecosystem type. A variety of classification systems exist. Using the IUCN Global Ecosystem Typology (IUCN GET), adopted by

Concepts

Environmental assets

Asset stock accounts for environmental assets (resources such as minerals, water and timber) are covered in the SEEA-CF. The SEEA-CF asset accounts record the opening and closing stocks of the relevant individual resource and then the various additions and reductions in stock, including regeneration and depletion (United Nations, 2021).

Ecosystem typology for ecosystem assets

IUCN Global Ecosystem Typology (IUCN GET) is a global typological framework that applies an ecosystem process-based approach to ecosystem classification for all ecosystems around the world. It is the recommended ecosystem typology in SEEA-EA and using it may enable the data to be more easily scaled up and to be comparable to regional, national or international assessments (IUCN Global Ecosystem Typology). For forestry, plantations would be classified under "T7.3 Plantations", while native forest in Australia can be classified in a variety of IUCN-GET ecosystem functional groups including "T1.1 Tropical-subtropical lowland rainforests", "T2.3 Oceanic cool temperate rainforests", T2.4 Warm temperate laurophyll forests", "T2.5 Temperate pyric humid forests", "T2.6 Temperate pyric sclerophyll forests and woodlands" and "T4.4 Temperate woodlands." Rivers and streams can likewise be classified in various ecosystem functional groups such as "F1.1 Permanent upland streams" or "F1.4 Seasonal upland streams."

Measuring ecosystem extent

Ecosystem extent is "the spatial area of an ecosystem asset" (SEEA-EA 2021, s. 2.13, p. 27). Although usually measured in two-dimensional area, ecosystem assets may be measured in one dimension (e.g. stream length) or three dimensions (e.g. water body volume). Care must be taken not to add quantities expressed in different dimensional units.

Measuring ecosystem condition

Ecosystem condition is "the quality of an ecosystem measured in its abiotic and biotic characteristics" (SEEA-EA 2021, s.2.13, p.27).

[2] E.g. IAS 41 *Agriculture* applies to the harvested produce of an entity's biological assets, such as felled timber from trees in a plantation; IAS 16 *Property, Plant and Equipment* and IAS 40 *Investment Property* apply to land owned by an entity.

SEEA-EA, may promote comparability to other natural capital accounts. However, an organisation may wish to use more industry-relevant classifications, for example for forestry it might be relevant to separate softwood plantations from hardwood plantations or by species.

Consider natural capital assets owned or controlled and classify in a way that is most useful to the organisation.

Step 2: Measure opening and closing **ecosystem extent**: the size of each ecosystem asset in terms of spatial area (see additional explanation in sidebar). Produce an extent account.

Step 3: Consider appropriate **ecosystem condition** variables, indicators or indices for each natural capital asset and measure opening and closing values of each selected condition metric (see additional explanation in sidebar). Produce a condition account.

Consider how condition is related to the ecosystem services the asset provides.

Step 4 (optional): Produce a combined natural capital extent and condition account

Requires a single condition index for each asset.

Classify the reason for change (e.g. conversions of ecosystem type, condition change (upgrades / downgrades), natural increase/decrease or reappraisal).

Example:

- There are numerous ways to compile extent and condition accounts. The examples below show options for presenting separate extent and condition accounts (using condition variables and condition indices) and an option for presenting a combined extent and condition account. Combining information may not be feasible or desirable for all organisations, and separate tables may enable a higher level of detail to be captured. Other relevant information such as identified critical thresholds, tipping points, non-linearities and capacities could also be documented, if known.
- The example accounts show potential natural capital asset condition measures, but these will vary depending on the priorities of the organisation and their stakeholders.

Ecosystem condition can be measured using condition variables, indicators or indices. Ecosystem condition variables are quantitative biophysical metrics describing individual characteristics of an ecosystem asset (SEEA-EA 2021, s.5.41 p. 92). Indicators are ecosystem condition variables which have been normalised on a common scale relative to a reference level (SEEA-EA 2021, s.5.60 p. 95). Variables and indicators can be weighted and aggregated to composite indices of ecosystem condition (SEEA-EA 2021, s.5.81 p. 99).

The SEEA Ecosystem Typology (SEEA-EA 2021, Table 5.1) provides a useful guide to systematically considering different types of condition characteristics, including abiotic characteristics (physical and chemical state, e.g. % soil organic carbon), biotic characteristics (compositional, structural and functional state, e.g. species richness, forest age class, disturbance) and landscape level characteristics (e.g. connectivity and fragmentation). Further examples are given in SEEA-EA 2021, Table 5.6.

Change Matrix

Ecosystem extent/condition change matrices can be produced to show additional detail related to conversions between ecosystem types or condition categories: for example, see the SEEA-EA:4.3.2 (SEEA Change Matrix).

Other examples

Additional example extent and condition accounts and guidance are available in the British Standard on natural capital accounting for organizations (BS 8632:2021, section 6.7.1.2, p21) and SEEA-EA (SEEA Extent Account) (SEEA-EA Condition Account).

Several natural capital accounts exist that include forestry extent and condition accounts:

- Forestry England Natural Capital Accounts (Forestry England Asset Register).
- Experimental natural capital accounts for the forestry industry in the Green Triangle (Stewart et al., 2020a).
- Experimental natural capital accounts for cotton (Stewart et al., 2020b).
- Experimental natural capital accounts for the prawn-fishing industry in the Wallis Lake estuary (Ware et al., 2020).
- Central Highlands experimental ecosystem accounts (Keith et al., 2017).

Example Extent Account

	Units	Plantation forest[a]	Native forest[b]	Upland streams[c]	Infrastructure and other[d]	Total
Opening Extent (Baseline / previous year)	Ha 000's	75	70	7	13	165
Additions	Ha 000's	-	4	-	-	4
Reductions	Ha 000's	-	-	-	4	4
Closing Extent (Reporting year)	Ha 000's	75	74	7	9	165
Net change (Trend)	Ha 000's	-	4	-	-4	-

[a] The plantation forest column shows no change in the overall extent of total plantation forests of 75,000 hectares.

[b] The native forest column shows an increase in the overall extent of total native forest from 70,000 hectares to 74,000 hectares.

[c] The upland streams column shows no change in the overall extent of total upland streams of 7,000 hectares.

[d] The infrastructure and other column describes any addition land owned as part of the forest estate, including roads, agricultural or scrub land. It shows a reduction in the overall extent of 4,000 hectares; this represents the 4,000 hectares of agricultural or scrub land regenerated into native forest.

Example Condition Variable Account

	Plantation forest				Native forest			Upland streams
	Young regen and regrowth (ha 000's)	Mature (ha 000's)	Carbon stock (above ground) (tCO_2e/ha)	Carbon stock (below ground) (tCO_2e/ha)	Carbon stock (above ground) (tCO_2e/ha)	Carbon stock (below ground) (tCO_2e/ha)	Threatened species (Number)	Water turbidity (Nephelometric Turbidity Unit NTU)
Opening condition (Baseline / previous year)	40	35	70	40	140	116	67	4.5
Closing condition (Reporting year)	42	33	65	40	158	124	67	5
Net change (Trend)	2	-2	-5	0	18	8	0	0.5

Example Condition Index Account

	Plantation forest	Native forest	Upland streams
	Plantation forest productivity index (average across estate) (Index 0-100)	Habitat condition index (average across estate) (Index 0-100)	Water quality index (average across estate) (Index 0-100)
Opening condition (Baseline / previous year)	56	45	65
Closing condition (Reporting year)	54	49	58
Net change (Trend)	-2	4	-7

Example Combined Extent and Condition Account

		Plantation forest[a] (forest productivity index / stage of rotation)						Native forest[b] (habitat condition)			Upland streams[c] (water quality)			Infrastructure and other[d]	
	Units	High / Late Rotation	High / Early Rotation	Medium / Late Rotation	Medium / Early Rotation	Low / Late Rotation	Low / Early Rotation	Good	Fair	Poor	Good	Fair	Poor	Roads & other intensive land use	Total
Opening extent (Baseline / previous year)	Ha 000's	20	15	10	25	5	-	40	20	10	2	4	1	13	165
Additions	Ha 000's	2	4	2	-	-	-	-	4	-	2	-	-	-	14
Reductions	Ha 000's	4	2	-	-	2	-	-	-	-	-	2	-	4	14
Closing extent (Reporting year)	Ha 000's	18	17	12	25	3	-	40	24	10	4	2	1	9	165
Net change (Trend)	Ha 000's	-2	2	2	-	-2	-	-	4	-	2	-2	-	-4	-

[a] The plantation forest columns show no change in the overall extent of total plantation forests of 75,000 hectares. 4,000 hectares of high productivity late rotation forest has been harvested and this land will be replanted, so is reclassified as high productivity early rotation forest. In addition, 2,000 hectares of high productivity early rotation forest has matured and been reclassified as high productivity late rotation forest. Finally, 2,000 hectares of low productivity late rotation forest condition has changed to medium productivity.

[b] The native forest columns show an increase in the overall extent of total native forest from 70,000 hectares to 74,000 hectares. The expansion in native forest is from non-forest land (in the infrastructure and other column) being regenerated and shows as a 4,000 hectare increase in the native forest in fair condition.

[c] The upland stream columns show no change in the overall extent of total upland stream of 7,000 hectares. 2,000 hectares of upland streams that was in fair condition has improved to good condition.

[d] The infrastructure and other column describes any addition land owned as part of the forest estate, including roads, agricultural or scrub land. It shows a reduction in the overall extent of 4,000 hectares, this represents the 4,000 hectares of land regenerated into native forest.

1.2 Natural Capital Obligation Schedule

What?

- The natural capital obligation schedule documents the cost of restoring, maintaining, or enhancing the quantity and/or quality of natural capital assets in accordance with the organisation's legal or voluntary responsibilities.

Why?

- A natural capital obligation schedule provides information for tracking the organisation's natural capital **obligation costs**. The obligation costs have a specific link to the liabilities in the natural capital balance sheet.

How?

Step 1: Consider any natural capital obligations (legal or voluntarily adopted).

Step 2: Measure the historical costs of each obligation.

Step 3: Estimate the future costs of each obligation. Document any assumptions.

Step 4: Complete the natural capital obligation schedule using the measures from steps 2 and 3.

Obligation costs

- Obligation costs include costs of activities undertaken and activities expected in the future.
- Obligation costs should be attributed to the natural capital assets managed by the organisation.

Example:

- The example natural capital obligation schedule combines information on current and future expected obligations the organisation has regarding natural capital assets, and the economic cost of meeting those obligations. Organisations should be explicit about which natural capital asset(s) the obligations refer to.

Concepts:

Liabilities, obligations, obligation costs and maintenance costs

According to IAS 137 *Provisions, Contingent Liabilities and Contingent Assets*, a liability is "a present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits." The standard furthermore distinguishes between 'legal obligations' and 'constructive obligations', such as those created by an established pattern of practice or publication of policies stating that the entity accepts certain responsibilities. These definitions are equally applicable to natural capital obligations and liabilities.

The BSI (BSI, 2021) uses the term 'maintenance costs' to describe:

"…the cost of restoring, maintaining or enhancing the quantity and quality of natural capital assets as per the organization's responsibility (legal or voluntary). (BS-8632:2021)."

Here we use the term 'obligation costs' to clarify that the relevant costs are those that are necessary to meet specific legal or voluntary (constructive) obligations for the organisation. A liability is stated on the natural capital balance sheet based on the present value of future obligation costs.

Actual expenditure on maintenance may or may not be sufficient to meet an organisation's obligations with respect to their natural capital assets, hence we recommend not using the term 'maintenance costs'. However, actual expenditure on maintenance may be a guide or proxy for calculating true obligation costs.

These obligation costs are distinct from any other costs of restoring, maintaining, or enhancing natural capital that the organisation does not have a legal or constructive obligation to incur. Such other costs should be included in 'production costs' (see monetary flow account).

Other examples

Additional guidance is available in the British Standard on natural capital accounting for organizations (BS 8632:2021, section 6.7.1.6, p23).

Example Natural Capital Obligation Schedule

	Obligation	Units	2021	2022 Forecast	2023 Forecast etc.	2050 Forecast etc.[e]
Plantation forest	Clean up contaminated land to meet regulation requirements[a]	$ 000's	-110	-70	0	0
Native forest	Native forest regeneration activities to meet certification requirements[b]	$ 000's	-950	-950	-950	-950
	Greenhouse gas emissions reduction to meet net zero commitment[c]	$ 000's	-65	-85	-150	-150
Upland streams	Planting and maintenance of riparian vegetation to meet water quality regulation requirements[d]	$ 000's	-150	-120	-80	-80
	Total obligation costs	$ 000's	-1,275	-1,225	-1,180	-1,180

[a] The plantation forest asset is subject to the organisation's voluntary commitments to clean up contamination. The schedule shows obligations of $110,000 in 2021 and $70,000 in 2022 with no further costs expected into the future.

[b] The native forest asset is subject to the organisation's voluntary commitments to regenerate after harvest. The schedule shows $950,000 of obligations in 2021 and that that will remain constant through to 2050.

[c] The native forest asset is also subject to the organisation's voluntary commitments to maintain and enhance carbon storage in their native forest. The schedule shows $65,000 of obligations in 2021 and that will increase to $85,000 in 2022 and $150,000 in 2023 – remaining constant to 2050.

[d] The upland streams asset is subject to the organisation's regulatory obligation to enhance riparian vegetation. The schedule shows $150,000 of obligations in 2021 and that will decrease to $120,000 in 2022 and $80,000 in 2023 – remaining constant to 2050.

[e] The forecast period covers 2022 to 2050. For simplification in this example, it is assumed that obligations remain constant after 2023. However, the organisation should produce a schedule for the whole accounting period or a written justification for their expectations about future ecosystem service flows.

1.3 Natural Capital Physical Flow Account

What?

- The natural capital physical flow account records flows of ecosystem services provided by natural capital assets over time, to the organisation and (if desired) to society. It includes information on historical actual flows and expected future flows. Technically, the information on historical, actual flows constitutes the 'account' while the information on projected future flows is a separate 'schedule', but for convenience in this handbook we will refer to a single 'account'.
- The flows are measured in the most relevant biophysical units of measurement, with monetary values documented separately in the monetary flow account.

Why?

- A natural capital physical flow account provides information for tracking flows of ecosystem services from the natural capital assets owned or controlled by the organisation. It underpins valuation of ecosystem services in the monetary flow account, which in turn provides a key input to the values reported in the natural capital balance sheet and natural capital income statement.

How?

Step 1: Consider which ecosystem services are most material to the organisation. Consider the appropriate ecosystem service metrics.

Step 2: Consider whether the beneficiary of each ecosystem service is the organisation or another user (e.g. society).

Step 3: Measure the historical flows of each ecosystem service in appropriate biophysical units. Measured flows should represent quantities that actually provide an economic benefit, e.g. timber harvested rather than total biomass production.

Step 4: Estimate the future flows of each ecosystem service in appropriate biophysical units. Future flows should incorporate management decisions and any changes in flows due to natural capital threats to those services (see section 2 on natural capital risk assessment), and any assumptions should be documented.

Step 5: Complete the natural capital physical flow account using the measures from steps 3 and 4.

Example:

- The example below combines information on the historical and forecast period covering all the priority natural capital assets and ecosystem services in our example scenario.

Concepts

Projecting future flows of benefits

Organisations may want to present multiple scenarios using a range of assumptions about future expectations.

Supply and use tables for ecosystem services

A key focus in national natural capital accounting (SEEA guidance) is reconciling the supply and the use of ecosystem services across multiple ecosystem assets and multiple users. As such SEEA recommends compiling 'ecosystem services supply/use tables' see SEEA-EA (Section 7.1 p161) (SEEA Physical Flow Account) for details. The historical flows in our example natural capital physical flow account could be used as the basis of a supply/use table, which may be more applicable to government organisations.

Other examples

Additional guidance on physical flow accounts is available in the British Standard on natural capital accounting for organizations (BS 8632:2021, section 6.7.1.4, p22) and SEEA-EA (Section 7.1 p161) (SEEA Physical Flow Account).

Forestry England Natural Capital Accounts provide an example for forestry (Forestry England Physical Flow Account).

Example Natural Capital Physical Flow Account

Asset	Ecosystem service			2021		2022 forecast		2023 forecast		…	2050 forecast[e]	
		Indicators	Units	Flows to organisation	Flows to society	Flows to organisation	Flows to society	Flows to organisation	Flows to society		Flows to organisation	Flows to society
Plantations	Timber biomass	Timber harvested[a]	Tonnes 000's	350	-	400	-	325	-	…	325	-
	Carbon sequestration	Carbon sequestration[b]	Tonnes 000's		700		660	10	700		10	700
Native Forest	Seeds and plants	Seeds and plants harvested[c]	Tonnes 000's	20		20		30			30	
Upland streams	Recreational fishing	Recreational fishing visits[d]	Visits 000's		15		17		18			18

[a] The timber account shows 350,000 tonnes harvested in 2021 and expectations that that will increase to 400,000 tonnes in 2022 before falling to 325,000 tonnes in 2023. The harvest benefit goes to the organisation.

[b] The carbon sequestration account shows the overall accumulation or reduction of carbon in trees, debris and soil in the plantation estate. The schedule shows that the benefit mainly goes to society (700,000 tonnes sequestered in 2021, and expectations of 660,000 tonnes in 2022 and 700,000 in 2023). However, the schedule also records that in 2023 the organisation expect to get some benefit from the carbon sequestration by selling carbon credits.

[c] The seeds and plants account shows 20,000 tonnes harvested in 2021 and expectations that that will remain constant in 2022 before increasing to 30,000 tonnes in 2023. The seeds and plants benefit goes to the organisation.

[d] The recreational fishing account shows 15,000 visits in 2021 and expectations of an increase in the future to 17,000 in 2022 and 18,000 visits in 2023. The benefits go to society because the upland streams are available for open access opportunities for fishing. If there were private recreation sites with an access fee then they could be recorded as a benefit to the organisation.

[e] The forecast period covers 2022 to 2050. For simplification in this example, it is assumed that flows remain constant after 2023. However, the organisation should produce a schedule for the whole accounting period or a written justification for their expectations about future ecosystem service flows.

1.4 Natural Capital Monetary Flow Account

What?

- The natural capital monetary flow account records monetary values of the benefits from flows of ecosystem services provided by natural capital assets over time, to the organisation and (if desired) to society. It includes information on historical actual flows and expected future flows. It is the monetary equivalent of the physical flow account.
- It records separately the **value to the organisation** (the costs and benefits to the organisation, also referred to as internal or private value (NCP 2016, p. 124)) and the **value to society** (the costs and benefits to wider society, also referred to as external, public, or external value (NCP 2016, p. 124)).

Why?

- A natural capital monetary flow account provides information for tracking the monetary value of flows of ecosystem services from the natural capital assets owned or controlled by the organisation. It underpins the monetary values reported in the natural capital balance sheet and the natural capital income statement.

How?

Step 1: Consider and decide on the appropriate value concepts to be used:

> Exchange values can be based on market prices, consistent with those reported elsewhere in financial accounts, or non-market values estimated 'as if' a market existed. Exchange values are consistent with SEEA.
>
> Welfare values estimate the additional value to human welfare of things for which no market could exist. Welfare values are often used in cost-benefit analysis.
>
> Whichever values are chosen should be applied consistently, reported separately and never added together.

Step 2: Measure the historical flows of each ecosystem service in monetary terms. Monetary flows should be measured in net terms, i.e. gross value minus production costs (see sidebar).

Step 3: Estimate the future flows of each ecosystem service in monetary terms. Future flows should incorporate management decisions and any changes in flows resulting from natural capital

Concepts:

Production costs

The BSI (BSI, 2021) use the term 'production costs' to describe:

> *the costs that are necessary to incur to realize the flow of benefits at a point in time. (BS 8632:2021, section 6.7.1.5, p22)*

Here, we extend this definition of production costs to also include the subset of 'maintenance costs' of natural capital where the organisation has no legal or voluntary responsibility to incur those costs. Examples could include, for example, forestry organisations enhancing soil carbon content or thinning activities to enhance timber potential.

Where the organisation does have legal or voluntary requirements to restore, maintain, or enhance natural capital they should be included in the natural capital obligation schedule and NOT deducted from revenue to derive monetary flows.

Valuing natural capital and ecosystem services

Valuation of market goods and services should use market prices (net of taxes and subsidies) to monetise the benefit flows.

- Taking harvested plantation timber as an example: an organisation could use the mill-door price to estimate the gross value. The production costs of operation activities (such as thinning, fertilisation, irrigation) and harvesting and transport costs should then be deducted to produce the net value. An alternative method could be to use a stumpage price - the advantage of a stumpage price is that it represents the value before any harvesting and transport costs, making the production costs easier to calculate.

Valuation of non-market goods and services can either use market price

threats to those services (see section 2 on natural capital risk assessment), and any assumptions should be documented.

Step 4: Complete the natural capital monetary flow account using the measures from steps 2 and 3.

Valuing natural capital and ecosystem services

- Natural capital accounts can include **market values** (the amount for which something can be bought or sold in a given market NCP 2016, p. 124) or **non-market values** (the value of goods and services that are not traded for money but are valued based on what people would be willing to pay for them). Natural capital accounts that include market values should ensure that clarity is given so that these are not double counted across financial and natural capital accounts. Natural capital accounts that include non-market values should ensure that clarity is given so that they are not confused with financial values.

Example:

- The example below follows the format of the natural capital physical flow account in the previous section.
- The example natural capital monetary flow account includes rows showing the gross value, the **production costs** (the costs necessary to incur to realise the flow of benefits) and the net value. Showing these rows means organisations must be explicit about the value provided by natural capital and the value which results from human and produced capital (the production costs). The net value is calculated by deducting the production costs from the gross value to reflect the net value of the flow of benefits provided by natural capital.

proxies (exchange values), or welfare values.

- Taking net carbon sequestration as an example: an organisation could calculate the value using an exchange value method (e.g., using equivalent market prices from existing carbon trading schemes or marginal abatement costs to meet carbon targets) or welfare value methods (e.g., a social cost of carbon).
- Taking recreation as an example: an organisation could calculate an exchange value by using market price proxies such as fuel costs or entry fees; however, it is worth noting that this is likely to significantly underestimate the full social value of recreation sites. This welfare value can be estimated using the travel cost method.

Other examples

Additional guidance on monetary flow accounts is available in the British Standard on natural capital accounting for organizations (BS 8632:2021, section 6.7.1.5, p22) and SEEA-EA (Section 7.1 p161) (SEEA Monetary Flow Account).

Forestry England Natural Capital Accounts provide an example for forestry (Forestry England Monetary Flow Account).

Example Natural Capital Monetary Flow Account

				2021		2022 forecast		2023 forecast		2050 forecast[i]	
Asset	Ecosystem service	Indicators	Units	Benefits/ costs to organisation	Benefits/ costs to society	Benefits/ costs to organisation	Benefits/ costs to society	Benefits/ costs to organisation	Benefits/ costs to society	Benefits/ costs to organisation	Benefits/ costs to society
Plantations	Timber biomass	Value of Timber Harvested[a]	$ 000's	35,000	-	40,000	-	32,500	-	32,500	-
		Production Costs[b]	$ 000's	-20,000	-	-22,000	-	-18,000	-	-18,000	-
		Net Value: Timber Harvested	$ 000's	15,000	-	18,000	-	14,500	-	14,500	-
	Carbon sequestration	Value of carbon sequestration[c]	$ 000's	-	14,000	-	13,200	200	14,000	200	14,000
		Production Costs[d]	$ 000's	-	-	-	-	-	-	-	-
		Net Value: Carbon Sequestration	$ 000's	-	14,000	-	13,200	200	14,000	200	14,000
Native Forest	Seeds and plants	Value of Seeds and plants harvested[e]	$ 000's	4,000	-	4,000	-	6,000	-	6,000	-
		Production Costs[f]	$ 000's	-1,000	-	-1,500	-	-2,500	-	-2,500	-
		Net Value: Seeds/Plants	$ 000's	3,000	-	2,500	-	3,500	-	3,500	-
Upland streams	Recreational fishing	Value of Recreational fishing visits[g]	$ 000's	-	225	-	255	-	270	-	270
		Production Costs[h]	$ 000's	-25	-	-25	-	-25	-	-25	-
		Net Value: Recreation visits	$ 000's	-25	225	-25	255	-25	270	-25	270

[a] Timber harvest value is calculated using a mill-door price of $100/tonne – with the price assumed to remain constant into the future. The value of the timber is a benefit to the organisation. The gross value for the timber harvested is $35M in 2021, this increases to $40M in 2022 and reduces to $32.5M in 2023 – remaining constant to 2050.

[b] Production costs for timber include thinning, fertilisation, irrigation, harvesting and transport. The total production costs associated with the timber harvested is $20M for 2021, this increases to $22M in 2022 and reduces to $18M in 2023 – remaining constant to 2050.

[c] The carbon sequestration value is calculated based on a value of $20/tonne – with the price assumed to remain constant into the future. The value of carbon sequestration all goes to society except for 2023 onwards where the organisation expects to sell some carbon credits worth $200,000 per year (shown in the benefit to organisation column). The value of the carbon sequestration to society is $14M in 2021, $13.2M in 2022 and $14M in 2023 – remaining constant to 2050.

[d] No production costs are directly associated with carbon sequestration in the plantation.

[e] Seed and plant harvest value is calculated using a price of $200/tonne – with the price assumed to remain constant into the future. The value of the seeds and plants is a benefit to the organisation. The gross value for the seeds and plants harvested is $4M in 2021 and 2022, this increases to $6M in 2023 – remaining constant to 2050.

[f] Production costs for seeds and plants include harvesting and transport costs. The total production costs associated with the seeds and plants harvested is $1M for 2021, this increases to $1.5M in 2022 and $2.5M in 2023 – remaining constant to 2050.

[g] The recreation fishing value is calculated based on a value of $15/visit – with the value assumed to remain constant across space and into the future. The value of recreation fishing all goes to society as the upland streams are open access. The value of recreational fishing is $225,000 in 2021, increases to $255,000 in 2022 and increases again to $270,000 in 2023 - remaining constant to 2050.

[h] Production costs for recreation include operation costs associated with the recreation sites. The total production costs associated with recreation is $25,000 for 2021, 2022, 2023 – remaining constant to 2050.

[i] The forecast period covers 2022 to 2050. For simplification in this example, it is assumed that flows remain constant after 2023. However, the organisation should produce a schedule for the whole accounting period or a written justification for their expectations about future ecosystem service flows.

1.5 Natural Capital Balance Sheet

What?

- The natural capital balance sheet reports on the monetary value of natural capital assets and liabilities, calculated as the sum of discounted future benefit flows (for assets) and the sum of discounted future obligation costs (for liabilities). The difference between the value of natural capital assets and natural capital liabilities (i.e. net natural capital assets) can also be thought of as the organisation's (or shareholders') natural capital equity.
- The natural capital balance sheet can also present summary information on physical extent and condition of natural capital assets alongside monetary values.
- It shows whether the value from natural capital assets owned or controlled by the organisation goes to the organisation itself or to the rest of society.

Why?

- The natural capital balance sheet summarises information relevant for both internal decision making and external reporting/disclosure, aligned with financial and annual reporting (analogous to a financial balance sheet).

How?

Step 1: Consider and decide on appropriate asset lifetimes and discount rates.

Step 2: Calculate the net present value of each natural capital asset using the sum of discounted future monetary flows from the natural capital monetary flow account.

Step 3: Calculate the net present value of any natural capital liabilities using the sum of discounted future obligation costs from the natural capital obligation schedule.

Step 4: (optional): Compile summary information on physical extent and condition of natural capital assets using the extent and condition accounts.

Step 5: Complete the natural capital balance sheet using the measures from steps 2, 3 and 4.

Example:

- The example natural capital balance sheet below summarises the monetary value of natural capital assets and liabilities.

Concepts

Valuing stocks of natural capital

The value of the stock of natural capital assets is calculated as the discounted sum of the projected benefit flows over the accounting period. The benefit is net of any costs of producing those benefits. This is consistent with the SNA and SEEA guidance on valuing assets where no market exists.

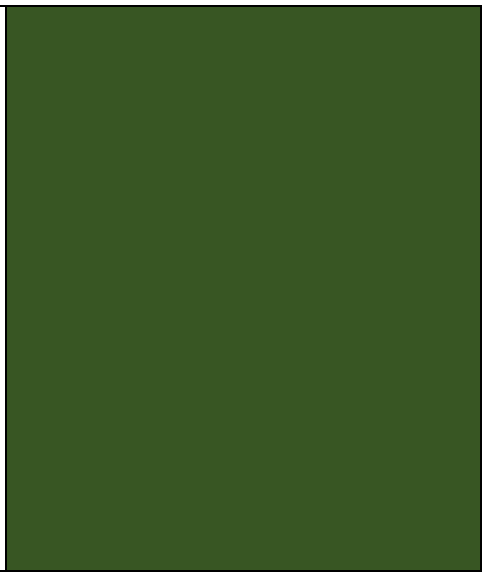
Other examples

Additional guidance on natural capital balance sheets is available in the British Standard on natural capital accounting for organizations (BS 8632:2021, section 6.7.1.7, p23) and SEEA-EA on extended balance sheets (Section 10.3 p240) (SEEA Extended balance sheets).

Forico's natural capital report 2021 provides an example natural capital balance sheet for forestry (Forico, 2021 p34) (Forico natural capital balance sheet).

Forestry England Natural Capital Accounts provide another example for forestry (Forestry England Balance Sheet).

- The net present value (NPV) calculations for the natural capital asset values use the projected future benefit flows from each asset in the monetary flow account and discount them back to a present value. For the example below we value the assets over a 30-year period (to 2050). As with traditional financial statements, including the previous reporting year's information is likely to be useful. Example values for the previous years are shown on the right of the statement.
- The NPV calculations for the natural capital liabilities use the projected future costs for each liability in the natural capital obligation schedule and discount them back to a present value.



Example Natural Capital Balance Sheet

Net present value over 30-year period

Discount rate of 3.5%

Exchange value concept used for the non-market value to society

Date: 31/12/2021

		2021 Statement		2020 Previous statement	
	Indicators	**Value to organisation ($ 000's)**	**Value to society ($ 000's)**	**Value to organisation ($ 000's)**	**Value to society ($ 000's)**
Natural Capital Assets					
Plantation Forest	NPV Timber[a]	264,900	-	265,269	-
	NPV Carbon sequestration[b]	3,414	251,728	3,227	251,754
Native Forest	NPV Seeds and plants[c]	62,159	-	61,709	-
Upland stream	NPV Recreation[d]	264,900	4,855	-451	4,812
Total Natural Capital Assets		330,022	256,583	329,754	256,566
Natural Capital Liabilities					
Plantation Forest	NPV liabilities[e]	-68	-	-172	-
Native Forest	NPV liabilities[f]	-19,777	-	-19,697	-
Upland stream	NPV liabilities[g]	-1,482	-	-1,548	-
Total Natural Capital Liabilities		-21,326	-	-21,416	-
Net Natural Capital Assets (= Natural Capital Equity)		308,697	256,583	308,338	256,566

[a] NPV timber value is based on the net present value of flows of benefits over a 30-year time period and using a 3.5% discount rate. Future values beyond 2023 are assumed to remain constant. The NPV of timber is $264.9M with the value going to the organisation, which is a change of -$369k compared to the previous year's statement.

[b] NPV carbon value is based on the net present value of flows of benefits over a 30-year time period and using a 3.5% discount rate. Future values beyond 2023 are assumed to remain constant. The NPV of carbon for the organisation is $3.414M and $251.728M for society, which is an increase of $187k for the organisation and a decrease of -$26k for society compared to the previous year's statement.

[c] NPV seeds and plants value is based on the net present value of flows of benefits over a 30-year time period and using a 3.5% discount rate. Future values beyond 2023 are assumed to remain constant. The NPV of seeds and plants is $62M with the value going to the organisation, which is an increase of $450k compared to the previous year's statement.

[d] NPV recreational fishing value is based on the net present value of flows of benefits over a 30-year time period and using a 3.5% discount rate. Future values beyond 2023 are assumed to remain constant. The NPV of recreational fishing for the organisation is $451k and $4.855M for society, this is a change of $0k for the organisation and $43k for societal value from the previous year's statement.

[e] NPV liabilities value for plantation forests is based on the net present value of the obligations to clean up contaminated land over a 30-year time period using a 3.5% discount rate. Future costs beyond 2023 are assumed to remain constant at $0. The NPV of plantation forest liabilities is $68k, this is a change of $104k compared with the previous year's statement.

[f] NPV liabilities value for native forests is based on the net present value of the obligations to regenerate native forest and meet net-zero carbon commitments over a 30-year time period using a 3.5% discount rate. Future costs beyond 2023 are assumed to remain constant. The NPV of native forest liabilities is $19.777M, this is a change of -$80k compared with the previous year's statement.

[g] NPV liabilities value for upland streams is based on the net present value of the obligations to plant and maintain riparian vegetation over a 30-year time period using a 3.5% discount rate. Future costs beyond 2023 are assumed to remain constant. The NPV of upland stream liabilities is $1.482M, this is a change of $66,000 compared with the previous year's statement.

1.6 Natural Capital Income Statement

What?

- The natural capital income statement reports on the flows of benefits from natural capital assets that an organisation owns or controls, associated costs, and gains or losses in the value of those natural capital assets.
- The natural capital income statement can also present summary information on physical flows of ecosystem services alongside monetary values.

Why?

- The natural capital income statement summarises information for both internal decision-making and external reporting, aligned with financial and annual reporting (analogous to a financial income statement). It explains changes from one reporting period to the next in the natural capital balance sheet.

How?

Step 1: Take the current gross value from the natural capital monetary flow account for each ecosystem service.

Step 2: (optional): Take the current flows from the natural capital physical flow account for each ecosystem service.

Step 3: Calculate any revaluations on natural capital assets (compared with the previous reporting period).

Optional: Separate out revaluations into those based on physical changes in the asset (for example, unexpected changes in future growth of biomass or carbon sequestration, e.g. due to catastrophic loss from fire or disease) and those based on changes in monetary values (for example, changes in timber or carbon prices).

Step 4: Take the current production costs from the natural capital monetary flow account for each ecosystem service.

Step 5: Take the costs associated with the discharge of current obligations from the natural capital obligation schedule.

Step 6: Complete the natural capital income statement using the measures from steps 2, 3, 4 and 5.

Concepts

Consistency of terminology for natural capital income statements

The BS8632 standard (BSI, 2021) adopts the term 'natural capital income statement' for a statement of an organisation's operations impacts (positive and negative) on (any) natural capital. Here, we propose that the term 'natural capital income statement' is reserved for a statement of the comprehensive (positive and negative) flows of benefits from natural capital assets that an organisation owns or controls.

Comprehensive natural capital income

In order to be comprehensive, the natural capital income statement should include:

- The flows of positive benefits from owned/controlled natural capital assets over the reporting year;
- If relevant, the flows of negative disbenefits from owned/controlled natural capital assets over the reporting year (also known ecosystem disservices, e.g. health impacts from pollen); and
- Accrued gains or losses resulting from fluctuations in the value of the organisation's assets.

Other examples

Forico's natural capital report 2021 in their 'environmental profit and loss statement' provide an example which has elements of the natural capital income statement described here (noting that it also includes elements which refer to the organisation's impact on natural capital which we cover in the 'natural capital impact statement') (Forico, 2021 p32) (Forico natural capital environmental profit and loss).

Asset revaluations

- The gains or losses on natural capital assets describe the fluctuations in the value of the organisation's natural capital assets. These gains or losses are calculated through revaluation of the natural capital assets with the change in value recognised in the natural capital income statement as the revaluation increment (decrement) of future estimated value.

Example:

- The example natural capital income statement summarises 'natural capital revenue' and 'natural capital expenses' to reveal 'net natural capital income'.
- Natural capital revenues show the flows of benefits realised in the current time period from the information documented in the natural capital monetary flow account. In addition, it shows any gains or losses on natural capital assets value in the revaluation increment (decrement). The revaluation due to physical changes in the asset is documented separately to the revaluation due to any monetary value changes.
- Natural capital expenses show the production costs associated with each of the flows of benefits realised in the current time period from information in the natural capital monetary flow account. In addition, it shows any costs associated with the discharge of current obligations from the natural capital obligation schedule.
- The value to the organisation is shown separately to the value to the rest of society. As with traditional financial statements, including the previous year's values is likely to be useful. Example values for the previous years are shown on the right of the statement.

Example Natural Capital Income Statement

Flows from natural capital assets over the accounting period: 01 Jan 2021 to 31 Dec 2021 Date: 31/12/2021				2021		2020 Previous statement	
		Indicators	**Units**	**Value to organisation**	**Value to society**	**Value to organisation**	**Value to society**
Revenue	Gross value	Timber harvested	$ 000's	35,000	-	31,000	-
		Carbon sequestration	$ 000's	-	14,000	-	15,000
		Seeds/plants	$ 000's	4,000	-	3,000	-
		Recreation visits	$ 000's	-	225	-	225
	Revaluation increment	Timber biomass (physical changes)	$ 000's	3,000	-	-	-
		Timber biomass (value changes)	$ 000's	-	-	-	-
		Carbon sequestration (physical changes)	$ 000's	-	-	-	-
		Carbon sequestration (value changes)	$ 000's	-	5,000	-	-
		Seeds and plants (physical changes)	$ 000's	-	-	-	-
		Seeds and plants (value changes)	$ 000's	-	-	-	-
		Recreational fishing (physical changes)	$ 000's	-	-	-	-
		Recreational fishing (value changes)	$ 000's	-	-	-	-
Total revenue			$ 000's	42,000	19,225	34,000	15,225
Expenses	Production costs	Timber harvested	$ 000's	-20,000	-	-18,000	-
		Carbon sequestration	$ 000's	-	-	-	-
		Seeds/plants	$ 000's	-1,000	-	-1,000	-
		Recreation visits	$ 000's	-25	-	-25	-
	Expenses associated with discharge of current obligations	Plantation forest	$ 000's	-110	-	-	-
		Native forest	$ 000's	-1,015	-	-1,100	-

	Upland stream	$ 000's	-150	-		-40	-
Total expenses		$ 000's	-22,300	-		-20,165	-
Net natural capital income		$ 000's	19,700	19,225		13,835	15,225

[a] Timber harvest value is calculated using a price of $100/tonne. The gross value for the timber harvested is $35M in 2021, the production costs are $20M and therefore the net value is $15M with the value going to the organisation. This is $2M higher than the previous year. In 2021 the organisation undertook a revaluation of future estimated timber biomass which shows an increase of $3M, the revaluation is due to additional growth observed in the biomass above what was expected and is therefore shown in the revaluation (physical changes) row.

[b] Net Carbon sequestration value is calculated using a price of $20/tonne. The gross value for the carbon sequestration is $14M in 2021, there are no production costs and therefore the net value is $14M with the value going to society. This is $1M lower than the previous year. In 2021 the organisation undertook a revaluation of future estimated carbon sequestration which shows an increase of $5M, the revaluation is due to carbon sequestration value increase above what was expected and is therefore shown in the revaluation (value changes) row.

[c] Seeds and plants value is calculated using a price of $200/tonne. The gross value for the seeds and plants is $4M in 2021, the production costs are $1M and therefore the net value is $3M with the value going to the organisation. This is $1M higher than the previous year.

[d] Recreational fishing value is calculated using a price of $15/visit. The gross value for the recreational fishing is $225,000 in 2021 with the value going to society, the production costs are $25,000. Since the value goes to society but the organisation pays the production costs, the net value for society is $225,000 with a net cost to the organisation of -$25,000. This is the same as the previous year.

2. Natural Capital Impact, Dependency and Risk Assessment

What?

- Natural capital impact, dependency and risk assessments identify and record consistent and comparable information on the organisation's relevant (material) impacts and dependencies on natural capital and the associated risks (and opportunities) for the organisation and how these are projected to change in the future (e.g. through management changes, climate change or social preferences and regulation).
- The focus is on the organisation and covers all of their impacts and dependencies on natural capital, whether that natural capital is owned/controlled by the organisation, or not.
- **Natural capital impacts** are negative or positive effects of an organisation's operations on natural capital NCP 2016 p.16-17). Natural capital impact assessments focus on the impacts on natural capital that are attributable to the organisation's activities and operations.
- **Natural capital dependencies** are the reliance on or use of natural capital NCP 2016 p.16-17) related to the organisation's operations. Natural capital dependency assessments focus on the natural capital that the organisation's activities and operations depend on.
- **Natural capital risks** are the risks to the organisation arising from their impacts and dependencies on natural capital. It is also important to note that reducing risks or increasing the organisation's resilience can provide natural capital opportunities.

Why?

- Natural capital impact, dependency and risk assessments are relevant for all organisations.
- Natural capital impact and dependency assessments provide information relevant for internal decision-making and external reporting/disclosure, aligned with the organisation's sustainability reporting, Environmental, Social, and Governance (ESG) or integrated report.
- Natural capital risk assessments provide information relevant for internal decision-making and external reporting/disclosure, aligned with the organisation's corporate risk reporting or with disclosure frameworks

Concepts

Scope of the assessment

Natural capital impact, dependency and risk assessments can either be limited in scope to the operations of the organisation or expanded to include those attributable to the organisation through its value chain (see guidance on 'scope 1' and 'scope 2' in BS8632:2021 section 5.1 p10 (BSI, 2021)). In this handbook, our examples are limited in scope to the operations of the organisation.

Natural capital risks link to natural capital accounting

Natural capital risks (and opportunities) identified in the natural capital risk assessment should be reflected in the projections of physical and monetary flows and associated obligations in the natural capital accounts. This can be done through adjustments to physical flows, monetary values of flows and obligations, and/or the discount rate used to calculate present values.

Physical risks and transition risks

Physical changes such as climate change or habitat loss that affect natural capital dependencies can be thought of as 'physical risks', while changes in social responses to natural capital impact are often driven by society's transition towards a lower-impact state, hence 'transition risks'. However, in principle, transitions can also affect natural capital dependencies (e.g. by increasing demand for some forms of natural capital and reducing demand for others), while physical risks can also affect the context and social consequences of impacts (e.g. climate change may increase water scarcity in a region, hence increasing the impacts of water consumption, which may lead to stricter regulation or higher pricing).

such as the Task Force on Climate-Related Financial Disclosures (TCFD) or the Task Force on Nature-Related Financial Disclosures (TNFD).

How?

Impact, dependency and risk assessments consist of three supporting registers:

- **Natural capital impact register**
- **Natural capital dependency register**
- **Natural capital risk register**

Which are used to produce three reporting statements:

- **Natural capital impact statement**
- **Natural capital dependency statement**
- **Natural capital risk statement**

We show how to organise natural capital impact, dependency and risk information in the subsequent example registers and statements. Additional detail is provided in the complementary workbook 'Natural capital impact, dependency, and risk assessment: Forestry'.

Natural capital impacts, dependencies, and risks for forestry

- A list of 20 forestry-relevant dependencies and impacts (10 dependencies and 10 impacts) were identified in the sector/region-level materiality assessment conducted in 'Natural Capital Risk Assessment – Australian Forestry' report (Smith et al., 2021b, Smith et al., 2021a) and are shown below.
- A list of 20 forestry-relevant natural capital risks were identified in the sector/region-level materiality assessment conducted in 'Natural Capital Risk Assessment – Australian Forestry' report (Smith et al., 2021b, Smith et al., 2021a) and are shown below.

Other examples

The example natural capital impact and dependency assessments proposed here are broadly consistent with the recommendations of the Natural Capital Protocol (Natural Capital Coalition, 2016) and with BS8632:2021 (BSI, 2021).

The Transparent Project may also provide additional guidance in the future (Transparent Project, 2021).

The example natural capital risk assessment proposed here is broadly consistent with the recommendations of the BS8632:2021 (section 6.7.1.3 p21) for natural capital accounting (BSI, 2021), the Natural Capital Finance Alliance (NCFA) on portfolio-level natural capital risk assessment (NCFA and PwC, 2018, NCFA and UN Environment World Conservation Monitoring Centre, 2018) and individual asset-level natural capital risk assessment (Ascui and Cojoianu, 2019) which is consistent with the guidance of the NCP. In addition, it is broadly consistent with the recommendations of the TNFD which provides guidance for organisations to disclose: *"how the organisation identifies, assesses and manages nature-related risks"* (TNFD, 2022 p10).

Additional guidance on risk management for organisations is available in the ISO standard on risk management (ISO, 2018). In addition, the Climate Disclosure Standards Board has published a framework to guide corporate reporting of natural-capital-related climate information (CDSB 2018) and the TCFD on climate-related risks (TCFD, 2017).

Example impacts and dependencies relevant for forestry

Thematic area	Dependency / Impact	Definition
Water	**Water availability (dependency)**	Adequate water to meet target biomass
	Water use (impact)	Forestry operations affect the quantity of surface or sub-surface water
	Water quality (impact)	Forestry operations affect the quality of surface or sub-surface water
Weather and climate	**Temperature (dependency)**	Appropriate temperature to meet target biomass
	Bushfires (dependency)	Absence of destructive bushfire
	Bushfires (impact)	Forestry operations affect bushfire frequency or severity.
	Storms and floods (dependency)	Absence of destructive storms and floods
Land and soil	**Soil quality (dependency)**	Adequate soil quality to meet target biomass
	Soil quality (impact)	Forestry activities affect soil quality
	Fertiliser use (dependency)	Adequate fertiliser to meet target biomass
	Contamination and waste (impact)	Forestry operations create contamination and waste
Biodiversity and ecosystems	**Biodiversity (dependency)**	Adequate abundance and distribution of biodiversity to meet target biomass
	Biodiversity (impact)	Forestry activities affect biodiversity
	Weeds (dependency)	Absence of destructive weeds and infestations
	Weeds (impact)	Forestry activities affect the presence and spread of weeds
	Pests and diseases (dependency)	Absence of destructive pests and diseases
	Pests and diseases (impact)	Forestry activities affect the presence and spread of pests and diseases
Energy	**Energy (dependency)**	Adequate energy and fuel
Air emissions	**Greenhouse gas emissions (impact)**	Forestry operations emit or sequester greenhouse gases
	Other air emissions (impact)	Forestry operations emit or sequester other air emissions (e.g. $PM_{2.5}$, PM_{10})

Example natural capital risks relevant for forestry

Thematic area	Dependency / Impact	Definition
Water	**Water availability (dependency)**	The risk of lower productivity and/or increased costs due to inadequate water to meet target biomass
	Water use (impact)	The risk of consequences for the organisation arising from forestry activities negatively affecting the quantity of surface or sub-surface water
	Water quality (impact)	The risk of consequences for the organisation arising from forestry activities negatively affecting the quality of surface or sub-surface water
Weather and climate	**Temperature (dependency)**	The risk of lower productivity and/or increased costs due to exposure to changes in average temperature or temperature extremes
	Bushfires (dependency)	The risk of lower productivity and/or increased costs due to exposure to destructive bushfire
	Bushfires (impact)	The risk of consequences for the organisation arising from forestry activities negatively affecting bushfire frequency or severity in surrounding areas
	Storms and floods (dependency)	The risk of lower productivity and/or increased costs due to exposure to destructive storms and floods
Land and soil	**Soil quality (dependency)**	The risk of lower productivity and/or increased costs due to inadequate soil quality to meet target biomass
	Soil quality (impact)	The risk of consequences for the organisation arising from forestry activities negatively affecting soil quality
	Fertiliser use (dependency)	The risk of lower productivity and/or increased costs due to fertiliser being less available or priced at higher levels in future.
	Contamination and waste (impact)	The risk of consequences for the organisation arising from forestry activities creating contamination and waste
Biodiversity and ecosystems	**Biodiversity (dependency)**	The risk of lower productivity and/or increased costs due to inadequate abundance and distribution of biodiversity to meet target biomass
	Biodiversity (impact)	The risk of consequences for the organisation arising from forestry activities negatively affecting biodiversity
	Weeds (dependency)	The risk of lower productivity and/or increased costs due to exposure to competition from weed infestations
	Weeds (impact)	The risk of consequences for the organisation arising from forestry activities spreading weeds
	Pests and diseases (dependency)	The risk of lower productivity and/or increased costs due to exposure to pests and diseases
	Pests and diseases (impact)	The risk of consequences for the organisation arising from forestry activities spreading pests and diseases
Energy	**Energy (dependency)**	The risk of lower productivity and/or increased costs due to energy being less available or priced at higher levels in future.
Air emissions	**Greenhouse gas emissions (impact)**	The risk of consequences for the organisation arising from forestry activities emitting greenhouse gases
	Other air emissions (impact)	The risk of consequences for the organisation arising from forestry activities negatively affecting emitting other air emissions (e.g. $PM_{2.5,}$ PM_{10})

Scenario used in the following example natural capital impact, dependency and risk assessment registers and statements:

For the example natural capital impact, dependency and risk assessments presented in this document the following impacts, dependencies and risks are used throughout:

Natural capital impacts:

- Water quality: forestry operations affect the quality of surface or sub-surface water
- Weeds: Forestry activities introduce or spread weeds

Natural capital dependencies:

- Water availability: Adequate water to meet target biomass
- Bushfire: Absence of destructive bushfire

Natural capital impact risks:

- Water quality: The risk of consequences for the organisation arising from forestry activities negatively affecting the quality of surface or sub-surface water
- Weeds: The risk of consequences for the organisation arising from forestry activities spreading weeds

Natural capital dependency risks:

- Water availability: The risk of lower productivity and/or increased costs due to inadequate water to meet target biomass
- Bushfire: The risk of lower productivity and/or increased costs due to exposure to destructive bushfire

2.1 Natural Capital Impact Register

What?

- The natural capital impact register tracks an organisation's material impacts on natural capital (whether or not the natural capital affected is owned or controlled by the organisation). It can track either qualitative or quantitative metrics, and positive or negative impacts.
- Most organisations' impacts are likely to be negative; however, positive impacts can also be recorded.

Why?

- The natural capital impact register provides information for organisations to internally track their natural capital impacts over time, allowing trends or performance to be monitored. It also enables the production of a natural capital impact statement and can be used to develop part of a natural capital risk assessment register.

How?

Step 1: Identify those impacts that are potentially material for the organisation and prioritise the natural capital impacts to be included in the natural capital impact register. This may be done using a natural capital risk materiality assessment (Step 3 in section 2.3), or on the basis of other criteria for materiality, consistent with the objectives of the natural capital impact assessment.

Step 2: Consider the appropriate qualitative and quantitative metrics and targets to measure the state of each material natural capital impact.

Step 3: Measure historical changes in the selected metrics and project future values for the selected metrics.

Step 4: Document the organisation's mitigation and adaptation activities for each impact. This may include details such as the timing and costs of undertaking these activities and any monitoring of their effectiveness.

Step 5: Complete the natural capital impact register using the measures in step 3 and 4.

Example:

- The example below shows how to combine qualitative and quantitative information for two negative impacts from forestry operations into a single register.

Concepts

Positive or negative impacts

Natural capital impacts are defined as negative or positive effects of an organisation's operations on natural capital NCP 2016 p.16-17.

In this handbook we follow this definition and use the terms 'positive' and 'negative' for impacts that generally improve or degrade natural capital, respectively. However, this is a complex topic and impacts could be positive for some aspects of natural capital and negative for others, and/or viewed differently from different value perspectives or by different stakeholders. The organisation should clarify the basis on which any distinction between 'positive' and 'negative' impacts is made, particularly if using these concepts to report 'net' impacts.

Indicators and metrics

The choice of impacts, metrics and targets is likely to vary by industry, geography, and the priorities of the organisation. We provide additional examples in the companion workbook.

Quantitative metrics should include a target level to compare performance against.

Other examples

The Biological Diversity Protocol provides detailed guidance on measuring and reporting on biodiversity impacts (Endangered Wildlife Trust, 2020).

The Bioregional Assessment Program also proposed a natural capital impact framework (Henderson et al., 2018) and implemented this using a Hunter Valley coal industry example (Herron et al., 2018).

Companies such as Kering and PUMA have tracked and reported on their natural capital impacts (Kering, 2020, PUMA, 2011).

Impacts on natural capital for forestry are also explored in O'Grady et al. (2020).

• The example impact register records a definition of the impact, a qualitative classification of the degree of impact and quantitative measures of the degree of impact over time (from 2010 to 2021). For example, forestry activities can impact on water quality. One way to measure that is through monitoring the number of days where water quality exceeds certain water quality thresholds. An alternative might be to measure specific physical or chemical properties such as water turbidity or sediment load, and compare these with target levels.	

Example Natural Capital Impact Register

	TOPIC	IMPACT	METRICS	TARGET	HISTORICAL MEASURE			CURRENT YEAR	FUTURE PROJECTION		
					2010	2015	2020	2021	2030	2050	2070
Water	**Water quality**[a]	Forestry activities affect the quality of surface or sub-surface water.	Number of days of exceedances of water quality threshold levels per year in waterways in the forest estate (exceedance-days/Yr)	0 days / Yr	28 days per year	35 days per year	21 days per year	**12 days per year**	0-10 days per year	0 days per year	0 days per year
Biodiversity and ecosystems	**Weeds**[b]	Forestry activities introduce and spread weeds	Number of pine wildling infestations in adjacent land associated with the plantation estate	0 pine wildlings infestations in surrounding areas associated with the plantation estate	N/A No inspections	N/A No inspections	10 infestations (15 hectares total)	**6 infestations (10 hectares total)**	0-5 infestations (< 5 hectares total)	0-5 infestations (< 5 hectares total)	0-5 infestations (< 5 hectares total)

[a] The water quality impact register shows water quality exceedances of 28 days in 2010, increasing to 35 in 2015 before falling to 21 days in 2020 and falling again to 12 days in 2021. The exceedances are projected to decrease to between 0 and 10 by 2030 and then decrease further to 0 by 2050.

[b] The weeds impact register shows monitoring of pine wildling infestations in adjacent land only starts in 2020 so no data is recorded for 2010 or 2015. In 2020 there were 10 infestations recorded, affecting 15 hectares of adjacent land, decreasing to 6 infestations affecting 10 hectares in 2021. The pine wildling infestations are projected to decrease to between 0 and 5 by 2030 (affecting less than 5 hectares) and then remain constant out to 2070.

2.2 Natural Capital Dependency Register

What?

- A natural capital dependency register tracks an organisation's material dependencies on natural capital (whether or not the natural capital depended on is owned or controlled by the organisation). It can track either qualitative or quantitative metrics.

Why?

- A natural capital dependency register provides information for organisations to internally track their natural capital dependencies over time, allowing trends or performance to be monitored. It also enables the production of a natural capital dependency statement and can be used to develop part of a natural capital risk assessment register.

How?

Step 1: Identify those dependencies that are potentially material for the organisation and prioritise the natural capital dependencies to be included in the natural capital dependency register. This may be done using a natural capital risk materiality assessment (Step 3 in section 2.3), or using other criteria for materiality, consistent with the objectives of the natural capital dependency assessment.

Step 2: Consider the appropriate qualitative and quantitative metrics and targets to measure each material natural capital dependency.

Step 3: Measure historical changes in the selected metrics and project future values for the selected metrics.

Step 4: Document the organisation's mitigation and adaptation activities for each dependency. This may include details such as the timing and costs of undertaking these activities and any monitoring of their effectiveness.

Step 5: Complete the natural capital dependency register using the measures in step 3 and 4.

Example:

- The example below shows how to combine qualitative and quantitative information into a single register.
- The example dependency register records a definition of the dependency, a qualitative classification of the degree of dependency and quantitative measures over time (from 2010 to 2021). For example, tree growth depends on water availability, and one way to measure that is through annual rainfall. In the example register we suggest a 10-year rolling average to capture the long-term trends; however, alternative metrics might focus on the period since the trees were planted or use a different metric such as soil moisture.

Other examples

A natural capital dependency register is a relatively new concept and therefore there are limited existing examples.

A conceptual exploration of dependencies on natural capital for forestry can be found in O'Grady et al. (2020).

Example Natural Capital Dependency Register

	TOPIC	DEPENDENCY	METRICS	TARGET	HISTORICAL MEASURE			CURRENT YEAR	FUTURE PROJECTION		
					2010	2015	2020	2021	2030	2050	2070
Water	**Water availability[a]**	Adequate water to meet target biomass	mm of rainfall received per year (mm/yr) (5-year average across the estate)	>550 mm/Yr	490mm (5-year average to 2010)	459mm (5-year average to 2015)	468mm (5-year average to 2020)	**461mm (5-year average to 2021)**	420 - 485mm (5-year average centring on 2030)	415 - 490mm (5-year average centring on 2050)	410 - 475mm (5-year average centring on 2070)
Weather and climate	**Bushfire[b]**	Absence of destructive bushfire	Percent of forest estate unaffected by destructive bushfire (%) (5-year average)	100%	100% (5-year average to 2010)	99% (5-year average to 2010)	95% (5-year average to 2010)	**96%** (5-year average to 2010)	95-100% (5-year average centring on 2030)	95-100% (5-year average centring on 2050)	90-95% (5-year average centring on 2070)

[a] The water availability dependency register shows the 5 year average of rainfall across the estate was 490mm in 2010, decreasing to 459mm in 2015, increasing to 468mm in 2020 and decreasing to 461mm in 2021. The projection of future rainfall across the estate is between 420mm and 485mm by 2030 and is projected to decrease slightly to between 410mm and 475mm by 2070.

[b] The bushfire dependency register shows the 5 year average for the percent of estate unaffected by destructive bushfire. In 2010 100% of the estate was unaffected in the preceding 5 years, this decreased to 99% in 2015, decreasing again to 95% in 2020 before increasing slightly to 96% in 2021. The projection of estate unaffected by destructive bushfire is projected to be between 95% and 100% by 2030 and 2050, and to decrease to between 90% and 95% by 2070, reflecting an expected increase in incidence of destructive bushfire over time.

2.3 Natural Capital Risk Register

What?

- A natural capital risk register **tracks how the organisation identifies, assesses, and manages natural capital risks.** It includes a natural capital materiality assessment and information on the organisation's risk mitigation and adaptation activities for each natural capital impact and dependency risk.
- A similar approach can be used to create a natural capital opportunity register (see sidebar).

Why?

- A natural capital risk register allows an organisation to monitor risks for internal management purposes. It shows actions aligned with mitigating these risks.
- The risk register should enable organisations to identify and prioritise where natural capital impacts and dependencies are potentially material financial risks for the organisation.

How?

Step 1: Define the organisation's objectives in relation to managing natural capital risks. This may help to define the scope of the natural capital risk register, including the organisational boundary (e.g. whether to include all business units or subsidiaries, or operations in a given geography), the value-chain boundary (e.g. whether to limit to direct operations, or include upstream and/or downstream interactions), the temporal boundary (e.g. next 30 years), the value perspective (e.g. business value, societal value, or both), and whether to focus on natural capital impact risks, dependency risks, or both. See (Ascui and Cojoianu, 2019) steps 2.1 to 2.3.4.

Step 2: List potentially material natural capital impact and dependency risks. These can be defined as the consequences of the organisation's impacts on natural capital and of threats to the future availability of its dependencies on natural capital. The starting point can therefore be the impacts and dependencies listed in the organisation's impact and dependency registers. Another starting point may be an existing natural capital risk materiality assessment that is relevant for the organisation's sector and geography, e.g. for Australian forestry organisations, (Smith et al., 2021b, Smith et al., 2021a).

Step 3: Conduct a natural capital risk materiality assessment. Identify criteria for materiality, consistent with the objectives

Concepts:

Natural capital opportunities

The TNFD defines natural capital opportunities as: *"activities that create positive outcomes for corporates and/or financial institutions and nature by avoiding or reducing impact on nature, or contributing to its restoration. Nature-related opportunities can occur: i) when organisations mitigate the risk of natural capital and ecosystem services loss; and, ii) through the strategic transformation of business models, products, services and investments that actively work to halt or reverse the loss of nature, including the implementation of nature-based solutions or support for them through financing or insurance." (TNFD, 2022)*

Materiality

The concept of materiality has been adopted from the field of accounting (Whitehead, 2017, Edgley et al., 2015). Broadly, something is 'material' if it has reasonable potential to significantly alter the decisions being taken by a user of the information being reported.

Degree of impact

For negative impacts, the degree of impact can be assessed by considering to what extent the relevant stock of natural capital or flow of ecosystem services could continue to function after a plausible impact. A high degree of impact would indicate the natural capital or ecosystem service is likely to be significantly damaged and unable to repair itself without costly intervention. For positive impacts, a high degree of impact would indicate a significant improvement to natural capital. See (Smith et al., 2021b, Smith et al., 2021a).

Degree of dependency

The degree of dependency can be assessed by considering to what extent the organisation could continue to function without the relevant natural capital or ecosystem services. A high degree of dependence would indicate the function would be significantly

established in Step 1, and evaluate the potentially material natural capital risks from Step 2 against these criteria. A recommended approach is as follows:

Step 3a: For each potentially material risk from Step 2, evaluate the 'degree of impact' and 'severity of consequences' (for impact risks) and 'degree of dependency' and 'severity of threat' (for dependency risks). This evaluation may be qualitative, quantitative, or a mix of both. For example, each component may be ranked 'low', 'moderate' or 'high'.

Step 3b: Combine the degree of impact with severity of consequences to calculate overall materiality for each impact risk, and the degree of dependency with severity of threat to calculate overall materiality for each dependency risk. An example is provided below.

		Severity of consequences/threats		
		Low	Moderate	High
Degree of impact/ dependency	High	**Moderate**	**High**	**V. High**
	Moderate	**Low**	**Moderate**	**High**
	Low	**V. Low**	**Low**	**Moderate**

Step 4: Prioritise the identified material natural capital risks from Step 3, e.g. by listing from highest to lowest materiality.

Step 5: Document the organisation's mitigation and adaptation activities for each prioritised risk from Step 4. For example, list the actions being taken and to be taken, by when and by whom, current status, and the expected adequacy of the actions in reducing risk. It may be helpful to identify whether actions are expected to reduce the degree of impact or dependency, or the severity of threats or consequences.

Step 6: Calculate an overall residual risk score for each natural capital impact and dependency risk by adjusting for the adequacy of the organisation's mitigation and adaptation activities.

Step 7: (optional): Document natural capital opportunities, e.g. through mitigating risks or through strategic changes.

Step 8: Document the outcomes of each step in the natural capital risk register. Regularly review and respond to changes over time.

impaired, and substitutes either do not exist or are only available at significantly higher prices. See (Smith et al., 2021b, Smith et al., 2021a)

Severity of consequences

Severity of consequences can be assessed by considering how significantly an organisation could be affected (now or in the future) by any plausible societal or ecosystem response to the organisation's natural capital impact. A high severity of consequence would indicate the response to natural capital impacts could have significant financial consequences for the organisation.

Severity of threat

Severity of threat can be assessed by considering how significantly an organisation could be affected (now or in the future) by plausible changes in the availability of natural capital or ecosystem services that the organisation depends on. A high severity of threat would indicate the current or future threat to natural capital dependencies could have significant financial consequences for the organisation.

Example:

- The example below shows one way to combine qualitative and quantitative materiality assessment information.
- The example for natural capital impact risks records a definition of the risk, a qualitative classification of the degree of impact, severity of consequences and overall risk materiality score together with an example quantitative indicator. For example, forestry activities can impact on water quality which can lead to financial costs for the organisation – these costs could include things such as monitoring water quality or implementing controls to prevent pollutants entering the waterways.
- The example for natural capital dependency risks records a definition of the risk, a qualitative classification of the degree of dependency, severity of threats and overall risk materiality score together with an example quantitative indicator. For example, forestry productivity depends on water availability, changes in water availability could reduce yield, increase tree mortality, and increase tree replanting costs.
- Each example also shows a brief summary of the organisation's risk mitigation and adaptation activities and their adequacy in reducing risk, leading to a "residual risk materiality score".

Example Natural Capital Risk Register (impact risks)

	TOPIC	IMPACT RISK	DEGREE OF IMPACT	SEVERITY OF CONSEQUENCES	OVERALL RISK MATERIALITY	MITIGATION AND ADAPTATION ACTIVITIES	RESIDUAL DEGREE OF IMPACT	RESIDUAL SEVERITY OF CONSEQUENCES	RESIDUAL RISK MATERIALITY
Water	**Water quality**[a]	The risk of consequences for the organisation arising from forestry activities negatively affecting the quality of surface or sub-surface water	**Low**	**Moderate**	**Low ($50/ha/year)**	Maintain and expand riparian buffers Implement a broad waterway monitoring scheme before and after forestry operations	**Low**	**Low**	**Very Low**
Biodiversity and ecosystems	**Weeds**[b]	The risk of consequences for the organisation arising from forestry activities spreading weeds	**Moderate**	**Moderate**	**Moderate ($80/ha/year)**	Monitor adjacent land to pine plantations for wildlings	**Low**	**Moderate**	**Low**

[a] The water quality impact risk materiality assessment shows a qualitative classification of low for degree of impact and moderate for severity of consequences, resulting in an overall low risk materiality score. A quantitative indicator of financial costs of on average $50 per hectare per year is also shown, representing organisation costs from lost productivity, monitoring, management or control due to societal concerns or regulation related to water quality impacts from forestry operations (e.g. the costs of water quality monitoring and maintenance of riparian buffers). The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from low to very low, due to the activities being adequate to reduce the severity of consequences from moderate to low.

[b] The weeds impact risk materiality assessment shows a qualitative classification of moderate for degree of impact and moderate for severity of consequences, resulting in an overall moderate risk materiality score. A quantitative indicator of financial costs of on average $80 per hectare per year is also shown, representing organisation costs from lost productivity, monitoring, management or control due to societal concerns or regulation related to weed impacts from forestry operations (e.g. the costs of weed monitoring and control measures). The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from moderate to low, due to the activities being adequate to reduce the degree of impact from moderate to low.

Example Natural Capital Risk Register (dependency risks)

	TOPIC	DEPENDENCY RISK	DEGREE OF DEPENDENCY	SEVERITY OF THREAT	OVERALL RISK MATERIALITY	MITIGATION AND ADAPTATION ACTIVITIES	RESIDUAL DEGREE OF DEPENDENCY	RESIDUAL SEVERITY OF THREAT	RESIDUAL RISK MATERIALITY
Water	**Water availability**	The risk of lower productivity and/or increased costs due to inadequate water to meet target biomass	**High**	**High**	**Very High ($600/ha/year)**	Develop drought resistant phenotypes Change species planted Decrease tree planting density	**Low**	**High**	**Moderate**
Weather and climate	**Bushfires[b]**	The risk of lower productivity and/or increased costs due to exposure to destructive bushfire	**High**	**High**	**Very High ($170/ha/year)**	Create firebreaks and buffers Increase prescribed burning activities to reduce fuel load	**High**	**Moderate**	**High**

[a] The water availability dependency risk materiality assessment shows a qualitative classification of high for degree of dependency and high for severity of threat, resulting in an overall very high risk materiality score. A quantitative indicator of financial costs of on average $600 per hectare per year is also shown, representing organisation costs from lost productivity, monitoring, management or control due to inadequate water availability (e.g. lost productivity and replanting costs). The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from very high to very moderate, due to the activities being adequate to reduce the degree of dependency from high to low.

[b] The bushfire dependency risk materiality assessment shows a qualitative classification of high for degree of dependency and high for severity of threat for the organisation, resulting in an overall very high risk materiality score. A quantitative indicator of financial costs of on average $170 per hectare per year is also shown, representing organisation costs from lost productivity, monitoring, management or control due to destructive bushfire (e.g. lost productivity and replanting costs). The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from very high to high, due to the activities being adequate to reduce the severity of threat from high to moderate.

2.4 Natural Capital Impact Statement

What?

- The natural capital impact statement summarises an organisation's material positive and negative impacts on natural capital (whether or not the natural capital affected is owned or controlled by the organisation). Sometimes called an 'environmental profit & loss statement'.
- It can track either qualitative or quantitative metrics and can also include summary information on any mitigation or adaptation activities undertaken by the organisation.

Why?

- A natural capital impact statement provides information for an organisation to externally report on the positive and negative impacts of their operations on natural capital over time, allowing trends or performance to be monitored by stakeholders. Aligned with the organisation's sustainability reporting, Environmental, Social, and Governance (ESG) or integrated report.

How?

Step 1: Consider the natural capital impacts to be included.
Step 2: Take the appropriate current measures from the natural capital impact register.

Step 3: Summarise the organisation's mitigation and adaptation activities for each impact, using information from the natural capital impact register. ***Optional:*** Include timing and costs of undertaking these mitigation and adaptation activities and any monitoring of their effectiveness.

Step 4: Complete the natural capital impact statement using the measures in steps 2 and 3.

Example:

- The example below shows qualitative and quantitative information on an organisation's natural capital impacts and mitigation and adaptation activities.
- The left side of the statement shows the definition of the impact, a qualitative assessment of the materiality of the impact and the quantitative metrics and targets used. The mitigation and adaptation column summarises information on activities undertaken by the organisation to minimise or measure their impacts on natural capital.
- Including the previous year's values is likely to be useful, as are future projections. Example values for the previous year are shown to the left of the current values, with future projections on the right.

Concepts

Consistency of terminology: natural capital impact statement

Several organisations have produced statements or guidance on how to report on natural capital impacts from an organisation's operations, but the terminology used to describe these statements varies and this can create confusion. Here, the term 'natural capital impact statement' is used to specifically refer to a statement of an organisation's material impacts on natural capital and has the organisation's wider relationship with natural capital as the focus (as compared to natural capital accounting, which generally focuses on the natural capital assets that the organisation owns or controls).

Natural capital impacts reporting frameworks

A variety of frameworks provide guidance for organisations to report on their natural capital impacts, such as sustainability reporting and environmental, social and governance (ESG) reporting, and SDG reporting (Global Reporting Initiative (GRI), 2013). An international standard on monetary valuation of environmental impacts has been published (ISO 2019).

Other examples

Companies such as PUMA (Kering) have produced statements similar to natural capital impact statements (they referred to them as environmental profit and loss statements) where they track the impacts of their products across the whole lifecycle (Kering, 2020, PUMA, 2011).

Example Natural Capital Impact Statement

	TOPIC	IMPACT	MATERIALITY	METRICS	TARGET	MITIGATION & ADAPTATION	HISTORICAL 2020	CURRENT YEAR 2021	FUTURE PROJECTION 2030
Water	**Water quality**[a]	Forestry activities affect the quality of surface or sub-surface water.	**Low**	Number of days of exceedances of water quality threshold levels per year in waterways in the forest estate (exceedance-days/Yr)	0	Maintain and expand riparian buffers. Implement a broad waterway monitoring scheme before and after forestry operations.	21	**12**	0-10
Biodiversity and ecosystems	**Weeds**[b]	Forestry activities introduce and spread weeds	**Moderate**	Number of pine wildlings infestations in adjacent land associated with the estate (infestations/yr)	0	Monitor adjacent land to pine plantations for wildlings.	10	**6**	0-5

Notes on mitigation and adaptation activities (timing, cost & monitoring):

- $500k spent on maintaining and expanding riparian buffers over the previous 10 years.
- $50k to be invested in the next two years on expanding the monitoring of pine wildlings in adjacent land.

[a] The water quality impact statement shows the impact of the organisation on water quality exceedances with 12 days of exceedances in 2021 and that this has decreased from 21 days in 2020, and the impact is projected to decrease in the future.

[b] The weeds impact statement shows the impact of the organisation on weed infestations with 6 infestations recorded affecting 10 hectares of adjacent land in 2021 and that this has decreased from 10 infestations recorded affecting 15 hectares of adjacent land in 2021, and the impact is projected to decrease in the future.

2.5 Natural Capital Dependency Statement

What?

- The natural capital dependency statement summarises the state of an organisation's material dependencies on natural capital (whether or not the natural capital depended on is owned or controlled by the organisation).
- It can track either qualitative or quantitative metrics and include information on any mitigation or adaptation activities undertaken by the organisation.

Why?

- A natural capital dependency statement provides information for an organisation to externally report on their natural capital dependencies over time, allowing trends or performance to be monitored by stakeholders. Aligned with the organisation's sustainability reporting, Environmental, Social, and Governance (ESG) or integrated report.

How?

Step 1: Consider the natural capital dependencies to be included.

Step 2: Take the appropriate current measures from the natural capital dependency register.

Step 3: Summarise the organisation's mitigation and adaptation activities for each dependency, using information from the natural capital dependency register. ***Optional:*** Include timing and costs of undertaking these mitigation and adaptation activities and any monitoring of their effectiveness.

Step 4: Complete the natural capital dependency statement using the measures in steps 2 and 3.

Example:

- The example below shows qualitative and quantitative information on an organisation's dependencies and mitigation and adaptation activities.
- The left side shows the dependency definition, a qualitative assessment of materiality and the quantitative metrics and targets. The mitigation and adaptation column summarises information on activities undertaken by the organisation to increase resilience to changes in natural capital or to measure their dependencies (with detailed notes documented separately).
- Including the previous year's values is likely to be useful, as are future projections. Example values for the previous year are shown to the left of the current values, with future projections on the right.

Other examples

A natural capital dependency statement is a new concept proposed in this handbook and therefore there are no other examples.

Example Natural Capital Dependency Statement

	TOPIC	DEPENDENCY	MATERIALITY	METRICS	TARGET	MITIGATION AND ADAPTATION	HISTORICAL 2020	CURRENT YEAR 2021	FUTURE PROJECTION 2030
Water	**Water availability**[a]	Adequate water to meet target biomass	**High**	mm of rainfall received per year (mm/yr) (5-year average across the estate)	>550	Deploy drought resistant phenotypes Change species planted Decrease tree planting density	468	**461**	420 - 485
Weather and climate	**Bushfire**[b]	Absence of destructive bushfire	**High**	Percent of forest estate unaffected by destructive bushfire (%) (5-year average)	100%	Create firebreaks and buffers Increase prescribed burning activities to reduce fuel load	95%	**96%**	95-100%

Notes on mitigation and adaptation activities (timing, cost & monitoring):

- $200k spent on researching and trialling drought resistant phenotypes and species changes over the previous 5 years.
- $300k spent on 10km of new fire breaks and 10,000Ha of prescribed burning activities over the previous 10 years.

[a] The water availability dependency statement shows records of average rainfall across the estate show the 5-year average was 461mm in 2021 and that this decreased from 468mm in 2020. Rainfall is projected to be between 420mm and 485mm on average across the estate by 2030.

[b] The bushfire dependency statement. Records show the percent of estate unaffected by destructive bushfire, with a 5-year average of 96% in 2021 and 95% in 2020. The percent of estate unaffected by destructive bushfire is projected to be between 95% and 100% by 2030.

2.6 Natural Capital Risk Statement

What?

- The Natural Capital risk statement d**iscloses how the organisation identifies, assesses, and manages natural capital risks.** It summarises information from the natural capital risk register. It can report qualitative or quantitative metrics.

Why?

- A natural capital risk statement allows an organisation to disclose information externally on their natural capital risks and show how their actions are mitigating these risks. It can be aligned with the organisation's corporate risk reporting, TCFD or TNFD report.

How?

Step 1: Consider the natural capital risks to be included.

Step 2: Take the appropriate qualitative and/or quantitative measures from the natural capital risk register and document the organisation's mitigation and adaptation activities for each risk.

Step 3: (optional): Document natural capital opportunities, e.g. through mitigating risks or through strategic changes.

Step 4: Complete the natural capital risk statement using the measures in steps 2 (and 3 if applicable).

Example:

- The example below uses the qualitative risk materiality scores, the mitigation and adaptation activities and the residual risk materiality scores from the natural capital risk register.

Other examples

External disclosure frameworks that focus on risk include the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) and the Task Force on Nature-related Financial Disclosures (TCFD).

An example of a natural capital risk statement is given in (Ascui and Cojoianu, 2019), Table 4.

Potential natural capital risks and opportunities for forestry are shown in Appendix A2 and A3.

The TNFD recommends that organisations should specifically "*describe the organisation's processes for managing nature-related risks*" and "*describe how processes for identifying, assessing, and managing nature-related risks are integrated into the organisation's overall risk management*" (TNFD, 2022 p10)

Example Natural Capital Risk Statement (impact risks)

	TOPIC	IMPACT RISK	RISK MATERIALITY SCORE	MITIGATION AND ADAPTATION ACTIVITIES	RESIDUAL RISK MATERIALITY SCORE
Water	**Water quality**[a]	The risk of consequences for the organisation arising from forestry activities negatively affecting the quality of surface or sub-surface water	**Low**	Maintain and expand riparian buffers Implement a broad waterway monitoring scheme before and after forestry operations	**Very Low**
Biodiversity and ecosystems	**Weeds**[b]	The risk of consequences for the organisation arising from forestry activities spreading weeds	**Moderate**	Monitor adjacent land to pine plantations for wildlings	**Low**

[a] The water quality impact risk statement shows a qualitative assessment of overall low risk materiality score. The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from low to very low.

[b] The weeds impact risk statement shows a qualitative assessment of overall moderate risk materiality score. The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from moderate to low.

Example Natural Capital Risk Statement (dependency risks)

	TOPIC	DEPENDENCY RISK	RISK MATERIALITY SCORE	MITIGATION AND ADAPTATION ACTIVITIES	RESIDUAL RISK MATERIALITY SCORE
Water	**Water availability**	The risk of lower productivity and/or increased costs due to inadequate water to meet target biomass	**Very High**	Develop drought resistant phenotypes Change species planted Decrease tree planting density	**Moderate**
Weather and climate	**Bushfires**	The risk of lower productivity and/or increased costs due to exposure to destructive bushfire	**Very High**	Create firebreaks and buffers Increase prescribed burning activities to reduce fuel load	**High**

[a] The water availability dependency risk statement shows a qualitative assessment of very high for the risk materiality score. The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from very high to moderate.

[b] The bushfire dependency risk statement shows a qualitative assessment of very high for the risk materiality score. The right side summarises the mitigation activities undertaken by the organisation and shows that once these are considered the residual risk materiality score is reduced from very high to high.

Appendix

A1. Key concepts and background

Basics of natural capital and ecosystem services

- Ecosystems provide organisations and society with a wide range of goods and services.
- For example, forests provide timber and wood fibre, food such as fungi, habitat for a variety of fauna, climate regulation through absorbing carbon dioxide, and provide recreation and cultural opportunities.
- The relationship between humans and the environment is now commonly viewed through the concepts and language of natural capital (Pearce, 1988, Natural Capital Coalition, 2016, Millennium Ecosystem Assessment, 2005). The natural capital approach extends the economic notion of capital (resources which enable economic production) to the natural environment. The term '**natural capital**' conceptualises nature as assets: stocks of resources such as clean air, water, soil and living things which produce flows of **ecosystem services** that have value because they **benefit** humans (households or firms). Some ecosystem services (such as clean air) benefit us directly, but often they are combined with other forms of capital (e.g. manufactured, financial, human and social capital) in the economy to produce traditional economic goods and services, as illustrated in Figure A1. The flows of ecosystem services are dependent on both the amount (or extent) and condition of the natural capital stock.

Natural capital, ecosystem services and benefits

Natural capital assets provide flows of ecosystem services which can generate benefits to humans directly and support the production of goods and services.

Natural capital
Soil,
Water,
Forests,
Air,
Living things

Ecosystem services
Tree Biomass
Crops and grazed biomass
Energy
Genetic resources
Water quality / flow
Pest control
Landscapes/views
Wild species

Goods / Benefits
Sawn Timber
Drinking water
Nature watching, Recreation, Food
Physical / mental health
Amenity and enjoyment e.g. Aesthetic, sound & scent.

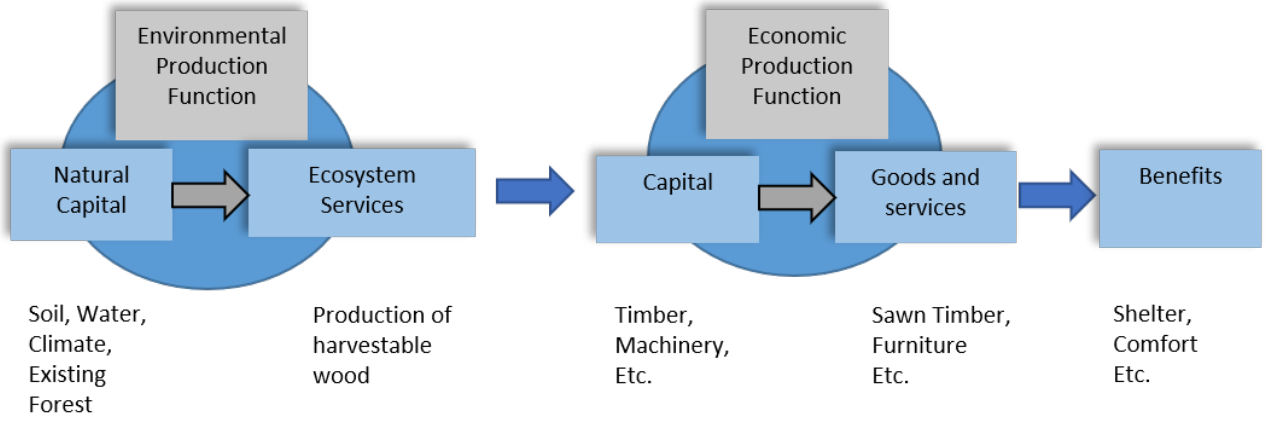


Figure A1. Natural capital as an input into economic production (adapted from (Binner et al., 2017))

Basics of natural capital impacts, dependencies, and risks

All organisations cause **natural capital impacts** (which may be positive or negative) either directly from their operations and activities or indirectly through their value chain. For example, impacts such as land degradation, emissions and pollution would generally be regarded as negative, while ecological rehabilitation could be regarded as a positive impact. Forestry has the potential to have substantial impacts (both positively and negatively) on natural capital.

All organisations also have **natural capital dependencies** either directly for their operations and activities or indirectly through their value chain. For example, an organisation may depend on natural capital for production inputs such as land, raw materials, water etc. In some cases, the relevant 'service' might be the absence of conditions that would otherwise be unfavourable (such as extreme weather or pests and diseases). Forestry is one of the industries with the greatest dependencies on natural capital (NCFA and UN Environment World Conservation Monitoring Centre, 2018): the health and productivity of forests are underpinned by ecosystem services provided by natural capital such as fertile soil, adequate water and suitable climate.

Changes in the availability of natural capital and the ecosystem services that organisations depend on can threaten the productivity, profitability or even viability of the organisations. Natural capital impacts can also affect the financial position of organisations, for example when society responds to natural capital impacts through regulation (such as fines) or changes in consumer acceptance (such as restricted access to certain markets in the absence of sustainability certification). Here, we describe these natural capital dependency and impact risks as **natural capital risks**.

A **dependency** is a "business reliance on or use of natural capital" (Natural Capital Coalition 2016 pp.16-17). For example, forestry organisations depend on adequate rainfall and soil suitable for growing trees.

An **impact** is a "negative or positive effect of business activity on natural capital" (Natural Capital Coalition 2016 pp.16-17). For example, forestry activities such as harvesting can have impacts on soil and water quality.

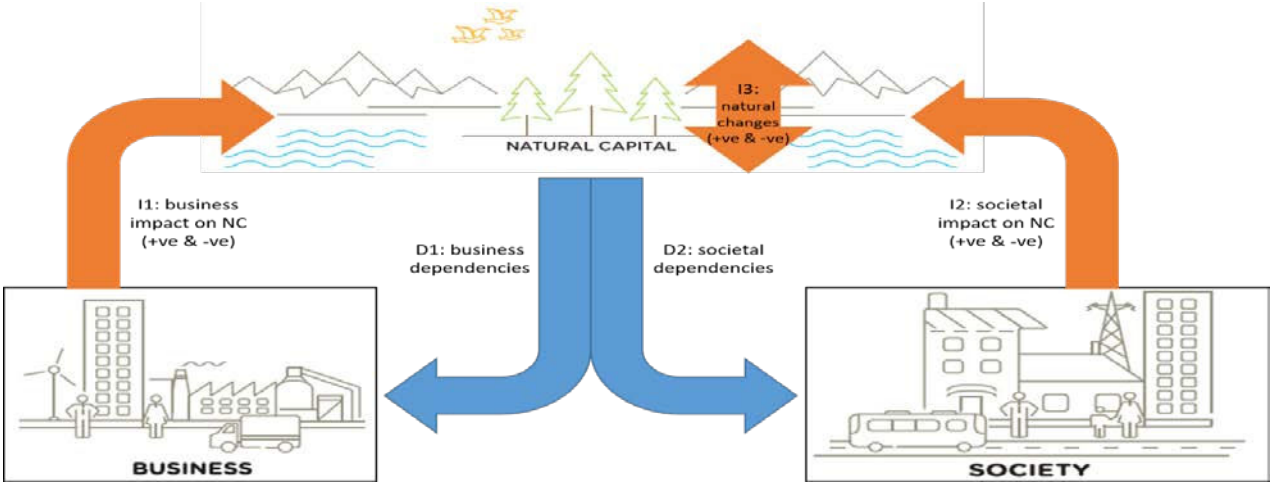


Figure A2 Source NCP p15.

Measuring natural capital and ecosystem services

- It is now widely accepted that natural capital and ecosystem services need to be measured and managed in order to maintain and enhance the values they provide into the future.

Stocks and flows

- It is important to clearly distinguish between stock and flow concepts. Natural capital refers to stocks of natural assets, which can be measured at a selected point in time. Ecosystem services are flows of environmental goods or services that provide benefits, which can be measured over a selected time period.
- Natural capital assets can be divided into environmental assets and ecosystem assets. Ecosystem assets are commonly described in terms of a particular land cover class or ecosystem type (for example, forest type) and the stock of these assets is defined in terms of their extent (quantity) and condition (quality).
- Ecosystem services provide benefits to households or firms. Flows of benefits can be positive or negative (disbenefits).
- Ecosystem services are commonly grouped into categories of provisioning, regulating and cultural services. Table A1 shows example services for each category that are provided by forests. An additional category of supporting services is sometimes used, where such supporting services underpin other services.

Frameworks for classifying ecosystems and ecosystem services

There are several different frameworks for classifying ecosystems and ecosystem services, for example:

- The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005);
- The Economics of Ecosystems and Biodiversity (TEEB) (TEEB, 2010);
- The IUCN Global Ecosystem Typology (Keith et al., 2020) adopted by the UN SEEA-EA for ecosystems (United Nations, 2021); and
- The Common International Classification of Ecosystem Services (CICES) adopted by the UN SEEA-EA for ecosystem services (Haines-Young and Potschin, 2017).

Table A1 Ecosystem services provided by forests

Categories	Example ecosystem services provided by forests
Provisioning services	Biomass (timber, plants, seeds, food, energy), water, minerals.
Regulating services	Biodiversity, water (water purification, water flow regulation), soil (erosion control, remediation), climate (climate regulation, storm mitigation).
Cultural services	Recreation and access, aesthetic, sound and scent, education, scientific/research, spiritual.

Intermediate and final goods and services

- The distinction between intermediate and final ecosystem services is also an important one. **Intermediate ecosystem services** are environmentally produced goods and services that act as inputs to some other environmental process. Whereas final ecosystem services enter household or firm production functions. In other words, **final ecosystem services** are the subsets of environmental goods and services that have direct and immediate consequences for productive activities in the economy, and intermediate ecosystem services underpin the output of final ecosystem services.
- However, the distinction between intermediate and final ecosystem services is not always straightforward. The same environmental good or service may act as both an intermediate and a final ecosystem service (e.g., clean water could be regarded as a final ecosystem service if used for drinking water, but as an intermediate ecosystem service from the perspective of recreational fishing, in that clean water contributes to the final service of fish population) (Boyd and Banzhaf, 2007, Fisher et al., 2009).

Spatial considerations

- The spatial dimension is important in assessing and reporting on natural capital. Ecosystem services generated by forests can vary substantially over small distances. Spatial configuration, connectivity, proximity to other ecosystems and distance from human populations are important determinants of the services generated by forests. Location and spatial configuration determine the provision of flood defence services; connectivity has implications for wildlife habitats and susceptibility to weeds and pests and diseases; proximity to lakes and rivers has implications for the supply of water purification services or downstream impacts; and distance from human populations influences recreation visits.

Threshold considerations

- Thresholds are another important consideration. One of the greatest obstacles to assessing and reporting on natural capital is our incomplete scientific understanding of ecosystem function and resilience. For example, the existence, location and severity of threshold or non-linear effects and the extent to which functional redundancies exist within an ecosystem.

Valuing natural capital and ecosystem services

- Monetary valuation provides a common metric through which goods and services can be aggregated and compared.

Value, price and cost

- While the terms ‘value’, ‘price’ and ‘cost’ are commonly used interchangeably, they are not in fact equivalent. Nature is clearly a source of great value, yet many of the services that come from nature are not bought or sold in markets and therefore do not have market prices. The value of a natural asset may therefore be quite different from its market price. Similarly, the value produced by a natural asset may be quite different to the costs associated with maintaining or enhancing the asset.
- Taking forestry as our example, many of the benefits provided by forests are not traded through markets and are therefore unpriced public goods or **non-market goods** (Binner et al., 2017, Binner et al., 2018). Non-market goods from forests include the value of (non-traded) carbon stored or sequestered, the value of the biodiversity or unique habitats present, and the value of enjoyment from using the forests for recreation (amongst a range of other non-market goods). While the value of these non-market goods has been shown to be very substantial, it is not reflected in market prices or the valuation of the forest asset, therefore the value is not reflected in traditional financial accounts. Instead, the value of the non-market goods from forests represents a positive externality which goes to wider society.

Private value and public value

- It is useful when valuing natural capital and ecosystem services to separate the concepts of private and public value, which may also be termed internal and external value.
- **Internal / private value** represents the internal economic benefit of the natural capital to the organisations that own or control the natural capital (commonly valued based on market prices).
    - For forestry, this is commonly the value of marketable forest products such as timber.
- **External / public value** represents the value natural capital provides to other beneficiaries.

- For forestry, ecosystem service provision often represents a positive externality to society. These ecosystem services provide substantial value to society but since most of the benefits are not traded through markets, non-market valuation techniques are required to estimate an external value.

Exchange values and welfare values

- Both exchange and welfare values are important, but they have different economic interpretations and uses.
- **Exchange values** represent the contribution of an asset or service to the economy, regardless of its impact on human welfare. Exchange values are used in national accounting and conventional corporate accounting. The exchange value does not capture the total welfare value provided by goods and services, but rather accounts more pragmatically for the values of those services as or as if traded. For most market goods, exchange value data is readily available. However, for natural capital and ecosystem services, most of which are not traded in markets, it is impossible to observe an exchange value and instead exchange values need to be imputed. Identifying exchange values for ecosystem services is conceptually challenging and the subject of ongoing discussions in the international accounting community. Since exchange values don't capture the full welfare value, for some services, exchange values are likely to be significantly smaller than welfare values (for example, for outdoor recreation or the physical health benefits derived from it).
- **Welfare values** reflect the contribution of an asset or service to human welfare, regardless of its contribution to the economy. The welfare value concept is related to changes in consumer surplus. The consumer surplus represents the difference between consumers' full willingness to pay and the price they actually pay, which is typically smaller. For many policy analyses and decisions, it is the welfare value concept that is of relevance. The welfare value concept underpins Cost-Benefit Analysis guidelines (e.g. Sartori et al. (2014)) and the majority of environmental economics studies analysing the values of ecosystem services are based on the welfare value concept.

Accounting using exchange values or welfare values

If the sole purpose of valuing natural capital and ecosystem services is to construct natural capital accounts that integrate into the System of National Accounts (SNA), it might be necessary to only use the exchange value concept (Badura et al., 2017, Obst et al., 2016). For natural capital accounting at corporate or local level it is not necessarily the case that accounts are created to fit into SNA. It is common for there to be other policy or business reasons behind the decision to create accounts (some of which might require a broader concept of value) and therefore the use of exchange values may be less essential. Using welfare values within natural capital accounts is possible, however, it is important to note that in such cases there may not be consistency between the valuation of services valued at market rates and other non-market services which reflect the full welfare benefit (consumer surplus) to users and this should be made clear in the accounts. Because of these differences in valuation basis, exchange values and welfare values should always be presented separately and never added together.

Valuing stocks of natural capital

- Valuing stocks of natural assets is inherently difficult because there may not be a market that could be used to estimate the value of those assets. The SNA's recommended approach for such situations (and the approach adopted in the SEEA-EA) is to use the net present value (NPV) of the expected flows of ecosystem services to estimate ecosystem asset values.
- The NPV asset valuation method requires three steps: first, an estimation of the values of ecosystem services provided by natural capital assets; second, an estimation of the expected future flows of values from those ecosystem services discounted to the present; and third, a decision about an appropriate discount rate.
- The NPV asset valuation method therefore depends on factors such as the asset's future condition, pressures or environmental changes, natural regeneration, sustainable rate of usage, and the long-term viability of the asset. This requires either substantial detailed knowledge or it requires the valuer to make bold assumptions such as calculating value based on current patterns of use and condition (Hein et al 2016).
- Asset lifetime considerations also raises considerations about an appropriate discount rate. Most environmental economists agree that for environmental long-lived assets a discount rate based on market rates is not appropriate as markets are essentially driven by short term considerations. For ecosystem assets an accounting lifetime of 100 years may be considered reasonable, together with a lower discount rate. For example, for such long-lived assets that may involve intergenerational wealth transfers, the UK Treasury recommends a discount rate of 3.5% for the first 50 years and further declining discount rates thereafter[3].

Accounting for biological assets

Existing accounting standards on the valuation of biological assets (IAS 41) provide some basis for valuing natural capital assets. Accounting for the fair value of standing trees often suffers from a lack of market prices and therefore it is common for forestry companies to already use the net present value of expected future cash flows to estimate the fair value of their standing trees.

Valuing flows of ecosystem services

- The environmental economics literature contains a range of valuation methods and techniques for valuing market and non-market goods and services – many of which are applicable to valuing ecosystem service flows. Values can

Accounting for final ecosystem services

Only final ecosystem services are consistent with the use and supply accounts of the SNA and therefore final ecosystem services should be used in the construction of monetary ecosystem service accounts. Nevertheless, measuring

[3] https://www.gov.uk/government/publications/green-book-supplementary-guidance-discounting

be derived either from related markets or from stated behaviour in hypothetical situations.

- For valuing ecosystem services, it is crucial to identify the benefit, beneficiaries, and the usage or demand of the ecosystem services. Note that this also holds true for expected future use of ecosystem services to estimate asset values. The identification of the use of services might differ across service types. For example, most provisioning services' usage will be reflected in increased extraction or output quantities (e.g., food produced, timber harvested). In contrast, the usage (and value) of many regulating and cultural services generally increases with the number of people in the relevant area (e.g., flood protection, air and water purification or recreation).
- It is common to see a distinction between use and non-use values, traditionally characterised as being the difference between a value that is derived from physical interaction **(use value)** and one in which value is derived without physical proximity to or interaction with an ecosystem service **(non-use value)**.
- Use values can arise from a direct interaction with nature, including timber extraction and enjoyment of a view of nature, or indirectly, where nature provides services such as water purification or protection from natural hazards. Potential future use values from nature are sometimes referred to as option values.
- Non-use values capture the value that people derive from the knowledge that natural assets (e.g. habitats or species) exist, irrespective of any use of these; or from the knowledge that the natural environment is maintained for the benefit of current or future generations (i.e. existence, altruistic and bequest values). This component of value might in some cases be significant, particularly for values related to charismatic or rare species or habitats.

intermediate ecosystem services is still important, as it can provide useful information for understanding the interdependencies between multiple natural capital assets and natural processes. Indeed, valuing intermediate ecosystem services can in some cases provide valuable information for cost effectiveness and other management decisions (e.g. restoration of ecosystems or conservation interventions) (Badura et al., 2017). However, if intermediate ecosystem services are valued, it is essential that they are clearly distinguished from final services to avoid double counting (Fisher et al., 2009).

Valuation techniques

Four broad categories of valuation methods are potentially available:

- **1. Market-based methods**. Market based methods are used to estimate the value of ecosystem services when that ecosystem service is an input to a good or service that is sold in a market and so has an observable market price (McConnell and Bockstael, 2005). For example, estimating the value of protecting wetlands through their

Marginal values

Most environmental economic valuation methods are designed to estimate the value of small (marginal) changes rather than large (stock) changes. This is appropriate for most decision-making purposes (including project appraisal and investment decisions), where for example it may be necessary to value the likely impact of afforesting or deforesting in a specific unit of land

contribution (as nurseries for fish species) to the market price of commercially harvested fish (Barbier and Strand, 1998). Example methods include unit resource rent, production function or profit function methods.

- **2. Cost-based methods**. Cost-based methods use cost as a convenient approximation of value. It is important to note that costs might have little relationship to the values they aim to approximate and so such methods should be used with caution. Example methods include damage-cost avoided, replacement cost and substitute cost methods.
- **3. Revealed preference methods**. Revealed preference methods use the purchase of market goods to indicate the value of a related non-market good (Freeman III et al., 2014). For example, when ecosystem services are bundled up as part of another market good – the standard example here is property, in which a house's location includes environmental qualities such as noise or views (Day et al., 2007). An analysis of property prices can then be used to identify the contribution of the ecosystem service as an attribute of the total property price (hedonic pricing). Another example is when there are complementary market goods to the ecosystem services. For example, the travel cost method uses an individual's willingness to incur costs to travel to recreation sites to reveal their value for that site (Parsons, 2003, Willis and Garrod, 1991, Willis et al., 2003).
- **4. Stated preference methods**. Stated preference methods rely on survey methods which present respondents with hypothetical questions asking them to indicate amounts of money they would exchange for changes in an ecosystem service (Freeman III et al., 2014). Stated preference methods can be used to estimate non-use values. Example methods include contingent valuation and choice experiments.
- **Value transfer.** Value transfer is not a valuation method itself, instead it takes information from previously assessed study sites and utilizes this information to estimate values for alternative sites, (or different changes at the same site). It is a pragmatic approach, recognising that it is not possible (or necessary) to value all natural capital and ecosystem services when we have other studies from which values can be extrapolated (Badura et al., 2016, Bateman et al., 2011).

without having a significant effect on the country's total forest stock. The values estimated in such instances are marginal in that they represent a relatively small change when compared to the nation's total stock of forest. However, those marginal values are unlikely to remain constant when we consider large-scale changes in the stock. The use of point estimates for ecosystem services values when non-marginal stock changes occur and thresholds are crossed is problematic, and increasing scarcity rents and threshold effects may need to be incorporated in such cases (Badura et al., 2017, Fenichel et al., 2016).

The Ecosystem Services Valuation Database (ESVD)

The ESVD is a collection of publicly available monetary valuation data for ecosystem services across the globe (https://www.esvd.info/).

A2. Natural capital risks

Natural capital risks

- Natural capital risks can arise when important **dependencies** are threatened by environmental or social changes, such as climate change resulting in different rainfall patterns, or changes in agricultural practices altering the availability of land for new plantations. Managing such changes can result in increased costs, such as increasing fertiliser application to improve soil nutrition. In extreme cases, lack of availability of a critical dependency can make an organisation unviable.
- Risks can also arise if an operation or activity negatively **impacts** natural capital that the organisation itself depends on (such as degrading soil quality on their own land), or when society responds to environmental impacts through regulation or changes in consumer acceptance. For example, negative impacts on natural capital could result in an organisation incurring regulatory penalties or losing a sustainability certification, thus restricting its access to certain markets.
- At an organisational level, financial, operational, reputational, regulatory or societal risks can arise as a result of dependencies and/or impacts on natural capital. These **direct risks** for the organisation translate into **indirect risks** for private or public investors.
- Another common framing of natural capital risks divides them into **physical risks**, **transition risks** and **systemic risks**.
- Examples of nature-related dependency risks and impact risks are shown in Table 1. The risks are split into subcategories of physical risks and transition risks, consistent with the recommendations of the TCFD and TNFD. The transition risks are further subdivided into operational, regulatory and legal, reputational, market and product, and financing risk categories. However, it should be noted that some overlap between the subcategories may exist.

Physical risks: risks to an organisation linked to its and other organisations' dependencies on nature and nature impacts. For example, climate change and biodiversity loss leading to a lack of availability of ecosystem services that the organisation depends on.

Transition risks: risks to organisations arising from misalignment between an organisation's strategy and management and the changing regulatory and policy landscape in which it operates. For example, transition risks may arise from society's transition to low carbon and/or biodiversity positive economies.

Systemic risks: risks arising from the breakdown of entire systems, rather than the failure of individual parts.

These concepts are important for the Task Force on Climate-related Financial Disclosures (TCFD) and Task Force on nature-related Financial Disclosures (TNFD) (TCFD, 2017, TNFD, 2020).

Table 1 Nature-related risks

	Example nature-related dependency risks	Example nature-related impact risks
Operational	Decreased resource availability. Increased susceptibility of operations and/or supply chain to physical risks e.g. extreme weather events. Decreased provision of nature-related services that the organisation relies on – e.g. changing precipitation patterns leading to inadequate water supply. Increased nature-related disservices - e.g. pests and diseases. Reduced revenue and higher costs from negative impacts on workforce – e.g. health and safety restrictions on working in extreme weather. Increased insurance premiums.	Decreased revenue and higher costs due to changes in the availability or ability of nature to mitigate impacts such as emissions and pollution.
Regulatory and legal	Reduced revenue and higher costs from future regulatory changes that restrict resource use or nature-related services that an organisation relies on.	Reduced revenue and higher costs from future regulatory changes that restrict nature-related impacts or create additional obligations to maintain or enhance natural capital. Increased costs from exposure to future fossil fuel price increases. Increased costs from exposure to any current or future carbon price.
Reputational	Decreased demand for products and services due to increased stakeholder concern about nature-related dependencies. Reduced revenue and higher costs from stigmatisation of the industry or sector and negative impacts on workforce – e.g. attracting and retaining employees.	Decreased trust and acceptance of operations as consumers become more aware of nature-related impacts – loss of social licence to operate.
Market and product	Decreased revenue due to changing consumer preferences related to natural capital dependencies. Decreased market valuation reflecting the susceptibility or lack of resilience to physical risks.	Reduced demand for products and services due to changing consumer preferences related to natural capital impacts – such as lower emissions / lower pollution. Decreased market access - e.g. customers only willing to buy green certified products.
Financing	Decreased finance availability due to nature-related dependency risks such as extreme weather events.	Decreased finance availability and the inability to access new kinds of finance (green bonds, sustainability-linked loans) due to impacts on nature.

Forestry natural capital risks

- Forestry is one of the industries with the greatest dependencies on natural capital (NCFA and UN Environment World Conservation Monitoring Centre, 2018): the health and productivity of forests are underpinned by ecosystem services provided by natural capital such as fertile soil, adequate water and suitable climate. Changes in the availability of natural capital can threaten the productivity of forests, and thus the ongoing financial viability of forestry organisations. At the same time, forestry operations and activities have the potential to impact (positively or negatively) on natural capital. This can also affect the financial position of a forestry organisation if the natural capital it depends on is affected (for example, degrading soil quality), or when society responds to natural capital impacts through regulation (such as fines) or changes in consumer acceptance (such as restricted access to certain markets in the absence of sustainability certification).

A3. Natural capital opportunities

Natural capital opportunities

- An organisation's interactions with nature can also create opportunities.
- Opportunities can arise from an increased resilience of the organisation to nature-related physical or transition risks. For example, through switching to operations or products that have lower risk exposure or from an understanding of how to position the organisation in the face of changing regulatory requirements or societal preferences. In addition, reducing or mitigating negative impacts on nature can create opportunities to access new markets or finance; for example, the rise in new sustainable finance market instruments such as sustainability-linked loans and green bonds (Smith et al., 2021c).
- Organisations that are **natural capital asset owners** have an **additional set of natural capital opportunities** available to them. Natural capital asset owners are involved in creating, maintaining, or enhancing a range of ecosystem services. Therefore, there may exist opportunities to better manage their natural capital dependencies to maintain or enhance the services provided to their organisation, or to demonstrate the continued sustainable management of their natural capital assets to various stakeholders.
- Many of the ecosystem services provided by natural capital asset owners are likely to provide benefits to society rather than directly to the organisation itself, with the majority of these ecosystem services classed as "public goods". Public goods are non-excludable, in that no one can be excluded from enjoying their benefits, and non-rivalrous, in that use by one individual does not reduce availability to others. These characteristics make them valuable to society but difficult for organisations to extract financial returns (Bateman et al., 2019). Despite these difficulties, there may exist opportunities to internalise some of those social benefits into private benefits, and such opportunities are expected to increase in the future. For example, through market-based mechanisms such as carbon payments, emissions trading schemes, offsets (such as carbon or biodiversity offsets), payments for ecosystem service schemes, subsidies or conservation payments (Smith et al., 2021c).

- Examples of nature-related dependency opportunities and impact opportunities are shown in Table 2. The opportunities are split into subcategories relevant to operational, regulatory and legal, reputational, market and product, and financing opportunity categories. However, it should be noted that some overlap between the subcategories may exist.

Table 2 Nature-related opportunities

	Example nature-related dependency opportunities	Example nature-related impact opportunities
Operational	Increased resource use efficiency. Increased resilience of operations and/or supply chain to physical risks. Better management of natural capital to maintain or enhance the services it provides.	Reduced exposure to future fossil fuel price increases. Reduced exposure to any current or future carbon price.
Regulatory and legal	Better positioning of the organisation for any future regulatory changes related to resource supply or services from nature.	Better positioning of the organisation for any future regulatory changes related to natural capital impacts, such as greenhouse gas emissions, pollution or obligations to maintain or enhance natural capital owned. Increased influence on relevant policy decisions.
Reputational	Increased reputation with stakeholders from the ability of the organisation to communicate any dependencies on nature and how it is managing any risk related to those dependencies.	Increased trust and acceptance of operations – maintained social licence to operate. Increased reputation or market access from demonstration of sustainable operations and nature enhancements.
Market and product	Better positioning of the organisation to reflect changing services provided by nature or future threats.	Better positioning of the organisation to reflect changing consumer preferences related to natural capital impacts. Increased revenue from demand for lower emission / lower polluting products and services. Increased market access - e.g. green certified products.
Financing	Increased market valuation reflecting improved resilience to physical risks. Increased finance availability or access to new kinds of finance (e.g. green bonds, sustainability-linked loans) resulting from the ability of the organisation to communicate its improved resilience to nature-related risks.	Increased finance availability or access to new kinds of finance (green bonds, sustainability-linked loans) from the ability of the organisation to communicate its mitigation of impacts on nature – or to show nature enhancements. Access to new environmental markets – e.g. payment for ecosystem services schemes, carbon or biodiversity credits – for owners of natural capital assets.

Forest natural capital opportunities

- Forestry is also one of the industries with the greatest potential opportunities from natural capital. Consideration of natural capital has the potential to influence balance sheets, cash flows or risk management through a variety of different financial mechanisms: equity, bonds, loans, public sector finance, philanthropy, environmental markets and insurance. Some of the largest-scale financial opportunities relate to the growth in responsible investment demand for sustainable forestry assets. Additional investment growth is possible if additional financial returns are available through environmental markets, sale of conservation covenants or public or philanthropic incentives (Smith et al., 2021c, O'Grady et al., 2020).

Nature-based solutions:

Nature-based solutions are defined by IUCN as 'actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

A4. Glossary

An **asset** is "a store of value representing a benefit or series of benefits accruing to an economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another" (SEEA-CF 2014, s. 5.32).

Ecosystem assets are "contiguous spaces of a specific ecosystem type characterised by a distinct set of biotic and abiotic components and their interactions" (SEEA-EA 2021, s.2.11). Accounting for ecosystem assets is covered in the SEEA-EA.

Environmental assets are individual non-ecosystem assets such as mineral deposits, land, water, timber and energy resources. Accounting for environmental assets is covered in the SEEA-CF. Note that timber is regarded as an individual environmental asset in the SEEA-CF but it is also an ecosystem service provided by forest ecosystem assets in the SEEA-EA.

Natural capital is the stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people (Natural Capital Coalition, 2016 p. 2)

Ecosystem extent is "the size of an ecosystem asset in terms of spatial area" (SEEA-EA 2021, s. 2.13, p. 27)

Ecosystem condition is "the quality of an ecosystem measured in terms of its abiotic and biotic characteristics. Condition is assessed with respect to an ecosystem's composition, structure and function which, in turn, underpin the ecological integrity of the ecosystem, and support its capacity to supply ecosystem services on an ongoing basis. Measures of ecosystem condition may reflect multiple values and may be undertaken across a range of temporal and spatial scales" (SEEA-EA 2021, s.5.2 p. 85).

Ecosystem condition variables are "quantitative metrics describing individual characteristics of an ecosystem asset. A single characteristic can have several associated variables, which may be complementary or overlapping" (SEEA-EA 2021, s.5.41 p. 92).

Ecosystem condition indicators are "rescaled versions of ecosystem condition variables. They are derived when condition variables are set against reference levels determined with respect to ecological integrity" (SEEA-EA 2021, s.5.60 p. 95).

Ecosystem condition indices and sub-indices are "composite indicators that are aggregated from the combination of individual ecosystem condition indicators recorded in the ecosystem condition indicator account" (SEEA-EA 2021, s.5.81 p. 99).

Ecosystem services are "the contributions of ecosystems to the benefits that are used in economic and other human activity" (SEEA-EA 2021, s. 2.14, p. 27).

Intermediate ecosystem services are "those ecosystem services in which the user of the ecosystem services is an ecosystem asset and where there is a connection to the supply of final ecosystem services" (SEEA-EA 2021, s. 6.26, p. 124).

Final ecosystem services are "those ecosystem services in which the user of the service is an economic unit – i.e., business, government, or household" (SEEA-EA 2021, s. 6.24, p. 124).

Provisioning services are "those ecosystem services representing the contributions to benefits that are extracted or harvested from ecosystems" (SEEA-EA 2021, s. 6.51, p. 130).

Regulating services are "those ecosystem services resulting from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles, and thereby maintain environmental conditions beneficial to individuals and society" (SEEA-EA 2021, s. 6.51, p. 130).

Cultural services are "the experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contributes to a range of cultural benefits" (SEEA-EA 2021, s. 6.51, p. 130).

Benefits are "the goods and services that are ultimately used and enjoyed by people and society" (SEEA-EA 2021, s. 2.15, p. 27).

Market value is the amount for which something can be bought or sold in a given market (NCP 2016, p. 124).

Non-market value is the value of goods and services that are not traded for money but are valued based on what people would be willing to pay for them, if markets existed.

Exchange values represent the contribution of an asset or service to the economy, regardless of their impact on human welfare (Binner et al., 2017).

Welfare values reflect the contribution of an asset or service to human welfare, regardless of their contribution to the economy (Binner et al., 2017).

Value to the organisation / Internal Value / Private value is the costs and benefits to the organisation (NCP 2016, p. 124).

Value to society / External value / Public Value is the costs and benefits to wider society (NCP 2016, p. 124).

A **natural capital dependency** is a "business reliance on or use of natural capital" (Natural Capital Coalition 2016 pp.16-17). For example, forestry depends on adequate rainfall and soil suitable for growing trees.

A **natural capital impact** is a "negative or positive effect of business activity on natural capital" (Natural Capital Coalition 2016 pp.16-17). For example, forestry activities such as harvesting can impact soil and water quality, or retention/improvement of riparian buffers may minimise impacts on water quality and provide corridors for biodiversity.

An impact or dependency on natural capital is **material** if consideration of its value has the potential to significantly alter the decisions being taken by a user of the information (Natural Capital Coalition 2016, p. 43).

Drivers are natural or anthropogenic factors that cause changes in natural capital and its ability to supply ecosystem services.

Thresholds are a point or level at which new properties emerge in an ecological, economic or other system, whereby a small change in a pressure or driver can lead to a relatively large change in the state of natural capital, with consequences for the benefits it provides (Natural Capital Committee, 2019).

Obligation costs are the cost of restoring, maintaining or enhancing the quantity and quality of natural capital assets as per the organization's responsibility (legal or voluntary). (BS-8632:2021). **Production costs** in the BSI (BSI, 2021) are the costs that are necessary to incur to realize the flow of benefits at a point in time. (BS 8632:2021, section 6.7.1.5, p22). Here, we extend this definition of production costs to also include the subset of 'maintenance costs' of natural capital where the organisation has no legal or voluntary obligation to incur those costs. Examples could include forestry organisations enhancing soil carbon content, or undertaking thinning activities to enhance timber potential.
Natural capital accounting is "the process of compiling consistent, comparable and regularly produced data using an accounting approach on natural capital and the flow of services generated in physical and monetary terms" (Lammerant, 2019, p. 7).
Natural capital impact and dependency assessment is "the process of identifying, measuring and valuing relevant ("material") natural capital impacts and/ or dependencies, using appropriate methods" (Lammerant, 2019, p. 7).
Natural capital risk assessment is the process of identifying, measuring and evaluating relevant ("material") risks arising from an entity's impacts and/or dependencies on natural capital (Ascui and Cojoianu, 2019).
Natural capital reporting or disclosure involves the communication of natural-capital-related information to external stakeholders, such as shareholders, regulators, and civil society.

A5. Companion Workbook - Natural Capital Accounting: Forestry

See separate Excel workbook

For a copy of the file emails Greg.S.Smith@csiro.au

A6. Companion Workbook - Natural Capital Impact, Dependency, and Risk Assessment: Forestry

See separate Excel workbook

For a copy of the file emails Greg.S.Smith@csiro.au

References

AASB 2019. Conceptual Framework for Financial Reporting. Australia: Australian Accounting Standards Board.

Ascui, F. & Cojoianu, T. F. 2019. Natural Capital Credit Risk Assessment In Agricultural Lending: An Approach Based on the Natural Capital Protocol. Oxford: Natural Capital Finance Alliance.

Badura, T., Bateman, I., Agarwala, M. & Binner, A. 2016. Valuing preferences for ecosystem-related goods and services. *In:* POTSCHIN, M. B., HAINES-YOUNG, R., FISH, R. & TURNER, K. (eds.) *Routledge Handbook of Ecosystem Services.* Routledge.

Badura, T., Ferrini, S., Agarwala, M. & Turner, K. 2017. Valuation for Natural Capital and Ecosystem Accounting: Synthesis report for the European Commission. Norwich: Centre for Social and Economic Research on the Global Environment, University of East Anglia.

Barbier, E. B. & Strand, I. 1998. Valuing mangrove-fishery linkages–a case study of Campeche, Mexico. *Environmental and resource economics,* 12**,** 151-166.

Bateman, I. J., Binner, A., Day, B., Fezzi, C., Rusby, A., Smith, G. & Welters, R. 2019. United Kingdom: Paying for Ecosystem Services in the Public and Private Sectors. *In:* MANDLE, L., OUYANG, Z., SALZMAN, J. & DAILY, G. C. (eds.) *Green Growth That Works - Natural Capital Policy and Finance Mechanisms Around the World.* USA: Island Press.

Bateman, I. J., Brouwer, R., Ferrini, S., Schaafsma, M., Barton, D. N., Dubgaard, A., Hasler, B., Hime, S., Liekens, I., Navrud, S., De Nocker, L., Sceponaviciute, R. & Semeniene, D. 2011. Making Benefit Transfers Work: Deriving and Testing Principles for Value Transfers for Similar and Dissimilar Sites Using a Case Study of the Non-Market Benefits of Water Quality Improvements Across Europe. *Environmental & Resource Economics,* 50**,** 365-387.

Binner, A., Smith, G., Bateman, I. J., Day, B., Agarwala, M. & Harwood, A. 2017. Valuing the social and environmental contribution of woodlands and trees in England, Scotland and Wales. Edinburgh: Forestry Commission Research Report, Forestry Commission,.

Binner, A., Smith, G., Faccioli, M., Bateman, I., Day, B., Agarwala, M. & Harwood, A. 2018. Valuing the social and environmental contribution of woodlands and trees in England, Scotland and Wales, Second edition: to 2018. UK: Report to the Forestry Commission, Ref No.: CFSTEN 2/14 and CFS 8/17.

Boyd, J. & Banzhaf, S. 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics,* 63**,** 616-626.

BSI 2021. BS 8632:2021: Natural Capital Accounting for Organizations — Specification The British Standards Institution Standards Publication.

CDP, CDSB, GRI, IIRC & SASB 2020. Statement of Intent to Work Together Towards Comprehensive Corporate Reporting. Summary of alignment discussions among leading sustainability and integrated reporting organisations CDP, CDSB, GRI, IIRC and SASB. Facilitated by the Impact Management Project, World Economic Forum and Deloitte.

CDSB 2019. CDSB Framework for reporting environmental & climate change information: Advancing and aligning disclosure of environmental information in mainstream reports.

Day, B., Bateman, I. & Lake, I. 2007. Beyond implicit prices: recovering theoretically consistent and transferable values for noise avoidance from a hedonic property price model. *Environmental & Resource Economics,* 37**,** 211-232.

Edgley, C., Jones, M. J. & Atkins, J. 2015. The adoption of the materiality concept in social and environmental reporting assurance: A field study approach. *The British Accounting Review,* 47**,** 1-18.

Eftec, RSPB & PricewaterhouseCoopers 2015. Developing Corporate Natural Capital Accounts: Guidelines. London, UK: Natural Capital Committee.

Endangered Wildlife Trust 2020. The Biological Diversity Protocol (BD Protocol) (2020). South Africa: National Biodiversity and Business Network.

Fenichel, E. P., Abbott, J. K., Bayham, J., Boone, W., Haacker, E. M. K. & Pfeiffer, L. 2016. Measuring the value of groundwater and other forms of natural capital. *Proceedings of the National Academy of Sciences,* 113**,** 2382.

Fisher, B., Turner, R. K. & Morling, P. 2009. Defining and classifying ecosystem services for decision making. *Ecological Economics,* 68**,** 643-653.

Forico 2021. Forico Natural Capital Report of the Tasmanian Forest Trust for the year ended 30 June 2021. Tasmania, Australia.

Freeman III, A. M., Herriges, J. A. & Kling, C. L. 2014. *The measurement of environmental and resource values: theory and methods*, Routledge.

GRI 2011. Approach for reporting on ecosystem services: Incorporating ecosystem services into an organization's performance disclosure.

Haines-Young, R. & Potschin, M. B. 2017. Common International Classification ofEcosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure.

Henderson, B. L., Barry, S., Hayes, K. R., Hosack, G., Holland, K., Herron, N., Mount, R., Schmidt, R. K., Dambacher, J., Ickowicz, A., Lewis, S., Post, D. A. & Mitchell, P. J. 2018. Impacts and risks: Submethodology M10 from the Bioregional Assessment Technical Programme. Australia: Department of the Environment and Energy, Bureau of Meteorology, CSIRO and Geoscience Australia.

Herron, N. F., Macfarlane, C., Henderson, B. L., Post, D. A., O'Grady, A. P., Rachakonda, P. K., Wilkins, A., Peeters, L., Dawes, W. R., McVicar, T. R., Hosack, G., Ickowicz, A., Hayes, K. R., Dambacher, J., Barry, S., Brandon, C., Zhang, Y. Q., Crosbie, R., Viney, N. R., Sudholz, C., Mount, R., Tetreault-Campbell, S., Marvanek, S., Buettikofer, H., Gonzalez, D., Crawford, D., Schmidt, R. K. & Lewis, S. 2018. Impact and risk analysis for the Hunter subregion: Product 3-4 for the Hunter subregion from the Northern Sydney Basin Bioregional Assessment. Australia: Department of the Environment and Energy, Bureau of Meteorology, CSIRO and Geoscience Australia.

ISO 2018. ISO 31000:2018 Risk management — Guidelines.

Keith, D., Ferrer-Paris, J. R., Nicholson, E. & Kingsford, R. T. 2020. IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups. Gland, Switzerland: IUCN.

Keith, H., Vardon, M., Stein, J., Stein, J. & Lindenmayer, D. 2017. Experimental Ecosystem Accounts for the Central Highlands of Victoria.

Kering 2020. Environmental Profit & Loss (EP&L) 2020 Group Results. Paris, France.

Lammerant, J. State of play of business accounting and reporting on ecosystems. Forum of Experts on SEEA Experimental Ecosystem Accounting, 26-27th June 2019 2019 New York. System of Environmental Economic Accounting (SEEA).

McConnell, K. E. & Bockstael, N. E. 2005. Chapter 14 Valuing the Environment as a Factor of Production. *In:* MLER, K.-G. & VINCENT, J. R. (eds.) *Handbook of Environmental Economics.* Elsevier.

Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington.

Natural Capital Coalition 2016. Natural Capital Protocol. London: Natural Capital Coalition.

Natural Capital Committee 2019. Natural Capital Terminology: August 2019. UK.

NCFA & PwC 2018. Integrating Natural Capital in Risk Assessments: A Step by Step Guide for Banks. Oxford, UK: Natural Capital Finance Alliance and PricewaterhouseCoopers.

NCFA & UN Environment World Conservation Monitoring Centre 2018. Exploring natural capital opportunities, risks and exposure: A practical guide for financial institutions. Natural Capital Finance Alliance and UN Environment World Conservation Monitoring Centre.

O'Grady, A. P., Pinkard, E. A., Mount, R. E., Schmidt, R. K., Cresswell, I. D. & Stewart, S. B. 2020. Conceptual model to support natural capital accounting of a forestry enterprise. Hobart, Australia: CSIRO.

O'Grady, A. P., Smith, G. S., Ascui, F. & Pinkard, E. A. 2020. The rise and rise of natural capital: what role for forestry? *Australian Forestry,* 83**,** 103-106.
Obst, C., Hein, L. & Edens, B. 2016. National Accounting and the Valuation of Ecosystem Assets and Their Services. *Environmental & Resource Economics,* 64**,** 1-23.
Parsons, G. R. 2003. The Travel Cost Model. *In:* CHAMP, P. A., BOYLE, K. J. & BROWN, T. C. (eds.) *A Primer on Nonmarket Valuation.* Dordrecht: Springer Netherlands.
Pearce, D. 1988. Economics, equity and sustainable development. *Futures,* 20**,** 598-605.
PUMA 2011. PUMA's Environmental Profit and Loss Account for the year ended 31 December 2010.
Sartori, D., Catalano, G., Genco, M., Pancotti, C., Sirtori, E., Vignetti, S. & Bo, C. 2014. Guide to cost-benefit analysis of investment projects. Economic appraisal tool for cohesion policy 2014-2020.
Smith, G. S., Ascui, F., O'Grady, A. P. & Pinkard, E. 2021a. Materiality Assessment of Natural Capital Risks in Australian Forestry. *Current Forestry Reports,* 7**,** 282-304.
Smith, G. S., Ascui, F., O'Grady, A. P. & Pinkard, E. 2021b. Natural Capital Risk Assessment – Australian Forestry. Launceston, Australia: Prepared for National Institute for Forest Products Innovation (Launceston): NIF076-1819 [NT011].
Smith, G. S., Ascui, F., O'Grady, A. P. & Pinkard, L. 2021c. Opportunities for Natural Capital Financing in the Forestry Sector. Launceston, Australia: Prepared for National Institute for Forest Products Innovation (Launceston): NIF076-1819 [NT011].
Stewart, S. B., O'Grady, A. P., Mount, R., England, J., Opie, K., Roxburgh, S., Ware, C., Scheufele, G., McVicar, T., Van Niel, T. & Smith, G. 2020a. Experimental natural capital accounts for the forestry industry in the Green Triangle. Report to Forests and Wood Products Australia and Department of Agriculture, Water and the Environment as part of the Rural Research for Development and Profit program (Project number RnD4Profit-16-03-003).
Stewart, S. B., Pinkard, E., O'Grady, A. P. & Wall, J. 2020b. Experimental ecosystem accounts for Cowal Agriculture, Emerald. Report to Department of Agriculture, Water and Environment, Canberra, Australia.
TCFD 2017. Recommendations of the Task Force on Climate-related Financial Disclosures. Task Force on Climate-Related Financial Disclosures.
TEEB 2010. The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. *In:* KUMAR, P. (ed.). Earthscan, London and Washington.
TNFD. 2020. *Bringing Together a Task Force on Nature-related Financial Disclosures* [Online]. Task Force on Nature-Related Financial Disclosures. Available: https://tnfd.info/ [Accessed 12/11/2020 2020].
TNFD 2022. The TNFD Nature-related Risk & Opportunity Management and Disclosure Framework: A Prototype for Consultation with Market Participants. Taskforce on Nature-related Financial Disclosures, v0.1 Beta Release – for consultation.
Transparent Project 2021. Standardized Natural Capital Accounting: a methodology promoting standardized natural capital accounting for business. Draft for consultation July 2021.
United Nations 2021. System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA). White cover publication, pre-edited text subject to official editing.
United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development & The World Bank 2012. System of Environmental-Economic Accounting: Central Framework. New York, United Nations.
Ware, C., Stewart, S. B., Cresswell, I. D., Schmidt, R. K., Raoult, V., Taylor, M., Mount, R., Pinkard, E. A., Gaston, T. F. & O'Grady, A. P. 2020. Experimental natural capital accounts for the prawn-fishing industry in the Wallis Lake estuary. A report to Forests and Wood Products Australia and Department of Agriculture, Water and the Environment from the Lifting farm gate profits: the role of natural capital accounts project (RnD4Profit-16-03-003).

Whitehead, J. 2017. Prioritizing sustainability indicators: Using materiality analysis to guide sustainability assessment and strategy. *Business Strategy and the Environment,* 26**,** 399-412.
Willis, K. G. & Garrod, G. D. 1991. An Individual Travel-Cost Method of Evaluating Forest Recreation. *Journal of Agricultural Economics,* 42**,** 33-42.
Willis, K. G., Garrod, G. D., Scarpa, R., Powe, N. A., Lovett, A. A., Bateman, I. J., Hanley, N. & Macmillan, D. C. 2003. The Social and Environmental Benefits of Forests in Great Britain. Social & Environmental Benefits of Forestry Phase 2, Report to Forestry Commission, Edinburgh.

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