NATURAL CAPITAL PROTOCOL

FOREST PRODUCTS SECTOR GUIDE

NATURAL CAPITAL COALITION

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Foreword

Diogo da Silveira, CEO The Navigator Company, Co-Chair Forest Solutions Group

Every business depends on – and impacts – natural capital. These impacts and dependencies create costs and benefits for business and society, generating risks but also creating opportunities. In the forest products sector, the relationship between an enterprise and natural capital underscores its profitability and sustainability. Wood fiber is the life blood of the entire forest products value chain. Its production and processing depend on and contribute to many services provided by natural capital, including soil nutrient cycling, water provision and purification, and climate regulation. Forests and forest products also have the ability to capture and store carbon, an attribute that places the sector at the heart of the ongoing transition to a low carbon economy built on a foundation of renewable, natural resources.

Understanding, measuring, valuing, and ultimately managing the values of natural capital is critical to the forest products sector. Failing to do so would be leaving value on the table. This is the rationale behind the development of this sector guide — the world's first generally accepted natural capital measurement and valuation guidance for the forest products sector to accompany the Natural Capital Protocol.

This guide is the fruit of a broad engagement process which helped develop and inform its content in consultation with relevant stakeholders and across all forested continents. We would like to thank all who contributed to the development of what we hope to be a widely accepted, scientifically robust, and useful guide. We hope you feel ownership of this tool, and never stop experimenting with it. We also hope you will inspire other companies along the forest products value chain to re-think their relationship with nature, and trigger action and meaningful conversations from forests to boardrooms.

wbcsd

The World Business Council for Sustainable Development (WBCSD)'s Forest Solutions Group co-funded and led the development of this guide on behalf of the Coalition.

WBCSD is a global, CEO-led organization of over 200 leading businesses and partners working together to accelerate the transition to a sustainable world. WBCSD helps its member companies become more successful and sustainable by focusing on the maximum positive impact for shareholders, the environment and societies.

WBCSD's Forest Solutions Group (FSG) is a global platform for the forest sector value chain; building and sharing business solutions to lead sustainable development in the forest products sector. FSG's mission is to advance the bio-economy and a thriving forest sector that sustains healthy productive forests and society's well-being.

Members of the Forest Solutions Group at time of publication are: 3M, AkzoNobel Pulp & Performance Chemicals, CMPC, IKEA, International Paper Company, Mondi Group, PwC, SCG Packaging, Smurfit Kappa Group, Stora Enso, The Navigator Company.

www.wbcsd.org/Projects/Forest-Solutions-Group

Orientation

Introducing natural capital, the Protocol, and the sector guides

The Natural Capital Protocol (hereafter Protocol) is a standardized framework to help businesses identify, measure, and value their impacts and dependencies on natural capital. Since natural capital impacts and dependencies are often specific to the sector in which a business operates, sector guides, such as this one, provide additional sector-specific guidance for relevant businesses.

The guidance herein does not replace the Protocol but is meant to accompany it. You will therefore need a copy of the Protocol with you to use the sector guide – if you do not already have a copy you can find one at www.naturalcapitalcoalition.org/protocol.

The natural capital community continues to develop additional sector guides and supplementary information. Of particular interest to the forest products sector is work relating to biodiversity and data (see Natural Capital Coalition website) , as well as the 'Connecting Finance and Natural Capital' supplement to the Natural Capital Protocol (Natural Capital Coalition, Natural Capital Finance Alliance, VBDO 2018).

The WBCSD's Forest Solutions Group led the development of the Forest Products Sector Guide on behalf of the collaboration that is the Natural Capital Coalition. Technical support was provided by PwC. An inclusive global approach including workshops, teleconferences, and meetings in many countries including Switzerland, Canada, Mexico, the UK, Brazil, Finland, and Singapore, as well as an online public consultation, was used to develop this guidance and to consider and include the diversity of ecosystems and opinions involved.

Glossary

Natural capital
The stock of renewable and non-renewable natural resources (for example, plants, animals, air, water, soils, and minerals) that combine to yield a flow of benefits to people (adapted from Atkinson and Pearce 1995; Jansson et al. 1994).

Natural Capital Protocol
A standardized framework to identify, measure, and value direct and indirect impacts (positive and negative) and/or dependencies on natural capital.

Sector guide
Additional, sector-specific guidance to be used alongside the Protocol by businesses in a relevant sector conducting a natural capital assessment.

How do the sector guides support the Protocol?

The sector guides support the Protocol by providing additional guidance and sector-specific business insights. The sector guides do not provide additional methodologies, but assist in the implementation of the Protocol. Like the Protocol itself, the sector guides have been developed for business, aimed primarily at managers from sustainability, environmental, health and safety, and operations departments to help them integrate natural capital into existing business processes.

More specifically, the sector guides:

- Provide context on why natural capital is relevant to your business and how your business benefits from it
- Develop the business case for natural capital assessments
- Identify natural capital impacts and dependencies relevant to your business
- Use practical examples to demonstrate sector-specific business applications of the Protocol

Principles

The sector guides are underpinned by the same principles as the Protocol to help guide your natural capital assessment.

Relevance
Ensure that you consider the most relevant issues throughout your natural capital assessment including the impacts and/or dependencies that are most material for the business and its stakeholders *(Adapted from original in CDSB 2015; and WRI and WBCSD 2004).*
Rigor
Use technically robust (from a scientific and economic perspective) information, data, and methods that are also fit for purpose.
Replicability
Ensure that all assumptions, data, caveats, and methods used are transparent, traceable, fully documented, and repeatable. This allows for eventual verification or audit, as required (Adapted from GRI 2013).
Consistency
Ensure the data and methods used for an assessment are compatible with each other and with the scope of analysis, which depends on the overall objective and expected application (Adapted from WRI and WBCSD 2004; and IIRC 2013).

Note: Whereas **Relevance** is a principle to adhere to throughout the application of the Protocol, **Materiality** is covered in Step 04, "Determine the impacts and/or dependencies". Although it is recommended that the principle of **Consistency** is adhered to throughout your assessment, the Protocol does not propose that outputs will be consistent and comparable between companies, as they are context specific. Comparability of results is something that will be addressed at a later date.

The Protocol Framework, Stages, and Steps and their relevance in the sector guides

The Protocol Framework covers the four stages of a standard decision-making process, "Why", "What", "How", and "What Next". These Stages are further broken down into nine Steps, which contain specific questions to be answered when carrying out a natural capital assessment (Figure 0.1).

The Stages and Steps are iterative, and you should expect to revisit previous Steps as necessary. For example, after identifying your most material impacts and dependencies in Step 04, you may need to go back and change the objective or scope of your assessment in Steps 02 and 03.

Each Step in the Protocol follows the same structure. Steps begin with a statement of the overarching question to be addressed and a brief introduction, followed by a detailed description of the actions required to complete the Step, together with guidance on how to proceed, and a template for outputs.

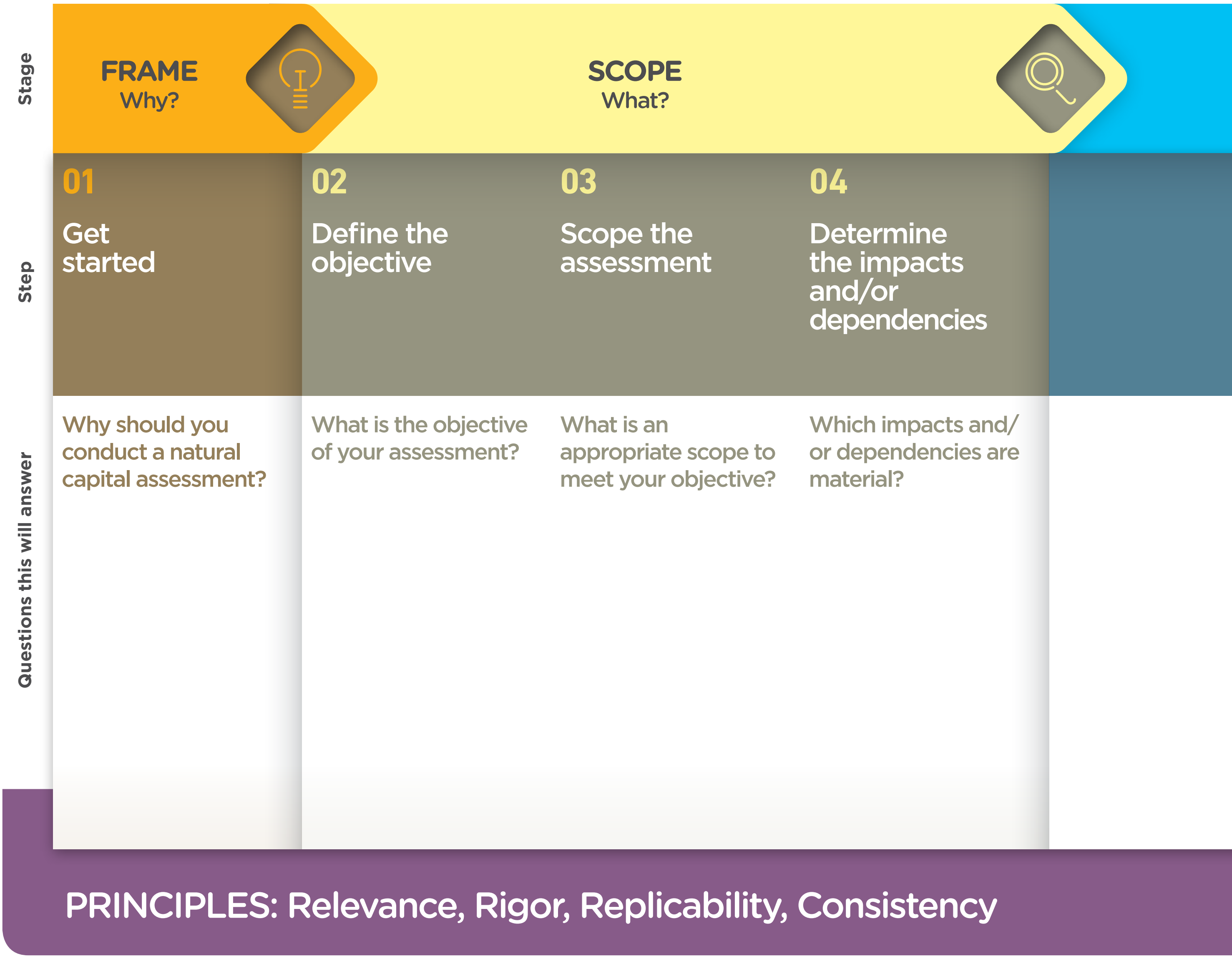


Figure 0.1:
The Natural Capital Protocol Framework

The sector guides follow the overarching Protocol Framework exactly and do not introduce any additional Stages or Steps. Each Step in the sector guides contains additional guidance that will help your business complete the actions within that Step and navigate through the Protocol Framework.

For some actions, additional sector-specific guidance may not be appropriate. At the beginning of each Stage and Step, the sector guides outline the actions that have been extended to provide additional sector-specific guidance.

Businesses implementing the Protocol should follow all Stages and Steps as described in the Protocol Framework. The sector guides should be used together with the Protocol rather than in isolation. To help bring sector-specific business applications to life, the sector guides include hypothetical examples that summarize how a business would complete each of the Stages.

Useful definitions of key terms are provided when they are first introduced. For a complete glossary, please refer to the Protocol.

MEASURE AND VALUE
How?

APPLY
What next?

05	06	07	08	09
Measure impact drivers and/or dependencies	**Measure changes in the state of natural capital**	**Value impacts and/or dependencies**	**Interpret and test the results**	**Take action**
How can your impact drivers and/or dependencies be measured?	What are the changes in the state and trends of natural capital related to your business impacts and/or dependencies?	What is the value of your natural capital impacts and/or dependencies?	How can you interpret, validate, and verify your assessment process and results?	How will you apply your results and integrate natural capital into existing processes?

Definition of the forest products sector and its value chain

This sector guide defines the forest products sector as encompassing all businesses operating in and inputting into the forest products sector value chain, from forest production (including nurseries) and processing (including primary and secondary), to use and end of life (see figure 0.2). The forest products sector value chain includes all economic activities that mostly depend on the production of goods and services from forests. While the sector guide and the majority of examples are focused on wood fiber products (e.g., paper, packaging, lumber, personal care products, bioproducts), the guide is intended to be relevant for non-wood fiber forest products as well (e.g., Brazil nuts, palm oil, understory plants). Similarly, while the guide focuses on productive or working forests (i.e., forests used to provide physical goods for sale), concepts and principles outlined in the guide can be used to conduct a natural capital assessment of forest that is being conserved or restored.

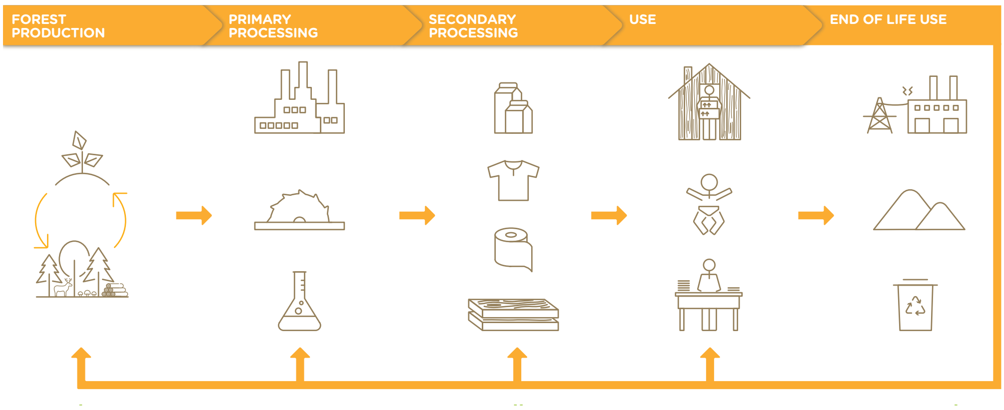


Figure 0.2:
The forest products value chain

This sector guide considers the natural capital impacts and dependencies of businesses operating across the forest products value chain, including the consumer use stages and companies that supply inputs into the value chain. While all stages of the value chain are important for an accurate assessment, the guide gives more weight to the forest production stage that comprises the most sector-specific characteristics.

Hypothetical examples

Five sector-specific hypothetical examples are presented in Appendix 1. Although purely illustrative, the examples demonstrate how businesses operating in the forest products sector can use the Forest Products Sector Guide to frame, scope, measure, value, and apply a natural capital assessment to inform business decision making. For real-life examples of natural capital assessments from the forest products sector, please refer to the case studies accompanying this guide (see Natural Capital Coalition website or WBCSD Forest Solutions Group website for these studies).

FRAME STAGE

What is the Frame Stage?

The Frame Stage of the Protocol helps you to frame why you would undertake a natural capital assessment and to consider the benefits an assessment could deliver.

How does the sector guide map to the Protocol?

Table F.1 provides an overview of the questions and actions of the Frame Stage in the Protocol and an outline of the actions for which the sector guide provides additional guidance.

Table F.1:
The Frame Stage: Mapping between the Protocol and the sector guide

Step	Questions this Step will answer	Actions	Additional guidance included in this sector guide?
01 Get Started	**Why should you conduct a natural capital assessment?**	1.2.1 Familiarize yourself with the basic concepts of natural capital	**Yes** See page 09 in this guide.
		1.2.2 Apply the basic concepts of natural capital to your business context	**Yes** See page 11 in this guide.
		1.2.3 Prepare for your natural capital assessment	**No** Revert to Protocol page 19 for general guidance.

Additional notes
Businesses operating in the forest products sector should address all of the actions associated with Step 01 in the Frame Stage. The sector guide provides additional guidance for some of actions, where it is most appropriate, but it is important that you familiarize yourself with the foundational concepts and terms introduced in Step 01 of the Protocol as you use the sector guide.

01 Get Started

This section of the sector guide provides additional guidance for answering the following question:
Why should you conduct a natural capital assessment?

In particular, the sector guide will help you undertake the following actions:
1.2.1 Familiarize yourself with the basic concepts of natural capital

1.2.2 Apply the basic concepts of natural capital to your business context

1.2.1 Familiarize yourself with the basic concepts of natural capital

Natural capital is another term for the **stock** of renewable and non-renewable natural resources on earth (e.g., plants, animals, air, water, soils, minerals) that combine to yield a **flow** of benefits or "services" to people (adapted from Atkinson and Pearce 1995; Jansson et al. 1994).

These **flows** can be **ecosystem services** or **abiotic services**, which provide **value** to business and to society (see figure 1.1).

Ecosystem services are the benefits that people obtain from ecosystems, such as timber, fiber, pollination, water regulation, climate regulation, recreation, mental health, and others. For more information about the classification of ecosystem services, see box 1.1 on page 13 of the Natural Capital Protocol.

Abiotic services are benefits to people that do not depend on ecological processes but arise from fundamental geological processes and include the supply of minerals, metals, and oil and gas, as well as geothermal heat, wind, tides, and the annual seasons.

Biodiversity is critical to the health and stability of natural capital as it provides resilience to shocks like floods and droughts, and it supports fundamental processes such as the carbon and water cycles as well as soil formation. Biodiversity can be a benefit in itself (e.g. cultural value of species conservation) and contribute to other services (e.g. recreation like bird watching, or genetic resources). This breadth of attributes is part of what makes biodiversity a complex issue. For more discussion of biodiversity, see box 1.2 on page 14 of the Natural Capital Protocol.

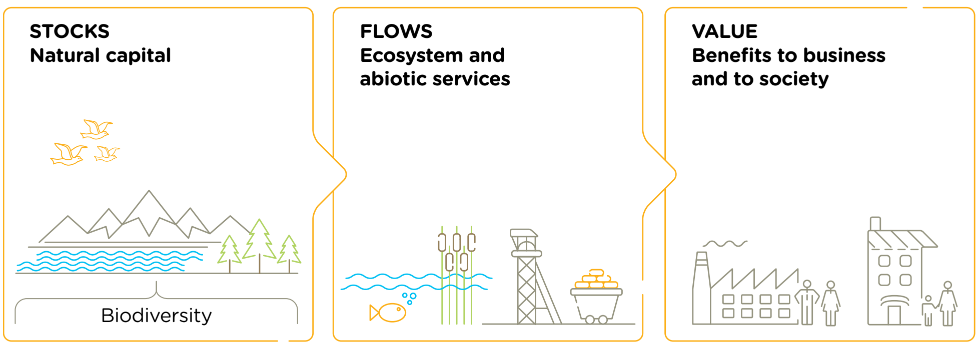


Figure 1.1:
Natural capital stocks, flows, and values

Glossary

Natural capital impact
The negative or positive effect of business activity on natural capital.

Impact driver
In the Protocol, an impact driver is a measurable quantity of a natural resource that is used as an input to production (for example, volume of sand and gravel used in construction) or a measurable non-product output of business activity (for example, a kilogram of NOx emissions released into the atmosphere by a manufacturing facility).

Natural capital dependency
A business reliance on or use of natural capital. Dependencies can be consumptive (e.g., energy, water, nutrition, materials) or non-consumptive (e.g., the regulation of physical environment, regulation of biological environment, regulation of waste and emissions, experience, knowledge, well-being, and spiritual or ethical values).

Externality
A consequence of an action that affects someone other than the agent undertaking that action, and for which the agent is neither compensated nor penalized. Externalities can be either positive or negative (WBCSD et al. 2011).

Ecosystem
A dynamic complex of plants, animals, and microorganisms, and their non-living environment, interacting as a functional unit. Examples include deserts, coral reefs, wetlands, and rainforests (MA 2005). Ecosystems are a component of natural capital.

Ecosystem services
The most widely used definition of ecosystem services is from the Millennium Ecosystem Assessment: "the benefits people obtain from ecosystems". The MA further categorized ecosystem services into four categories: Provisioning, Regulating, Cultural, and Supporting (MA 2005).

Biodiversity
The variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (UN 1992).

Introduction
Frame stage
Scope stage
Measure and value stage
Apply stage
References

For the purposes of a natural capital assessment, the Protocol distinguishes between value to business and value to society. Clearly this binary simplification does not reflect the complex and connected relationship between business and society, but does help to assess the ways in which values can differ between each.

Natural capital and the benefits that flow from it sustain us all: individuals, families, companies, and society as a whole. At the same time, our individual or collective actions can build or degrade natural capital, depending on how we use it.

To help set the context for your assessment, the interactions between natural capital, business, and society are depicted in figure 1.2. This also illustrates the approach used in the Protocol to measure and value impacts and dependencies on natural capital, in terms of business risks and opportunities, or costs and benefits, to society.

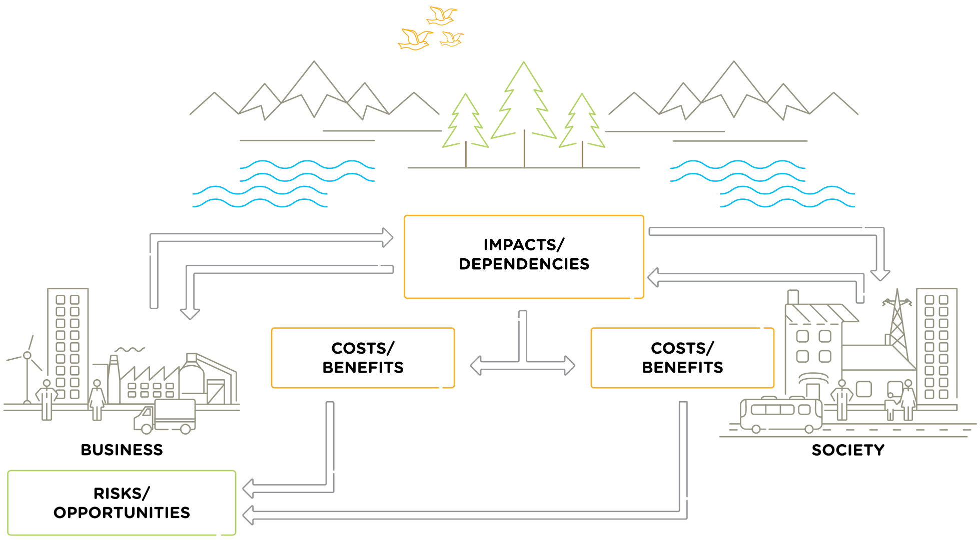


Figure 1.2:
Natural capital impacts and dependencies: conceptual model for business

Every business depends on—and impacts—natural capital (TEEB 2012). Figure 1.2 shows how these impacts and dependencies create costs and benefits for business and society, generating risks but also creating opportunities. Natural capital impacts and dependencies can directly affect business performance; they may also generate positive or negative effects on particular stakeholders or on society as a whole.

Stakeholder and societal responses to natural capital costs and benefits can create additional risks and opportunities for a business through mechanisms including consumer preferences, media coverage, license to operate, and policy interventions. This sector guide considers only impacts on society that are brought about through a change in natural capital. For a discussion of other societal issues that may not be linked to natural capital (such as human rights, health and safety, skills and education), you should refer to the Forest Products Sector Guide to the Social Capital Protocol (WBCSD 2017).

1.2.2 Apply the basic concepts of natural capital to your business context

In this section, the sector guide builds on the basic concepts of natural capital outlined in Step 01 of the Protocol and demonstrates how these concepts relate to your business. In undertaking this action, you will consider potential natural capital impacts and/or dependencies and explore potential risks and opportunities that are relevant to your business and its stakeholders.

A key natural capital dependency, wood fiber is the life blood of the entire forest products value chain. Its production and processing depend on and contribute to many services provided by natural capital, including soil nutrient cycling, water provision and purification, and climate regulation. The interconnection between active forest management and natural capital is complex and bi-directional, with the potential for both positive and negative feedback responses depending on factors such as landscape conditions, species composition, and the temporal and spatial scales of analysis (Gaudreault et al 2016, EFCT n.d.). Many forest products companies are therefore already aware of the importance of understanding and effectively managing risks and opportunities associated with natural capital.

The application of a natural capital approach builds on the tools and methodologies already in use by the forest products industry, but provides additional benefits, such as those described in table 1.1.

The forest products sector is well placed to capitalize on opportunities associated with sustainable management of natural capital including:

- Forest management optimization (i.e., the optimization of the growth, yield, and biodiversity associated with provision of natural resources used as production inputs);
- Product design effectiveness (i.e., the optimization of natural resources used for a given unit of product output);
- Manufacturing efficiency (i.e., the minimization of natural resources used as production inputs);
- Recovery of forest products and alternative uses for manufacturing residuals (i.e., the maximization of natural resources used repeatedly and/or converted for use in other parts of the economy);
- Sequestration of carbon and the potential for wood fiber to replace other more GHG-intensive materials. This may have significant consequences for forest products companies as carbon-related regulations (e.g., carbon taxes, subsidies, and emissions trading markets) increase in occurrence globally (FSB 2017). In this way, natural capital assessments can help companies not only adapt to physical climate change-related risks or opportunities, but also risks and opportunities arising from the transition to a low-carbon economy. This opportunity may equally apply to the conservation of biodiversity or other ecosystem service benefits provided by forests beyond carbon sequestration such as water provisioning services.
- Capitalizing on global trends towards optimizing and implementing renewable solutions where possible. For example, a natural capital assessment can be used to demonstrate the value created in the product life cycle that goes beyond the price of the product itself (i.e., a forest product may be more expensive than an alternative, but may create significant benefits throughout the value chain).
- Accessing new financing streams. Investors are increasingly committed to considering environmental and social data and so there is potential for additional financing options (e.g., access to green or social bonds) for companies that are reporting on progress on environmental and social impacts (eftec, 2018). There may be increased long-term market share for companies that can demonstrate sustainable natural capital stewardship to their customers or investors.
- Raising awareness and educating consumers, users, investors, activist groups, and others about the role of the forest products sector in contributing to sustainable growth. Many stakeholders still have a negative perception of the activities undertaken by the forest industry. This guide, in addition to helping companies make better decisions towards more sustainable and more profitable practices, can also help demonstrate that the forest products sector can maintain and even increase stocks of natural capital and associated benefit flows.

Conversely, natural capital-related risks can present themselves through an increase in operating costs (e.g., soil degradation leading to reduced productivity), changes in regulation (e.g., carbon taxes), or undermining of the business model (e.g., a company having to transition from an integrated value chain to importing wood from foreign sources due to the depletion of their existing resources).

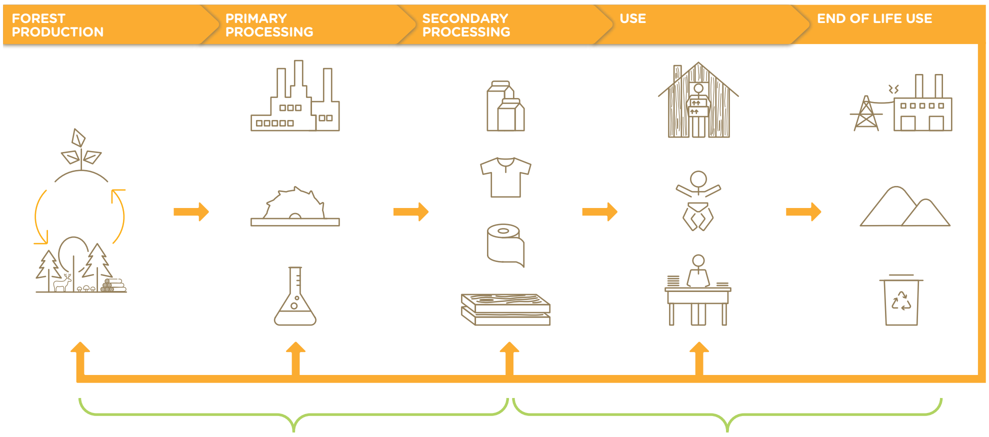
Some ways in which companies have been taking action on these risks and opportunities (as you can read in Stage 4, 'Apply') include: incorporating shadow pricing; enhancing sourcing, procurement, and supply chain management; considering product alternatives and design; testing the business case for change in management practices; scenario planning; and business disclosure.

Forests and forest products have been recognized in international agreements for their key role in climate change mitigation. Forests globally store approximately 638 Gt of carbon, more than the total amount of carbon in the entire atmosphere (WBCSD, 2015). Products from forests also store carbon, and may displace materials that are emissions intensive or derived from fossil fuels. In the Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) stated that: In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fiber or energy from the forest, will generate the largest sustained mitigation benefit (IPCC 2007).

The forest products sector can also play a substantial role in achieving the UN Sustainable Development Goals (SDGs), more than half of which are linked closely to forests and forest products (UNECE 2016). Indeed, in addition to its central role in climate change mitigation through natural carbon capture and storage, the sector contributes to several critical SDGs. For example members of the WBCSD Forest Solutions Group report yearly on their businesses' contribution to SDG 15 (life on land) through the area of land surface certified for sustainable forest management; on SDG 6 (clean water and sanitation) through the amount of water running through production facilities that is returned to the water source; and SDG 7 (affordable and clean energy) through the share of energy consumption from renewable sources – principally biomass (WBCSD 2016). Sustainable forest management practices that make productive use of forest but lead to the maintenance of forest assets over time (which means retaining a forest's ability to provide both timber and other benefits into the future) are critical to ensure that forests are able to play this role in delivering the SDGs. The natural capital benefits that a well-managed forest can provide to society can be measured and valued using this sector guide.

Natural and social capital assessments

The forest products sector has social impacts throughout its value chain, from the people who depend on forests for their livelihoods to the consumers of forest products. Forest production and initial processing often occur in remote areas with limited job opportunities, access to social support services, or infrastructure. This operating context can leave a gap for business to fill. Some impacts arising within the forest products sector value chain can therefore be positive, such as the provision of livelihoods and infrastructure in remote areas; others may be negative, such as infringing upon indigenous communities' land rights. It is important for companies to consider both types of impacts (see figure 1.3).



Surrounding communities:
- Access to education
- Access to energy
- Access to healthcare
- Access to infrastructure
- Access to water and sanitation
- Jobs and livelihoods
- Economic development
- Exposure to hazardous waste
- Indigenous rights
- Land-use rights

Employees (direct/indirect):
- Jobs and livelihoods
- Fair wages
- Gender and equality
- Health and safety
- Human rights
- Road safety
- Training and skills development

Consumers:
- Consumer awareness raising
- Product safety

Figure 1.3:
Examples of societal issues along the forest products value chain

Adapted from WBCSD 2017

The sector can also have positive and negative impacts on society through changes in natural capital. Business activity affecting society directly is considered a social capital impact (e.g., job provision), while business activity affecting society via a change in natural capital is considered a natural capital impact (e.g., positive impact on human health through air pollution mitigation by forest production). Natural capital impacts are often ultimately valued by their consequences on society and thus can be considered in the same analysis as direct social capital impacts. For example, the ecosystem services flowing from a stock of understory plants can be assessed in part through the nutritional and health benefits that the local communities derive from these plants.

This sector guide focuses on natural capital impacts and dependencies. However, we recognize that some assessments may benefit from integrating natural, social, and human capital impacts and dependencies, in particular to understand the relative importance of each, as well as potential trade-offs between them. For more information on assessing social and human capital, please refer to the work of the Social & Human Capital Coalition as well as the Forest Products Sector Guide to the Social Capital Protocol (WBCSD 2017).

A natural capital approach should be compatible and complimentary to many existing environmental management approaches within your business. Table 1.1 explains how a natural capital approach can provide additional value when compared with, or used alongside, existing practices.

Table 1.1:
The additional value of a natural capital approach

Area	Existing approaches	Additional value of a natural capital approach
Impacts and dependencies	**Focus on Impact** A focus on the impacts to natural capital, rather than dependencies. Water discharge, waste, and carbon are some more advanced issues in relation to impact, with concerted efforts to develop tools and instruments around these issues.	**Impacts and dependencies** A natural capital approach importantly includes a consideration of dependencies (e.g., fiber, minerals, pollination, climate regulation, water regulation) to provide a holistic view of risks and opportunities.
Valuation	**Focus on measurement** Many companies in the forest products value chain are already effectively measuring environmental aspects of their activities. This tends to be focused on measuring quantities of natural resources used as inputs to production (water, minerals, etc.) or the non-product outputs of business activities (emissions, discharges, etc.). Measurement is often undertaken using Life Cycle Assessment (LCAs) with the principles defined in the ISO 14000 standards, e.g., 14040.	**Focus on valuation** A natural capital approach provides an understanding of what these inputs and outputs mean in terms of their relative importance or worth to society and to business (i.e., their value). While a measured environmental input or output might be the same in two different locations, the value is highly location specific. This progression from measurement to valuation is critical in understanding the extent of risk, exposure, and opportunity to better inform decision making.
Scope	**Limited issues** Environmental assessments tend to focus on a relatively limited set of natural capital issues (e.g., relatively little attention is paid to regulating services and cultural values).	**Broader range of issues** Able to consider a much wider range of natural capital impact drivers and dependencies, including those which might vary depending on context. Provides increased coverage of regulating services and cultural values. From this broader range, users are then equipped with better information to identify which factors are material.
Connectivity	**Stand-alone** Environmental considerations tend to be seen as a series of stand-alone issues (e.g., climate change is often analyzed and treated as a distinct issue to water, biodiversity, or public health). The consequence is that relationships between these issues are often missed (e.g., issues of scarcity, multiple uses, and trade-offs).	**Interrelated system** Able to treat natural capital as a set of interrelated issues, considering trade-offs and net positions.

Box 1. Natural capital assessments and forest certification

Forest-based natural capital assessments and forest certification programs, including the Forest Stewardship Council (FSC), The Programme for the Endorsement of Forest Certification (PEFC), and the Sustainable Forestry Initiative (SFI), share the common goal of bolstering sustainable forest management globally. While the two approaches are distinct, they are mutually reinforcing and overlap in several significant ways. If you are engaged with both certification and natural capital approaches, better understanding these connections will lead to more effective management.

Natural capital assessments are generally used internally by organizations to understand to what extent their forest management practices, and forest product sourcing, are having an impact on the environment, and to what extent changes in natural capital are affecting the health of the natural resources on which they depend. By measuring and valuing natural capital impacts and dependencies, you understand the risks and opportunities associated with these interconnected relationships, and how they can be managed over time.

Box 1. Natural capital assessments and forest certification continued

While the natural capital approach aims to inform internal decision making, forest certification largely focuses on standard setting, external disclosure (e.g., verifiable claims), and stakeholder engagement. This is achieved by providing a globally recognized, transparent, trusted, and independently accredited verification mechanism to assure investors, clients, downstream customers, and other stakeholders that the certified organization is taking steps to minimize environmental impact, improve ongoing sustainability, and mitigate potential future risk. Certification also enables certificate holders to access environmentally sensitive markets and allow environmentally conscious consumers to leverage market forces to strengthen responsible forestry practices and policies.

While advocates of natural capital and certification approaches both believe that better environmental management will lead to better social and economic outcomes, their approaches differ in how to apply these practices. The Natural Capital Protocol offers leeway for business to adapt applications to specific impacts and dependencies at a product, project, or organizational scale. This contrasts with the rigorous procedures and verifications prescribed by certification. Additionally, certification bodies evaluate an organization's practices against a set of requirements, while a natural capital assessment is not subject to a standard other than those voluntarily set by the business.

If your business is active upstream in the forest products value chain (e.g., harvesting and silviculture), following good practice in sustainable forest management will allow many potentially negative impacts to be mitigated or avoided entirely. If you are active downstream in the value chain (e.g., furniture retailer) you will find yourself further removed from a significant proportion of natural capital risks arising from the active forest operations. Chain-of-custody certification allows you to mitigate or avoid risks through the assurance that the forests from which resources originate are managed responsibly.

Moreover, if your business has already achieved forest certification, there will be a number of useful elements that can feed into the process of conducting natural capital assessments:

1) Engaging in the certification processes can increase the availability and accessibility of sound and reliable primary data, thereby helping to overcome a significant hurdle of the Measure and Value Stage of the Protocol. For example, certificate license numbers can be used to access databases holding information about a supplier or product. Also, chain of custody standards require detailed tracking of both incoming and outgoing fiber flows.

2) Certification provides a foundation for methodologies and processes to help certificate holders measure, manage, and communicate their impacts on natural capital. For example, the FSC Ecosystem Services Procedure helps certificate holders assess the impact of their activities on ecosystem services (FSC 2017). These same techniques can be used as part of a natural capital assessment, and feed into an application of the Natural Capital Protocol which is flexible and non-prescriptive.

3) Forest management and environmental management standard requirements (e.g., FSC, PEFC, SFI, ISO14001, etc.) can be used as a list of pre-identified impacts (positive and negative) of forestry activities that are likely to be most material. This can feed into a natural capital materiality assessment and therefore help expedite the Scope Stage of the Protocol.

While businesses tend to approach natural capital assessments and certification programs as independent from one another, failing to connect the two is a missed opportunity to make the most of data, resources, investments, and experience utilized during and learned from the certification process. In this way, certificate holding organizations are in an advantageous position when it comes to conducting a natural capital assessment, and vice versa.

Before considering some of the potential natural capital impacts and dependencies that are relevant to your business, figure 1.4 outlines the main risk and opportunity categories that have a direct link to business performance: higher resource costs, new government regulations, reputational damage, reduced market share, and fewer financing options. These types of risks are already affecting corporate income statements and balance sheets. In contrast, businesses that already manage natural capital create for themselves a range of opportunities from new products, services, and technology that positively affect their bottom lines. For more examples of risks and opportunities, please refer to page 18 of the Protocol.

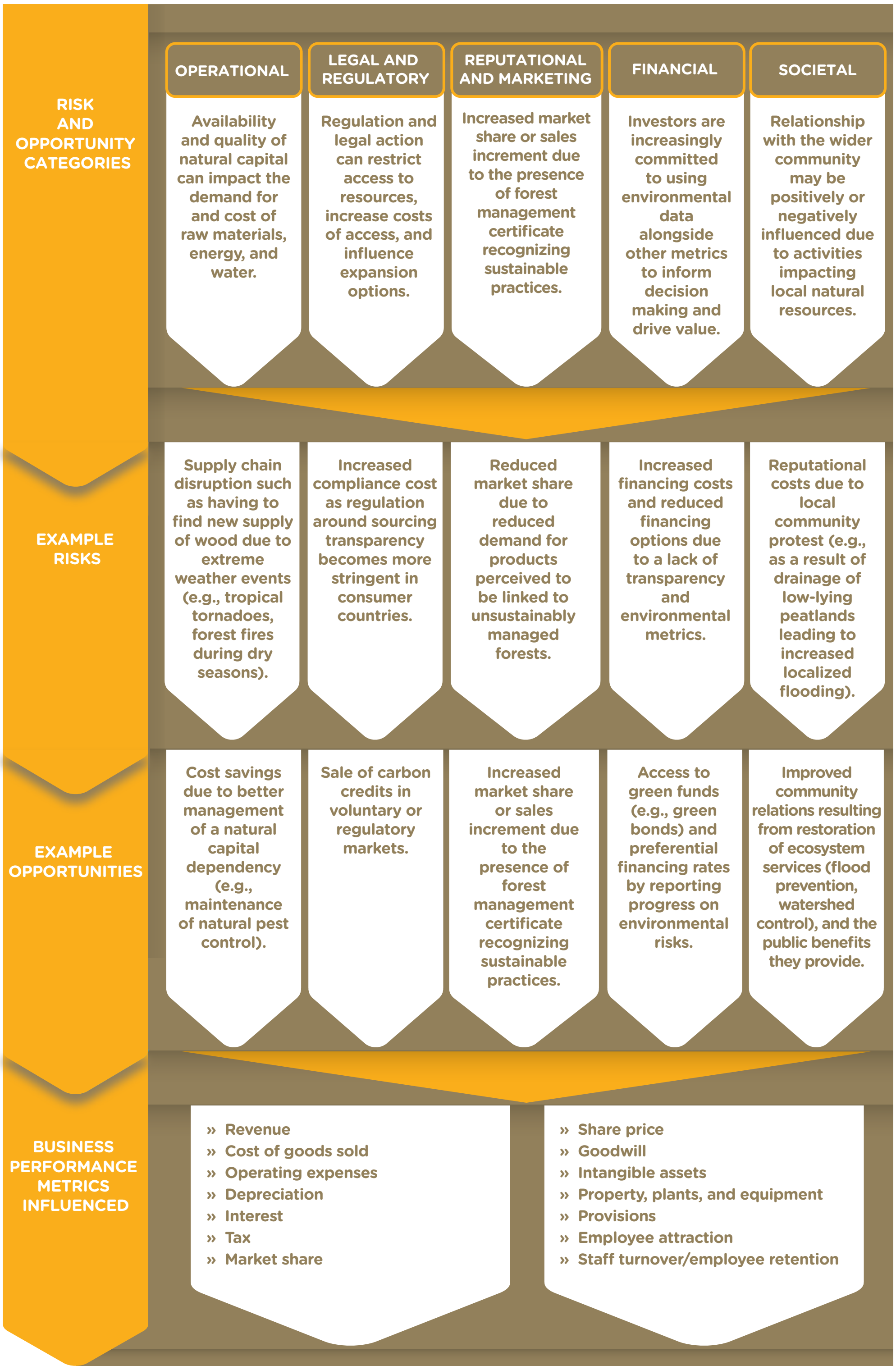


Figure 1.4:
Examples of business implications from key natural capital risks and opportunities

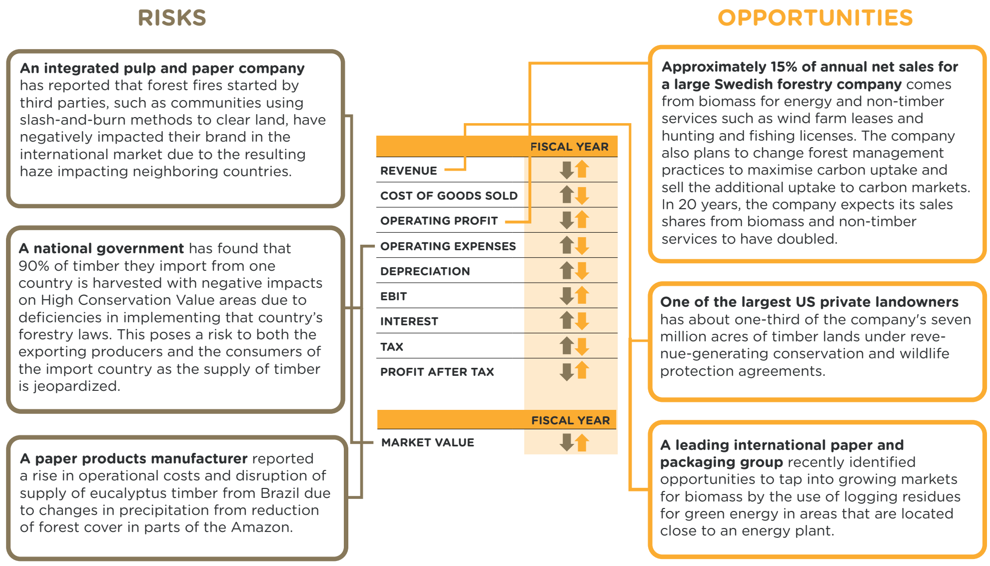


Figure 1.5:
Real world examples of recognized risk and opportunity

Figure 1.5 translates theoretical risk and opportunity categories into practice through a growing list of real world examples where business implications have been realized. The examples have been anonymized. Table 1.2 provides a small selection of some relevant impact drivers for the forest products sector. The table also provides examples of risks and opportunities relating to each impact driver and business performance metrics that can be influenced. Other important potential impact drivers to consider include water use, regulation of water timing and flows, soil pollutants, solid waste, disturbances, and other resource use such as food & fuel and natural medicines & pharmaceuticals (for a more detailed list, see figures 4.3, 4.4, and 4.5 in Step 04).

Table 1.2:
Three examples of natural capital impact drivers in the forest products sector

	Carbon sequestration	Water pollution	Air pollution
Overview	Forests (whether natural or plantation) are a significant part of the global carbon cycle, using sunlight to convert CO_2 into sugars and carbohydrates. Once trees die, they release their stored carbon to the atmosphere quickly or to the soil where it decomposes slowly and increases soil carbon levels (Gorte 2009). Forest soils are a significant carbon sink, containing approximately two-thirds of the carbon stored in forest ecosystems. Net carbon sequestration potential depends on the previous condition of the land being used for forest production and the type of tree grown (e.g., fast-growing plantations established on land that was previously degraded forest or agricultural land are likely to be more effective at sequestering in this regard (Kongsager et al. 2013)). The long-term impacts of carbon sequestration will depend on the ultimate use of the forest product in question (e.g., timber beams used for construction will store carbon for longer than single use paper products that end up in landfill).	Water that is used and recycled in pulp and paper manufacturing processes until it can no longer be reused in the process is called wastewater. Wastewater is treated on site or off site in treatment systems. Once treated, the resulting effluents are, in most cases, discharged to surface waters. Wastewater treatment systems are designed to remove oxygen-demanding substances (BOD/COD) and solid particles (TSS). Wastewater may contain toxic and non-conventional pollutants such as chlorinated organic compounds. There has been significant reduction in the global pulp and paper industry's production-normalized releases of BOD and TSS since the 1970s due to a combination of wastewater treatment system improvements and in-process improvements, particularly manufacturing process control measures taken to reduce the formation and release of chlorinated organic compounds. However, more intensive wastewater treatment methods are available and may be appropriate tools in some site-specific cases where water quality is an issue of local significance (Hubbe et al. 2016).	Forests are among the most effective air purifiers and also play an important role in regulating air temperatures (Ansari 2003). A broad-scale estimate of air pollution removal by trees nationwide showed that trees and forests in the United States removed 17.4 million tons of air pollution in 2010, with human health effects valued at US $6.8 billion, including the avoidance of 850 deaths and 670,000 incidences of acute respiratory symptoms (Nowak et al. 2014).
Risk and opportunity category	– Legal and regulatory – Reputational and marketing – Financial – Societal	– Operational – Legal and regulatory – Reputational and marketing – Financial – Societal	– Legal and regulatory – Reputational and marketing – Financial – Societal
Example risk	Not quantifying the carbon sequestration provided by forests may mean that forests are not managed in a way that maximizes this benefit.	Breach of discharge licenses or other instances of non-compliance could result in the suspension or closing down of operations, fines, downstream compensation and mitigation costs, and class action lawsuits depending on the severity of the offense.	Not understanding how forest ecosystems provide this potentially significant benefit to local populations could mean that forest cover is not maintained. Increased air pollution levels can have negative human health, visual amenity (i.e., haze), and crop yield impacts.

Table 1.2: continued
Three examples of natural capital impact drivers in the forest products sector

	Carbon sequestration	Water pollution	Air pollution
Example opportunity	There are a number of potential financial benefits related to carbon sequestration including state or regional subsidies, payments for ecosystem services (PES), carbon credits, avoidance of carbon tax obligations, etc.	Recapturing chemicals before discharge can potentially allow for recycling, reducing operational costs, and reducing wastewater treatment costs. For instance, advanced technologies can turn waste sludge into fertilizer and biogas, therefore reducing the mill's waste disposal burden by turning a cost into a profit driver. Firms pioneering technological innovations which go on to become industry standard can dominate the market and realize significant profits.	As levels of air pollution continue to increase globally with growing impacts on productivity and human health, plantation and forest owners may receive payments for ecosystem services (PES) in the future for maintaining tree cover in areas that are close to human populations and are quantifiably reducing air pollution impacts.
Significant value chain stage	Throughout value chain, particularly during production and use.	Production, primary and secondary processing, and end of life.	Forest production.
Geographical relevance	Global.	Local.	Local.
Business performance metrics influenced	– Increased revenues from payments for ecosystem services (PES) or other subsidies, the sale of carbon credits, or other financial opportunities afforded by regulation and market mechanisms. – Improved customer loyalty and market share through the reputational benefits of good management.	– Avoided increase in cost of goods sold due to compliance costs, fines, or compensation costs. – Decreased operational costs through recovery of chemicals and internal reuse. – Avoided revenue losses from negative publicity or consumer demand for more environmentally friendly processes.	– Increased revenues from payment for ecosystems services (PES). – Improved customer loyalty and market share through the reputational benefits of good management.

For more information on these and examples of other impact drivers see table 4.2.

Natural capital dependencies for the forest products sector span all categories of ecosystem service, including provisioning, regulating, and cultural services. Table 1.3 focuses upon some of the critical dependencies relevant to the sector. Dependencies can be consumptive (e.g., energy, water, nutrition, materials) or non-consumptive (e.g., regulation of the physical environment, regulation of the biological environment, regulation of waste and emissions, experience, knowledge, well-being, and spiritual or ethical values). The raw material stage in a value chain typically interacts with nature directly through forest production and primary processing activities. As such, these stages tend to have the most significant dependency on natural capital.

Table 1.3:
A selection of natural capital dependencies in the forest products sector

	Consumptive: Water	Consumptive: Materials	Non-consumptive: Regulation of living environment
Overview	Dependency on water can be experienced throughout the forest products value chain. In a pulp or paper mill, water is required for various purposes: it is used to carry fiber and chemicals, to cool process equipment, for cleaning, and for many other purposes. Water is also necessary for developing the chemical bonds between cellulose fibers that give paper its strength. The pulp and paper industry has a long history of water-use reduction. For instance, since 1960, there has been a reduction of nearly 70% in the average treated effluent flow volume at pulp and paper mills in North America (EFCT n.d.). While manufacturing of pulp and paper is water-use intensive relative to most other industries, the amount of water consumed (i.e., evaporated or exported with product or residuals) represents a small fraction of the overall water used. Recycling of water used in the pulp and paper process is limited by the accumulation of dissolved matter from wood and other raw materials entering the process, and while strategies for controlling these contaminants can be developed, the degree to which further water reduction can be achieved becomes a site-specific challenge. Inherent differences in process type and product characteristics have a strong influence on the amount of water used at mills. Many mills have multiple process types, such as chemical, mechanical or recycled pulping processes, and produce a variety of products onsite, which further complicates mill water-use patterns.	Soils have provided the foundation for trees and entire forests over millions of years, helping to provide and regulate important ecosystem processes such as nutrient uptake, decomposition, and water availability (FAO 2015). Soils of a poor or inappropriate quality (depending on the species) are likely to result in stunted growth or outright crop failure. For instance, commercial teak plantations in southern tropical China failed due to poor quality soil which had been acidified by previous plantations of Chinese fir and Chinese red pine (Bingchao and Jiayu n.d.).	Dependency on natural pest control systems is growing as pests become increasingly resistant to artificial control methods such as pesticides and insecticides and as outbreaks of pests increasingly occur outside their natural range due to a combination of climate change and globalization. The North American spruce budworm outbreak between 1966 and 1992 affected over 500 million hectares of forest. Evidence suggests that spruce budworm populations increase first in areas where natural enemies are unable to curtail increases in the local density of budworms (Natural Resources Canada 2011).
Risk and opportunity category	– Operational – Financial – Legal and regulatory – Reputational and marketing – Societal	– Operational – Financial – Reputational and marketing – Societal	– Operational – Financial – Legal and regulatory – Reputational and marketing – Societal

Table 1.3: continued
A selection of natural capital dependencies in the forest products sector

	Consumptive: Water	Consumptive: Materials	Non-consumptive: Regulation of living environment
Example risk	While most mills are specifically located in areas of abundant water resources there may be some facilities located in areas of water quantity stress, especially at the seasonal level. For these facilities, extreme water quantity constraints can potentially lead to curtailment of production at the facility. As water stress increases worldwide, government may increasingly regulate or tax facilities that are using high volumes of water.	Plantation owners looking to cultivate certain tree species on ill-suited soil types or soil of generally poor quality are likely to face low-quality crops, reduced yields, and increased susceptibility to pests and diseases. If no steps are taken, this can translate into operational failures and financial losses. The use of inputs such as fertilizers to remedy this situation will add further costs to the process, as well as potentially having adverse downstream effects environmentally and socially, depending on the quantity and manner in which inputs are used.	Forests lacking natural pest control protection may require the use of potentially harmful and expensive preventative pesticides, which as well as having possible downstream impacts (e.g., chemical runoff and leaching), can further suppress natural systems of control. The lack of natural control may also increase the likelihood of pest outbreaks, which can devastate entire plantations resulting in significant financial losses or require intensive treatment programs which can also incur considerable costs.
Example opportunity	Growing water scarcity and heightened awareness of water conservation are prompting more industrial manufacturers to explore water recycling within facilities – a strategy which drives savings both in sourcing water but also in lower treatment costs associated with reduced wastewater effluent volumes. For example, pulp and paper mills can treat paper machine "whitewater" and recycle it back to the bleach plant for use as shower water and pulp dilution water. Such innovations drive clear savings, allow pulp and paper mills to keep abreast or ahead of increasingly stringent environmental regulation, and can enhance their corporate social responsibility (CSR) credentials amongst customers and the wider public.	Thorough investigations of soil types and of their compatibility with proposed plantation species can reduce the likelihood of problems further along the cultivation process. Furthermore, as trees themselves can gradually change soil conditions, longer-term cultivation strategies might include the use of a transition tree crop, which as well as yielding a financially viable harvest in its own right, can alter previously unsuitable soil conditions, making soil amenable to the future growth of higher-value species.	The creation or preservation of zones with higher levels of biodiversity and consisting of complex, patchwork habitats enables natural predators and feedback mechanisms to regulate pests and minimize crop damage (Bianchi et al. 2006), at a fraction of the cost of future losses that might otherwise be incurred. Best Management Practice (BMP) guidelines, regulations, and various sustainable forest management certification schemes require buffer zones around water bodies to help keep herbicides out of surface water. Buffer zones help prevent herbicide movement into streams both during application, where brush and trees in the buffer intercept herbicide spray, and following application, where ground cover helps prevent stormwater runoff from treated areas, which might contain herbicides, from reaching streams (McBroom et al. 2013, Norris 1967). Using this zoning approach may have associated societal benefits such as cultural or recreational benefits from the increased biodiversity.
Significant value chain stage	Forest production and primary and secondary processing.	Forest production.	Forest production.
Geographical relevance	Local.	Local.	Local and regional.

Table 1.3: continued
A selection of natural capital dependencies in the forest products sector

	Consumptive: Water	Consumptive: Materials	Non-consumptive: Regulation of living environment
Business performance metrics influenced	– Increased operating costs to source alternative water supplies. – Revenue implications due to constraints on production or damaged plantations due to water shortages. – Reduced operating costs if onsite management allows internal recycling of water. – Improved customer loyalty and market share through the reputational benefits of good management.	– Revenue implications due to constraints on production. – Increased operating costs associated with remedial actions and materials (such as higher agrochemical input costs). – Revenue losses from negative publicity or consumer demand for more environmentally friendly species selection/ management techniques-increased revenues and/ or market share from the inverse scenario.	– Potential significant loss of revenue due to plantation damage. – Increased operating costs associated with the artificial prevention of pest outbreaks, and in the event of an outbreak, containing pest outbreaks. – Potential fines from regulatory bodies, public and customer backlash (and subsequent reduced revenues), and compensation claims from fellow landowners. – Higher insurance premiums for the forest owner in the event of an outbreak.

For more information on these and examples of other dependencies see Table 4.3.

1.2.3 Prepare for your natural capital assessment

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 19 FOR GENERAL GUIDANCE

Step 01 of the Forest Products Sector Guide has provided additional guidance to help you explore potential risks and opportunities and understand your company's relationship with natural capital. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

SCOPE STAGE

What is the Scope Stage?

The Scope Stage of the Protocol sets out what you will need to consider in order to set the specific objective for your natural capital assessment.

How does the sector guide map to the Protocol?

Table S.1 provides an overview of the questions and actions of the Scope Stage in the Protocol and an outline of the actions for which the sector guide provides additional guidance.

Table S.1:
The Scope Stage: Mapping between the Protocol and the sector guide

Step	Questions this Step will answer	Actions	Additional guidance included in this sector guide?
02 Define the objective	**What is the objective of your assessment?**	2.2.1 Identify the target audience	**No** **Revert to Protocol page 26 for general guidance.**
		2.2.2 Identify stakeholders and the appropriate level of engagement	**Yes** **See page 25 in this guide.**
		2.2.3 Articulate the objective of your assessment	**Yes** **See page 26 in this guide.**
03 Scope the assessment	**What is an appropriate scope to meet the objective?**	3.2.1 Determine the organizational focus	**No** **Revert to Protocol page 31 for general guidance.**
		3.2.2 Determine the value-chain boundary	**No** **Revert to Protocol page 32 for general guidance.**
		3.2.3 Specify whose value perspective	**No** **Revert to Protocol page 33 for general guidance.**
		3.2.4 Decide on assessing impacts and/or dependencies	**No** **Revert to Protocol page 34 for general guidance.**
		3.2.5 Decide which type of values you will consider	**No** **Revert to Protocol page 37 for general guidance.**
		3.2.6 Consider other technical issues (i.e., baselines, scenarios, spatial boundaries, and time horizons)	**Yes** **See page 28 in this guide.**

Table S.1: continued
The Scope Stage: Mapping between the Protocol and the sector guide

Step		Questions this Step will answer	Actions	Additional guidance included in this sector guide?
03	Scope the assessment	**What is an appropriate scope to meet the objective?**	3.2.7 Address key planning issues	**No** **Revert to Protocol page 41 for general guidance.**
04	Determine the impacts and/or dependencies	**Which impacts and/or dependencies are material?**	4.2.1 List potentially material natural capital impacts and/or dependencies	**Yes** **See page 34 in this guide.**
			4.2.2 Identify the criteria for your materiality assessment	**Yes** **See page 46 in this guide.**
			4.2.3 Gather relevant information	**No** **Revert to Protocol page 49 for general guidance.**
			4.2.4 Complete the materiality assessment	**No** **Revert to Protocol page 50 for general guidance.**

Additional notes
Businesses operating in the forest products sector should address all of the actions associated with each Step in the Scope Stage. The sector guide provides additional guidance for some of the actions where it is most appropriate.

02 Define the objective

This section of the sector guide provides additional guidance for answering the following question:
What is the objective of your assessment?

In particular, the sector guide will help you undertake the following action:
2.2.2 Identify stakeholders and the appropriate level of engagement

2.2.3 Articulate the objective of your assessment

2.2.1 Identify the target audience

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 26 FOR GENERAL GUIDANCE

2.2.2 Identify stakeholders and the appropriate level of engagement

You will have identified your target audience in section 2.2.1 of the Protocol, but it is likely to be the case that there are additional stakeholders who are key to engage with even if they are not the primary audience. For example, the target audience may be internal decision makers, but local government and local communities are important stakeholders to engage with. A natural capital assessment is likely to be more relevant, reliable, and useful in the longer term if you are able to consult and involve the right internal and external stakeholders from the outset.

The scope of the assessment will determine the appropriateness and feasibility of engaging with particular stakeholders. For example, if your assessment is project-based and concerning direct operations in a specific location, then local stakeholder engagement is highly recommended.

If you are a company closer to the end stages of the value chain (i.e., secondary production) and your assessment is looking at upstream impacts or dependencies, you may be several steps removed from the raw material production site (or you may even not know the exact location of the production site). In these cases, local stakeholder engagement may be unfeasible and less appropriate. But it will be important to understand if there are any issues associated with land tenure or ownership that could result in more significant impacts or dependencies (see the materiality criteria in section 4.2.2).

A special case for the forest products sector is that, as well as local stakeholders living near production sites, there may well be communities living within forest concessions. In these cases, meaningful consultation with local communities and indigenous peoples should be undertaken.

It also may be that there are key stakeholders who are not geographically close to the company or operations, for example, environmental NGOs may not be local but may be interested in specific issues in areas where the forest products company is operating.

Where the scope determines that stakeholder engagement is recommended, you should follow the best practice recommendations set out in published guidance (Convention on Biological Diversity 2010; IFC 2007, 2012a, 2012b; ILO 1989; WBCSD 2016).

2.2.3 Articulate the objective of your assessment

In Step 01 of the Protocol, you began thinking about how you intend to use the results of your natural capital assessment—your potential business application. In Step 02, you develop and articulate the objective, or why you are doing it. In addition, it is important to articulate the anticipated benefits that your business stands to gain from undertaking an assessment. Table 2.1 sets out a list of potential business applications alongside example objectives and benefits for the forest products sector. The list is not exhaustive and you may use different terms within your company.

Table 2.1:
Examples of business applications, objectives, and benefits from natural capital assessments in the forest products sector

Business application (intended use)	Example business decisions	Example outputs
Assess risks and opportunities	An overarching assessment is often a good starting point to understand the implications of your company's impacts and dependencies, informing decisions regarding strategy development and risk mitigation. For example, a forest products company that has never previously measured natural capital may choose to assess its entire value chain to identify and value areas of potential natural capital risk to determine where targeted improvements can be made. This would help shift the focus many forest products companies currently have on measuring biodiversity impacts to understanding wider impacts on ecosystem services and the subsequent benefits to people.	Improved decision making; increased competitive advantage; improved risk management; greater potential to capture opportunities
Compare options	Option comparisons can help companies better understand the trade-offs between alternative options in natural capital terms, when presented with various scenarios. This can be used to inform business decisions relating to procurement such as new technologies or processes, or for prioritization. For example, a plantation owner may choose to compare the consequences of growing different tree species on different plantation sites to inform their planting strategy. In addition, option comparisons can be used to inform investment decisions by identifying potential solutions which yield the greatest natural capital return. Another example would be comparing options for improving the overall health of watersheds across a company's individual facilities. For facilities where water stress may exist, there may be a variety of approaches to address water-related issues and limit community and operational risk.	Improved decision making; increased competitive advantage; enhanced reporting and communication
Assess impacts on stakeholders	Ascertain which stakeholders are affected by a change in natural capital due to your business activity (e.g., the potential disruption to the water supply of local communities caused by a large-scale primary processing facility).	Improved decision making; improved risk management; enhanced reporting and communication/enhanced brand value
Estimate total value and/or net impact	A means to assess the total value of natural capital generated by a system. For instance, the forest products sector faces competition from non-forest fiber product alternatives; by estimating the net positive natural capital it generates in comparison to other products, a competitive advantage may be secured (e.g., the carbon balance benefits of using timber for construction instead of steel and concrete).	Improved decision making; increased competitive advantage

Table 2.1: continued
Examples of business applications, objectives, and benefits from natural capital assessments in the forest products sector

Business application (intended use)	Example business decisions	Example outputs
Communicate internally and/or externally	Reporting results of natural capital assessments, such as the publication of Environmental Profit and Loss accounts (EP&Ls), a natural capital balance sheet (e.g., using Corporate Natural Capital Accounting (CNCA) (Natural Capital Committee 2015)), or Life-cycle Impact Assessments (LCIAs), can help inform and streamline communication strategies with internal and external stakeholders. Such assessments can also support applications or ongoing submissions to sustainability reporting initiatives and indices (e.g., Global Reporting Initiative, Dow Jones Sustainability Index, FTSE4Good Index). Using monetary valuation techniques for a natural capital assessment may allow for integration into conventional financial accounting for a comprehensive understanding of business activities. This can help inform business decisions on communications strategies and context-based target setting across the forest products sector.	Increased competitive advantage; enhanced reporting and communication; enhanced brand value

Step 02 of the Forest Products Sector Guide has provided additional guidance to help you develop and articulate the objective of your assessment. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

03 Scope the assessment

This section of the sector guide provides additional guidance for answering the following question:
What is an appropriate scope to meet the objective?

In particular, the sector guide will help you undertake the following action:
3.2.6 Consider other technical issues (i.e., baselines, scenarios, spatial boundaries, and time horizons)

3.2.1 Determine the organizational focus

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 31 FOR GENERAL GUIDANCE

3.2.2 Determine the value-chain boundary

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 32 FOR GENERAL GUIDANCE

3.2.3 Determine the value perspective

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 33 FOR GENERAL GUIDANCE

3.2.4 Decide on assessing impacts and/or dependencies

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 34 FOR GENERAL GUIDANCE

3.2.5 Decide on which types of value you will consider

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 37 FOR GENERAL GUIDANCE

3.2.6 Consider other technical issues (i.e., baselines, scenarios, spatial boundaries, and time horizons)

There are several details to consider during the Scope Stage in terms of the technical specifications of the assessment. These include defining appropriate baselines, scenarios, spatial boundaries, and time horizons. Consideration of these technical issues will be dependent on the results of Step 01 and Step 02, in particular the identification of potential business applications. This section provides some considerations on baselines, scenarios, spatial boundaries, and time horizons for the forest products sector specifically.

Baselines

A baseline is the starting point or benchmark against which changes in natural capital can be compared. Many forest products companies will have a large land footprint and may be seeking to measure their impact (or dependency) on the ability of this land to provide ecosystem services now and into the future.

When undertaking an assessment that covers an extended period (e.g., to assess the impacts of a project over 20 years), you will need to consider how the baseline would have changed over the same period. For example, even without your company's project or intervention, natural capital is dynamic and may change due to other pressures (e.g., population influx, climate change, or the impacts of other businesses). The changes that would have occurred independently of your project or intervention are sometimes referred to as "business as usual", or a "future projection" scenario (i.e., what is projected to happen anyway). Considering these trends allows you to compare your "with project" and "without project/intervention" scenarios in a meaningful way.

You will also need to decide whether you are most interested in assessing changes in "stocks" of natural capital and/or "flows" of goods and services (including ecosystem services) from natural capital. In some contexts it will be sufficient to consider changes in ecosystem service flows, and these may provide a good indication of how stocks (the present value of future flows) will also change. However, this may not always be the case. For example, where stocks and/or services are non-renewable (i.e., forests that are deemed to be culturally or spiritually significant are a non-renewable resource in economic terms) or changes in flows are significant and continue over time (i.e., a trend of ongoing degradation or enhancement is evident), it will be important to estimate changes in the value of stocks.

Valuing natural capital stocks requires additional information and effort to estimate future trends in flows of goods and services under your baseline scenario and assessment scenario. This effort allows an understanding of how benefits might be sustained into the future. This can be recorded as a qualitative trend but is still useful in assessing risks and opportunities. Baseline specification can be subject to ongoing review and refinement as improved/updated data concerning the status of natural capital become available or lessons are learnt through iterations of the assessment (Natural Capital Committee 2015).

The example baselines outlined in the Protocol are described here in the context of the forest products sector and ecosystem service provision (descriptions related to emissions are included in the Protocol). Each baseline example given below can be used for assessments relating to stocks of natural capital or flows from natural capital.

- **Prevailing conditions:** where impacts this year are compared to the average over previous years (e.g. a company could compare provision of ecosystem services to the observed level in the previous year, given a change in the company's activities within this time period).
- **Pristine baseline:** impacts are measured relative to what the land would be in its natural state (i.e., if the company did not exist and no other company had taken its place).
- **Counterfactual scenario:** impacts are described relative to a plausible alternative state of natural capital that would occur if the company did not operate (e.g., if there is a high concentration of cattle ranching on land surrounding a forested area, it may be deduced that the forest land would be used for cattle ranching if it weren't for the current forest use). A notable feature of forestry is that a change of land use from agriculture to forestry results very often in improvements in natural capital – in this context the 'counterfactual' baseline is likely to be a good choice for communicating this impact.
- **A sector-wide or economy-wide average level** where impacts are compared with impacts from relevant peers, e.g. other forestry land in the region.

Figure 3.1 presents a simplified view of the differences between the pristine and counterfactual baselines. It is simplistic in the representation of the two types of baselines as straight lines. As discussed above baselines will usually be dynamic in nature and it is difficult to predict what the situation would have been over time in the absence of your company's activities.

HYPOTHETICAL REPRESENTATION OF PRISTINE AND COUNTERFACTUAL BASELINES

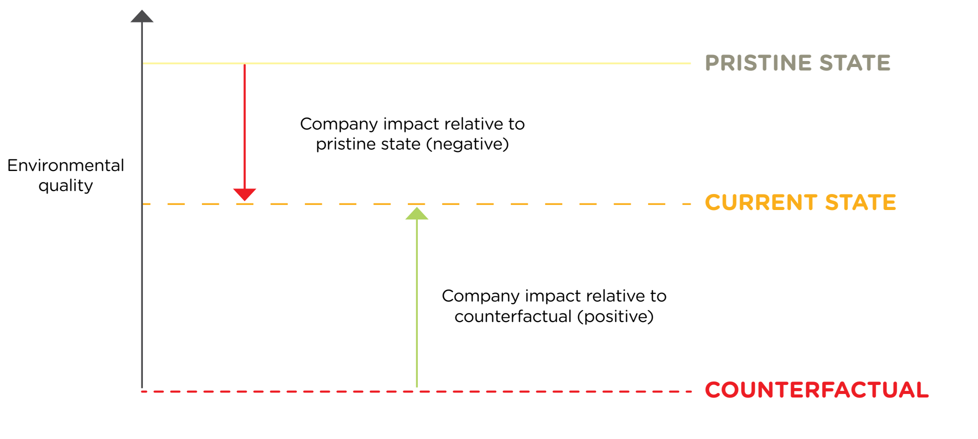


Figure 3.1:
Hypothetical representation of pristine and counterfactual baselines Adapted from PwC 2015

An additional baseline that is not explicitly described in the Protocol but could be applicable for the forest products sector and particularly for organizations attempting sustainable land management at a landscape level is:

An optimal landscape management scenario where changes are measured relative to an estimated optimal landscape management scenario (i.e., the optimal balance of productive land and natural ecosystem is calculated for a particular region and the severity of impacts is measured based on how close the landscape is to this optimal system).

Table 3.1:
Advantages and disadvantages of different baselines

	Prevailing conditions	Pristine state	Counterfactual scenario	Sector-wide comparison baseline	Optimal landscape scenarios
Advantages	Easy to define as first year of measurement is the baseline. Can show positive impacts if the company is restoring degraded land. Offers motivation for forest products sector companies to design multi-year forest management enhancements that show improvement in natural capital over time.	Conceptually easy to understand as a desired state for the natural world. Relatively easy to estimate the natural land cover of the area. Global datasets of natural land cover are available. For land that is already owned by a company, this provides an incentive to restore land cover and reduce negative impacts.	Provides an incentive to restore degraded land or manage forests in areas where there is a high conversion rate to other more destructive uses.	Relatively simple to define the baseline by observation of other current practice in the region or using sector data.	Incentivizes the reduction of impact to a point where the production landscape is sustainable. Takes into account the level of conversion that has occurred within the whole region. Balances productive area with natural area.
Disadvantages	Does not take into account the wider context of land use in the surrounding region and landscape.	Most impacts (even those associated with sustainable land management) are valued negatively since the productive land use will likely be reducing the ecosystem service flows relative to pristine land cover. Limited incentive to take on new areas of degraded land for reforestation or restoration.	Difficult to estimate what the counterfactual might be, particularly as different production systems can require very different intensities of land use.	Does not take into account the specific location of the forest. Incentivizes forest managers only to be better than the average.	Defining what a sustainable productive landscape comprises is difficult and costly. It will most likely involve primary data collection very specific to the landscape in question.

Table 3.1: continued
Advantages and disadvantages of different baselines

	Prevailing conditions	Pristine state	Counterfactual scenario	Sector-wide comparison baseline	Optimal landscape scenarios
Example usage	Where the objective is to understand year on year changes or improvements from a baseline year of operations.	Where the objective is to compare impact between multiple sites in different locations where the likely counterfactual is not known or cannot be consistently defined between locations. Where assessment results are to be compared or aggregated across different impact drivers and a consistent baseline across all impact drivers is required (i.e., the use of a pristine baseline for ecosystem service impacts is consistent with the measurement of GHG impact where it is common to measure the company's total GHG emissions and not to assume that another company would emit the GHGs in its place).	Where the objective is to determine the opportunity cost of different types of potential land uses at a particular site (e.g., social and economic opportunity cost differences between oil palm plantations and timber plantations). Communicating the positive impact of forestry relative to a plausible alternative land-use scenario.	Where the objective is to benchmark the company's performance against peers.	Where the objective is to plan optimal land uses within a defined area (usually landscape-level planning).

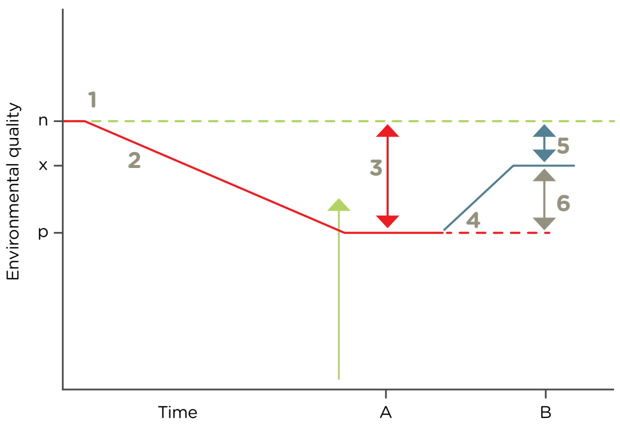
Choosing when to use different baselines

The pristine baseline is unlikely to be helpful for companies seeking to demonstrate a net positive impact on natural capital, however it has the significant benefit of being a baseline that is pre-defined by external datasets (e.g., WWF Wildfinder (WWF, n.d)) and therefore allows for comparable results across different organizations. This means it might be a useful baseline for a forest products manufacturing company that procures materials from multiple companies in different locations and would struggle to estimate counterfactuals in a consistent way across the different companies.

When the objective of the assessment is to compare two products, one that is derived from a land-based system and one that is not, using a pristine baseline could unfairly skew the conclusions in favor of the non-land based product. In this instance a more balanced approach would be to estimate a most likely counterfactual natural capital impact for the production of each product.

Companies may be reluctant to choose a pristine baseline for comparing to their current ecosystem service provision, since, for nearly all ecosystem services, provision will be lower in the current state as opposed to the pristine state, therefore implying a negative natural capital impact. It is possible, however, to demonstrate improvements and motivate positive changes in behavior using this baseline. This can be done by showing that the year-on-year impact is less negative as a result of a change in management practice, as shown in figure 3.2.

IMPROVEMENTS AGAINST A PRISTINE BASELINE



1. Environmental quality of the system in the absence of the company's operations is given by 'n'.
2. Human intervention results in a reduction in environmental quality.
3. The natural capital impacts at time A are given by the red arrow, 'p' minus 'n'.
4. Actions change the trajectory, improving the environmental quality, represented by the blue line.
5. The resultant natural capital impacts at time B are given by the blue arrow. 'x' is the prevailing environmental quality as a result of the new blue trajectory, minus 'n'.
6. The scale of the improvement is given by the gold arrow, 'x' minus what would have happened anyway, 'p'.

Figure 3.2:
Improvements against a pristine baseline
Adapted from Kering and PwC, 2016.

The choice of baseline is particularly important in areas where the local environment is of particular societal interest such as peatlands, areas of high biodiversity, areas of cultural significance, or areas that are upstream of an ecosystem service catchment area. Using a historical benchmark or a sector-wide comparison as a baseline may not be appropriate in these cases as they may not adequately reflect the sensitivity or importance of the area.

Some examples of when the different baselines may be used are shown under "example usage" in table 3.1.

Time horizons

The forest products sector is unusual in its need to make decisions that will have consequences over a long timescale. Rotation periods for forestry vary widely according to climate, forest type, and species but can range from 10 to 80+ years. The consideration of time is critical in several parts of the natural capital assessment framework:

- The choice between using a stocks or flows approach (see "baselines" in section 3.2.6) influences and is influenced by your choice of time horizon. Often, taking a stock approach will require longer term consideration of impacts and dependences than a flows approach. When considering the time horizons of an impact, it is important to consider whether the impact could ultimately reduce the ability of the forest to provide benefits in the future (i.e., could it impact the natural capital stock). Therefore, the time horizon of your natural capital assessment needs to be able to reflect key trends in future benefit flows (e.g., a time horizon spanning at least one rotation period to understand business values and a sufficient length of time to understand trends in the external ecosystem service values). As per box 7.2 of the Protocol, a common way of measuring the value of a natural capital stock is in terms of the discounted future benefits that can be derived from it.
- Baselines are dynamic (see "baselines" in section 3.2.6) and therefore defining how a baseline may change over such long time periods can be challenging. To address this, it is important to test your results using different assumptions in your baseline scenarios.
- Impacts and their consequences to business and society can occur over varying timescales. Some impacts that are relatively insignificant now may have much greater consequences in the future, for example the impacts of a company's water use may be exacerbated in the case of increased frequency of drought caused by climate change (see section 4.2.2 on materiality criteria).

- When undertaking a natural capital assessment that includes the use and end-of-life phases of a forest product, assumptions around time can significantly change the value of the impacts. For example, assuming that forest biomass is used for making paper will create a different time horizon for carbon sequestration compared to assuming that the forest biomass is used in the construction of a building.
- The valuation of impacts and dependencies will be affected by the choice of time horizon:

– Impacts: Consider how persistent the impact driver is in the environment to assess whether it will create long- or short-term natural capital changes. In the forest production stage, many positive impacts of forests can last for a long time (e.g., carbon sequestration or nutrient cycling). Conversely, some of the significant negative impacts are short term (e.g., disturbance caused by harvesting).

– Dependencies: The time horizon for valuing a dependency may be for as long as the business wishes to operate in the area. However, in considering time horizon you should take into account that society is also dependent on natural capital and will be indefinitely. The choice of discount factor when considering dependencies on natural capital over time is key as a high discount rate can lead to the dependency not being managed sustainably in the long term.

The points described above reinforce the importance of assumptions concerning time and highlight the fact that time should be a key variable for testing in your sensitivity analysis (see section 8.2.1).

Spatial boundaries

Consider the spatial boundaries used in an assessment, particularly if collecting primary data. Your direct operational impacts on natural capital may extend beyond your operational boundaries, for example water pollutants from pesticide or fertilizer use in forests may be dispersed over a wide area or effluent from wastewater treatment can enter into a receiving environment well beyond the manufacturing site. Some considerations are given below:

- Impacts: Consider the geographical range of an impact. For example, how far will the impact driver cause change in natural capital. Is it localized, regional, or global? Do you have indirect market impacts (e.g., do materials you are purchasing come from land-based raw materials and therefore have impacts beyond your scope of control)?
- Dependencies: Where possible, spatial boundaries for specific sourcing regions should be set according to the objective—ideally as granular as the specific production forest. If this level of detail is unavailable, the region or country of origin should be used.

In land management scenarios where there is active conservation of an area of protected land alongside a productive forest (e.g., land conservation requirements under Brazil's Forest Code), the scope of the assessment should include this conservation land. This is often not taken into account in Life Cycle Assessments (LCAs) that focus only on the area of productive land required to produce the raw material.

3.2.7 Address key planning issues

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 41 FOR GENERAL GUIDANCE

Step 03 of the Forest Products Sector Guide has provided additional guidance to help you consider other technical issues of your assessment. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

04 Determine the impacts and/or dependencies

This section of the sector guide provides additional guidance for answering the following question:
Which impacts and/or dependencies are material?

In particular, the sector guide will help you undertake the following action:

4.2.1 List potentially material natural capital impacts and/or dependencies

4.2.2 Identify the criteria for your materiality assessment

4.2.1 List potentially material natural capital impacts and/or dependencies

Global forests provide a range of ecosystem services including carbon sequestration, water purification, habitat creation, and nutrient cycling. Concurrently, forests also provide important products such as timber, food, fuel, and bioproducts. While regulated and/or certified forest management areas are managed to minimize the scope and duration of negative effects on natural capital, in other cases natural capital impacts may arise from poor management of a productive forest. Such impacts may include, for example, soil pollution, carbon emissions, and the change in availability of water resources important to local communities. For credibility and balance, it is important for companies to consider both positive and negative impacts when undertaking a natural capital assessment.

The first activity in a materiality assessment is to consider all potentially relevant impacts and dependencies for the chosen objective and scope. At this point, the Protocol introduces the concepts of impact pathways and dependency pathways. Understanding these terms is fundamental to conducting a natural capital assessment. Impact pathways describe how, as a result of a specific business activity, a particular impact driver results in changes in natural capital and how these changes affect different stakeholders. Figure 4.1 provides a theoretical example of an impact pathway for how a pulp and paper mill could potentially be causing water pollution impacts if not managed well.

Glossary

Materiality
In the Protocol, an impact or dependency on natural capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision (Adapted from OECD 2015 and IIRC 2013).

Materiality assessment
In the Protocol, the process that involves identifying what is (or is potentially) material in relation to the natural capital assessment's objective and application.

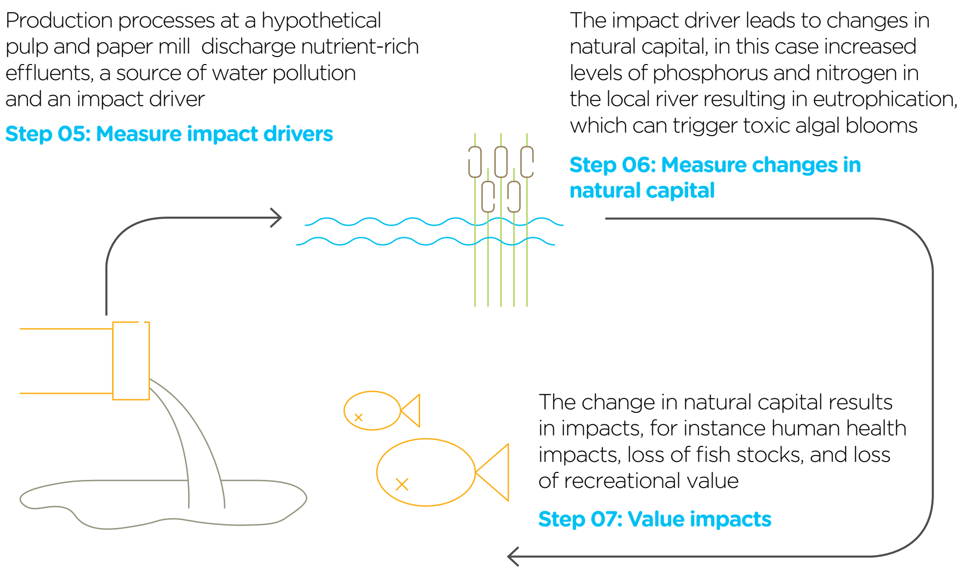


Figure 4.1:
Example of an impact pathway

A dependency pathway shows specifically how a particular business activity depends upon certain features of natural capital or associated natural processes which are often external to your business. Figure 4.2 provides a theoretical example of a dependency pathway showing how a forestry plantation could potentially be dependent on natural pest control services.

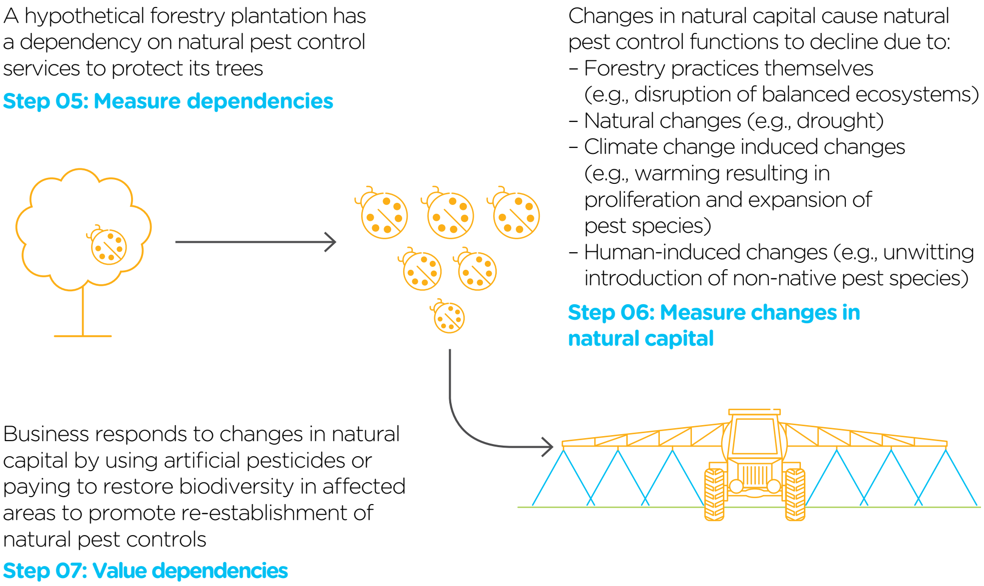


Figure 4.2:
Example of a dependency pathway

These pathways can help you to start identifying potentially material natural capital issues. There may be several impact drivers and/or dependencies within your scope that you are already aware of; with a literature review or expert brainstorming sessions, you could start mapping possible changes in natural capital that arise from each. The consequence of these changes can then be considered using the value perspective you are most interested in, whether value to business or value to society. Your pathways can be a starting point for measurement and valuation. You might consider discussing your pathways with other experts, to check you haven't missed any possible consequences.

Table 4.1 offers further examples.

Table 4.1:
Examples of pathways and consequences for materiality

Business activity	Impact driver or dependency *(Explored further in Step 05)*	Change in natural capital *(Explored further in Step 06)*	Consequence for society *(Explored further in Step 07)*	Consequence for business *(Explored further in Step 07)*	Note on materiality
Increased use of water at a pulp mill due to an expansion in operational capacity	Dependency: Local water sources.	Reduced local water supply available due to climate change.	Possible negative impact on local farmers who rely on the same surface water supply as the pulp mill.	Business could suffer an increase in water supply cost or a reputational loss due to local stakeholder protest of business water consumption during shortage periods.	Some operating locations may have higher density of other users, such as smallholders or residents. This could affect the materiality of increasing water consumption.
Gradual expansion of plantation	Impact driver: Land-use conversion to forest.	If previous land use was large-scale intensive agriculture, reforestation could improve soil regulation and flood prevention for local communities. If previous land use was virgin forest, plantation expansion could cause a loss of biodiversity and cultural value for local communities.	Positive or negative consequences for society: positive (e.g., reduced flooding and higher productivity for smallholders) or negative (e.g., loss of cultural value and biodiversity) depending on the baseline.	.Positive or negative reputational consequences, depending on the baseline. Reforestation could help strengthen your licensing or permitting opportunities, expansion into virgin forest could remove vital biodiversity that your plantation was dependent upon.	Consider mapping this pathway for each individual site, as baseline will have a great bearing on materiality.
Investment in a conservation area next to a plantation	Impact driver: Increased conservation of biodiversity and local ecosystem.	Increased biodiversity in the conservation area, resulting in better regulation of physical and biological environment in the local proximity.	Positive impact where ecosystem services like flood protection and pollination overflow into local communities. Also increased recreational and well-being values, and possible increased tourism trade.	Positive operational opportunity from pollination and other regulating services overflowing from the conservation area. Reduced cost of artificial substitutes. Positive regulatory and reputational opportunity by demonstrating a positive impact for local communities.	These benefits could be particularly material for locations experiencing increasing episodes of natural hazards.

These pathways might reveal potentially material risks and opportunities, which you can now put through a materiality assessment to select which issues you most want to gain a more detailed understanding of through your natural capital assessment. There are many different approaches to assessing the materiality of issues affecting a business. Most companies have experience with at least one approach often through their risk, governance, finance, or strategy functions.

The Protocol does not specify one particular method for assessing materiality, but instead sets out the importance of carrying out an assessment through a generic, systematic, and transparent process. This process includes the following four activities:

- List potentially material natural capital impacts and/or dependencies.
- Identify the criteria for your materiality assessment.
- Gather relevant information.
- Complete the materiality assessment.

This section of the sector guide supports your business in completing the first step of the process by providing a narrowed list of potentially material impact drivers and dependencies relevant to the forest products sector.

The materiality matrices can be used as a building block to complete your own materiality assessment when you are assessing similar raw materials and products. However, even if this is the case, it is still important that you identify the criteria for a materiality assessment that are relevant to your objectives and complete all Steps outlined in the Protocol. Large companies with many different products should undertake an initial screening to determine which products are the most important to consider.

The materiality matrices

Figures 4.3, 4.4, and 4.5 (the materiality matrices) provide an overview of potential impacts and dependencies commonly encountered within the life cycle of a wide range of forest products. Figures 4.3 and 4.4 consider potential impacts and are split into two parts for ease of reference: impacts in the forest production stage and impacts in the rest of the forest products value chain, respectively. Figure 4.5 considers potential dependencies across the whole value chain from forest production to end of life. The matrices are designed to help stakeholders prioritize action in relation to their potential impacts and dependencies, as well as to assist in communication of positive and negative impacts to a broad range of stakeholder groups.

The impacts and dependencies are "potential" to reflect the fact that even within the same processes at the same stages of the value chain, a broad spectrum of different practices may be employed. Since it would be impractical to list all of these, the matrices are intended to represent typical impacts and dependencies, but where significant or likely variation may occur (e.g., by process or by location) this is acknowledged in the full text versions of the matrices in Appendix 2. It is possible that a number of potentially negative examples can be effectively mitigated or avoided altogether if more sustainable practices are adopted. In the same way, some of the potentially positive examples will only be realized if actively managed or promoted.

The color coding of the materiality of impacts and dependencies in the matrices is a preliminary indication of the likely significance of the potential impact or dependency and can be used to help guide an initial discussion on where material issues may lie. The significance of an impact or dependency will be dependent on the baseline that is chosen (i.e., what you are comparing the practices to). For more information on baselines please see section 3.2.6 of this sector guide.

The matrices are not to be understood as a comprehensive materiality assessment of impacts and dependencies of forest products. A comprehensive materiality assessment requires applying a number of lenses through which companies view their operations more holistically. For examples of these lenses, please see section 4.2.2 of the Protocol.

Similarly, figure 4.3, Forest production impacts, is not intended to be a guide on how to undertake sustainable forest management, since comprehensive guides already exist elsewhere and in greater detail. For example, many forest products companies have proprietary handbooks for this already, and more generic guidance can be found as part of third-party certification schemes. Figure 4.3 will be most useful instead for downstream stakeholders who are less familiar with the day-to-day management of the forests they source from and who wish to gain an insight into the kinds of dependencies they may have or the potential impacts they may indirectly be bringing about. The impact driver categories in figure 4.3 reflect those in table 4.2, with the exception of the ecosystem service categories (taken from the Millennium Ecosystem Services Assessment) which are a more detailed expansion of the Protocol's category of 'terrestrial ecosystem use'.

Forest types and corresponding management practices

There are many classifications of forest types used to distinguish between forests in great detail. For the purposes of this guide, the reference to distinct forest types is used to simply demonstrate how different management practices can lead to different impacts or dependencies. Towards this end, the following three forest types are referenced in the matrices:

1. Naturally regenerated forest refers to natural forests that are being managed for forest products but no planting is undertaken for regeneration purposes.
2. Semi-natural planted forest refers to forest where some establishment or regeneration is natural and some is undertaken through planting of native or non-native tree species.
3. Plantation refers to forest where establishment or regeneration is undertaken through planting of native or non-native tree species.

While these different types of forests often co-exist, figure 4.3 uses a simple yes/no format to provide an indication of which management practices are typically associated or could reasonably be used with that forest type. This is not intended as a definitive list, in reality many combinations of management practice may occur in each forest type. The columns in figure 4.3 are grouped into management practices that may occur at different stages of the forest production lifecycle. A number of practices could apply at more than one stage of forest production, but for the sake of simplicity, the matrix lists these once at the stage with which they are most typically associated and acknowledges in parentheses where else this practice may apply. As with the other features of the matrices, the information is intended to be indicative and will need to be adapted to the specific context of the assessment.

The management practices referred to in the matrices have primarily been taken from the University of Cambridge Institute for Sustainability Leadership (CISL) report on the business case for consideration of natural resources in the forestry sector (CISL 2017) with further practices added by companies consulted during the drafting of the sector guide.

The matrices have been verified by forest products sector stakeholders and other experts to ensure that they reflect the current understanding of environmental impacts and dependencies arising in the forest products sector. The sources used for the initial literature review are summarized in References. For an explanation of the different impact drivers and dependencies, please see tables 4.2 and 4.3 below. Note that these lists are illustrative, not exhaustive.

Table 4.2
Examples of possible impact drivers

Business input or output	Impact driver category	Examples of specific, measurable impact drivers
Inputs	**Water use**	Volume of groundwater consumed, volume of surface water consumed, etc.
	Terrestrial ecosystem use	Area of agriculture by type, area of forest plantation by type, area of open cast mine by type, etc.
	Freshwater ecosystem use	Area of wetland, ponds, lakes, streams, rivers or peatland necessary to provide ecosystem services such as water purification, etc.
	Marine ecosystem use	Area of aquaculture by type, area of seabed mining by type, etc.
	Other resource use	Volume of mineral extracted, volume of wild-caught fish by species, number of wild-caught mammals by species, etc.
Outputs	**GHG emissions**	Mass of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Sulphur hexafluoride (SF_6), Hydrofluorocarbons, (HFCs) and perfluorocarbons (PFCs), etc.
	Non-GHG air pollutants	Mass of fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10}), Volatile Organic Compounds (VOCs), mono-nitrogen oxides (NO and NO_2, commonly referred to as NO_x), Sulphur dioxide (SO_2), Carbon monoxide (CO), etc.
	Water pollutants	Mass discharged to receiving water body of nutrients (e.g., nitrates and phosphates) or other substances (e.g., heavy metals and chemicals).
	Soil pollutants	Mass of waste matter discharged and retained in soil over a given period.
	Solid waste	Mass of waste by classification (i.e., non-hazardous, hazardous, and radioactive), by specific material constituents (e.g., lead, plastic), or by disposal method (e.g., landfill, incineration, recycling, specialist processing).
	Disturbances	Decibels and duration of noise, lumens and duration of light, etc. at site of impact.

Table 4.3
Examples of possible dependencies

Business inputs	Dependency category	Specific dependencies
Consumptive	**Energy**	Solar, wind, hydro, geothermal, biofuel, fossil fuel.
	Water	Fresh water (ground, surface, or rain) or sea water.
	Nutrition	Human or animal food.
	Materials	Wood fiber, genetic resources, metals, minerals, plant and animal materials.
Non-consumptive	**Regulation of physical environment**	Flood attenuation, water quality regulation.
	Regulation of biological environment	Crop pest control, pollination.
	Regulation of waste and emissions	Waste assimilation, noise and dust regulation.
	Experience	Nature-based recreation, tourism.
	Knowledge	Information from nature (e.g., for biomimicry).
	Well-being and spiritual/ethical values	Employee satisfaction and stress release, sacred sites and indigenous traditions that support company staff or operations.

Note: The lists above are not exhaustive; impacts and/or dependencies that are relevant to your business but not included here should also be considered.

Figure 4.3:
Forest production impacts*

POTENTIAL IMPACTS OF FOREST PRODUCTION

IMPACT DRIVER CATEGORY		IMPACT DRIVER	FOREST TYPE
			Naturally regenerated forest**
			Semi-natural, planted forest**
			Plantation forest**
Outputs		Carbon sequestration	
		GHG emissions	
		Non-GHG air pollutants	
		Water pollutants	
		Soil pollutants	
		Solid waste	
		Disturbances (e.g., noise & odor)	
Resource use	Provisioning service	Water use (groundwater)	
		Water use (surface water)	
		Fiber	
		Food and fuel	
		Fresh water (groundwater)	
		Fresh water (surface water)	
		Biochemicals, natural medicines, and pharmaceuticals	
	Regulating service	Regulation of air quality	
		Regulation of local, regional, and/or global climate	
		Regulation of water timing and flows (groundwater)	
		Regulation of water timing and flows (surface water)	
		Soil erosion control	
		Water purification and waste treatment (groundwater)	
		Water purification and waste treatment (surface water)	
		Regulation of soil quality	
		Regulation of pests and diseases	
		Pollination	
		Regulation of natural hazards	
	Cultural service	Recreation and nature-based tourism/educational and spiritual values	

Resource use	Supporting service	Change in habitat/biodiversity: Flora	
	Supporting service	Change in habitat/biodiversity: Fauna	

Likely to be significant   Potential to be significant   Unlikely to be significant or not applicable

* For actors located further down the value chain, the criteria in figure 4.3 can be used for assessing fiber sourcing decisions.
** ✓/✗ refers to whether the forest management practice is typically associated with each forest type.

	PRE-ESTABLISHMENT								ESTABLISHMENT					MANAGEMENT						HARVESTING				
	Zoning conservation areas or practicing low impact forest management	Sourcing trees locally	Sourcing trees from abroad	Constructing roads & railroads	Use of nurseries for seedling production	Prescribed burning [may also apply to management]	Tilling soils	Establishing drainage systems	Planting native tree species	Planting non-native tree species	Planting mixed-species plantations	Planting - by hand	Planting - mechanized	Thinning and pruning	Fertilizing soils	Irrigation [may also apply to (pre)establishment]	Controlling pests: pesticide	Controlling pests: bio-control	Fire prevention & suppression	Constructing skids trails and landings	Harvesting: selective logging	Harvesting: clear-cutting	Harvesting: underwater	Restoring lands
	✓	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
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Management practices *adapted from: www.cisl.cam.ac.uk/publications/publication-pdfs/resilience-in-commercial-forestry-technical.pdf*

Ecosystem services *adapted from: www.wri.org/publication/weaving-ecosystem-services-into-impact-assessment*

Figure 4.4:
Rest of value chain impacts*

POTENTIAL IMPACTS OF THE REST OF THE FOREST PRODUCTS VALUE CHAIN				TRANSPORTATION FROM CUTTING SITE TO PRIMARY PROCESSING			PRIMARY & SECONDARY PROCESSING				SHIPPING & TRANS-PORT TO USER		USE	REUSE & RECYCLING		END OF LIFE	
IMPACT DRIVER CATEGORY		IMPACT DRIVER		Use of roads	Use of railroads	Use of waterways	Recovery of process chemicals	Recovery of process water	Use of residues as energy	Manufacturing	(Non-electric) road & rail	Shipping	Length of product lifetime	Reuse of product	Recycling	Incineration for energy	Landfill
				a	b	c	d	e	f	g	h	i	j	k	l	m	n
Outputs		Carbon sequestration	1	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Likely	Unlikely	Unlikely	Unlikely	Unlikely
		GHG emissions	2	Likely	Potential	Potential	Potential	Unlikely	Potential	Potential	Potential	Potential	Unlikely	Likely	Potential	Potential	Likely
		Non-GHG air pollutants	3	Likely	Potential	Potential	Potential	Unlikely	Potential	Potential	Potential	Likely	Unlikely	Likely	Potential	Potential	Potential
		Water pollutants	4	Unlikely	Unlikely	Potential	Potential	Unlikely	Unlikely	Potential	Unlikely	Likely	Unlikely	Likely	Potential	Unlikely	Potential
		Soil pollutants	5	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Potential	Unlikely	Unlikely	Unlikely	Likely	Potential	Unlikely	Potential
		Solid waste	6	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Potential	Potential	Unlikely	Unlikely	Unlikely	Likely	Likely	Likely	Potential
		Disturbances (e.g., noise, odor)	7	Likely	Likely	Potential	Unlikely	Unlikely	Unlikely	Potential	Potential	Potential	Unlikely	Likely	Potential	Potential	Potential
Resource use	Provisioning services	Water use (groundwater)	8	Unlikely	Unlikely	Unlikely	Potential	Potential	Unlikely	Likely	Unlikely	Unlikely	Unlikely	Likely	Potential	Unlikely	Unlikely
		Water use (surface water)	9	Unlikely	Unlikely	Unlikely	Potential	Potential	Unlikely	Likely	Unlikely	Unlikely	Unlikely	Likely	Potential	Unlikely	Unlikely
Resource use	Supporting service	Change in habitat/ biodiversity: Fauna & Flora	10	Likely	Likely	Potential	Unlikely	Unlikely	Unlikely	Likely	Likely	Likely	Unlikely	Likely	Likely	Unlikely	Potential

Likely to be significant   Potential to be significant   Unlikely to be significant or not applicable

* Fiber sourcing decisions of actors in these stages of the value chain, who may be located further from the forest, are critical and can be assessed using the criteria in figure 4.3.

Impacts *adapted from the Natural Capital Protocol: naturalcapitalcoalition.org/protocol*

Ecosystem services *adapted from: www.wri.org/publication/weaving-ecosystem-services-into-impact-assessment*

Figure 4.5:
Value chain dependencies

POTENTIAL DEPENDENCIES IN THE FOREST PRODUCTS VALUE CHAIN

DEPENDENCY CATEGORY	DEPENDENCY		Forest production	Primary & secondary processing	Use	End of life
			a	b	c	d
Consumptive	Energy (non-photosynthetic)	1	Potential to be significant	Likely to be significant	Unlikely to be significant or not applicable	Potential to be significant
	Water	2	Likely to be significant	Potential to be significant	Potential to be significant	Potential to be significant
	Nutrition	3	Potential to be significant	Unlikely to be significant or not applicable	Unlikely to be significant or not applicable	Unlikely to be significant or not applicable
	Materials	4	Likely to be significant	Likely to be significant	Potential to be significant	Likely to be significant
	Land use	5	Likely to be significant	Potential to be significant	Unlikely to be significant or not applicable	Potential to be significant
Non consumptive	Regulation of physical environment (e.g., ecosystem providing water filtration)	6	Likely to be significant	Potential to be significant	Unlikely to be significant or not applicable	Potential to be significant
	Regulation of biological environment (e.g., resilience against disease)	7	Likely to be significant	Unlikely to be significant or not applicable	Unlikely to be significant or not applicable	Unlikely to be significant or not applicable
	Regulation of waste and emissions (e.g., pollution assimilation by ecosystem)	8	Potential to be significant	Likely to be significant	Unlikely to be significant or not applicable	Likely to be significant

Likely to be significant   Potential to be significant   Unlikely to be significant or not applicable

Dependencies *adapted from the Natural Capital Protocol: naturalcapitalcoalition.org/protocol/*

Introduction
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Measure and value stage
Apply stage
References

4.2.2 Identify the criteria for your materiality assessment

As described above, there are a number of lenses which you should use to understand which impacts and dependencies are material for your particular assessment. These will vary according to each different situation, but possible criteria to consider are listed below in table 4.4.

Table 4.4:
Potential criteria for a materiality assessment

Potential criteria	Possible influence on materiality
Local ecological and climatic context	For example, you may be cultivating a highly water-demanding tree species in an area suffering water stress, or conserving forest cover to help prevent local soil erosion.
The ownership model of the forest concession and wider national or jurisdictional forest tenure regimes	For example, lack of clarity around ownership of a concession may lead to lower incentives for long-term sustainable forest management , or creation of transport routes into otherwise inaccessible forest may create an inadvertent route for illegal logging and illegal hunting in territories with weak regulatory enforcement.
Presence or absence of indigenous peoples and communities living in the forest concession	For example, a local presence might automatically increase the scale of some impacts, positive and negative, and require stakeholder engagement to get a complete picture of material issues.
Proximity of concession to national parks or conservation areas	For example, operations may disrupt fragile wildlife corridors, or concessions could be managed so as to actively enhance connectivity between national parks.
Accessibility of forest concession to public for recreation, fuelwood gathering, and other activities	For example, forestry operations may impinge upon public traditions and livelihood activities, or active engagement between the company and the public may create enhanced opportunities for recreation.
Customer attitudes	For example, if certain ecosystem services gain more prominence publicly then their conservation may be rewarded by the market, or specific management practices may alternately be perceived as harmful by the public.
Harvesting cycles and regeneration times	For example, if sites are likely to be re-harvested before they have fully regenerated, this may result in increased rates of carbon sequestration in the short term, but an overall decrease in average carbon stock (above and below ground) over several harvesting cycles.

Important note regarding disclosure

Materiality is both a general and legal concept (Corporate Reporting Dialogue 2016). Materiality within the Natural Capital Protocol does not necessarily equate to the legal concept of materiality which applies to formal corporate reporting in many jurisdictions (for example, as defined in the US by the Supreme Court). Many companies around the world regularly disclose information about their impacts and dependencies on natural capital. However, if you have concerns about the potential interpretation of disclosures you plan to make on natural capital impacts or dependencies (for example by investors, regulators, or other stakeholders), you are advised to seek independent legal advice relevant to your industry and jurisdiction.

4.2.3 Gather relevant information

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 49 FOR GENERAL GUIDANCE

4.2.4 Complete the materiality assessment

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 50 FOR GENERAL GUIDANCE

Step 04 of the Forest Products Sector Guide has provided additional guidance to help you identify material natural capital impacts and dependencies relevant to the forest products sector. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

MEASURE AND VALUE STAGE

What is the Measure and Value Stage?

The Measure and Value Stage of the Protocol introduces guidance on how impacts and/or dependencies can be measured and valued.

How does the sector guide map to the Protocol?

Table MV.1 provides an overview of the questions and actions of the Measure and Value Stage in the Protocol and an outline of the actions for which the sector guide provides additional guidance.

Table MV.1:
The Measure and Value Stage: Mapping between the Protocol and the sector guide

Step		Questions this Step will answer	Actions	Additional guidance included in this sector guide?
05	Measure impact drivers and/or dependencies	How can your impact drivers and/or dependencies be measured?	5.2.1 Map your activities against impact drivers and/or dependencies	**Yes** See page 51 in this guide.
			5.2.2 Define which impact drivers and/or dependencies you will measure	**No** Revert to Protocol page 60 for general guidance.
			5.2.3 Identify how you will measure impact drivers and/or dependencies	**Yes** See page 51 in this guide.
			5.2.4 Collect data	**No** Revert to Protocol page 65 for general guidance.
06	Measure changes in the state of natural capital	What are the changes in the state and trends of natural capital related to your business impacts and/or dependencies?	6.2.1 Identify changes in natural capital associated with your business activities and impact drivers	**Yes** See page 53 in this guide.
			6.2.2 Identify changes in natural capital associated with external factors	**Yes** See page 54 in this guide.
			6.2.3 Assess trends affecting the state of natural capital	**No** Revert to Protocol page 72 for general guidance.
			6.2.4 Select methods for measuring change	**No** Revert to Protocol page 72 for general guidance.
			6.2.5 Undertake or commission measurement	**No** Revert to Protocol page 78 for general guidance.

Table MV.1: continued
The Measure and Value Stage: Mapping between the Protocol and the sector guide

Step		Questions this Step will answer	Actions	Additional guidance included in this sector guide?
07	Value impacts and/or dependencies	What is the value of your natural capital impacts and/or dependencies?	7.2.1 Define the consequences of impacts and/or dependencies	**Yes** See page 56 in this guide.
			7.2.2 Determine the relative significance of associated costs and/or benefits	**No** Revert to Protocol page 82 for general guidance.
			7.2.3 Select appropriate valuation technique(s)	**Yes** See page 59 in this guide.
			7.2.4 Undertake or commission valuation	**No** Revert to Protocol page 91 for general guidance.

Additional notes
Businesses operating in the forest products sector should address all of the actions associated with each Step in the Measure and Value Stage. The sector guide provides additional guidance for some of the actions where it is most appropriate. For a detailed appraisal of the suitability and potential accuracy of different methods of measurement and valuation please refer to the Protocol.

Before you get started with the Measure and Value Stage

Before you get started with the measurement and valuation Steps of your assessment, it is important to consider any planning requirements. The Protocol, for example, identifies some of the resource needs that should be considered for each component of the assessment. For impacts on your business, fewer external resources are typically needed, as some data may be available in your company or in published literature. However, for your impacts on society and your business dependencies, more resources are typically needed and may require specialist environmental/natural resource modelling expertise.

The availability of existing data and the ability to leverage existing sector-specific published literature are important planning considerations not only for measurement and valuation but also in scoping your natural capital assessment. In the forest products sector, there are a number of important examples of published literature including sector-specific frameworks, initiatives, and datasets. Table MV.2 provides a non-exhaustive list summarizing some of these and illustrates how they may be useful for your assessment. The Natural Capital Toolkit (www.naturalcapitaltoolkit.org) provides an updated list of additional resources for practitioners when conducting natural capital assessments.

Table MV.2:
Examples of sector-specific resources relating to measurement and/or valuation

Author	Name	Type	Description
Alliance for Water Stewardship (AWS)	The AWS International Water Stewardship Standard	Standard/ Assessment framework	A globally applicable framework for major water users to understand their water use and impacts. The Standard is intended to drive social, environmental, and economic benefit at the scale of a catchment (AWS 2014).
BirdLife International, UNEP-WCMC, Anglia Ruskin University, University of Cambridge, RSPB, and TBA	TESSA (Toolkit for Ecosystem Service Site-based Assessment)	Assessment framework	The toolkit provides accessible guidance on low-cost methods for how to evaluate the benefits people receive from nature at particular sites in order to generate information that can be used to influence decision making (Peh et al. 2017).
BRE Centre for Sustainable Products	BRE LINA	Assessment framework	Life-cycle assessment tool for construction products, which looks at the environmental impacts of a product through its lifespan from raw materials acquisition and manufacturing to application, use, and disposal (BRE 2017).
Cambridge Institute for Sustainability Leadership (CISL)	Resilience in Commercial Forestry: Doing business with nature	Report	A report highlighting business impacts and dependencies on water, biodiversity, soil, and carbon and looking at existing efforts to address the related challenges. The report shows how sustainable management of production landscapes can simultaneously benefit natural resources and build resilience in the commercial forestry sector (CISL 2017).
European Commission	Product Environmental Footprint (PEF) and Organizational Environmental Footprint (OEF)	Assessment framework	Provides a harmonized methodology for calculating the environmental footprint of products and organizations (including carbon) (European Commission 2013).
FAO (Food and Agriculture Organization)	The system of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA-AFF)	Statistical framework	A statistical framework that facilitates description and analysis of agriculture, forestry, and fisheries as economic activities and their relationship with the environment. The SEEA AFF is unlikely to provide additional information to support improved management of individual natural resources, but the common framework will highlight linkages among different natural resources and between natural resources use and economic drivers (FAO 2018).
Forest Enterprise England (Forestry Commission)	Natural Capital Accounts 2015/2016	Accounting framework/ management tool	A strategic management tool that helps inform decision-making processes through tracking the condition of natural capital and its value over time and helping managers to understand sources of value and trade-offs in maintaining England's woods and forests (Forest Enterprise England 2016).
Forest Stewardship Council (FSC)	Ecosystem Services Procedure	Market tools	The tool enables companies to demonstrate ecosystem service impacts and provide an economic argument for responsible forest management over short-term harmful exploitation of forest resources (FSC 2017).
Global Forest Watch	Global Forest Watch	Real-time monitoring	An online forest monitoring and alert system that can be used to monitor deforestation an other trends within an area (Global Forest Watch 2014).
HCV Resource Network	Common Guidance for the Identification of High Conservation Values	Guidance	The Common Guidance is a tool to help HCV practitioners and other interested parties implement the HCV approach in a consistent way across different natural resource sectors or geographies. The Common Guidance aims to widen the scope of use of HCV to other ecosystems and to provide guidance on the updated HCV definitions, as well as examples from practical field experience (HCV Resource Network 2013).
IPCC	Guidelines for National Greenhouse Gas Inventories: Volume 4 Agriculture, Forestry and other Land Use	Measurement tool	A reference for the measurement and quantification of carbon sequestration and storage in the forestry context (IPCC 2006).
Swedish Life Cycle Centre	Environmental Priority Strategies (EPS)	Valuation tool	EPS is a systematic approach to choose between design options in product and process development. Its basic idea is to make a list of environmental damage costs available to the designer in the same way as ordinary costs are available for materials, processes, and parts. The designer may then calculate the total costs over the product's life cycle and compare optional designs (Swedish Life Cycle Centre 2015).

Table MV.2: continued
Examples of sector-specific published literature

Author	Name	Type	Description
The Economics of Ecosystems and Biodiversity (TEEB) / United Nations Environmental Programme (UNEP)	TEEB for Agriculture & Food	Assessment framework	A framework being developed for comprehensive economic evaluation of the "eco-agri-food systems" complex, road tested in externalities-heavy agricultural sectors (livestock, palm oil, agro-forestry) (TEEB 2018).
The Economics of Ecosystems and Biodiversity (TEEB)	The Economics of Ecosystems and Biodiversity – Valuation Database Manual	Valuation database	The Manual presents an overview and explains the potential uses and functions of the TEEB Valuation Database. The Manual discusses the origin of the database; describes its content and structure; outlines its contents and discusses how it may be used, including important caveats (TEEB 2013).
UN Convention to Combat Desertification (UNCCD)	Scientific Conceptual Framework for Land Degradation Neutrality	Assessment framework	Provides a scientific foundation for understanding, implementing, and monitoring land degradation neutrality (LDN). It has been designed to create a bridge between the vision and the practical implementation of LDN, by defining LDN in operational terms (UNCCD 2017).
USDA Agricultural Research Service (USDA-ARS) and Texas A&M University	Soil and Water Assessment Tools (SWAT)	Tool	SWAT is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control, and regional management in watersheds (SWAT 2016-2018).
World Bank	Forests Sourcebook: Practical guidance for sustaining forests in development cooperation	Guidance	The Forests Sourcebook is an introduction to how forests can contribute to poverty reduction, how the private sector can be engaged in development, how to optimize forest functions at the landscape level, as well as detail on implementing the World Bank's safeguard on forests (World Bank 2008).
World Business Council for Sustainable Development (WBCSD)	Guide to Corporate Ecosystem Valuation (CEV)	Valuation tool	The tool offers companies a process for identifying and valuing which ecosystem services they depend upon and impact, a popular precursor to the Natural Capital Protocol (WBCSD et al. 2011).
World Business Council for Sustainable Development (WBCSD), World Resources Institute (WRI)	Sustainable Procurement Guide	Guidance	The purpose of this Guide is to assist sustainability officers and business procurement managers to develop and implement their wood and paper-based procurement policies. The Guide identifies and reviews issues central to procurement of wood and paper-based products, and highlights resources that can be of help (WBCSD and WRI 2016).
World Business Council for Sustainable Development (WBCSD), World Resources Institute (WRI), Meridian Institute	The Corporate Ecosystem Review (ESR)	Business strategy tool	The ESR is a structured methodology for corporate managers to proactively develop strategies for managing business risks and opportunities arising from their company's dependence and impact on ecosystems (WRI, WBCSD and Meridian Institute 2012).
World Resources Institute (WRI)	A Guide to Selecting Ecosystem Service Models for Decision Making: Lessons from Sub-Saharan Africa	Modeling guidance	This guide was developed for technical advisors to government officials, business people, investors, and others who need to draw on ecosystem assessments to inform decision making. It assesses several types of ecosystem service modeling tools, discusses issues involved in modeling ecosystem services, and provides guidance on how to choose the right model to address a specific policy question (WRI 2018).

05 Measure impact drivers and/or dependencies

This section of the sector guide provides additional guidance for answering the following question:
How can your impact drivers and/or dependencies be measured?

In particular, the sector guide will help you undertake the following actions:

5.2.1 Map your activities against impact drivers and/or dependencies

5.2.3 Identify how you will measure impact drivers and/or dependencies

5.2.1 Map your activities against impact drivers and/or dependencies

In order to complete this action in the Protocol, you will need to identify all of the relevant activities associated with your assessment and map these against material natural capital impacts drivers and/or dependencies.

The materiality matrices in Step 04 can help you to identify potentially material impacts and dependencies based on the management practices that are being undertaken both by your company and by actors upstream and downstream of you. Depending on the value chain scope of the analysis, you may need to gather additional information from your suppliers and/or customers to understand the activities that they are undertaking that may be driving impacts and dependencies outside of your direct operations.

Once you have identified the impact drivers and/or dependencies that your business or value chain activities are linked to, you will need to select the impact drivers and/or dependencies to take forward into measurement and valuation. You should consider (within the scope of your resources) including all impacts and dependencies that are perceived by stakeholders to be material, regardless of whether they are positive or negative. Especially in cases where the objective of the assessment is public communication, an assessment that can demonstrate it is balanced is more credible to readers.

It may transpire that an issue that is perceived by a stakeholder group to be significant turns out to not be significant when measured and valued. This “null result” can still be valuable for use in public engagement.

5.2.2 Gather relevant information

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 60 FOR GENERAL GUIDANCE

5.2.3 Identify how you will measure impact drivers and/or dependencies

To complete this action in the Protocol, you need to determine how you will obtain the data needed to quantitatively or qualitatively measure your impact drivers and/or dependencies. There are many potential sources of available data (for further detail on primary and secondary data options, please see the Protocol) including:

Primary data:

- Internal business data collected for the assessment being undertaken.
- Data collected from suppliers or customers for the assessment being undertaken.

Secondary data:

- Published, peer-reviewed, and grey literature (for example, life-cycle impact assessment (LCIA) databases; industry, government, or internal reports).

- Past assessments.
- Estimates derived using modeling techniques (for example, environmentally extended input-output (EEIO) models, productivity models, mass balance).

It is important to recognize that measurement may take very different forms depending on location and that one approach may not be best applied across a range of sites or projects. For example, primary studies on biodiversity may in one location require assessment through a microscope and in other locations could involve surveying for large mammals.

Table 5.1 provides some sector-specific considerations for the use of primary and secondary data. Once again, for a detailed appraisal of the suitability and potential accuracy of different methods of measurement please refer to the Protocol.

Table 5.1:
Sector-specific considerations for primary and secondary data approaches

Type of data	Sector-specific considerations
Primary data	The forest production stage of the forest products value chain is highly regulated in some jurisdictions and less regulated in others, altering the nature and volume of data collected by companies. Engagement in certification processes should increase the availability and accessibility of data. In 2016, an estimated 11% of global forest area (432.5 million hectares) was certified, with 87% of the global certified forest area located in the Northern Hemisphere (UNECE, 2016). Consumer-facing parts of the value chain (e.g., those dealing with finished products) tend to have good data on their own operations.
Secondary data	There are multiple sources of secondary data relevant to the forest products sector. Some useful examples of sector-specific secondary data sources are presented in table MV.2. Similar to many sectors, relatively few forest products companies publish information on environmental impacts in their supply chains. For example, according to the 2017 CDP report, only 22% of responding companies are engaging with their own suppliers on carbon emissions and just 16% of companies are engaging on water (CDP 2017). However, increasingly sophisticated modeling approaches are available to help companies account for their supply chain emissions and many of these are freely available online (e.g., environmentally extended input-output models and life cycle impact assessment models (see table MV.2)).

5.2.4 Collect data

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 65 FOR GENERAL GUIDANCE

Step 05 of the Forest Products Sector Guide has provided additional guidance to help you map your activities against impact drivers and/or dependencies and identify how you will measure them. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

Glossary

Primary data
Data collected specifically for the assessment being undertaken.

Secondary data
Data that were originally collected and published for another purpose or a different assessment.

06 Measure changes in the state of natural capital

This section of the sector guide provides additional guidance for answering the following question:
What are the changes in the state and trends of natural capital related to your business impacts and/or dependencies?

In particular, the sector guide will help you undertake the following actions:

6.2.1 Identify changes in natural capital associated with your business activities and impact drivers

6.2.2 Identify changes in natural capital associated with external factors

6.2.1 Identify changes in natural capital associated with your business activities and impact drivers

This action considers the changes in natural capital that are likely to result from the impact drivers measured or estimated in Step 05. The Protocol presents some generic examples of changes in natural capital for a range of impact drivers. Table 6.1 presents some sector-specific examples for the impact drivers that were introduced in Step 01 of the sector guide. In addition to providing examples of changes in natural capital, the table also presents some examples of how the changes may vary according to location-specific factors.

Table 6.1:
Sector-specific examples of relevant changes in natural capital for different impact drivers

	Carbon sequestration	Water pollution	Air pollution
Example indicator	Sequestration of metric tons of GHGs.	Nutrient levels (nitrate and phosphorus compounds) and other chemical inputs.	Kilograms of emissions of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), carbon monoxide (CO) and volatile organic compounds (VOCs), levels of atmospheric particulate matter PM_{10} and $PM_{2.5}$.
Example changes in natural capital	Reduction of GHG concentration, and so reduction of climate change.	Nutrients entering waterways through the process of leaching lead to a change in eutrophication levels and affect ecosystems through the reduction in species (for example, fish).	Trees remove air pollution by the interception of particulate matter on plant surfaces and the absorption of gaseous pollutants through the leaf stomata.
Examples of variation in changes in natural capital	Climate change leads to many natural capital changes around the world – in the atmosphere, on land, and in the oceans. Quantifying these requires an understanding of atmospheric chemistry, meteorology, fire outbreak patterns, insect and pathogen outbreaks, introduced and native species population dynamics and range, seasonal changes in flora and fauna (phenology), silvicultural practices, and extreme weather events amongst others. The impacts of these changes can be geographically specific, for instance with some regions likely to experience increased fire and drought risk (such as the Mediterranean, southern Australia, and western North America) (Carbon Brief 2017) and others, such as the boreal Taiga region (constituting nearly a third of the planet's forested area) which are struggling to withstand rising temperatures and increased susceptibility to pest attacks (UPI 2015).	Water pollution is primarily a local impact driver because it has a direct and traceable impact on local ecosystems and the quality of the water into which it is discharged. As such, understanding the change in natural capital from the emission of water pollutants requires a consideration of location-specific factors such as the type of water body pollutants are discharged into, the ecology of the catchment area, and the background concentrations of the pollutants. For example, Bangladesh is ranked by the Asian Water Development Outlook (Asian Development Bank 2016) in the bottom four of the 48 Asian countries in terms of how well river basins are being managed to sustain ecosystem services; nearly half (47.4%) of the water pollution flowing into the Buriganga River in the capital city of Dhaka is attributable to the pulp and paper industry, with the next closest contributor responsible for only 15.9% (Financial Express 2017).	The beneficial impact on air quality from trees can be both short- and long-range in its scope, whether through the local interception of particulate matter from nearby roads, or preventing the far-reaching impacts of acid rain by reducing airborne concentrations of nitrogen dioxide. Factors determining locational variation include the density of trees, their ability to clean air, and their proximity to sources of air pollution. This locational variation is demonstrated in a recent US study which found that even though the greatest health benefits from air pollution removal by trees accrued to urban areas, air pollution removal itself was substantially higher in rural areas than urban areas (16.7 million tons vs. 651,000 tons) (Nowak et al. 2014).

6.2.2 Identify changes in natural capital associated with external factors

You should also identify any external factors that could result in major changes in the state of natural capital, as these may directly or indirectly affect the significance of impacts on your business, your impacts on society, and/or your business dependencies. External factors potentially leading to changes in natural capital include both natural changes and human-induced changes. The Protocol provides a definition of these and some examples of changes in natural capital influencing dependencies. Table 6.2 presents some sector-specific examples of changes in natural capital influencing the dependencies that were introduced in Step 01. The table also presents some examples of how the change in natural capital may vary according to location-specific external factors.

Table 6.2:
Sector-specific examples of relevant changes in natural capital for different dependencies

	Consumptive: Water	Consumptive: Materials	Non-consumptive: Regulation of living environment
Example indicator	Cubic meters of water (m^3).	Soil acidity (pH).	Density of biological control agents.
Example changes in natural capital	Diversion or desiccation of a fresh water body that provided a source of process water.	Acid rain and application of fertilizers increasing soil acidity.	Unbalanced ecosystems leading to loss of biological control agents and/or lack of their efficacy resulting in decreased yields.
Examples of variation in changes in natural capital	External factors that could impact the state and trends of fresh water provision include economic and population growth driving the demand for resources, as well as background environmental change such as climate change. It is estimated that the forests of Central Europe (Hlásny et al. 2014), Canada's Boreal region (Peng et al. 2011), and virtually all of the continental US (an area of approximately 2,500,000 km^2 (Ritters et al. 2002; Climate Home 2016)) are threatened by climate change-induced drought. Tree species itself plays a role, with some species consuming significant quantities of water. For example, in 2009 the Kenyan government ordered farmers to cut down eucalypts near water sources after forestry officials had cited their significant contribution to depleting water sources, estimating that a 20-year-old eucalyptus will consume approximately 200 liters of water a day (World Rainforest Movement 2009).	Although there are many factors comprising soil quality, acidity (pH) can be used as a general guide for determining nutrient availability and therefore the species that may grow on a given site. The vast majority of commercially important tree species can live in a broad range of soil acidity (pH) values so long as the proper balance of essential nutrients is available; this balance is most typically available in soils with a pH of 6.0-7.0. Extremes in soil pH (<4.5 and >8.5) can encourage excessive uptake of certain nutrients by trees (while limiting others) to the point that nutrients become toxic to trees (ALRI 2006). Dependency on soil acidity (pH), however, is geographically specific and will depend on the extent of local variations in pH and the sensitivity of the tree species in question. For example, in Southern China, a large area of approximately 480,000 km^2 is available for cultivation of commercially valuable teak species, but even with the aid of various soil remediation efforts and the selection of acid-tolerant cultivars, the soil is still too acidic to support viable teak plantations (Bingchao and Jiayu n.d.). Many pines, by contrast, thrive in more acidic conditions (ALRI 2006).	Globally, insect invasions have increased dramatically in the last two decades as the increase in international trade has led to increased movement of alien species (Kenis et al. 2017). As a result, insect control by natural means is a significant dependency throughout different climates, forest types, and regions. Additionally, through the effects of climate change, pests – which typically prefer warmer, wetter weather – have steadily been extending their ranges towards the poles and are now not only surviving but thriving in previously inaccessible regions. For example, the mountain pine beetle now occurs well beyond its historic range, spreading into Canada's boreal forests from its traditional habitat in British Columbia and now affecting new species (e.g., Jack pine, the dominant pine species of the boreal forest) (Time 2013; Natural Resources Canada 2011). In parallel, the use of insecticides is increasingly banned or severely restricted in forests (Kenis et al. 2017) thereby increasing reliance on natural control systems to regulate both the increasing volume and range of pest species worldwide.

6.2.3 Assess trends affecting the state of natural capital

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 72 FOR GENERAL GUIDANCE

6.2.4 Select methods for measuring change

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 72 FOR GENERAL GUIDANCE

6.2.5 Undertake or commission measurement

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 78 FOR GENERAL GUIDANCE

Step 06 of the Forest Products Sector Guide has provided additional guidance to help you identify changes in natural capital associated with your business activities, impact drivers, and external factors. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

07 Value impacts and/or dependencies

This section of the sector guide provides additional guidance for answering the following question:
What is the value of your natural capital impacts and/or dependencies?

In particular, the sector guide will help you undertake the following action:
7.2.1 Define the consequences of impacts and/or dependencies

7.2.3 Select appropriate valuation techniques

7.2.1 Define the consequences of impacts and/or dependencies

Based on the impact drivers and dependencies, and associated changes in natural capital, identified in Step 04 and (as appropriate) measured in Steps 05 and 06, you should now be able to identify the consequences—or the types of business and societal costs and benefits—that may arise under one or more relevant scenarios. The Protocol provides some useful examples of the consequences of natural capital impacts on business and society as well as the consequences of natural capital dependencies. In this section, the sector guide provides some examples for the forest products sector specifically.

Consequences of natural capital impacts on your business

Forest products businesses may be impacted directly by the natural capital impacts of their activities. These business impacts include any financial costs or benefits that directly affect your bottom line. Some of these were introduced in Step 01 of the sector guide in the discussion of business performance metrics influenced by different risks and opportunities relating to natural capital. They also include less tangible impacts that may affect the bottom line indirectly, such as reputational damages (or benefits), delays in permitting, and employee attraction and retention. Business impacts may relate to the cost of production inputs (for example, the purchase costs of raw materials, water, or energy), as well as the costs or benefits of outputs (for example, increased compliance costs to meet biodiversity targets, or increased revenue from burning waste residues to produce energy).

Environmental market mechanisms are being introduced in many jurisdictions, whereby companies increasingly need to pay for their use of or impacts to natural capital, or get paid for environmental enhancements they provide. While a global carbon market remains elusive, a report published by the World Bank and Ecofys (2017) showed that 40 nations and over 25 subnational jurisdictions now have a price on CO_2 emissions, covering around 15% of annual global GHG emissions, or the equivalent of nearly 8 billion tons of CO_2. Carbon regulation systems that recognize carbon credits arising from forest carbon sequestration or the storage of carbon in harvested wood products include the California cap-and-trade market and the Chinese ETS pilot scheme (van der Gaast et al. 2016). In payments for ecosystem services (PES) schemes, people managing and using natural resources, typically forest owners or farmers, are paid to manage their resources to protect watersheds, conserve biodiversity, or capture CO_2 (carbon sequestration) through, for example, replanting trees or keeping living trees standing, or by using different agricultural techniques. The proliferation of environmental mechanisms such as these may create new costs and/or benefits for forest products companies and these are often scaled according to the amount of emissions generated or resources used.

Conversely, fines or legal claims for environmental damages (or revenues from payments for ecosystem services) may be linked to measured changes in natural capital.

If the scope of your assessment extends over several years, you will need to consider not only potential future direct business impacts, but also the possibility that future business impacts may arise indirectly through your company's impacts on society. While assessing your company's impacts on society is more demanding than assessing impacts on your business, it is more likely to capture the risk and opportunity associated with your impacts being internalized at some point in the future.

Consequences of natural capital impacts on society

The natural capital impacts of your business may also affect society. Societal impacts include all costs or benefits accruing to individuals, communities, or organizations that are not captured through current market systems and are external to your business—these are often referred to as "externalities". Societal impacts arise from changes in natural capital resulting from the impact drivers of your business. Again, some of these were introduced in Step 01 in the discussion of risks and opportunities and how they may indirectly influence business performance metrics. Societal impacts will vary depending on the "receptors" that are affected (for example, people, buildings, agriculture).

The forest products value chain is one of the few sectors where communities live on/amongst the primary production sites (i.e., in the forests themselves). According to WWF, around 300 million people live in forests with more than one billion people depending on forests for their livelihoods (WWF 2017). This means that both positive and negative externalities can be significant.

Negative externalities from forest production typically affect human well-being directly and can include loss of livelihoods from natural resource degradation. For example, forest catchments supply 75% of fresh water therefore practices that threaten the provision of clean water to local communities may pose substantial reputational risks to businesses (CISL 2017). Similarly, water pollution from the excessive use of fertilizer creates a cost for communities that then have to pay to treat the water so they can safely use it, alongside finding an alternative source of food or employment if fish stocks have been depleted through the effects of eutrophication. In poorer or underdeveloped regions where communities may not have the ability to clean up affected water bodies, this may lead to illness, disability, and even death.

On the other hand, positive impacts that can be yielded from forests include the provision of various ecosystem services such as recreational and educational benefits or flood and soil erosion protection. The value of different consequences on society will depend on different value chains, for example the location of the forest concession will affect the potential for watershed disruption and/or maintenance and the proximity to local communities will affect the value of cultural ecosystem services.

Stages further down the forest product value chain such as wood transportation, process and manufacturing, use, and end of life can all have significant societal externalities. For example, impacts can occur from the transportation of wood from forests using large trucks on small rural roads to primary processing sites. This can cause air pollution, damage to roads, and collisions which can inconvenience local communities and be a direct threat to their health and wellbeing.

The end-of-life stage of a forest product can also have positive or negative impacts. For example, if a wood product is burned to produce energy, it may be offsetting the use of energy from a non-renewable source and therefore having a positive impact on GHG emissions. This positive impact can be even more pronounced if the wood burnt for energy is otherwise a waste-stream from more value-adding stages of the value chain (See Practical Example 3: Product alternatives and design in Step 09). However, if a wood product that has a high moisture content or has been treated with chemical coatings is burned then high levels of particulate matter or toxic air emissions respectively may be released that can have negative consequences on human health.

Consequences of natural capital dependencies

The dependence of your business on natural capital primarily affects the business itself. Potential costs and benefits associated with business dependencies fall into two categories: consumptive—or goods that you rely upon for your business (for example, water and timber)—and non-consumptive—goods or services nature provides that are often unseen and unpriced (for example, natural flood and erosion control). Once again, some of these costs and benefits were introduced in Step 01 in the discussion of risks and opportunities.

Table 7.1 presents some sector-specific examples of the consequences associated with the natural capital impacts that were introduced in Step 01 and Step 06. These natural capital impacts are presented in terms of their consequences for business and for society. Table 7.2 presents some sector-specific examples of the consequences associated with natural capital dependencies. These dependencies are presented in terms of their consequences for business.

Table 7.1:
Examples of the consequences of natural capital impacts

	Carbon sequestration	Water pollution	Air pollution
Example changes in natural capital	The locking away of carbon in trees and healthy soils will reduce global atmospheric GHG concentrations and slow the current rate of climate change. This assumes that during any required preparation of the land before forest establishment more carbon is not released than the forest operations will sequester over their lifetime.	Nutrients entering waterways through leaching from a forest plantation can lead to increased eutrophication levels which may result in harmful algal blooms (HABs) and the depletion of aquatic oxygen levels. This can result in lifeless aquatic ecosystems and potentially toxic bodies of water downstream.	Trees and forests help to clean polluted air by filtering and trapping pollution particles with attendant benefits for local flora and fauna.
Consequence of impact to business	Potential financial benefits related to carbon sequestration, for instance state or regional subsidies, payments for ecosystem services, carbon credits, avoidance of carbon tax obligations, etc.	Potential legal costs depending on local environmental regulations and/or compensation costs for any humans or animals affected by HABs attributable to the company.	Through the provision of a key ecosystem service, a business' social licence to operate may be strengthened in the eyes of increasingly environmentally-aware public stakeholders. This may be of particular importance as air quality deteriorates globally (especially in cities) and addressing it ranks ever higher on public agendas worldwide (WHO 2016). In addition, plantation and forest owners may in the future receive payments for ecosystem services for maintaining tree cover that quantifiably reduces air pollution.
Consequence of impact to society	Global implications of climate change abatement include lessening the impact of climate change on agricultural productivity, forestry, water resources, energy consumption, property damages from increased flood risk and other extreme weather events, human health, gender equality, and geopolitical security.	Water pollution from primary processing effluent may create a cost for communities which have to pay to treat the water for safe use, alongside finding an alternative source of food or employment if fish stocks have been depleted. In the case of HABs, people or animals who come into contact with them can be severely sickened or even die as a result. In poorer or underdeveloped regions where communities may not have the resources to clean affected water bodies, this may lead to illness, disability, and death.	The provision of clean air allows humans to lead longer and healthier lives, reducing the number of disability adjusted life years (DALYs see note below) caused by air pollution that can impede sustainable development in poorer regions of the world. In more economically developed nations where DALYs are less likely to be an issue, air pollution can cause productivity losses and place an unnecessary burden on national healthcare systems. A UK study has estimated that in 2015, plants in the UK saved £1 billion in health costs due to the removal of air pollution (Centre for Ecology and Hydrology 2017).

Note on DALYs: The disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death

Table 7.2:
Examples of the consequences of natural capital dependencies

	Consumptive: Water	**Consumptive: Materials**	**Non-consumptive: Regulation of living environment**
Example changes in natural capital	Depletion or desiccation of a fresh water body that provided a clean water source for a pulp and paper mill.	Degraded and acidified soil can no longer support plantations and is increasingly subject to wind and water erosion.	Lack or reduced presence of natural pest control such as predators, parasitoids, bacteria, fungi, or viruses can result in widespread destruction or reduction of crop yields by a pest.
Consequence of dependency to business	Increased operational costs, delays and potentially reputational damage (especially in water-scarce regions) associated with identifying and securing access to alternative fresh water sources. If an adequate replacement cannot be found, the business is likely to face a loss of revenue from crop damage and/or failure.	Degraded and eroded soil may be too poor to support growth even with various inputs, in which case the land is of diminished value or potentially worthless to the business. Alternatively, the land may be commercially salvageable, but only through the application of costly inputs such as fertilizers and/or other labor-intensive interventions which will all increase business costs.	Increased operational costs resulting from the use of pesticides and the potential downstream consequences (e.g., fines for polluting waterways). Increased operational costs from restoring biodiversity in affected areas to promote re-establishment of natural pest controls. In the event of an outbreak, reduced revenue from low yields and increased insurance premiums.

7.2.2 Determine the relative significance of associated costs and/or benefits

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 82 FOR GENERAL GUIDANCE

7.2.3 Select appropriate valuation technique(s)

Values can be expressed in qualitative, quantitative or monetary terms:

- **Qualitative valuation techniques** are used to inform the potential scale of costs and/or benefits expressed through qualitative, non-numerical terms (e.g., significant decrease of air pollutants that cause damage to human health, significant increase in regional population of globally threatened species).
- **Quantitative valuation techniques**, in turn, focus on numerical data which are used as indicators for these costs and/or benefits (e.g., 20% decrease in regional concentration of particulate matter pollutants that cause damage to human health, increase by one-third of people benefitting from recreation).
- **Monetary valuation techniques** translate quantitative estimates of costs and/or benefits into a single common currency (e.g., the financial cost of medical treatment needed in response to increased air pollution).

The choice of type of valuation will largely depend on the objective of your assessment and the audience. For example, the use of monetary valuation may facilitate conversations with certain stakeholders, such as board members, who are already familiar with monetary terms.

As described in the Protocol itself, one method for estimating part of the value of your impacts and dependencies can be through prices currently seen in the market for certain ecosystem services such as carbon prices (World Bank 2016) or nutrient markets.

However, these markets only reflect current prices and not the total value to society of these ecosystem services and thus are only a partial representation of value. To represent more complete values, non-market valuation techniques can be used. It should be noted that when comparing or aggregating values, care should be taken if different valuation techniques have been used or where they represent different value perspectives.
More information on different valuation techniques and which technique will be most appropriate for your natural capital assessment can be found in table 7.1 of the Protocol.
In general, valuation is a technical step of the Protocol and it may be useful to seek out the advice of academics or consultants when completing this Step.

Valuation of a natural capital stock is also possible and this may be particularly relevant for forest products companies, notably those at the start of the value chain who may own large areas of forest land. In general, the value of the stock is the sum of the stream of future benefits it can support. As above, qualitative, quantitative and monetary valuation can be applied to stocks, with examples given below:

- Qualitative valuation of a natural capital stock may be the designation of a forest as a protected area or "High Conservation Value" area, providing a qualitative indicator that the forest contains a high-value stock of natural capital.
- Quantitative valuation of a natural capital stock could include the tons of CO_2e stored in the biomass of a forest, or the number of a particular species present in a forest concession.
- Monetary valuation of a natural capital stock can be inferred from the expected future flow of benefits. Net present value (NPV) is one of the common methods for assessing the discounted future flow of costs and benefits from a given capital asset. The same method can be used to assess natural capital stocks, based on estimates of the value of benefit flows (which may include marketed and non-marketed goods and services).

Data required for monetary valuation of natural capital stocks may include:

- projection of future flows of benefits or extraction of resources on a sustainable basis (without undermining productive capacity);
- projection of changes in real marginal values (prices) of benefits over time (e.g., due to demographic trends or economic growth);
- estimation of the future costs of deriving benefits (e.g., extraction of resources);
- determination of the life of the asset (in years), which may be indefinite depending on the management regime and the nature of the resource;
- determination of appropriate discount rates (market or social, depending on the context).

Challenges

There is significant uncertainty about the future condition of natural capital and the resulting flows of benefits, which may be affected by climate change or other environmental conditions. For example, the 2010 Amazon drought caused an increase in tree mortality and declining growth rates to the point that some studied forest plots became carbon neutral rather than continuing to act as carbon sinks as they previously had (Feldpausch et al. 2016).

There is likewise uncertainty about future demand for the benefits currently provided by natural capital, which may vary due to socio-economic or technological changes. In the case of forest products these trends may be positive (e.g., a move to using renewable materials such as wood in construction rather than metal and concrete, or the increase in demand for carbon credits from forestry projects to offset GHG emissions elsewhere).

Such uncertainties about the future are one of the reasons why discounting is commonly applied to future values when assessing stock values in monetary terms. In fact, the discount rate is often the single parameter to which estimates of the net present value of stocks are most sensitive (see box 7.3 of the Protocol for discussion of discounting in natural capital valuations).

For examples of how different valuation techniques have been used, see Annex 1 of the Connecting Finance and Natural Capital: Supplement to the Natural Capital Protocol (Natural Capital Coalition, Natural Capital Finance Alliance, VBDO 2018).

7.2.4 Undertake or commission valuation

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 91 FOR GENERAL GUIDANCE

Step 07 of the Forest Products Sector Guide has provided additional guidance to help you value your natural capital impacts and dependencies. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

APPLY STAGE

What is the Apply Stage?

The Apply Stage of the Protocol summarizes the natural capital assessment process by helping you interpret, apply, and act upon your results in your business. It also encourages you to consider how to optimize the value from this and future assessments.

How does the sector guide map to the Protocol?

Table A.1 provides an overview of the questions and actions of the Apply Stage in the Protocol and an outline of the actions for which the sector guide provides additional guidance.

Table A.1:
The Apply Stage: Mapping between the Protocol and the sector guide

Step		Questions this Step will answer	Actions	Additional guidance included in this sector guide?
08	Interpret and test the results	**How can you interpret, validate, and verify your assessment process and results?**	8.2.1 Test key assumptions	**Yes** See page 62 in this guide.
			8.2.2 Identify who is affected	**Yes** See page 63 in this guide.
			8.2.3 Collate results	**No** Revert to Protocol page 97 for general guidance.
			8.2.4 Validate and verify the assessment process and results	**No** Revert to Protocol page 99 for general guidance.
			8.2.5 Review the strengths and weaknesses of the assessment	**No** Revert to Protocol page 101 for general guidance.
09	Take action	**How will you apply your results and integrate natural capital into existing processes?**	9.2.1 Apply and act upon the results	**Yes** See page 64 in this guide.
			9.2.2 Communicate internally and externally	**No** Revert to Protocol page 106 for general guidance.
			9.2.3 Make natural capital assessments part of how you do business	**Yes** See page 69 in this guide.

Additional notes
Businesses operating in the forest products sector should address all of the actions associated with each Step in the Apply Stage. The sector guide provides additional guidance for some of the actions where it is most appropriate.

08 Interpret and test the results

This section of the sector guide provides additional guidance for answering the following question:
How can you interpret, validate, and verify your assessment process and results?

In particular, the sector guide will help you undertake the following action:
8.2.1 Test key assumptions

8.2.2 Identify who is affected

At this point in the sector guide it is important to revisit the outputs of the scoping stage and remind yourself why you did the assessment: what was the objective, who was the audience, who are the stakeholders that were assumed to be affected? Taking a step back from the detail of the Measure and Value Stage will allow you place the results in context and help you prioritize which parts of the results need the most careful testing or scrutiny. For example, if a stakeholder group had been very vocal about a particular environmental impact and the results have shown this impact to be minimal, testing the assumptions around this result would be a priority.

8.2.1 Test key assumptions

There will always be some estimation or approximation involved in a natural capital assessment. You should therefore avoid spurious precision and instead present any numbers in a range or rounded and document your decision to do this.

To understand what level of confidence you can have in your results, you will need to carry out a sensitivity analysis. This involves testing how changes in assumptions or key variables affect the results of an assessment. The Protocol provides an outline of some of the different methods of carrying out a sensitivity analysis as well as some generic assumptions that you can test.

Any natural capital assessment in the forest products sector will involve some estimation and it is important to understand the significance of any assumptions made, especially as the sector is known to be complex, varied, and often lacking in transparency particularly in the supply chain (WRAP 2012). Natural capital assessments that involve upstream or downstream boundaries are often more challenging because of the potential lack of data availability in areas where businesses have less direct operational control or influence. In these situations, testing the sensitivity of key assumptions is even more important. In some cases you may decide to define different scenarios, each with a different set of assumptions. Scenarios can then be assigned a likelihood of occurring which puts the results into context.

Some examples of sector-specific assumptions that you can test as part of a sensitivity analysis are listed in table 8.1.

Table 8.1:
Sector-specific examples of assumptions that can be tested in a sensitivity analysis

Assumptions you can test:	How do my results change if...
Quantity of wood fiber used within a product	A metal or plastic component of my product is swapped for a wood fiber alternative
Sourcing location of key raw materials	The sourcing location changed from one country to another or from a certified forest to a non-certified forest
Magnitude of change in natural capital	Water availability at the pulp processing location is halved
Processing techniques	The chemicals used at a primary or secondary processing plant change
Changes in prices	The price of forest-generated carbon credits increased from USD 5 to USD 10 per ton of CO_2e
Time horizon	The wood fiber was used to make a different product that lasted 10 years longer

8.2.2 Identify who is affected

Distributional analysis is used to understand who is affected by a given activity, whether they gain or lose, and to what extent. You can conduct a distributional analysis to identify which stakeholders gain or lose as a result of your natural capital impacts, and whether they might gain or lose in the future as a result of actions you may choose to take following the natural capital assessment. Distributional analysis is not only an important element of the assessment itself, but also influences how your results should be interpreted and used.

Distributional analysis is particularly important when understanding changes in ecosystem services as a result of the forest products sector's activities. This is because different ecosystem services provide benefits at differing scales, both spatial and temporal. For example: an increase in carbon sequestration or protection of globally important biodiversity are benefits that act at a global scale and over a long timescale, however the actions undertaken to create these benefits may have negative effects in the short term on local populations (e.g., restricted access to forests may prevent cultural and recreational use, and other ecosystem service benefits that accrue locally).

Once you have better understood your natural capital impacts and dependencies – and who they affect at what scale – you may find it helpful to revisit Section 2.2.2 in this guide (Identify stakeholders and the appropriate level of engagement). For example, you may conclude on the basis of the outputs that you do need to engage with a set of stakeholders that you had previously decided would be relatively unaffected.

8.2.3 Collate results

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 97 FOR GENERAL GUIDANCE

8.2.4 Validate and verify the assessment process and results

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 99 FOR GENERAL GUIDANCE

8.2.5 Review the strengths and weaknesses of the assessment

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 101 FOR GENERAL GUIDANCE

Step 08 of the Forest Products Sector Guide has provided additional guidance to help you test the key assumptions of your natural capital assessment. See Appendix 1 for sector-specific hypothetical examples which illustrate how a business may complete this Step.

09 Take action

This section of the sector guide provides additional guidance for answering the following question:
How will you apply your results and integrate natural capital into existing processes?

In particular, the sector guide will help you undertake the following actions:

9.2.1 Apply and act upon the results

9.2.3 Make natural capital assessments part of how you do business

9.2.1 Apply and act upon the results

At this stage in the process, you have framed and scoped your assessment, measured and valued your interaction with natural capital according to a specific objective, and interpreted the results. The next step is to apply the results to inform business decision making processes using the information from this assessment. The application of the results is the real measure of success for your assessment and a crucial step in the Protocol Framework.

This section of the sector guide provides some practical examples of how the results of a natural capital assessment could be applied by businesses operating in the forest products sector. In each example, the sector guide refers back to the relevant business applications (explained in Step 02) that would help your business achieve each outcome.

Practical example 1: Shadow pricing

Shadow pricing is one way to account for risk and the cost of natural capital impacts. A shadow price is an estimated monetary value that is used internally to account for risk or profitability. A natural capital shadow price or valuation might be factored into actual operational costs in a profit and loss statement, included in a discounted cash flow statement for a capital investment, or considered alongside a capital asset on a balance sheet.

In 2016, more than 1,200 companies across the globe (a 23% increase from 2015) disclosed to their key stakeholders that they currently price their CO2 emissions—or intend to in the next two years—to try to manage their climate change risks (CDP 2016).

Companies across many sectors, including consumer discretionary and consumer staples, are using internal carbon pricing to offset the costs and risks of GHG production, and to finance the transition to secure sources of low-carbon energy. This demonstrates the ongoing mainstreaming of carbon pricing as a high priority for business and an essential component of the corporate strategy toolkit (CDP and We Mean Business 2015).

Shadow pricing for carbon has an added dimension for forest products companies that, as well as pricing in potential costs for GHG emissions, may also be able to price in a potential subsidy for carbon sequestration in forests and carbon storage in harvested wood products. In some carbon markets, forest carbon sequestration and storage in wood products is already being recognized and rewarded such as the California cap-and-trade market (California Air Resources Board 2012).

Relevant business applications: Compare options, Estimate total value and/or net impact

Practical example 2: Sourcing, procurement, and supply chain management

For many businesses operating in the forest products sector, a significant proportion of their natural capital risks and opportunities reside in the forest production stage of the value chain as noted in Figures 4.3, 4.4 and 4.5.

Practical ways to apply natural capital assessments include supply chain risk assessments, strategic sourcing or hedging of commodities, supplier relationship management, and sustainable procurement strategies and guidelines for buyers and suppliers.

The starting point for any company is a supply chain risk assessment that identifies which natural capital impacts and dependencies are material to the business and where they occur. This could involve measuring impacts and dependencies in physical terms or applying monetary valuations so that they can be compared in a common metric and prioritized.

Armed with this information, forest products companies can begin to build a more risk resilient supply chain and identify opportunities for increased competitive advantage. One of the most fundamental supply chain risks faced by this sector is the depletion of viable sources of wood; for example, a WWF report (WWF 2016a) indicates that up to two-thirds of UK furniture retailers have failed to adopt or publicly communicate robust sustainable sourcing policies for the procurement of timber they use to make their products. In doing so, they could be threatening the very resources upon which their business depends and by extension the long-term security of their business model. As well as ensuring the future viability of their supply chain, the adoption and communication of responsible timber sourcing policies can enhance their reputation by driving customer loyalty and attracting new, more environmentally conscious customers.

Key strategies could therefore include gaining third-party certification, publishing a responsible timber sourcing policy and ensuring this is communicated to all stakeholders, ensuring that all suppliers are aware of the company's supply chain requirements through training and guidance notes, and collaborating with suppliers, industry bodies, environmental groups, and industry peers to create a level playing field to help source responsibly. You can refer to Sustainable Procurement of Forest Products for further guidance on developing and implementing wood and paper-based procurement policies (WBCSD and WRI 2007-2016).

Relevant business applications: Assess risks and opportunities, Compare options, Assess impacts on stakeholders

Practical example 3: Product alternatives and design

Another way to operationalize natural capital assessments is in the choice and design of products. Many forward-thinking companies already use life-cycle impact assessments (LCIAs) to quantify and reduce impacts associated with sourcing, manufacturing, use, and disposal of products.

Natural capital valuation can enhance LCIAs by converting physical impacts into monetary values, which are more readily understood by a business audience and more accessible to a wider stakeholder base. Water, for instance, will be more valuable in an arid region of the world compared to a region which is water abundant.

There are many opportunities for businesses to transition to a more circular business model; one which is less dependent on primary energy and material inputs. Sustainable product choice and design can play an important role in unlocking new revenue streams.

A key advantage of the sector lies in its capacity to maximize resource efficiency through the "cascading use" of wood. This concept refers to a strategy to use raw materials such as wood, or other biomass, in chronologically sequential steps as long, often, and efficiently as possible for materials and only to recover energy from them at the end of the product life cycle (WWF 2016b). For instance, forestry waste can be used for biochar production, biomass incineration, or left on-site to prevent soil erosion, return nutrients to the soil, and provide habitats for wildlife (Smith 2013). Similarly, in pulp and paper mills and sawmills, waste products from wood fiber inputs are burned to supply a high percentage of the energy requirements for production.

A natural capital assessment can be used to demonstrate other value created in the product value chain that goes beyond the price of the product itself (i.e., a forest product may be more expensive than an alternative, but may actually create significant benefits throughout the value chain.) In some cases, the choice of forest products over more typical alternatives can lead to lower social and environmental impacts accompanied by financial benefits. For example, a construction company looking to build houses may choose to use timber instead of steel and concrete as a primary construction material and thereby realize benefits for the company and consumer alike. This can include: lower construction costs (e.g., reduced material and labor costs), a lower environmental impact and use of a renewable resource, enhanced performance (e.g., withstanding earthquakes) and visual amenity, reduced running costs for owners and occupiers, and increased potential for reuse and recyclability (Kremer and Symmons 2015).

Relevant business applications: Compare options, Estimate total value and/or net impact, Assess risks and opportunities

Practical example 4: Testing the business case for a change in management practices

A large global forest products company, for example, may want to consider changing management practices (e.g., to gain third-party certification) throughout its production sites, but experience resistance from investors or internal stakeholders concerned by implementation costs. Through conducting natural capital valuation on a scenario compared to the current baseline, the company may be able to illustrate that the avoided risks and captured opportunities outweigh the costs. To ensure all potential benefits are accounted for in all natural capital assessments, particularly those concerned with changing management practices, it will be important for forest products companies to extend the scope of their valuation beyond their impacts on biodiversity to include their impacts on wider ecosystem services.

Possible business cases for companies to consider when deciding how to manage their stocks of natural capital could include potential future payments for ecosystem services (e.g., carbon sequestration, watershed services), avoidance of operational delays (e.g., floods cutting off access to production sites), avoidance of fines and suspensions through non-compliance with regulatory requirements, enhanced brand value and increased customer willingness to pay, avoidance of customer boycotts or financial institutions withdrawing funding due to malpractice, avoidance or mitigation of devastating pest outbreaks and forest fires, and reduced insurance premiums.

Relevant business applications: Compare options, Estimate total value and/or net impact, Assess risks and opportunities

Practical example 5: Scenario planning

Businesses in the forest products sector can use natural capital assessments to inform decisions such as where to invest capital, whether to withdraw and divest assets, how to protect the business against anticipated challenges (e.g., increased energy and resource prices, climate regulation, biodiversity values), or how to weigh environmental constraints and opportunities for new or different business models.

A global pulp supplier may want to expand its operations in a way that is both cost effective and beneficial for its reputation among local stakeholders and its wider consumer base. The company is looking to site production close to growing urban centers to have proximity to a large and growing pool of consumers, for access to well-developed labor markets, and to reduce transportation costs and environmental impacts. By assessing the natural capital value of the significant dependencies for the company and the significant impacts on the urban population, such as water and clean air, the company may gain an insight into where best to expand. For instance, the costs of planting on nearby degraded agricultural land as opposed to planting on previously natural forest, may be justified by the additional value created in providing clean air to the urban population. Similarly, the extra initial cost and effort of sourcing a water supply which will not impact future municipal needs may be recouped through avoided reputational damage, operational delays, and consumer boycotts.

Another business might value natural capital to consider the feasibility of vertically integrating operations, for instance a plantation owner who buys a pulp and paper mill, knowing that the wood residues generated by their forest production sites can be used to power pulp and paper processes more effectively than competitors who rely on more expensive energy inputs.

When using scenario planning to manage natural capital risks, companies should use forward-looking models or scenarios to identify the likelihood and severity of future risks, and use robust datasets to support this analysis (Ceres 2015).

Relevant business applications: Compare options, Estimate total value and/or net impact, Assess risks and opportunities

Practical example 6: Disclosure

Although the Protocol is not a reporting framework, businesses may choose to report the findings of their natural capital assessments. Sustainability reporting, on the whole, can provide investors and civil society with an insight into the stewardship of natural resources, and into which companies are most transparent about performance. For companies, better disclosure can lead to better stewardship, which in turn can help increase efficiency and operational performance, and mitigate both reputational and operational risks that might have material financial impacts on their business (Nielsen 2015). In some cases the primary aim of natural capital assessments may be to raise awareness of issues and educate business users, consumers, and investors.

Relevant business applications: Communicate internally and/or externally

What future natural capital assessments are worthwhile?

A natural capital assessment can and should lead to new ways of thinking about how your business relates to the natural environment. For example, it may flag significant dependencies on ecosystem services that you were not aware of, or reveal previously unrecognized risks or opportunities associated with the indirect impacts of your business on society. In extreme cases, a natural capital assessment may fundamentally challenge your existing business model. In general, as you begin to include natural capital more systematically in your decisions, more and more of your business will be affected.

Applying the results of your assessment for one specific business application may have already generated ideas about additional business decisions that could be improved by a natural capital assessment. These ideas could be based upon what is most material (as identified in Step 04) or it might focus on new and unexpected natural capital impacts and dependencies that were revealed in your first assessment. Table 9.1 provides some ideas for undertaking further assessments in the forest products sector, including exploring new business opportunities, expanding the scope of your assessment, or broadening your assessment to include different types of value.

Table 9.1:
Examples of future assessments in the forest products sector

If you've already considered...	Could you now consider...?
Your direct operations	Impacts and dependencies of upstream (such as the supply chain of your products) or downstream activities (such as consumer use phase and especially at the end-of-life stage)
An impact assessment	Inclusion of dependency assessment, such as raw material provision, or regulating services required
A qualitative assessment	Quantifying impacts and dependencies, and/or applying monetary valuation techniques
A process improvement at a particular site	Rolling out this improved technique to all applicable production/processing sites
A particular key resource input	All resource inputs included within your production and processing stages
Business impacts	Considering the wider social implications, such as health impacts to neighboring communities at site of impact
One environmental indicator	Expanding the assessment to incorporate all the material impacts and dependencies of your assessment scope (for instance progressing from focusing on biodiversity impacts to wider ecosystem service impacts)
Internal sustainability performance metrics	Joining an (internationally) accredited certification scheme

9.2.2 Communicate internally and externally

FOR THIS ACTION, REVERT TO THE PROTOCOL PAGE 106 FOR GENERAL GUIDANCE

9.2.3 Make natural capital assessments part of how you do business

Any measure of success in the uptake of natural capital assessments would be evidenced in improved risk management, increased competitive advantage, and more informed decision making (Natural Capital Coalition 2016). Step 01 to Step 09 of the sector guide help demonstrate how these outcomes can be achieved through applications of the Protocol in the forest products sector. However, in order to truly unlock the value associated with more informed decision making, it is important that your natural capital assessment is not a one-off exercise, and that the results become embedded in the way you do business.

This poses a challenge as a radical shift in mind-set is needed if businesses are to adapt to the risks and opportunities that natural capital presents. In 2010, for example, a United Nations Principles of Responsible Investment (UNPRI) report revealed that the annual economic costs of natural resource depletion and pollution impacts linked to business activity equated to USD 6.6 trillion or 11% of global GDP. In addition, the research calculated that more than 50% of company earnings were at risk from environmental costs in an equity portfolio weighted according to the MSCI All Country World Index (MSCI 2017). Economy-wide, these risks are sufficiently large that the 2018 World Economic Forum's Global Risks report cites extreme weather events and temperatures; accelerating biodiversity loss; pollution of air, soil and water; failures of climate-change mitigation and adaptation; and transition risks as we move to a low-carbon future among the most pressing environmental challenges faced by economies (World Economic Forum 2018).

However, where there is risk, there is opportunity. Businesses using traditional decision-making processes to cope with the uncertainty posed by these economic, social, and environmental issues may find themselves playing catch-up with more forward-thinking competitors in the future.

Ultimately, we need new corporate thinking that:

- Identifies the material impacts and dependencies that businesses have on nature and society;
- Makes the connection between financial capital, natural capital, social capital, commercial opportunities, and business risk; and
- Integrates this information into decision making, strategies, business models, and reporting.

This section of the sector guide concludes with some key recommendations on how forest products companies can ensure natural capital becomes embedded in business decision making so that they can respond to the opportunities and risks that it may pose.

Continue to strengthen the business case for natural capital:

- Corporate board members have a fiduciary duty for risk management oversight. As such, board charters should be strengthened to explicitly mention natural capital to increase board oversight and understanding of material natural capital risks (Ceres 2015).
- Traditional approaches to strategy (analyzing trends, making forecasts, and committing to an appropriate course of action) are not calibrated to the uncertainty of a resource-constrained world. Engage board members by facilitating debate about how natural capital relates to your strategy, business model, performance, and social license to operate.

Continue to measure and value:

- Continue to explore the most appropriate methodologies and help shape evolving standards for measuring and valuing your natural capital impacts and dependencies.
- Engage with suppliers, customers, and other important stakeholders to better understand how your business is impacting critical natural resources and continue to identify risk "hotspots" across the value chain.
- Ensure that you continue to identify ways to expand your measurement and understanding of material natural capital impacts and dependencies and associated risks and opportunities.

Explore linkages with new and existing business processes:

- Ensure that information on natural capital is integrated with other business management systems, including financial and management accounting, to help prioritize where natural capital will drive management action.
- Consider how material natural capital issues could be integrated into reporting to external stakeholders including investors.
- Consider incorporating the collection of data for your natural capital assessment into existing data collection and reporting processes (e.g., those required by certification).

Continue to develop knowledge and strengthen collaboration:

- Develop the relevant skills internally to enable natural capital assessments to be conducted and communicated with the same rigor as for financial and business accounts.
- Collaborate with stakeholders, relevant experts, and specialists in the sector to increase your awareness of natural capital impacts and dependencies and their relationship with your business.
- Influence the global debate through links with international and professional organizations.

Step 09 of the Forest Products Sector Guide has provided additional guidance and recommendations to help you take action and embed the results of your natural capital assessment in business decision making. See Appendix 1 for sector-specific hypothetical examples illustrating how a business may complete this Step.

Appendix 1: Hypothetical company examples

Step		Company 1	Company 2	Company 3	Company 4	Company 5
01 **Get started**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	Organization	Global integrated pulp and paper and packaging company headquartered in Latin America.	North European biomass-energy company.	North American lumber company.	Multinational personal care products manufacturer producing tissues, toilet paper, utility wipes, disposable diapers, etc.	SME company involved in cork value chain, both harvesting and processing.
	Context	The company sources eucalyptus from third-party and its own plantations and operates pulp and paper mills and paper convertors in Brazil. **The company is planning to construct a new pulp and paper mill in Brazil and wants to compare this option with expanding capacity at its current operations, with regards to impacts on local stakeholders and dependency of wood fiber supply, as well as water supply.**	The company is engaged in electricity generation, energy supply, and compressed wood pellet manufacturing. Responsible for a significant percentage of its country's domestic energy needs. **The company has not yet conducted an analysis of its net environmental impacts and would like to have quantifiable impacts to share with policymakers.**	The company wants to understand how changing their management practices to a system that mimics natural disturbances will affect their stock of natural capital. **The company would like to compare the expected future ecosystem service flows of their current practices with those they can expect under a natural-disturbances-based management regime** (a management system intended to maintain ecological resilience by understanding the natural forest dynamic).	The company is facing stability of supply and environmental impacts concerns in regards to its wood fiber sourcing. **The company would like to compare potential locations for sourcing softwoods to mitigate potential future risks around stability of supply and reputational risks around environmental impact.**	The company is involved in the processing and supply of cork. **They are interested in applying a natural capital approach to identify market opportunities and design a mechanism to foster and capture the positive values of their products over alternatives on the market.**
	Which risks and opportunities might a natural capital assessment help to address?	Operational risk from disruptions in wood or water supply. . Opportunity to establish a robust social license to operate.	Biomass acceptability risks could be mitigated with a better public understanding of the impacts. Opportunity to make sourcing decisions on a more informed basis.	Opportunity to improve reputation with local stakeholders.	Financial and operational opportunity from supply chain stability. Reputational risks of inaction. Opportunity for competitive advantage over other brands.	Marketing and reputational opportunities through the recognition of the benefits of their products.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
02 **Define the Objective**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	What is the intended business application?	Assess impacts on business and stakeholders, as well as compare options.	Communicate internally and/or externally.	Compare options.	Compare options.	Compare options. Communicate internally and externally.
	Who is the targeted audience?	Senior management.	Regulators.	The finance and forest management teams.	Procurement team.	Customer.
	Who are the right stakeholders and what is the appropriate level of engagement?	Consult with NGOs and local communities living in the vicinity of prospective and existing mills, and the procurement department.	Inform regulators of assessment and progress.	Consult internal forest management staff and local stakeholders, including conservation organizations and local authorities'	Consult first-tier suppliers. Local and global conservation organizations.	Suppliers, conservation organizations, standard setters.
	What specific benefits do you anticipate from the assessment?	The assessment will help decision makers choose an expansion option that minimizes reputational and operational risks.	Assessment will allow for informed engagement with national and regional policymakers who may otherwise restrict wider biomass use.	The assessment will allow the forest management division to communicate the natural capital benefits that the change in management system will provide. This will facilitate their buy-in given the costs associated with changing practices.	The assessment will identify the stability and environmental risk level of different sourcing regions that can inform procurement decision making and reduce future costs associated with reactive changes in supply base.	Market share and additional revenues to invest in enhancing the natural capital values.
	What is the specified objective?	To identify the company's lowest negative/highest positive impact option for expansion.	To communicate to policy makers the net environmental impact of the use of biomass in order to inform legislative decision making.	To decide between different management practices.	To prioritize certain suppliers over others for future procurement needs and to identify possible supply chain risks that could be mitigated through collaboration with suppliers and other stakeholders.	To quantify and value the natural capital impacts of two specific products vs. their market alternatives. Identify design mechanisms to capture positive values and incorporate them into first stages of the value chain.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
03 Scope the assessment	*Company Name*	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	What organizational focus?	Project.	Product.	Corporate.	Corporate.	Product.
	Which value-chain boundary?	Own operations: prospective and existing mill sites.	Own operations and upstream.	Own operations.	Upstream.	Upstream and operations.
	Will the assessment cover impacts and/or dependencies?	Both.	Impacts.	Both.	Both (predominantly dependencies).	Impacts.
	Which value perspective?	Business and society.	Society.	Business and society.	Business and society.	Society.
	What types of value?	Monetary.	Quantitative.	Quantitative.	Monetary.	Monetary.
	Baselines	Expansion of existing plant.	The natural capital impacts of full life cycle of the different energy products offered by the company in a chosen year.	The current estimation of the natural capital stock of the forest estate.	The natural capital impacts and dependencies of the company's supply chain in a chosen year.	The natural capital impacts of the chosen product's value chain.
	Scenarios	Construction of a new site close to sawmills to be supplied by wood residues as energy source.	The natural capital impacts of an alternative energy source used for a significant part of the country's domestic energy needs.	The estimation of the natural capital stock under the new management scenario.	Alternative scenarios considered for different sourcing locations or different management practices (e.g., certified practices) in current sourcing locations.	An alternative, non-forest based product to compare the impacts against.
	Spatial boundaries	Regional boundaries around existing site and new site location based on potential areas affected by different impacts (water and air pollution, additional plantation areas, new transport infrastructure etc.).	Locations impacted by own operations and supply chain operations.	The forest estate and neighboring locations impacted by the estate's operations.	Locations impacted by supply chain operations.	Locations impacted during the full life cycle of the products.
	Time horizons	The lifetime of the plant.	Time needed to produce equivalent amounts of energy from biomass and from the alternative source. Length of time that the impacts are estimated to perpetuate for.	50+ years.	Length of time that impacts are estimated to perpetuate for.	The estimated life time of the product.
	Key planning issues to consider (for example, resource and time constraints)	Resources were assembled internally and potential data points for the two scenarios were designed by engagement with senior management.	The company has limited data on its suppliers, a third-party consultant was used to assist in secondary data modeling.	External consultant was hired but significant internal resources were also mobilized to work with consultants.	Internal resource was mobilized to undertake supplier engagement to understand current practices.	Support from a research institute was received but significant internal resources were also mobilized to work on the assessment.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
04 **Determine the impacts and/or dependencies**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	Summarize the key decisions on the materiality process, including who was involved	**What stakeholder engagement was carried out?** Local suppliers, NGOs, public authorities, academia, and local communities living in the vicinity of existing and prospective mill site were engaged. **What criteria were used to compare relative materiality?** Operational and societal. **What data were gathered?** Publicly available data on the social and environmental contexts of the two locations, internal data on mill operations, local community survey data.	**What stakeholder engagement was carried out?** Public authorities. **What criteria were used to compare relative materiality?** Societal materiality to understand and communicate the extent of positive impact delivered. **What data were gathered?** Internal supply chain data analyzed .	**What stakeholder engagement was carried out?** Some engagement with local government, NGOs, and academia. **What criteria were used to compare relative materiality?** Financial and societal . **What data were gathered?** Current ecosystem service provision and current changes and trends in ecosystem services.	**What stakeholder engagement was carried out?** Environmental specialists were consulted to better understand the dependencies associated with raw materials sourcing locations. **What criteria were used to compare relative materiality?** Financial, including future projected materiality to understand the extent to which the dependencies might change over time. **What data were gathered?** First-tier supplier location data were reviewed and compared against publicly available environmental risk tools and vulnerable ecosystem mapping analyses.	**What stakeholder engagement was carried out?** Some engagement with conservation organizations, standard setters, certifying bodies, and suppliers. **What criteria were used to compare relative materiality?** Societal materiality of the impacts. **What data were gathered?** Internal processes, supplier information, and Life Cycle Assessment databases.
	List the material impact drivers and/ or dependencies that will be brought forward to the Measure Value Stage	Wood fiber and water provisioning deemed most material dependencies. Disturbances (noise and odor) and air pollution were deemed the most material impacts.	Impacts around carbon sequestration and greenhouse gas emissions found to be most material.	Dependencies on wood fiber. Impacts on carbon sequestration and biodiversity.	Consumptive dependencies on wood fiber and water are most material.	Impacts around GHG and air pollution, as well as land use, water, and energy consumption.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
05 **Measure impact drivers and/or depend-encies**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	Specific impacts / dependencies	Impacts: • Noise • Odor • Air pollution Dependencies: • Wood fiber • Water use	Impacts: • Carbon sequestration • GHG emissions	Impacts: • Carbon sequestration • Biodiversity Dependencies: • Wood fiber	Dependencies: • Wood fiber • Water	Impacts: • GHG emissions • Air pollution • Land use • Water consumption • Energy consumption
	Quantitative/ qualitative indicator	Impacts: • Noise: Decibels of noise during operation (dB) • Odor: Odor units per cubic meter (ou/m^3) • Air pollution: Tons of SO_2, NO_x, CO, NH_3, VOCs and particu-late matter (PM) emis-sions Dependencies: • Wood fiber: Cubic me-ters of wood fiber (m^3) • Water: Cubic meters of water (m^3)	Impacts: • Carbon sequestration: Tons of CO_2 • GHG emissions: Tons of CO_2	Impacts: • Carbon sequestration: Tons of CO_2 • Biodiversity: Number of species per Hectare Dependencies: • Wood fiber: cubic meters of wood (m^3)	Dependencies: • Wood fiber: Cubic meters of wood produced (m^3) • Water: Cubic meters of water consumed (m^3)	Impacts: • GHG emission: Tons of CO_2 • Air pollution: Tons of SO_2, NO_x, CO, NH_3, VOCs and par-ticulate matter (PM) emissions • Land use: Hectares land used (Ha) • Water consumption: Cubic meters of water (m^3) • Energy consumption: Gigajoules of energy (GJ)
	Data sources	Existing data from the Environmental Management System of an existing plant offers a basis for extrapolation of an assessment at the new site. Also water scarcity maps and wood outlook reports.	Information from suppliers, complemented by Environmental Extended Input-Output databases (EEIO).	Field measurement, and estimation based on internal knowledge and historical data. Published literature. Ad-hoc modelling.	For wood fiber: Market and scientific reports. For water and energy: First tiers suppliers data and location specific water scarcity maps.	Data from operations and life cycle inventory data.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
06 **Measure changes in the state of natural capital**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	Approach for estimating natural capital change	Impacts: • Noise: modelling approach. • Odor: atmospheric dispersion modelling. • Air pollution: atmospheric dispersion modelling. Dependencies: • Wood fiber: published literature about forest trends and long term changes in wood fiber. • Water use: published hydrological models used to estimate availability of water.	Impacts: • Carbon sequestration and GHG emissions: The company re-vised literature to have a better understanding of the scale and magnitude of climate change, the relative contribution of the company, the energy sector and the country, as well as other external factors and trends.	Impacts: • Biodiversity: Basic populations dynamic modelling approach. Dependencies: • Wood fiber: Modelling resilience of forest against potential disturbances (fires, diseases, invasive species, etc.).	Dependencies: • Wood fiber: Published information about long term changes in forest productivity due to climate change and other external factors. • Water: published hydrological models used to estimate availability of water.	Impacts: • All impact categories: Simplified modelling by using life cycle characterization factors (midpoint & endpoint factors).
	Quantitative/ qualitative indicator	Impacts: • Noise: increase in hourly average level of noise during operations. • Odor: increase of odor concentration. • Air pollution: increase in atmospheric concentration of SO_2, NO_x, CO, NH_3, VOCs and PM. Dependencies: • Wood fiber: Long term changes (over 30-40 years) on wood fiber availability due to changes in precipitation, fires frequency, etc. • Water use: Long term changes (over 30-40 years) on water availability due to changes in precipitation.	Impacts: • Carbon sequestration and GHG emissions: Change in concentration of CO_2 in atmosphere.	Impacts: • Carbon sequestration: Change in concentration of CO_2 in atmosphere. • Biodiversity: change in the number of species per Hectare. Dependencies: • Wood fiber: changes in availability in wood fiber (over 50 years) due to changes in precipitation, fires frequency, pests.	Dependencies: • Wood fiber: Changed availability in wood fiber (average over 50 years) due to changes in precipitation, fires frequency, pests, etc. • Water use: changed availability of water (average over 50 years) due to long term changes in precipitation.	Impacts: • GHG emission: Change in concentration of CO_2 in atmosphere. • Air pollution: increase in atmospheric concentration of non-GHG pollutants. • Land use: increase in land use change. • Water consumption: change in availability of water resources.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
07 **Value impacts and/or dependen-cies**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	Valuation approach	Impacts: • Noise: mitigation cost. • Odor: contingent valuation. • Air pollution: damage cost. Dependencies: • Wood fiber: market prices. • Water use: replacement cost (e.g. desalination plant).	IImpacts: • Carbon sequestration: percentage of change of carbon sequestered between scenarios. • GHG emissions: percentage of change of GHG between scenarios.	Impacts: • Carbon sequestration: percentage change of carbon sequestered between scenarios. • Biodiversity: percentage of change on number of species/hectare. Dependencies: • Wood fiber: percentage of change of wood fiber production.	Dependencies: • Wood fiber: Market prices and production function. • Water: Value transfer.	Impacts: • All impact categories: Value transfer based on several valuation techniques (contingent valuation, damage cost, abatement costs, etc.).
	Value	Impacts: • Noise: Plant Expansion: US $ 0.3M; New site: US $ 0.02 M. • Odor: Plant expansion: US $ 0.1 M; New site: US $ 0.05 M. • Air pollution: Plant expansion: US $ 1.1 M; New site: US $ 0.6 M. Dependencies: • Wood fiber: Plant expansion: US $ 420 M; New site: US $ 38 M. • Water use: Plant expansion: US $ 40 M; New site: US $ 60 M.	IImpacts: • Carbon seques-tration: 8% in-crease of carbon seques-tered. • GHG emis-sions: 12% de-crease in GHG emission.	Impacts: • Carbon sequestration: 5% increase of carbon sequestered. • Biodiversity: 18% increase on number of species/hectare. Dependencies: • Wood fiber: 4% increase on wood fiber production.	Dependencies: • Wood fiber: an increase in 4% of revenues from provisioning from alternative sources. • Water: A decrease of 2% on water supply costs.	Impacts: • All impact categories: A reduction of US$ 1.2 of external cost per square meter of laminated cork, compared to other alternative products. A reduction of US$ 11 of external cost per per1,000 cork stoppers compared to bottle caps made with alternative materials.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
08 **Interpret and test the results**	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	What assumptions were tested?	• Water scarcity scenarios. • Parameters of dispersion models. • Disturbances valuation figures.	Different management practices and sourcing regions/ species were tested.	Frequency and magnitude of natural disturbances.	Different climate change scenarios.	CO_2 and biodiversity valuation approaches.
	Who is the audience of the results?	Local stakeholders and company senior management.	National authorities.	Finance and forest management teams, as well as local communities	Own business.	Customers.
	Validation/ verification	External: A panel of key local stakeholders followed and agreed with the assessment process.	External: an external auditing firm verified that the assessment process was fit for purpose.	Initially an internal validation process was done. Afterwards, a multi-stakeholder workshop was organized to validate results.	Internal verification by risk department.	Multi-stakeholder consultation process conducted to provide feedback about the assessment and assumption used.
	Strengths and weaknesses of the assessment	Strengths: comprehensiveness of the assessment. Weakness: some uncertainties associated with disturbance modeling and their valuation process.	Strengths: assessment is based on well recognized methodologies. Weakness: data for supplying sources are based on a number of assumptions.	Strengths: the inclusion of biodiversity and ecosystem services assessment allowed for a systems approach to explore the connections between these aspects. Weakness: uncertainties about biodiversity and habitat evolution in the future.	Strengths: long-term and integrated perspective (climate change and water). Weakness: uncertainties around future climate scenarios.	Strengths: as the company is involved in several stages of the value chain, most of the data to build the baseline scenarios came from primary sources Weakness: The use of characterization factors and value transfer factors is weak in terms of local contextual factors.

Step		Company 1	Company 2	Company 3	Company 4	Company 5
09 Take action	Company Name	**Continental Paper Co.**	**Biomex**	**Northern Lumber Inc.**	**Whitford Wipes**	**SpaCork**
	Business benefit	Well informed decision based on reliable information about relative importance of different impacts and dependencies Good understanding of impacts on local communities. An action plan to inform communities was set up, resulting in a decreased level of local opposition, and helped build the license to operate. Improved engagement with potential funders.	Reputational benefits from the provision of information about the benefits of biomass use, especially useful in informing regulators about the advantage of biomass as a source of energy.	Access to reliable information to internally consider a strategy towards new forest management practices.	Reduced risk of supply and operational costs.	More effective communication with customers and finance community. Access to additional resource to improve sustainability practices in the supply stage.
	Business decision	Construction of a new plant including incorporation of some precautionary measures in its design to minimize the impact on local and regional communities.	The information helped the company make better decisions about the source of the supply.	Start applying new forest management practices.	Change of supplying sources.	Market price strategy to capture the growing demand of sustainable products and reinvestment of extra revenues in improving sustainable practices during harvesting stage.
	Potential future assessments *Further embedding opportunities*	The company decided to design an indicator dashboard system for all their facilities to identify key installations that require some corrective actions to reduce future natural capital risks.	Expansion of the analysis to include other impacts and dependencies within the scope of the assessment.	Use natural capital assessments to inform the new long-term strategy of the company.	Expand the assessment to include dependencies on biodiversity.	Expand assessments to include material dependencies within the scope.

Appendix 2.a:
Justification for color coding in figure 4.3: Forest production impacts

The numerical references in this appendix refer to the cell numbers in figure 4.3.

Cell	Activity	Impact driver	Code	Justification
				Pre-establishment
A1	Zoning or low impact forest management	Carbon sequestration		Protecting high conservation value (HCV) areas as reserves may have a positive impact on carbon sequestration over time
A4	Zoning or low impact forest management	Water pollutants		The establishment of buffer zones has repeatedly been shown to be highly effective for protecting water quality
A10	Zoning or low impact forest management	Fiber		Protecting natural habitats may increase the availability of fiber for local communities depending on access
A11	Zoning or low impact forest management	Food and fuel		Protecting natural habitats may increase the provision of food and fuel types for local communities depending on access
A12	Zoning or low impact forest management	Fresh water (groundwater)		Protecting natural habitats can secure the watershed protection function of forests
A13	Zoning or low impact forest management	Fresh water (surface water)		Protecting natural habitats can secure the watershed protection function of forests
A14	Zoning or low impact forest management	Biochemicals, natural medicines, and pharmaceuticals		Protecting natural habitats can allow for the protection of important naturally occurring biochemicals, natural medicines, pharmaceuticals, etc.
A15	Zoning or low impact forest management	Regulation of air quality		Protecting high conservation value and other forest may help to clean polluted air by filtering and trapping pollution particles with attendant benefits for local flora and fauna
A16	Zoning or low impact forest management	Regulation of local, regional, and/or global climate		Protecting natural habitats will likely facilitate natural landscape regulation of local climate
A17	Zoning or low impact forest management	Regulation of water timing and flows (groundwater)		Protecting natural habitats can secure the watershed protection function of forests
A18	Zoning or low impact forest management	Regulation of water timing and flows (surface water)		Protecting natural habitats can secure the watershed protection function of forests
A19	Zoning or low impact forest management	Soil erosion control		Protecting natural habitats can secure the erosion control function of forests
A20	Zoning or low impact forest management	Water purification and waste treatment (groundwater)		Protecting natural habitats can secure the watershed protection function of forests
A21	Zoning or low impact forest management	Water purification and waste treatment (sur-face water)		Protecting natural habitats can secure the watershed protection function of forests
A22	Zoning or low impact forest management	Regulation of soil quality		Protecting natural habitats can maintain the natural soil quality in these areas
A23	Zoning or low impact forest management	Regulation of pests and diseases		Protecting natural habitats can maintain the natural heterogeneity required to regulate pests and disease in these areas
A24	Zoning or low impact forest management	Pollination		Protecting natural habitats can maintain the natural heterogeneity required to regulate pollination in these areas
A25	Zoning or low impact forest management	Regulation of natural hazards		Protecting natural habitats can maintain the functionality of natural hazard regulation in these areas (e.g., protecting against mudslides)
A26	Zoning or low impact forest management	Recreation and nature-based tourism/educational and spiritual values		By protecting areas of high conservation value, areas particularly valuable to tourists are also likely to be conserved

Appendix 2.a continued:
Justification for color coding in figure 4.3: Forest production impacts

Cell	Activity	Impact driver	Code	Justification
A27	Zoning or low impact forest management	Change in habitat/ biodiversity: Flora		Native and natural habitats zoned for protection will increase undisturbed area available for species
A28	Zoning or low impact forest management	Change in habitat/ biodiversity: Fauna		Maintaining connectivity and preventing isolated islands of native or natural habitats can have a significant positive impact on fauna (e.g., by maintaining migration routes)
B2	Sourcing trees locally	GHG emissions		Increased GHG emissions due to transportation impacts; this will vary according to both the distance travelled and the mode of transport used
B3	Sourcing trees locally	Non-GHG air pollutants		Increased non-GHG emissions due to transportation impacts; this will vary according to the distance travelled, the mode of transport, and fuel source used
C2	Sourcing trees from abroad	GHG emissions		Increased GHG emissions due to transportation impacts; this will vary according to both the distance travelled and the mode of transport used
C3	Sourcing trees from abroad	Non-GHG air pollutants		Increased non-GHG emissions due to transportation impacts; this will vary according to the distance travelled, the mode of transport, and fuel source used
C27	Sourcing trees from abroad	Change in habitat/ biodiversity: Flora		If trees are sourced from abroad there is a risk of invasive species and other pests being transported with the trees
C28	Sourcing trees from abroad	Change in habitat/ biodiversity: Fauna		If trees are sourced from abroad there is a risk of invasive species and other pests being transported with the trees
D2	Constructing roads & railroads	GHG emissions		The industrial processes required to construct roads and railroads may lead to the release of GHG emissions
D3	Constructing roads & railroads	Non-GHG air pollutants		The industrial processes required to construct roads and railroads may lead to the release of non-GHG air pollutants
D4	Constructing roads & railroads	Water pollutants		Roads and railroads can act as conduits of pollutants into water sources via runoff; the physical construction of roads could also lead to water pollution due to oil or fuelspillages, construction debris
D5	Constructing roads & railroads	Soil pollutants		May lead to soil pollution via the various substances required to construct the road and possible spillages/debris from ongoing road usage (pollutant substances include oil or fuel spillages, and construction debris)
D6	Constructing roads & railroads	Solid waste		Solid waste left by construction personnel (e.g., plastic) or from machinery if maintenance takes place in the forest (e.g., filters, cables)
D19	Constructing roads & railroads	Soil erosion control		Poorly designed roads and railroads may lead to soil erosion
D26	Constructing roads & railroads	Recreation and nature-based tourism/educational and spiritual values		May increase access to areas for education and public enjoyment. Or may negatively affect the spiritual value of a location
D27	Constructing roads & railroads	Change in habitat/ biodiversity: Flora		Constructing roads and railroads can open up access routes for illegal deforestation to take place, although controlling access to forest sites can reduce this risk
D28	Constructing roads & railroads	Change in habitat/ biodiversity: Fauna		Constructing roads and railroads can open up routes for poachers to enter forested areas (e.g., bushmeat hunting of threatened species), although controlling access can reduce this risk
E1	Use of nurseries for seedling production	Carbon sequestration		Seedling production may lead to an increase in carbon sequestration
E4	Use of nurseries for seedling production	Water pollutants		Nurseries can act as a point source for intensive chem-ical use, resulting in discharge to soil
E5	Use of nurseries for seedling production	Soil pollutants		Nurseries can act as a point source for intensive chem-ical use, resulting in discharge to soil
F2	Prescribed burning [may also apply to management]	GHG emissions		Burning leads to increased GHG emissions *BIOME VARIATION: Impact varies greatly depending on soil type and region (e.g., peatland, such as that in Southeast Asia, has a very high carbon content and so burning has a high negative impact)*
F3	Prescribed burning [may also apply to management]	Non-GHG air pollutants		Burning leads to the release of non-GHG air pollutants
F22	Prescribed burning [may also apply to management]	Regulation of soil quality		Carrying out prescribed burning may alter soil organic carbon levels which can affect soil quality
F25	Prescribed burning [may also apply to management]	Regulation of natural hazards		Carrying out prescribed burning can alter the ability of the forest to protect against natural hazards e.g. soil with a lower organic carbon content may be less effective as mitigating mudslides
G2	Tilling soils	GHG emissions		Results in the release of below-ground carbon. Operation of tilling machinery will also release GHG emissions. Nevertheless, increased fertility can increase soil carbon/ organic matter and increase above-ground carbon

Appendix 2.a continued:
Justification for color coding in figure 4.3: Forest production impacts

Cell	Activity	Impact driver	Code	Justification
G3	Tilling soils	Non-GHG air pollutants		Non-GHG air pollution could likely take place via the machines used to till soils
G4	Tilling soils	Water pollutants		Tilling soils may cause sediment leaching into water ways
G12	Tilling soils	Fresh water (groundwater)		Tilling soils may impact the way water moves through a forestry system
G19	Tilling soils	Soil erosion control		Tilling soils may disturb soil compaction and lead to erosion and sediment leaching
H2	Establishing drainage systems	GHG emissions		Ground preparation work required to establish drainage systems could result in release of below-ground carbon. If work is mechanized, GHG emissions are also emitted via the machines used to establish the drainage system *BIOME VARIATION: Impact varies greatly depending on soil type and region (e.g., peatland, such as that in Southeast Asia, has a very high carbon content and so draining has a high negative impact*
H3	Establishing drainage systems	Non-GHG air pollutants		Non-GHG air pollution could likely take place via the machines used to establish the drainage systems (if mechanized)
H4	Establishing drainage systems	Water pollutants		Establishing drainage systems may cause sediment leaching into water ways
H13	Establishing drainage systems	Fresh water (surface water)		Establishing drainage systems for plantations can redirect water away from natural surface water routes that serve local communities
		Establishment		
I1	Planting native tree species	Carbon sequestration		Planting, especially fast growing species, can increase forest carbon sequestration rates
I23	Planting native tree species	Regulation of pests and diseases		Native tree species are susceptible to local pests, which could proliferate in a plantation environment *BIOME VARIATION: This impact will likely be most material in boreal regions which, due to climate change and increasing temperatures, are becoming increasingly susceptible to pests and due to their greater landscape homogeneity are particularly vulnerable to the impacts of pests*
I27	Planting native tree species	Change in habitat/ biodiversity: Flora		Native species may provide habitat for local biodiversity
I28	Planting native tree species	Change in habitat/ biodiversity: Fauna		Native species may provide habitat for local biodiversity
J1	Planting non-native tree species	Carbon sequestration		Planting, especially fast-growing species, can increase forest carbon sequestration rates
J8	Planting non-native tree species	Water use (groundwater)		Some species are inappropriate to plant in areas of low rainfall, e.g. eucalyptus
J9	Planting non-native tree species	Water use (surface water)		Some species are inappropriate to plant in areas of low rainfall, e.g. eucalyptus
J20	Planting non-native tree species	Water purification and waste treatment (groundwater)		Planting a non-native tree species can impact the abil-ity of the ecosystem to purify ground water
J21	Planting non-native tree species	Water purification and waste treatment (surface water)		Planting a non-native tree species can impact the abil-ity of the ecosystem to purify surface water
J23	Planting non-native tree species	Regulation of pests and diseases		Non-native tree species may be less susceptible to local pests, but can potentially become invasive and replace native tree species (e.g., *Prunus serotina, Robinia pseudoacacia* in Europe)
J27	Planting non-native tree species	Change in habitat/ biodiversity: Flora		Non-native species are less likely to provide good habitat for local biodiversity compared to native species
J28	Planting non-native tree species	Change in habitat/ biodiversity: Fauna		Non-native species are less likely to provide good habitat for local biodiversity compared to native species
K1	Planting mixed-species plantations	Carbon sequestration		Planting, especially fast-growing species, can increase forest carbon sequestration rates
K23	Planting mixed-species plantations	Regulation of pests and diseases		Native tree species may be more susceptible to local pests, but planting with a mix of native and/or non-native species could reduce the negative impacts of pests in a plantation environment
K27	Planting mixed-species plantations	Change in habitat/ biodiversity: Flora		Will depend to a large extent on the composition and ratio of native and non-native trees
K28	Planting mixed-species plantations	Change in habitat/ biodiversity: Fauna		Will depend to a large extent on the composition and ratio of native and non-native trees

Appendix 2.a continued:
Justification for color coding in figure 4.3: Forest production impacts

Cell	Activity	Impact driver	Code	Justification
L22	Planting - by hand	Regulation of soil quality		Soil is less likely to suffer damage or impaction from machinery
M2	Planting - mechanized	GHG emissions		Mechanized tree planting will likely lead to the release of GHG emissions via soil disturbance and the release of below-ground carbon, and via the direct release of GHGs by machinery used
M3	Planting - mechanized	Non-GHG air pollutants		Mechanized tree planting will likely lead to the release of non-GHG air pollutants via the direct release by machinery used
M5	Planting - mechanized	Soil pollutants		Mechanized planting is likely impactful by causing soil pollution via the machinery required to plant
M6	Planting - mechanized	Solid waste		Solid waste left by planting personnel (e.g., plastic) or from machinery if maintenance takes place in the forest (e.g., filters, cables)
M7	Planting - mechanized	Disturbances (e.g., noise & odor)		Mechanized planting, although occurring over a shorter time period, is likely to be more impactful to local communities in terms of noise and odor than planting by hand. Level of significance will vary based on different machinery used
M22	Planting - mechanized	Regulation of soil quality		Mechanized planting is impactful to soils by disturbing compaction and quality
			Management	
N2	Thinning and pruning	GHG emissions		If mechanized, thinning activities are likely to release some GHG emissions via machinery used
N3	Thinning and pruning	Non-GHG air pollutants		If mechanized, thinning activities are likely to release some non-GHG air pollutants via machinery used
N7	Thinning and pruning	Disturbances (e.g., noise & odor)		Some noise-related disturbance could result from thinning and pruning activities, depending on level of mechanization
N12	Thinning and pruning	Fresh water (groundwater)		Removal of intercepting surfaces of the forest canopy directly affects the generation of runoff and results in higher water availability – contributing to soil moisture and/or streamflow
N13	Thinning and pruning	Fresh water (surface water)		Removal of intercepting surfaces of the forest canopy directly affects the generation of runoff and results in higher water availability – contributing to soil moisture and/or streamflow
O1	Fertilizing soils	Carbon sequestration		Increased tree growth may lead to an increase in carbon sequestration
O2	Fertilizing soils	GHG emissions		Intensive fertilizer use can cause an increase in nitrous oxide emissions from soil – nitrous oxide is a greenhouse gas. Application of fertilizer (if mechanized) may release GHG emissions
O4	Fertilizing soils	Water pollutants		Fertilizers which are drained into the water (leached) can lead to water pollution and eutrophication
O7	Fertilizing soils	Disturbances (e.g., noise & odor)		Some odor-related disturbance could result from extensive fertilizing
O10	Fertilizing soils	Fiber		Fertilizing soils improves the growth rate of commercial trees and surrounding vegetation increasing the availability of fiber for local communities
O27	Fertilizing soils	Change in habitat/ biodiversity: Flora		The nutrients that come from fertilizers washed off by rain or irrigation into water bodies may negatively impact flora adapted to nutrient-poor conditions, or conversely benefit other types of flora negatively affected by nutrient-poor soils
P8	Irrigation [may also apply to (pre) establishment]	Water use (groundwater)		Irrigation may lower levels of groundwater *BIOME VARIATION: Boreal forests and forests in North America are typically not irrigated*
P9	Irrigation [may also apply to (pre) establishment]	Water use (surface water)		Irrigation may lower availability of surface water *BIOME VARIATION: Boreal forests and forests in North America are typically not irrigated*
P10	Irrigation [may also apply to (pre) establishment]	Fiber		Drought and moisture stress can result in stunted tree growth rates or mortality
P23	Irrigation [may also apply to (pre) establishment]	Regulation of pests and diseases		Irrigation may reduce drought that increases susceptibility to insect pests and pathogens
Q1	Controlling pests: pesticide	Carbon sequestration		An infestation of pests may reduce the ability of the forest to sequester carbon
Q2	Controlling pests: pesticide	GHG emissions		Application of pesticide (if mechanized) may release GHG emissions
Q3	Controlling pests: pesticide	Non-GHG air pollutants		Pesticides are highly likely to result in higher air pollu-tant concentrations that can be locally dispersed

Appendix 2.a continued:
Justification for color coding in figure 4.3: Forest production impacts

Cell	Activity	Impact driver	Code	Justification
Q4	Controlling pests: pesticide	Water pollutants		Pesticides can be leached from the forest floor during rain storms and pollute water ways
Q5	Controlling pests: pesticide	Soil pollutants		Overuse of pesticides can lead to pesticides acting as a soil pollutant, reducing soil quality
Q7	Controlling pests: pesticide	Disturbances (e.g., noise & odor)		Some odor-related disturbance could be the result of extensive pesticide spraying
Q27	Controlling pests: pesticide	Change in habitat/ biodiversity: Flora		The overuse and leaching of pesticides may have highly impactful effects on local biodiversity *BIOME VARIATION: The loss of biodiversity will be particularly impactful in tropical regions which harbor high levels of species diversity*
Q28	Controlling pests: pesticide	Change in habitat/ biodiversity: Fauna		The overuse and leaching of pesticides may have highly impactful effects on local biodiversity *BIOME VARIATION: The loss of biodiversity will be particularly impactful in tropical regions which harbor high levels of species diversity*
R1	Controlling pests: bio-control	Carbon sequestration		The planting of beneficial cover crops may lead to increased carbon sequestration
R27	Controlling pests: bio-control	Change in habitat/ biodiversity: Flora		Depending on the type of bio-control the change in ecosystem dynamics may affect biodiversity *BIOME VARIATION: The loss of biodiversity will be particularly impactful in tropical regions which harbor high levels of species diversity*
R28	Controlling pests: bio-control	Change in habitat/ biodiversity: Fauna		Depending on the type of bio-control the change in ecosystem dynamics may affect biodiversity *BIOME VARIATION: The loss of biodiversity will be particularly impactful in tropical regions which harbor high levels of species diversity*
S27	Fire prevention & suppression	Change in habitat/ biodiversity: Flora		Potential impacts on biodiversity through habitat fragmentation
S28	Fire prevention & suppression	Change in habitat/ biodiversity: Fauna		Potential impacts on biodiversity through habitat fragmentation
		Harvesting		
T2	Constructing skids trails and landings	GHG emissions		Disturbs soil compaction and can lead to the release of some below-ground carbon. The mechanized process will have GHG emissions impacts
T3	Constructing skids trails and landings	Non-GHG air pollutants		Machinery used will result in the release of non-GHG air pollutants
T4	Constructing skids trails and landings	Water pollutants		May cause water pollution via sediment leaching
T6	Constructing skids trails and landings	Solid waste		Solid waste left by construction personnel (e.g., plastic) or from machinery if maintenance takes place in the forest (e.g., filters, cables)
T19	Constructing skids trails and landings	Soil erosion control		May result in soil erosion and subsequent sedimentation/leaching
T22	Constructing skids trails and landings	Regulation of soil quality		May result in soil erosion and subsequent sedimentation/leaching
T26	Constructing skids trails and landings	Recreation and nature-based tourism/educational and spiritual values		Change in land use and/or fragmentation can reduce recreational and spiritual values
U1	Harvesting: selective logging	Carbon sequestration		Harvesting reduces the carbon stock of the forest. Depending on the use of the wood fiber, the carbon may be stored for a long time period (see Use phase impacts)
U2	Harvesting: selective logging	GHG emissions		Mechanized cutting will have GHG emissions impacts
U3	Harvesting: selective logging	Non-GHG air pollutants		Mechanized cutting will likely release non-GHG air pollutants via the machinery used
U4	Harvesting: selective logging	Water pollutants		Possible sediment load increase
U5	Harvesting: selective logging	Soil pollutants		Harvesting can lead to soil pollution via the machinery used
U6	Harvesting: selective logging	Solid waste		Solid waste left by harvesting personnel (e.g., plastic) or from machinery if maintenance takes place in the forest (e.g., filters, cables)
U7	Harvesting: selective logging	Disturbances (e.g., noise & odor)		Harvesting by selective logging is likely to be mechanized but likely less disturbing both visually and audibly compared to clear-cutting
U10	Harvesting: selective logging	Fiber		Harvesting of wood fiber provides fiber to local and global communities

Appendix 2.a continued:
Justification for color coding in figure 4.3: Forest production impacts

Cell	Activity	Impact driver	Code	Justification
U12	Harvesting: selective logging	Fresh water (groundwater)		Harvesting can be highly impactful on soil erosion, reducing the soil's productivity and ability to retain water
U15	Harvesting: selective logging	Regulation of air quality		Leaving some trees standing will help maintain air quality regulation
U17	Harvesting: selective logging	Regulation of water timing and flows (groundwater)		Leaving some trees standing will help maintain groundwater regulation
U18	Harvesting: selective logging	Regulation of water timing and flows (surface water)		Leaving some trees standing will help maintain surface water regulation
U19	Harvesting: selective logging	Soil erosion control		Is likely to lead to erosion via disturbance of soil during tree removal. Damage will not be as impactful as clear-cutting
U26	Harvesting: selective logging	Recreation and nature-based tourism/educational and spiritual values		Leaving some trees standing will help maintain some recreational and/or spiritual benefits
U27	Harvesting: selective logging	Change in habitat/ biodiversity: Flora		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type
U28	Harvesting: selective logging	Change in habitat/ biodiversity: Fauna		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type
V1	Harvesting: clear-cutting	Carbon sequestration		Harvesting reduces the carbon stock of the forest. Depending on the use of the wood fiber, the carbon may be stored for a long time period (see Use phase impacts in figure 4.4)
V2	Harvesting: clear-cutting	GHG emissions		Mechanized cutting will have GHG emissions impacts
V3	Harvesting: clear-cutting	Non-GHG air pollutants		Mechanized cutting will likely release non-GHG air pollutants via the machinery used
V4	Harvesting: clear-cutting	Water pollutants		Possible sediment load increase
V5	Harvesting: clear-cutting	Soil pollutants		Clear-cut harvesting can lead to soil pollution via the machinery used
V6	Harvesting: clear-cutting	Solid waste		Solid waste left by harvesting personnel (e.g., plastic) or from machinery if maintenance takes place in the forest (e.g., filters, cables)
V7	Harvesting: clear-cutting	Disturbances (e.g., noise & odor)		Harvesting by clear cutting is likely to be highly mechanized. Large-scale land clearing will cause disturbances both visually and audibly
V10	Harvesting: clear-cutting	Fiber		Harvesting of wood fiber provides fiber to local and global communities
V12	Harvesting: clear-cutting	Fresh water (groundwater)		Harvesting can be highly impactful on soil erosion, reducing the soil's productivity and ability to retain water
V13	Harvesting: clear-cutting	Fresh water (surface water)		Harvesting can be highly impactful on soil erosion, reducing the soil's productivity and ability to retain water
V15	Harvesting: clear-cutting	Regulation of air quality		Clear-cutting trees reduces the ability of forests to clean polluted air by filtering and trapping pollution particles. The impact will have more potential to be significant if forests are situated in polluted areas or close to urban settlements/major transport infrastructure
V17	Harvesting: clear-cutting	Regulation of water timing and flows (groundwater)		Clear-cutting will reduce the resilience and continuity of ground water regulation services
V18	Harvesting: clear-cutting	Regulation of water timing and flows (surface water)		Clear-cutting will reduce the resilience and continuity of surface water regulation services
V19	Harvesting: clear-cutting	Soil erosion control		Is very likely to lead to erosion via disturbance of soil during tree removal. Damage will be more impactful than selective logging
V26	Harvesting: clear-cutting	Recreation and nature-based tourism/educational and spiritual values		Clear-cutting will reduce the resilience and continuity of ground water regulation services
V27	Harvesting: clear-cutting	Change in habitat/ biodiversity: Flora		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type
V28	Harvesting: clear-cutting	Change in habitat/ biodiversity: Fauna		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type

Appendix 2.a continued:
Justification for color coding in figure 4.3: Forest production impacts

Cell	Activity	Impact driver	Code	Justification
W1	Harvesting: underwater	Carbon sequestration		Harvesting reduces the carbon stock of the forest. Depending on the use of the wood fiber, the carbon may be stored for a long time period (see Use phase impacts in Figure 4.4)
W2	Harvesting: underwater	GHG emissions		Mechanized cutting will have GHG emissions impacts
W3	Harvesting: underwater	Non-GHG air pollutants		Mechanized cutting will likely release non-GHG air pollutants via the machinery used
W4	Harvesting: underwater	Water pollutants		The nature and practice of underwater harvesting may lead to water pollution
W7	Harvesting: underwater	Disturbances (e.g., noise & odor)		Harvesting underwater is likely to be highly mechanized and will cause disturbances both visually and audibly
W10	Harvesting: underwater	Fiber		Harvesting of wood fiber provides fiber to local and global communities
W17	Harvesting: underwater	Regulation of water timing and flows (groundwater)		Harvesting underwater is likely to cause disturbance to the underwater ecosystem and alter the dynamics of existing surface flows that feed ground water resources
W18	Harvesting: underwater	Regulation of water timing and flows (surface water)		Harvesting underwater is likely to cause disturbance to the underwater ecosystem and alter the dynamics of existing surface water flows
X1	Restoring lands	Carbon sequestration		Restoring forests after harvesting replenishes carbon stores and increases carbon sequestration rates
X15	Restoring lands	Regulation of air quality		Restoring forests helps to clean polluted air by filtering and trapping pollution particles
X22	Restoring lands	Regulation of soil quality		Restoring land to its pre-harvest state should improve the overall quality of the soil
X27	Restoring lands	Change in habitat/ biodiversity: Flora		Restoring land to its pre-harvest state should lead to an overall increase in biodiversity
X28	Restoring lands	Change in habitat/ biodiversity: Fauna		Restoring land to its pre-harvest state should lead to an overall increase in biodiversity

	Key
	Unlikely to be significant or not applicable
	Potential to be significant (positive or negative)
	Likely to be significant (positive or negative)

Carbon sequestration impact will be greater if it leads to an increase in total forest carbon stock over a greater period of time.

References
Management practices adapted from: http://www.cisl.cam.ac.uk/publications/publication-pdfs/resilience-in-commercial-forestry-technical.pdf
Impacts adapted from the Natural Capital Protocol: http://naturalcapitalcoalition.org/protocol/
Ecosystem services adapted from: http://www.wri.org/publication/weaving-ecosystem-services-into-impact-assessment

Appendix 2.b:
Justification for color coding in figure 4.4: Rest of value chain impacts

The numerical references in this appendix refer to the cell numbers in figure 4.4.

Cell	Activity	Impact driver	Code	Justification
Transportation from cutting site to primary processing				
A2	Use of roads	GHG emissions		Use of heavy-duty trucks on road may release significant GHG emissions
A3	Use of roads	Non-GHG air pollutants		Use of heavy-duty trucks on road may release significant non-GHG air pollutants
A7	Use of roads	Disturbances (e.g., noise, odor)		Noise and odor disturbances of trucks in rural forested areas may be significant
A10	Use of roads	Change in habitat/ biodiversity: Fauna & Flora		Noise, odor, and social considerations such as accidents and local road destruction due to trucks may be significant
B2	Use of railroads	GHG emissions		May release significant GHG emissions although comparatively less than on road
B3	Use of railroads	Non-GHG air pollutants		May release significant non-GHG air pollutants although comparatively less than on road
B7	Use of railroads	Disturbances (e.g., noise, odor)		Noise and odor disturbances may be significant
B10	Use of railroads	Change in habitat/ biodiversity: Fauna & Flora		Heavy traffic may result in animal fatalities and frighten species away from the area
C2	Use of waterways	GHG emissions		Will release GHG emissions, but much less than train or road transport
C3	Use of waterways	Non-GHG air pollutants		Will release non-GHG air pollutants, but less than train or road transport. Shipping may release high quantities of sulphur and nitrogen dioxide, causing acid rain, if heavy fuel is used
C4	Use of waterways	Water pollutants		Shipping through inland waters can cause the release of untreated blackwater, greywater, and bilge water
C7	Use of waterways	Disturbances (e.g., noise, odor)		Poorly planned log driving can impact the movement of inward and outward migrating fish and other marine species as well as disrupting sensitive spawning grounds
C10	Use of waterways	Change in habitat/ biodiversity: Fauna & Flora		This will depend on the manner of use. Interventions undertaken to alter the flow, shape, or other physical components of a water body are likely to result in significant negative impacts. Processes which do not alter anything, but make use of water bodies either to store or float timber are less likely to result in negative impacts
Primary and secondary processing				
D2	Recovery of process chemicals	GHG emissions		Chemical recovery (e.g., in pulping processes) avoids GHG emissions associated with the production of new chemicals
D3	Recovery of process chemicals	Non-GHG air pollutants		Chemical recovery (e.g., in pulping processes) avoids non-GHG air pollutant emissions associated with the production of new chemicals
D4	Recovery of process chemicals	Water pollutants		Chemical recovery (e.g., in pulping processes) can reduce the potentially negative water pollution impacts of manufacturing
D8	Recovery of process chemicals	Water use (groundwater)		Chemical recovery (e.g., in pulping processes) avoids water use impacts associated with the production of new chemicals
D9	Recovery of process chemicals	Water use (surface water)		Chemical recovery (e.g., in pulping processes) avoids water use impacts associated with the production of new chemicals
E8	Recovery of process water	Water use (groundwater)		Water recovery (e.g., in pulping processes) can reduce the potentially negative water use impacts of manufacturing
E9	Recovery of process water	Water use (surface water)		Water recovery (e.g., in pulping processes) can reduce the potentially negative water use impacts of manufacturing
F2	Use of residues as energy	GHG emissions		Potential reduction in GHG emissions relative to using alternative fuel sources
F3	Use of residues as energy	Non-GHG air pollutants		Potential reduction in non-GHG air pollutants relative to using alternative fuel sources
F6	Use of residues as energy	Solid waste		Prevents wood residues being sent to landfill
G2	Manufacturing	GHG emissions		GHG emissions vary according to the processing technique employed (e.g., handwork vs. mechanization)
G3	Manufacturing	Non-GHG air pollutants		Non-GHG air pollutants vary according to the processing technique employed (e.g., handwork vs mechanization)
G4	Manufacturing	Water pollutants		Water pollutants vary according to the materials or chemicals used in the manufacturing process and their disposal
G5	Manufacturing	Soil pollutants		Soil pollutants vary according to the materials or chemicals used in the manufacturing process and their disposal

Appendix 2.b: continued

Justification for color coding in figure 4.4: Rest of value chain impacts

Cell	Activity	Impact driver	Code	Justification
G6	Manufacturing	Solid waste		Solid waste impacts vary according to the materials used in the manufacturing process and their disposal
G7	Manufacturing	Disturbances (e.g., noise, odor)		Noise or odor pollution (e.g., around pulp mills) may impact neighboring communities
G8	Manufacturing	Water use (groundwater)		Some manufacturing processes can have high water-use impacts (e.g., pulp and paper mills require substantial amounts of water)
G9	Manufacturing	Water use (surface water)		Some manufacturing processes can have high water-use impacts (e.g., pulp and paper mills require substantial amounts of water)
G10	Manufacturing	Change in habitat/ biodiversity: Fauna & Flora		This will depend on the size of the site, how frequently access roads are used, and the ecological sensitivity of the site and its surroundings
		Shipping and transport to user		
H2	(Non-electric) road & rail	GHG emissions		Road and rail emissions per unit transported are higher than shipping and, particularly in the case of road transport, are a major driver of GHG emissions in absolute terms
H3	(Non-electric) road & rail	Non-GHG air pollutants		Air pollutants released from fuels and alternative-fuel engines include carbon monoxide, nitrogen oxides, un-burnt hydrocarbons, and particulate matter
H7	(Non-electric) road & rail	Disturbances (e.g., noise, odor)		Heavily travelled road and rail routes can cause significant noise pollution depending on the location
H10	(Non-electric) road & rail	Change in habitat/ biodiversity: Fauna & Flora		Road and rail routes cause habitat fragmentation which has impacts on local and migratory species, including reduced access to food and habitat, restriction of wildlife movements, and disruption of gene flows. Collisions with trains and vehicles can kill animals
I2	Shipping	GHG emissions		Shipping by boat has a lower GHG footprint per unit of shipped goods than by truck or train (and, if applicable, by plane)
I3	Shipping	Non-GHG air pollutants		Shipping may release high quantities of sulphur dioxide and nitrogen dioxide that causes acid rain, if heavy fuel is used
I4	Shipping	Water pollutants		Shipping may release untreated blackwater, greywater, and bilge water
I7	Shipping	Disturbances (e.g., noise, odor)		Marine noise pollution can disrupt and harm marine species who may rely on sound for communication, orientation, and feeding
I10	Shipping	Change in habitat/ biodiversity: Fauna & Flora		Whales, manatees, and other marine fauna are at risk of being injured or killed by collisions with shipping vessels. Discharges of ballast water can introduce a wide variety of non-native biological materials (e.g., plants, animals, viruses, and bacteria) which can damage native aquatic ecosystems and cause human health problems. Global circulation of wooden pallets, dunnage, and crates (which have not been adequately treated for pests) can introduction non-native pests and negatively impact native trees and ecosystems
		Use		
J1	Length of product lifetime	Carbon sequestration		Depending on the use of the product, carbon will remain in a fixed state for longer or shorter periods of time. Wooden construction materials in a building will store carbon for longer than a single-use, short-lived product such as paper
K2	Reuse of product	GHG emissions		This avoids GHG emissions in the stages prior to use and at end of life
K3	Reuse of product	Non-GHG air pollutants		This avoids the emission of air pollutants in the stages prior to use and at end of life
K4	Reuse of product	Water pollutants		This avoids the release of water pollutants in the stages prior to use and at end of life
K5	Reuse of product	Soil pollutants		This avoids the potential release of soil pollutants from poorly designed and/or maintained landfills
K6	Reuse of product	Solid waste		This avoids the generation of solid waste across the value chain, but particularly at the end-of-life stage
K7	Reuse of product	Disturbances (e.g., noise, odor)		This avoids disturbance impacts across the value chain
K8	Reuse of product	Water use (groundwater)		This avoids the water-use impacts associated with many upstream processes (e.g., tree production, primary and secondary processing)
K9	Reuse of product	Water use (surface water)		This avoids the water-use impacts associated with many upstream processes (e.g., tree production, primary and secondary processing)
K10	Reuse of product	Change in habitat/ biodiversity: Fauna & Flora		This avoids biodiversity impacts across the value chain
L2	Recycling	GHG emissions		Recycling can cause GHG emissions, but it avoids more significant emissions in the stages prior to use and at end of life

Appendix 2.b: continued
Justification for color coding in figure 4.4: Rest of value chain impacts

Cell	Activity	Impact driver	Code	Justification
L3	Recycling	Non-GHG air pollutants		Recycling can cause non-GHG air pollutant emissions, but it avoids more significant emissions in the stages prior to use and at end of life
L4	Recycling	Water pollutants		Recycling avoids the water pollution impacts in the stages prior to use and at end of life. However, in the case of paper, the chemicals required for de-inking during recycling and the waste sludge produced can cause significant water pollution if not properly controlled
L5	Recycling	Soil pollutants		This avoids the potential release of soil pollutants from poorly designed and/or maintained landfills
L6	Recycling	Solid waste		This avoids the generation of solid waste across the value chain, but particularly at the end-of-life stage
L7	Recycling	Disturbances (e.g., noise, odor)		Recycling can cause disturbances, but it avoids other more significant disturbances across the value chain
L8	Recycling	Water use (groundwater)		Recycling can have considerable water-use impacts, however it avoids the water-use impacts associated with many downstream processes (e.g., tree production, primary and secondary processing)
L9	Recycling	Water use (surface water)		Recycling can have considerable water-use impacts, however it avoids the water-use impacts associated with many downstream processes (e.g., tree production, primary and secondary processing)
L10	Recycling	Change in habitat/ biodiversity: Fauna & Flora		This avoids biodiversity impacts across the value chain
				End of life
M2	Incineration for energy	GHG emissions		Although this releases significant GHG emissions, if the energy produced from this process is used to replace a non-renewable, more GHG-intensive energy source then this may reduce net GHG emissions from energy production. This will depend on the sustainability of the source of the wood fiber
M3	Incineration for energy	Non-GHG air pollutants		Depending on the type of wood product being burnt and its moisture content, incineration can release particulate matter and a number of other toxic air pollutants. Chemically treated wood products can release further toxic non-GHG air pollutants, including dioxins
M6	Incineration for energy	Solid waste		This process avoids waste going to landfill. Ash from biomass incineration can also be used as a natural fertilizer. However, more harmful forms of ash can also be produced, such as fly ash, which is sent to landfill
M7	Incineration for energy	Disturbances (e.g., noise, odor)		Smoke from the incineration process can cause smog and haze, while the odor may affect local/downwind communities
N2	Landfill	GHG emissions		Landfills emit significant quantities of carbon dioxide and methane. In particular, the decomposition of paper is a significant source of landfill methane
N3	Landfill	Non-GHG air pollutants		If the landfill is not well designed or maintained, a variety of potentially harmful non-GHG pollutants may be released
N4	Landfill	Water pollutants		If the landfill is not well designed or maintained, there is a likelihood that harmful chemicals will leach into groundwater
N5	Landfill	Soil pollutants		If the landfill is not well designed or maintained, there is a likelihood that harmful chemicals will leach into the soil
N6	Landfill	Solid waste		If products that could be recycled or reused are sent to landfill, this is a negative solid waste impact
N7	Landfill	Disturbances (e.g., noise, odor)		Both odor from the site and noise from municipal trucks that service it constitute potentially significant disturbances depending on the site location
N10	Landfill	Change in habitat/ biodiversity: Fauna & Flora		This will depend on the size of the site, how frequently access roads are used, and the ecological sensitivity of the site and its surroundings

	Key
	Unlikely to be significant or not applicable
	Potential to be significant (positive or negative)
	Likely to be significant (positive or negative)

References
Impacts adapted from the Natural Capital Protocol: http://naturalcapitalcoalition.org/protocol/
Ecosystem services adapted from: http://www.wri.org/publication/weaving-ecosystem-services-into-impact-assessment

Appendix 2.c:
Justification for color coding in figure 4.5: Value chain dependencies

The numerical references in this appendix refer to the cell numbers in figure 4.5.

Cell	Activity	Dependency	Code	Justification
A1	Forest production	Energy (non-photosynthetic)		Energy will be required by a number of mechanized processes, including transport, site preparation, maintenance and restoration, and harvesting
A2	Forest production	Water		Moisture stress and drought can result in tree injury and mortality at any stage of its life, but is typically most critical at the seedling/sapling stage. The dependency on water will also vary according to the tree species and local climatic conditions
A3	Forest production	Nutrition		Trees primarily may require the application of fertilizers depending on a number of factors including current health and soil type and quality
A4	Forest production	Materials		Tree production depends heavily on the availability of soil nutrients as materials
A5	Forest production	Land use		Forests usually require large areas and can be in competition with urban areas, agricultural land use, natural forests, or protected areas
A6	Forest production	Regulation of physical environment (e.g., ecosystem providing water filtration)		Trees are typically dependent on healthy soils, with suitable pore space (not overly compacted), drainage, and organic matter to provide for long-term growth
A7	Forest production	Regulation of biological environment (e.g., resilience against disease)		Trees need to be situated in a resilient ecosystem which provides the natural checks and balances to prevent or mitigate the presence of pests and disease which can cause extensive damage to trees. In natural forests, resilience is usually higher
A8	Forest production	Regulation of waste and emissions (e.g., pollution assimilation by ecosystem)		Tree growth is dependent on clean air. The main gaseous air pollutants that damage trees are sulphur dioxide (through acid rain) and fluorides and oxidants (such as ozone), these pollutants may cause tree stunting and in some cases mortality
B1	Primary & secondary processing	Energy (non-photosynthetic)		Energy requirements vary according to the processing technique employed (e.g., handwork vs. mechanization). Some processes require significant energy inputs, especially in the case of pulp and paper mills (although in many cases a high percentage of these energy requirements can be met by burning wood fiber waste products)
B2	Primary & secondary processing	Water		Water requirements vary according to the processing technique employed. Pulp and paper mills are heavily dependent on significant volumes of water, while producers of wooden furniture, fencing, and construction materials will have a negligible dependency on water (if at all)
B4	Primary & secondary processing	Materials		Producers of pulp, paper, and other wood fiber products require wood fiber as a key input to their manufacturing process. Producers of non-wood fiber forest products may depend directly on forests (e.g., fruits, nuts, oils, barks, and resins) or indirectly (e.g., mushrooms, rattan, medicinal plants, furs, and game). In addition, a number of chemicals and other materials may be needed to turn the raw product into a finished one (e.g., rubber production, or chemical varnishes applied to wooden artifacts such as instruments and furniture)
B5	Primary & secondary processing	Land use		Relatively small areas are necessary for primary and secondary processing, compared to the tree production areas, but there can be competition for urban use
B6	Primary & secondary processing	Regulation of physical environment (e.g., ecosystem providing water filtration)		A number of processes have a remedial dependency on ecosystems' ability to absorb or remove the wastewater they emit. This is more likely to be material to processes involving significant volumes of water and chemicals
B8	Primary & secondary processing	Regulation of waste and emissions (e.g., pollution assimilation by ecosystem)		A number of processes have a remedial dependency on ecosystems' ability to absorb or remove the air pollutants and greenhouse gases they emit
C2	Use	Water		Use of wood fiber products will not require water. However, use of some non-wood fiber forest products may require water (e.g., coffee, cocoa)
C4	Use	Materials		Glue needed for the use of cross-laminated timber (CLT) wood panels for construction
D1	End of life	Energy (non-photosynthetic)		This will depend on the process: incineration and recycling are heavily dependent on energy, unlike landfill

Appendix 2.c: continued

Justification for color coding in figure 4.5: Value chain dependencies

Cell	Activity	Dependency	Code	Justification
D2	End of life	Water		This will depend on the process: recycling can require high quantities of water
D4	End of life	Materials		All end-of-life processes will require materials (e.g., paper/cardboard for landfill and recycling, biomass for incineration for energy). Moreover recycling processes typically require a number of chemicals
D5	End of life	Land use		Relatively small areas are necessary for landfill and recycling plants, compared to the tree production areas, but there can be competition for urban use
D6	End of life	Regulation of physical environment (e.g., ecosystem providing water filtration)		Paper recycling has a remedial dependency on ecosystems' ability to absorb or remove the wastewater it produces. It is also possible that poorly constructed or managed landfill sites are dependent on healthy soils to mitigate leaching from potentially toxic or harmful waste
D8	End of life	Regulation of waste and emissions (e.g., pollution assimilation by ecosystem)		Landfill and incineration have a remedial dependency on ecosystems' ability to absorb or remove the air pollutants and GHGs they emit. For example, landfill sites emit carbon dioxide and methane while incinerators emit carbon dioxide and other air pollutants (especially if burning chemically treated wood products). Paper recycling emits GHGs and air pollutants, but to a considerably lesser degree – any remedial dependency it may have is countered by the avoidance of negative impacts at other stages of the value chain through the act of recycling (e.g., rediverting waste paper from landfill)

	Key
	Unlikely to be significant or not applicable
	Potential to be significant (positive or negative)
	Likely to be significant (positive or negative)

References

Dependencies adapted from the Natural Capital Protocol: http://naturalcapitalcoalition.org/protocol/

Glossary

Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (UN 1992).
Business application	In the Protocol, the intended use of the results of your natural capital assessment to inform decision making.
Ecosystem	A dynamic complex of plants, animals, and microorganisms, and their non-living environment, interacting as a functional unit. Examples include deserts, coral reefs, wetlands, and rainforests (MA 2005). Ecosystems are a component of natural capital.
Ecosystem services	The most widely used definition of ecosystem services is from the Millennium Ecosystem Assessment: “the benefits people obtain from ecosystems”. The MA further categorized ecosystem services into four categories: Provisioning, Regulating, Cultural, and Supporting (MA 2005).
Externality	A consequence of an action that affects someone other than the agent undertaking that action, and for which the agent is neither compensated nor penalized. Externalities can be either positive or negative (WBCSD et al. 2011).
Impact driver	In the Protocol, an impact driver is a measurable quantity of a natural resource that is used as an input to production (for example, volume of sand and gravel used in construction) or a measurable non-product output of business activity (for example, a kilogram of NOx emissions released into the atmosphere by a manufacturing facility).
Materiality	In the Protocol, an impact or dependency on natural capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision (Adapted from OECD 2015 and IIRC 2013).
Materiality assessment	In the Protocol, the process that involves identifying what is (or is potentially) material in relation to the natural capital assessment’s objective and application.
Natural Capital	The stock of renewable and non-renewable natural resources (for example, plants, animals, air, water, soils, and minerals) that combine to yield a flow of benefits to people (adapted from Atkinson and Pearce 1995; Jansson et al. 1994).
Natural capital dependency	A business reliance on or use of natural capital. Dependencies can be consumptive (e.g., energy, water, nutrition, materials) or non-consumptive (e.g., regulation of the physical environment, regulation of the biological environment, regulation of waste and emissions, experience, knowledge, well-being, and spiritual or ethical values).
Natural capital impact	The negative or positive effect of business activity on natural capital.
Natural Capital Protocol	A standardized framework to identify, measure, and value direct and indirect impacts (positive and negative) and/or dependencies on natural capital.
Primary data	Data collected specifically for the assessment being undertaken.
Secondary data	Data that were originally collected and published for another purpose or a different assessment.
Sector guide	Additional, sector-specific guidance to be used alongside the Protocol by businesses in a relevant sector conducting a natural capital assessment.

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Designed and produced by **Radley Yeldar**
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