Forest Products Sector Guide to the Natural Capital Protocol

Consultation Details

12 October 2017 – 28 February 2018

Development

The Forest Products Sector Guide has been developed through a collaborative process which began in March 2017. The project underwent an engagement and scoping process with the wider community, via an online survey and workshops; read the engagement report here. The project has also been supported throughout by an expert advisory group, covering many different stakeholder perspectives.

This consultation will now allow a broader range of organizations to contribute to the development process. We recognize that to produce sector guidance that is practical and fit-for-purpose, we must gather the experience and expertise from across the forest products value chain, and from those who support it.

Consultation Objectives

1. Provide an opportunity for a wide range of organizations and experts to contribute to sector guide content and development.

2. Gather input from:
    - Public online consultation
    - Workshops with stakeholder groups in different regions
    - Pilot testing program

3. Build momentum and increase endorsement for integrating natural capital in decision-making within the forest products sector.

Submit your feedback: Collaborase

The public online consultation will be run through an online consultation system called Collaborase. Collaborase facilitates transparency, allowing comments to stay visible to everyone and collected in one place, facilitating open engagement and dialogue. Note that we can only accept comments and survey responses through the Collaborase platform and not via email. We do this to ensure that all comments are collected and addressed fairly.

If you do not already have access to Collaborase, you can register here.

- **Provide comments:** Collaborase includes the full text of the sector guide to which you can add comments at any level (word, line, section or overall).

- **Surveys:** Each section of the sector guide has a corresponding survey that helps to consolidate feedback on some specific features. These can be found below each section heading. The complete list of questions included in these surveys is also included in the consultation pack.

Participating in the consultation is on an **individual basis** (i.e. more than one person per organization may register). You can therefore chose to respond personally or on behalf of your organization.

We look forward to taking all input forward!

info@naturalcapitalcoalition.org

DRAFT FOR PILOT AND CONSULTATION

NATURAL CAPITAL PROTOCOL

FOREST PRODUCTS SECTOR GUIDE

NATURAL CAPITAL COALITION

Contents

Foreword by Mark Gough, Executive Director, Natural Capital Coalition

Forests require long term planning and investment and therefore it is not surprising to me that the first new guidance since the launch of the Natural Capital Protocol is from a sector that is always thinking of the future.

The draft you are now reading came out of engagement with many organizations in the forest products sector who identified the need and provided the examples and content. In this next important phase we would like you to contribute; to test, challenge, and where you find bits you agree with, support the guidance provided here. Nature teaches us that everything is connected, and therefore we need input from all parts of society to create a robust, widely accepted approach that is supported by everyone.

I would like to thank all of the people who have been involved to date and those of you who are just picking it up now. This is a significant step forward for the sector and for natural capital and it provides a strong platform for future integration of natural capital into the way that we think and work.

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. However, natural capital impacts and dependencies are often specific to the sector in which a business operates and therefore sector guides provide additional guidance for businesses.

This guidance is not to replace the Protocol, but accompany it and therefore you will need a copy of the Protocol with you as you read – if you do not already have a copy you can find one at www.naturalcapitalcoalition.org/protocol.

The natural capital community is also developing other sector guides and supplementary information. Of particular interest to this sector will be the work on biodiversity, data and finance that is under development.

The consultation and piloting of this draft will run through to December 2017. Companies are invited to submit case studies of their experience, to support the comments they make through the online collaboration system, Collaborase.

The publication of the final guidance is planned for March 2018 and will be freely available under a creative commons license.

The World Business Council for Sustainable Development's Forest Solutions Group has been leading the development of the 'Forest Products Sector Guide' on behalf of the collaboration that is the Natural Capital Coalition. Technical Support has been provided by PwC. A global inclusive approach including workshops, teleconferences and meetings in many countries including Switzerland, Vancouver, Mexico, UK, Sao Paulo and Singapore, has been used to develop this guidance and to address 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.

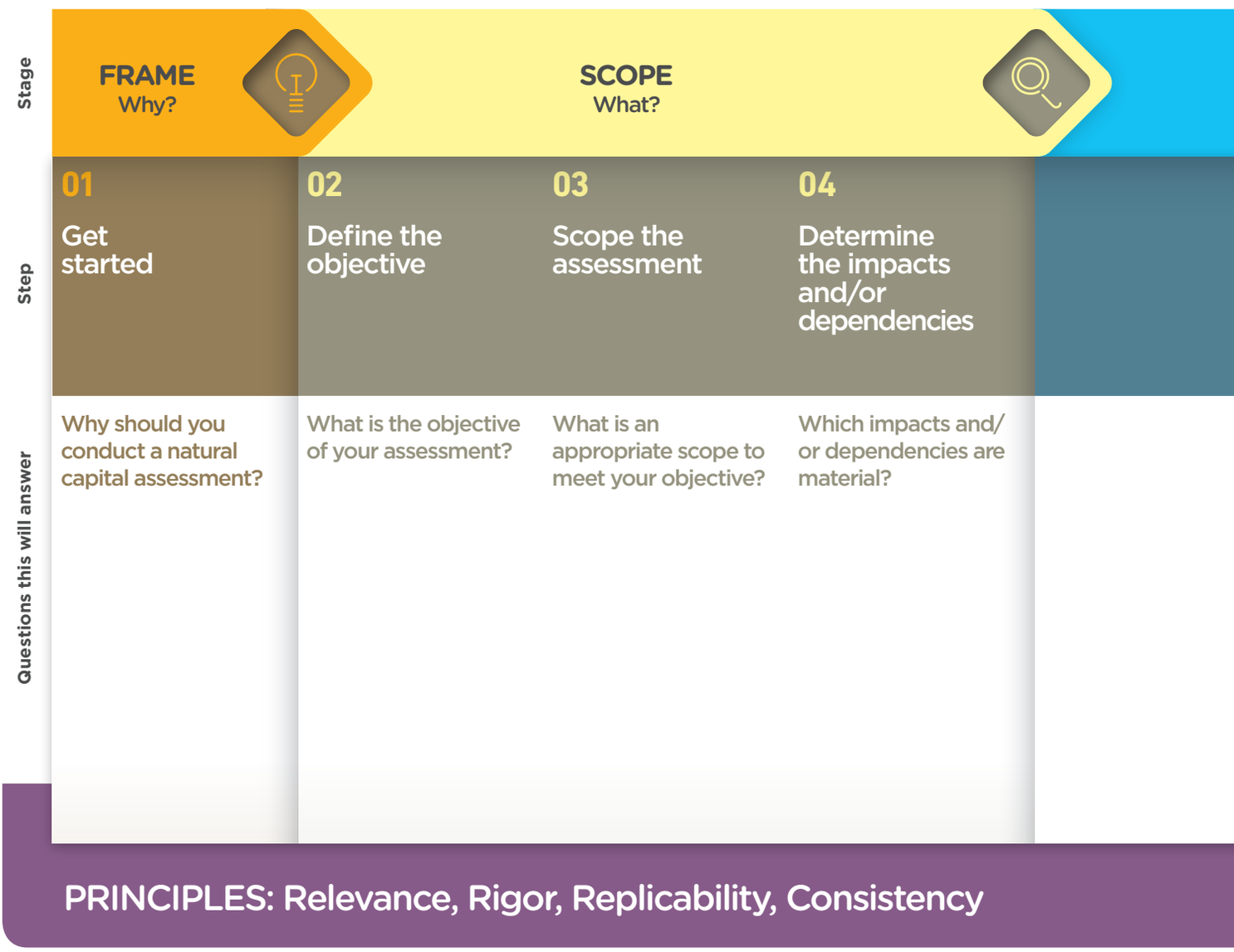


Figure 0.1
The Natural Capital Protocol Framework

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?

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.

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 tree 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, the guide is intended to be relevant for non-wood fiber forest products such as Brazil nuts, palm oil, and rubber as well. Similarly, while the guide focuses on productive 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 on forest that is being conserved or restored.

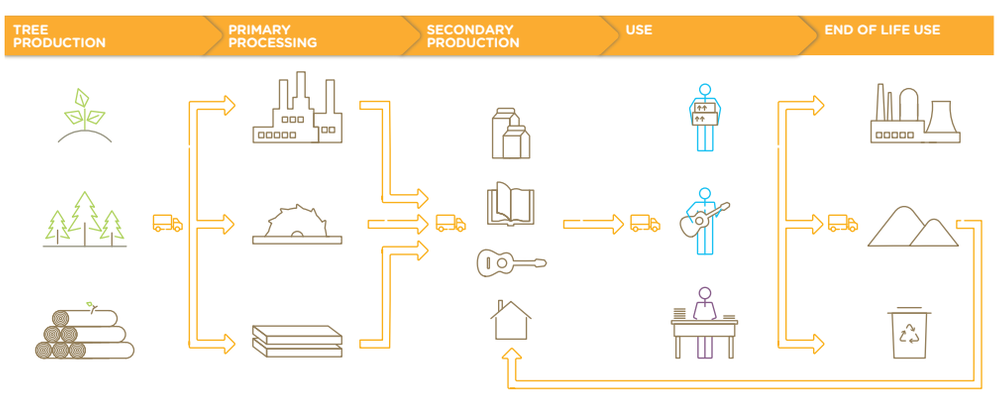


Figure 0.2
The forest products value chain
Adapted from WBCSD 2007.

This sector guide considers the natural capital impacts and dependencies of businesses operating across the forest product value chain, including the consumer use stages and companies that supply inputs into the value chain.

Hypothetical examples

Six sector-specific hypothetical examples are presented in the appendix that help bring the business applications to life. Although purely illustrative, the examples demonstrate how businesses operating in the forest products sector can use the Protocol to frame, scope, measure, value and apply a natural capital assessment to inform business decision making.

FRAME STAGE
Why?

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 this 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:
Mapping between the Protocol and the sector guide

Step	Question that this Step will answer	Actions	Additional guidance included in the 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	**No**
		1.2.2 Apply the basic concepts of natural capital to your business context	**Yes**
		1.2.3 Prepare for your natural capital assessment	**No**

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

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. Many forest products companies are therefore already aware of the importance of understanding and effectively managing risks and opportunities associated with natural capital.

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).

Equally, new opportunities can arise through, for example, development of new products and services responding to the challenge of natural capital protection and conservation. This may be particularly interesting for the sector given the role of forests in sequestering carbon and the potential for wood fiber in various forms to replace other more GHG-intensive materials.

The forest products sector can also have positive and negative impacts on society through changes in natural capital as a result of business activities. Business activity affecting society directly (e.g., job provision) is considered a social impact while business activity affecting society via a change in the environment is considered an environmental impact. This sector guide focuses on environmental impacts and dependencies; for more information on social impacts and dependencies please refer to the Social Capital Protocol (WBCSD 2017).

Forests have been recognized in international agreements as having a key role to play in reducing global atmospheric GHG concentrations. Article 5 of the UNFCCC Paris Agreement explicitly references forests in relation to "sinks and reservoirs of GHG emissions" (UNFCCC, 2015). Up to one-third of the emissions mitigation needed annually to limit temperature rises from climate change could be achieved by actions to address deforestation and forest degradation (International Sustainability Unit, 2015).. The forest sector will also play a substantial role in achieving the UN Sustainable Development Goals (SDGs), more than half of which are linked closely to forests or forest products (UNECE, 2016). Action towards reaching the SDGs can also be directly mapped against various Key Performance Indicators (KPIs), as defined by the WBCSD Forest Solutions Group, illustrating the link between the SDGs and business imperatives in the forest sector (e.g., Landscapes, Forest Management & Fiber Sourcing (SDG 15 – life on land), Resource Efficiency & Innovation (SDG 12 – responsible production and consumption), Energy & Climate (SDG 7 – affordable and clean energy & SDG 13 – climate action), Water Stewardship (SDG 6 – clean water and sanitation), Health & Safety (SDG 8 – decent work and economic growth), and Social

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).

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).

Impact (SDG 1 – no poverty)(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 forest ability to prove benefit into the future – both timber and other benefits) 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. Understanding these benefits can help make the case for using sustainable management practices, such as those required under forest certification schemes.

Before considering some of the potential natural capital impacts and dependencies that are relevant to your business, figure 1.1 outlines the main risk 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 the Protocol.

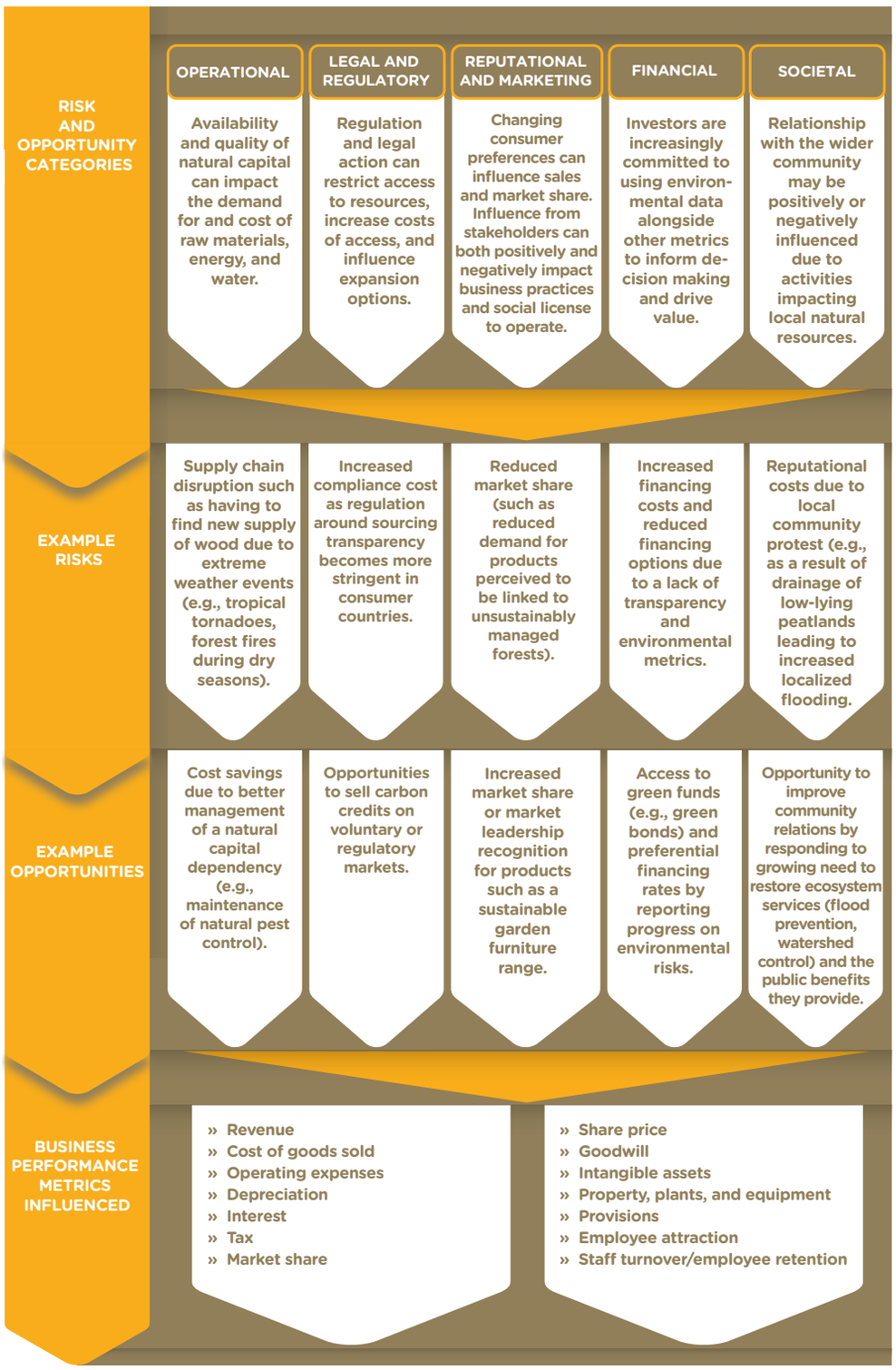


Figure 1.1:
Examples of business implications from key natural capital risks and opportunities

A note on the license to operate: The term "license to operate" does not necessarily refer to a regulatory permit or license that is required by an authority for the business to operate. According to Boutilier and Thomson (2011) a social license to operate (SLO) is a community's perceptions of the acceptability of a company and its local operations. The authors identify four levels of social license: withheld/ withdrawn, acceptance/tolerance, approval/support, and psychological identification.

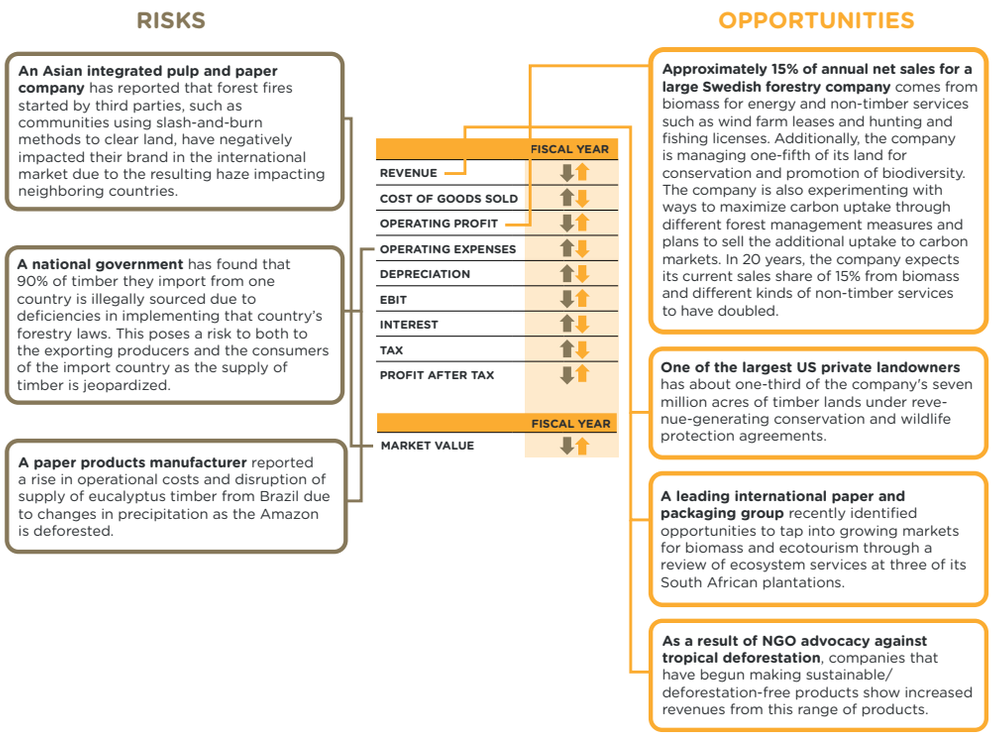


Figure 1.2:
Real world examples of recognized risk and opportunity

Figure 1.2 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 1.1 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 the Impact & Dependencies Tables in section 4)

Table 1.1:
A selection of natural capital impact drivers in the forest products sector

	Carbon sequestration	Water pollutants	Air quality
Overview	Forests 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 tree 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).	The manufacture of pulp and paper can generate significant quantities of potentially highly polluting wastewater (as high as 60 m3/ton of paper produced). If not managed properly, this can damage aquatic ecosystems and threaten the health of people living near a mill (Thompson et al., 2001). While new technology has substantially reduced water emissions from many mills, there can be significant variation around the world in the use of technology and major polluting incidents can still occur. Water pollutants can include: – persistent toxic chlorine compounds like dioxins – organic materials that consume oxygen during decomposition – sulphur dioxide that contributes to lake acidification – air-polluting nitrogenous compounds and phosphates that boost algae growth, thereby causing/exacerbating eutrophication leading to the death of marine life (WWF. n.d.)	Forests are among the most effective air purifiers in existence and also play an important role in regulating air temperatures (Ansari, 2003) A recent broad-scale estimate of air pollution removal by US trees nationwide revealed 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 they 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 offence.	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.
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 populations and are quantifiably reducing air pollution impacts.

Table 1.1: continued
A selection of natural capital impact drivers in the forest products sector

	Carbon Sequestration	Water pollutants	Air Quality
Significant value chain stage	Throughout value chain, particularly during production and use.	Production, primary and secondary processing and end of life	Tree 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	– Increased cost of goods sold due to compliance costs – Increased operating costs such as higher water charges – Fines and compensation increasing operating costs – Decreased operational costs through recovery of chemicals and internal reuse – Revenue losses from negative publicity or consumer demand for more environmentally friendly processes and increased revenues and/or market share from the inverse scenario	– Increased revenues from payment for ecosystems services (PES) – Improved customer loyalty and market share through the reputational benefits of good management

Natural capital dependencies for the forest products sector span all categories of ecosystem service, including provisioning, regulating, and cultural services. Table 1.2 focuses upon some of the critical dependencies relevant to the sector. The raw material stage in a value chain typically interacts with nature directly through tree production and primary processing activities. As such, these stages tend to have the most significant dependency on natural capital.

Table 1.2:
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 the drought-prone climate of the west coast of India, adequate irrigation of rubber plantations can reduce the immaturity period from >10 years to 6 years or less, while also leading to significant reductions in tree loss and better growth performance (Vijayakumar et al., 1998) The dependency on water in this case is crucial due to both its short supply and significant effect on yields. Although considerable progress has been made by pulp mills over the last few decades in increasing the proportion of recycled water in the processing stage (Gunderson, n.d.), the pulp and paper industry is still water-intensive (e.g., in the US, it is ranked as the most water-intensive of all industries, requiring on average 54m³ of water per metric ton of finished product (Walter, 1971).	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 current mountain pine beetle (MPB) outbreak in British Columbia, Canada started in the early 1990s and has since killed about 50% of the total volume of commercial lodgepole pine in the province (752 million cubic meters). Today the MPB occurs well beyond its historic range, extending into northern British Columbia and eastward into the boreal forest of north-central Alberta. As of 2011 the cumulative effect of the outbreak of the MPB had released an estimated 270 million tons of carbon, converting the forest from a carbon sink to a large net carbon source (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
Example risk	The cultivation of non-native, water-intensive plantations in water-limited regions risks causing unrest in local communities and the wider public. As water stress increases worldwide, governments may regulate which plantations can be grown in certain areas, or impose a tax on plantations consuming a high volume of water. Depleting catchments through the cultivation of thirsty crops may also incur operational and financial risks, since the crop may fail or become stunted as a result, thereby affecting margins or requiring irrigation at additional cost.	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.

Table 1.2: continued
A selection of natural capital dependencies in the forest products sector

	Consumptive: Water	Consumptive: Materials	Non-consumptive: Regulation of living environment
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.
Significant value chain stage	Tree production and primary and secondary processing	Tree production	Tree production
Geographical relevance	Local	Local	Local and regional
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

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 the appendix for sector specific hypothetical examples which illustrate how a business may complete this Step.

Glossary

Natural capital dependency
A business reliance on or use of natural capital.

SCOPE STAGE
What?

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:
Mapping between the Protocol and the sector guide

Step	Questions each Step will answer	Actions	Additional guidance included in the sector guide?
02 Define the objective	**What is the objective of your assessment?**	2.2.1 Identify the target audience	**No**
		2.2.2 Identify stakeholders and the appropriate level of engagement	**Yes**
		2.2.3 Articulate the objective of your assessment	**Yes**
03 Scope the assessment	**What is an appropriate scope to meet the objective?**	3.2.1 Determine the organizational focus	**No**
		3.2.2 Determine the value-chain boundary	**No**
		3.2.3 Specify whose value perspective	**No**
		3.2.4 Decide on assessing impacts and/or dependencies	**No**
		3.2.5 Decide which type of values you will consider	**No**
		3.2.6 Consider other technical issues (i.e., baselines, scenarios, spatial boundaries, and time horizons)	**Yes**
		3.2.7 Address key planning issues	**No**
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**
		4.2.2 Identify the criteria for your materiality assessment	**Yes**
		4.2.3 Gather relevant information	**No**
		4.2.4 Complete the materiality assessment	**No**

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

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.

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.

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

2.2.3 Articulate the objective of your assessment

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 business benefits of 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.	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, forestry companies considering joining certification schemes can estimate the additional natural capital value (and eventually financial value) this would create, thereby potentially justifying an often expensive process (which currently does not command a high product premium) to senior internal stakeholders and/or shareholders. The forest products sector also 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

Glossary

Business application
In the Protocol, the intended use of the results of your natural capital assessment to inform decision making.

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 the appendix 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)

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 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. old growth forest, where mature trees of 200+ years 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 to realize about whether benefits will be sustained into the future. This can just be recorded as a qualitative trend but is still useful to assess risk 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.

– **The situation over a specific period of time** (e.g., how does the level of ecosystem service provision this year compare to the level last year, given a change in the

company's activities within this time period).

– **The state of natural capital at a significant point in time** (e.g., how does the level of ecosystem service provision from an area of land today compare to the level before the current land management regime). In reality, this can be difficult to determine since records of past land management are often incomplete. This information challenge is compounded if your company procures wood products several steps down the value chain. You may choose to address this issue by using either:

- A "pristine baseline" where impacts are measured relative to what the land would be in its natural state.
- A "counterfactual scenario" where 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).

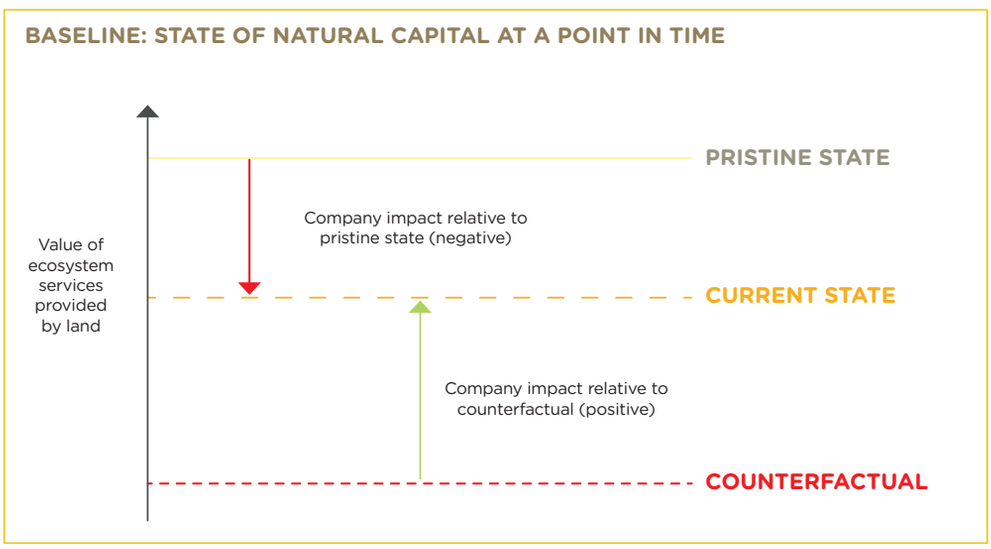


Figure 3.1
Baseline: state of natural capital at a point in time
Adapted from PwC 2015.

A sector-wide or economy-wide average level (e.g., how does the current level of ecosystem service provision on your land compare with the ecosystem service provision from other forestry land in the region).

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).

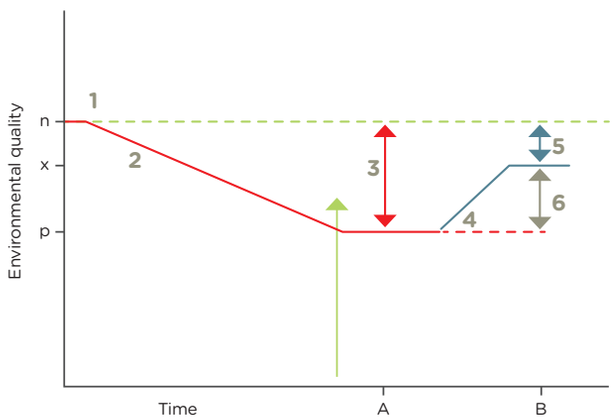
Table 3.1
Advantages and disadvantages of different baselines

	Over a time period	State of natural capital at a point in time		Sector-wide comparison baseline	Optimal landscape scenario
		Pristine baseline	Counterfactual scenario		
Advantages	– Easy to define as first year of measurement is the baseline. – Can show positive impacts if the company is restoring degraded land	– Relatively easy to estimate the natural land cover of the area. Global datasets of natural land cover are available.	– 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.	– Incentivises 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. – Does not provide strong motivation for improvement because as long as the impacts do not change year on year then you do not have a negative impact.	– 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. – The incentive here is to produce on land where the pristine state is low in value. There is no incentive to reforest or restore land that is previously degraded.	– 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.

Demonstrating improvements in your impacts if using a 'pristine' baseline.

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.

Other factors to consider when choosing baselines.

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.

In land management scenarios where there is active conservation of an area of pristine 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.

Spatial boundaries and time horizons

Table 3.2 provides sector-relevant considerations for selecting spatial boundaries and time horizons for your natural capital assessment.

Table 3.2:
Considerations for other technical specifications in forest products sector assessments

Technical specification	Considerations for forest products sector assessments
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. 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.
Time horizons	Impacts and their consequences to business and society can occur over varying timescales. Additionally, 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 being exacerbated in the case of increased frequency of drought caused by climate change. 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. 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. Therefore, the time horizon of your natural capital assessment needs to be able to reflect key trends in future benefits (e.g., a time horizon spanning at least one timber harvesting and regeneration cycle to understand business values and a sufficient length of time to understand trends in the external ecosystem service values). – Impacts: Consider how persistent the impact driver is in the environment to assess whether it will create long- or short-term natural capital changes. It is unique in the tree production stage that 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.

Step 03 of the Forest Products Sector Guide has provided additional guidance to help you consider other technical issues of your assessment. See the appendix 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

List potentially material natural capital impacts and/or dependencies

Global forests provide a range of ecosystem services, for instance; carbon sequestration, water filtration, habitat creation, and nutrient cycling. Forests also provide important products such as timber, food, fuel, and bioproducts. However, some natural capital impacts arising from poor management of a productive forest may be negative, for example, soil pollution, carbon emissions, and the erosion of watersheds 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 an example of an impact pathway for water pollution from a pulp and paper mill. 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 an example dependency pathway for natural pest control dependency of a forestry plantation.

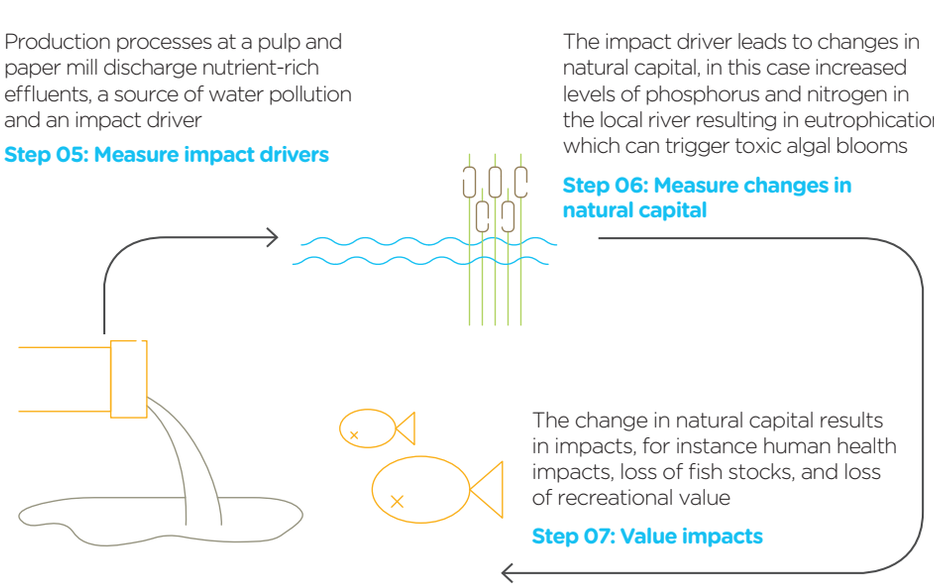


Figure 4.1
Example of an impact pathway

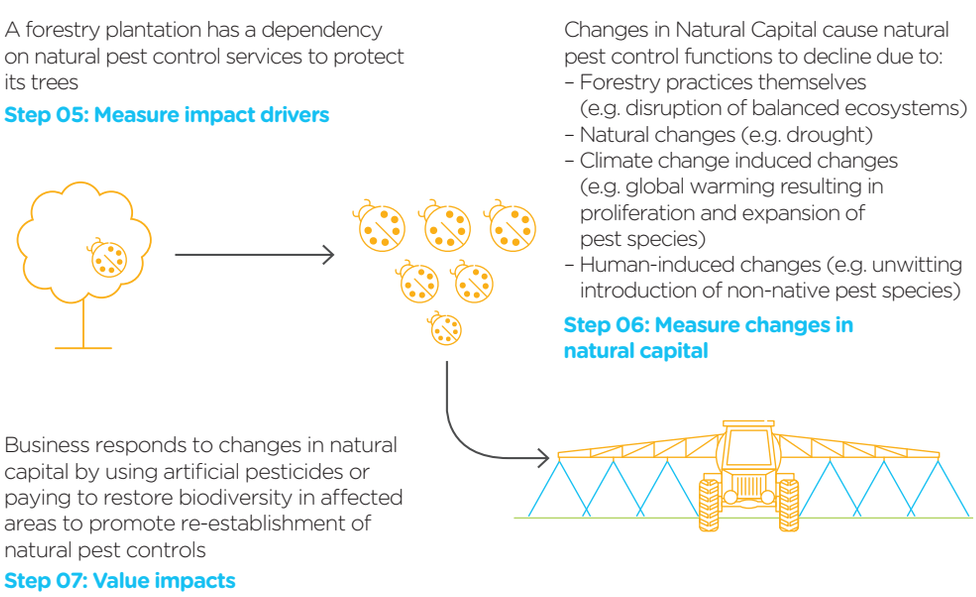


Figure 4.2
Example of a dependency pathway

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 a useful overview of potential impacts and dependencies commonly encountered within the life cycle of a wide range of forest sector products. 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. In general, impacts have been considered relative to a baseline of no human intervention (e.g., constructing roads versus not constructing roads). However, for ease of interpretation, where the practice itself describes an important improvement over a less sustainable practice (e.g., zoning natural habitats during production and harvesting versus not zoning natural habitats, or recycling wastewater from primary processing versus not recycling wastewater), the baseline is the less sustainable practice. For more information on baselines please see section 3.2.6 of this sector guide.

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 (e.g., by following best practice in sustainable forest management as required by forest certification bodies). 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 matrices are not to be understood as a comprehensive materiality assessment of impacts and dependencies of forest sector 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.

As above, Figure 4.3, Tree 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 forestry companies have proprietary handbooks for this already, and more generic guidance can be found as part of third-party certification schemes. The sector guide 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.

Forest Types and corresponding management practices

Three forest types are referenced in the matrices:

1. Naturally regenerated forest refers to natural forests that are being managed for a productive use 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

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 tree production lifecycle. A number of practices could apply at more than one stage of tree 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 refer to the Protocol.

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 4.3:
Tree production impacts

POTENTIAL IMPACTS OF TREE PRODUCTION

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

KEY:

POSITIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

NEGATIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

	PRE-ESTABLISHMENT								ESTABLISHMENT					MANAGEMENT						HARVESTING				
	Zoning sensitive areas and practicing low impact 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-felling	Harvesting: underwater	Restoring lands
	Y	N	N	Y	N	Y	N	N	N	N	N	N	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	N
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y

Figure 4.4:
Rest of value chain impacts

POTENTIAL IMPACTS OF THE REST OF THE FOREST PRODUCTS VALUE CHAIN

IMPACT DRIVER CATEGORY		IMPACT DRIVER
Outputs		Carbon sequestration
Outputs		GHG emissions
Outputs		Non-GHG air pollutants
Outputs		Water pollutants
Outputs		Soil pollutants
Outputs		Solid waste
Outputs		Disturbances (e.g., noise, odor)
Resource use		Water use (groundwater)
Resource use		Water use (surface water)
Resource use	Supporting service	Change in habitat/biodiversity: Fauna & Flora

KEY:

POSITIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

NEGATIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

	TRANSPORTATION FROM FELLING SITE TO PRIMARY PROCESSING			PRIMARY & SECONDARY PROCESSING				SHIPPING & TRANSPORT TO USER		USE	REUSE & RECYCLING		END OF LIFE	
	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

Figure 4.5:
Value chain dependencies

POTENTIAL DEPENDENCIES IN THE FOREST PRODUCTS VALUE CHAIN

DEPENDENCY DRIVER CATEGORY	DEPENDENCY DRIVER	Tree production	Primary & secondary processing	Use	End of life
Consumptive	Energy (non-photosynthetic)	POTENTIAL TO BE SIGNIFICANT	LIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT
Consumptive	Water	LIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT
Consumptive	Nutrition	POTENTIAL TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT
Consumptive	Materials	UNLIKELY TO BE SIGNIFICANT	LIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT	LIKELY TO BE SIGNIFICANT
Consumptive	Land use	LIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT
Non consumptive	Regulation of physical environment (e.g., ecosystem providing water filtration)	LIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	POTENTIAL TO BE SIGNIFICANT
Non consumptive	Regulation of biological environment (e.g., resilience against disease)	LIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT
Non consumptive	Regulation of waste and emissions (e.g., pollution assimilation by ecosystem)	POTENTIAL TO BE SIGNIFICANT	LIKELY TO BE SIGNIFICANT	UNLIKELY TO BE SIGNIFICANT	LIKELY TO BE SIGNIFICANT

KEY:

LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

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 typical factors could include:

- Local ecological and climatic context (e.g., cultivating a highly water-demanding tree species in an area suffering water stress)
- The ownership model of the forest concession and wider national or jurisdictional forest tenure regimes (e.g., is the ownership of the concession itself unclear or under dispute/ does creation of transport routes into otherwise inaccessible forest 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 (e.g., a local presence might automatically increase the scale of some impacts and require stakeholder engagement to get a complete picture of material issues)
- Proximity of concession to national parks or conservation areas (e.g., will operations disrupt fragile wildlife corridors)
- Accessibility of forest concession to public for recreation, fuelwood gathering, and other activities (e.g., will forestry operations impinge upon public traditions and livelihood activities)
- Customer attitudes (e.g., if certain ecosystem services gain more prominence publically and/or if specific management practices are perceived by the public to be harmful)
- Harvesting cycles and regeneration times (e.g., 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.

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.

MEASURE AND VALUE STAGE
How?

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:
Mapping between the Protocol and the sector guide

Step	Questions each Step will answer	Actions	Additional guidance included in the 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
		5.2.2 Define which impact drivers and/or dependencies you will measure	No
		5.2.3 Identify how you will measure impact drivers and/or dependencies	Yes
		5.2.4 Collect data	No
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
		6.2.2 Identify changes in natural capital associated with external factors	Yes
		6.2.3 Assess trends affecting the state of natural capital	No
		6.2.4 Select methods for measuring changes	No
		6.2.5 Undertake or commission measurement	No
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
		7.2.2 Determine the relative significance of associated costs and/or benefits	No
		7.2.3 Select appropriate valuation technique(s)	Yes
		7.2.4 Undertake or commission valuation	No

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 they 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 tools for practitioners when conducting natural capital assessments.

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

Author	Name	Type	Description
BRE Centre for Sustainable Products	BRE LINA	Life cycle assessment tool	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)	E.Valu.a.te: The practical guide	Assessment framework and tools	Evidential support around the process of valuation using a step-wise, bottom-up approach.(Cambridge Natural Capital Leaders Platform, 2013)
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 Business Council for Sustainable Development (WBCSD)	Guide to Corporate Ecosystem Valuation (CEV)	Valuation tool	The tool enables companies to consider the actual benefits and value of the ecosystem services they depend upon and impact, giving them new information and insights to include in business planning and financial analysis. (WBCSD et al., 2011)
Forest Stewardship Council (FSC)	Market Tools and Trademark Use for Demonstrated Ecosystem Services Impacts	Market tools	The tools will provide an economic argument for responsible forest management over short-term harmful exploitation of forest resources (FSC, 2017).
Institute for Development of Environmental-Economic Accounting	Environmental-Economic Accounting Toolkits (EEA Toolkits)	Accounting toolkit	Toolkit allows user to understand EEA, integrate ecosystem data, report EEA and how EEA can inform sustainable management of natural capital
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 to understand sources of value and trade-offs in maintaining England's woods and forests. (Forest Enterprise England, 2016)
The Economics of Ecosystems and Biodiversity (TEEB) / United Nations Environmental Programme (UNEP)	TEEB for Agriculture & Food	Assessment framework	A draft 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, 2017)
United Nations Statistical Commission (UNSC) *https://unstats.un.org/sdgs/hlg/Cape-Town-Global-Action-Plan/*	Cape Town Global Action Plan for Sustainable Development Data	Data & accounting framework	Global plan intended to provide a framework for discussion on, and planning and implementation of, statistical capacity building necessary to achieve the scope and intent of the 2030 Agenda for Sustainable Development (UNSC, 2017)

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

Author	Name	Type	Description
Alliance for Water Stewardship	The AWS International Water Stewardship Standard	Standard / 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 benefits at the scale of a catchment. (AWS, 2014).
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)
GreenFund (Government of South Africa, Department of Environmental Affairs)	Development of Sustainable Bio-based Composite Products from Agricultural Biomass Protocols related to carbon credits (such as the ones of Climate Action Reserve Biodiversity survey methodologies Forest certification Life cycle assessment	Report	A report investigating value-added utilization of waste residues from forest and agricultural streams to develop sustainable materials for specific uses in automotive parts, green buildings, and green packaging applications in South Africa (Green Fund, 2015).

See the appendix for sector specific hypothetical examples which illustrate how a business may complete this Step.

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

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.

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 modelling techniques (for example, environmentally extended input-output (EEIO) models, productivity models, mass balance)

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 5.2
Sector-specific considerations for primary and secondary data approaches

Type of data	Sector-specific considerations
Primary data	The tree 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 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 modelling 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)).

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 the appendix 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

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 pollutants	Air quality
Example indicator	Sequestration of metric tons of GHGs.	Nutrient levels (nitrate and phosphorus compounds) and other chemical inputs.	Kilograms of emissions of sulphur dioxide (SO2) and nitrogen dioxide (NO2), carbon monoxide (CO) and volatile organic compounds (VOC), levels of atmospheric particulate matter PM10 and PM2.5.
Example changes in natural capital	Reduction of net GHG emissions which act as a global impact driver, resulting in 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).

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 freshwater 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 km2 (Ritters et al., 2002, Climate Home, 2016)) are threatened by climate change-induced drought. The tree species itself has a role play, with various crops 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 (WRM, 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 km2 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 because of the increase in international trade increasing the 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.

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 the appendix 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

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 (World Bank Group & Ecofys, 2017)

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 unique in that it is one of the few sectors where communities live on/amongst the primary production sites (i.e., in the forests themselves). According to WWF (WWF, 2017) around 300 million people live in forests with more than one billion people depending on forests for their livelihoods. This means that 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 which 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 pollutants	Air quality
Example changes in natural capital	The locking away of carbon in trees and healthy soils will reduce global GHG concentrations and therefore 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 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 natural disasters, human health, gender equality, and geopolitical security.	Water pollution from the excessive use of fertilizer 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 up 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: Soil health	Non-consumptive: Regulation of living environment
Example changes in natural capital	Depletion or desiccation of a freshwater body that provided an irrigation source for plantations.	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 its 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.

Select appropriate valuation technique(s)

There are three types of valuation technique:

- 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, decrease in population of 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, 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.

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.

A useful resource for the forest products sector is the searchable valuation database from The Economics of Ecosystems and Biodiversity (TEEB, 2013), available online, that brings together estimates of monetary values of ecosystem services from multiple academic studies. Many of these values are expressed in units of US$/ha/per year therefore reflecting the value to humans in monetary terms of the flows of ecosystem services per hectare of ecosystem per year.

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. The same valuation types as above 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 the forest plots studied became carbon neutral rather than carbon sinks as they previously were (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).

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

APPLY STAGE
What next?

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:
Mapping between the Protocol and the sector guide

Step	Questions each Step will answer	Actions	Additional guidance included in the 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
		8.2.2 Identify who is affected	Yes
		8.2.3 Collate results	No
		8.2.4 Validate and verify the assessment process and results	No
		8.2.5 Review the strengths and weaknesses of the assessment	No
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
		9.2.2 Communicate internally and externally	No
		9.2.3 Make natural capital assessments part of how you do business	Yes

Additional notes
Businesses operating in the apparel 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

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 apparel 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 2012a). 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.

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

Identify who is affected

Distributional analysis is used to understand who is affected by a decision, and whether they gain or lose. Use a distributional analysis to identify which stakeholders gain or lose as a result of your natural capital impacts and/or dependencies, and whether they might gain or lose in the future as a result of your anticipated actions or responses following the natural capital assessment. Distributional analysis is not only an important element in the assessment itself, but also influences how your results may be interpreted and used.

Note: Remember that the type of stakeholder affected may influence the type and magnitude of different values. To give an obvious example, recreational or amenity values for a particular site will vary depending upon whether a person is a local resident or not.

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-time scale, 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 Identify stakeholders and the appropriate level of engagement. You may decide that you do need to engage with a set of stakeholders that you had previously decided would be relatively unaffected.

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 the appendix 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

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 new information. 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 (e.g., 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 tree production stage of the value chain. This is evidenced 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, 2016) 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 verification (e.g., Forest Stewardship Council (FSC), Programme for the Endorsement of Forest Certification (PEFC), or Sustainable Forestry Initiative (SFI)), 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.

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. A business also can understand the impact in relation to the amount of the resource actually available, as its value reflects its scarcity. 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 "cascading use of wood", the ability to make use of so-called waste streams generated in the production of high-value forest products. 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.

The choice of forest products over more typical alternatives can also 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 forestry 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 forestry 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, or withdraw and divest assets, 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 tree 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).

Relevant business applications: Communicate internally and/or externally

What future natural capital assessments are worthwhile?

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 or support 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

Make natural capital assessments part of how you do business

Any measure of success in the uptake of a protocol 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 World Economic Forum's Global Risks report (2017) cites water crises, failure of climate change mitigation and adaptation, and man-made environmental disasters within its top ten global risks over the next ten years as measured by likelihood and scale of global impact (World Economic Forum, 2017).

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.

Appendix 1: Hypothetical company examples

Step 01 Get started	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6
Company name	Continental Paper Co.	Biomex	Homes & More	Northern Lumber Inc.	Whitford Wipes	Country A government
Organization	Global integrated pulp and paper and packaging company headquartered in Latin America	European biomass-energy company	Global furniture manufacturer and retailer	A North American lumber company	Multinational care products manufacturer producing tissues, toilet paper, utility wipes, disposable diapers, etc.	National government
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, in regards to impacts on local stakeholders.	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 designs and produces furniture for sale in stores around the world. The company has a vast, complex supply chain and sources hardwoods from Africa, and softwoods from Europe, Russia, and Southeast Asia. The company wants to educate its customers on the net impacts of some of its leading products from inception to end of life.	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.	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.	Country A is a big importer of timber and therefore is offshoring a significant amount of their forest footprint. The government is keen to understand its dependencies and risk associated with this.
Which risks and opportunities might a natural capital assessment help to address?	Risks of local community stakeholders protesting averted. Financial risks of lost business associated with unhappy communities averted. Opportunity for establishing 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 for competitive advantage over other brands through the marketing of sustainable products.	Opportunity for improved reputation with local stakeholders.	Financial and operational opportunity from supply chain stability. Reputational risks of inaction are addressed. Opportunity for competitive advantage over other brands.	Financial risks of inaction mitigated, greater security of wood supply and less reliance on imports with price fluctuations. Opportunity for strategic planning.

Step 02 Define the Objective		Company 1	Company 2	Company 3	Company 4	Company 5	Company 6
	Company name	Continental Paper Co.	Biomex	Homes & More	Northern Lumber Inc.	Whitford Wipes	Country A government
	What is the intended business application?	Assess impacts on stakeholders and compare options	Communicate internally and/or externally	Communicate externally	Compare options	Compare options	Assess risks and opportunities
	Who is the targeted audience?	Senior management	Regulators	Customers	The finance and forest management teams	Procurement team	Policy makers
	Who are the right stakeholders and what is the appropriate level of engagement?	Consult with local communities living in the vicinity of potential and current mill and inform NGOs	Inform regulators of assessment and progress	Consult all tier suppliers and inform customers	Consult internal forest management staff and local stakeholders	Consult first-tier suppliers	Consult and collaborate with domestic businesses dependent on timber
	What specific benefits do you anticipate from the assessment?	The assessment will help decision makers deciding on the company's expansion options to choose an option that minimizes negative impacts on local stakeholders.	Assessment will allow for informed engagement with national and regional policymakers who may otherwise restrict wider biomass use.	The assessment will inform the communication strategy of the company and allow them to inform customers of product benefits leading to potential increase in revenue.	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.	Policy makers will be able to make strategic decisions once they understand the nature of the country's dependency and mitigate future risks.
	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 biomass in order to inform legislative decision making.	To communicate to customers the positive impact of popular products to provide an alternative narrative around the role wood products play in the environment.	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 understand the risks around the country's current timber imports.

Step 03 Scope the assessment	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6
Company name	Continental Paper Co.	Biomex	Homes & More	Northern Lumber Inc.	Whitford Wipes	Country A government
What organizational focus?	Project	Product	Product	Corporate	Corporate	National
Which value-chain boundary?	Processing: potential and current mill sites	Own operations and upstream	Whole value chain (upstream, operational, and downstream)	Own operations	Upstream	Imports for the national forest products manufacturing supply chain
Will the assessment cover impacts and/or dependencies?	Both (predominantly impacts)	Both	Impacts	Both	Both (predominantly dependencies)	Dependencies
Which value perspective?	Business and society	Society	Society	Business and society	Business and society	Business
What types of value?	Monetary	Quantitative	Quantitative	Quantitative	Monetary	Monetary
Other technical issues to consider						
Baselines	No single baseline - comparison between two scenarios	The natural capital impacts and dependencies of the company's operations and supply chain in a chosen year	The natural capital impacts of the chosen product's value chain	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 average natural capital impacts and dependencies of the country's imports over a chosen time period (e.g. 5 years)
Scenarios	Two scenarios, one for expansion and one for constructing the new site	The natural capital impacts and dependencies of an alternative energy source used for a significant part of the country's domestic energy needs	Could potentially consider an alternative, non-wood product to compare the impacts against	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	The natural capital impacts and dependencies of producing a greater proportion of wood fiber domestically
Spatial boundaries	Current site and potential site	Locations impacted by own operations and supply chain operations	Locations impacted during the full life cycle of the produce	The forest estate and neighboring locations impacted by the estates operations	Locations impacted by supply chain operations	Productive forest lands in countries that Country A imports from and the locations within Country A that could potentially contribute wood domestically
Time horizons	The length of time that impacts from the new plant and from the expansion of the old plant are estimated to perpetuate for	Time needed to produce equivalent amounts of energy from biomass and from the alternative source and the length of time that the impacts are estimated to perpetuate for.	The estimated life time of the product	Five harvesting cycles	Length of time that impacts are estimated to perpetuate for.	Last five financial years and up until the full implications of an increase in domestic production are evidenced (e.g. estimated to be 30 years)
Key planning issues to consider (for example, resource and time constraints)	Resources were assembled internally and potential data points for the 2 scenarios were designed by engagement with senior management.	Time needed to produce equivalent amounts of energy from biomass and from the alternative source and the length of time that the impacts are estimated to perpetuate for	Supplier surveys were undertaken to gather data on locations in the supply chain. This was undertaken by the internal procurement team.	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.	A third-party consultant assisted with the stakeholder consultation to define the scenario for increased domestic wood production.

Step		Company 1	Company 2	Company 3	Company 4	Company 5	Company 6
04 **Determine the impacts and/or dependencies**	Company name	Continental Paper Co.	Biomex	Homes & More	Northern lumber Inc.	Whitford Wipes	Country A government
	Summarize the key decisions on the materiality process, including who was involved	**What stakeholder engagement was carried out?** Local communities living in the vicinity of potential and current mill site were engaged. **What criteria were used to compare relative materiality?** Financial and societal **What data were gathered?** Publically available data about the social and environmental contexts of the two locations, internal data on mill operations, local community survey data.	**What stakeholder engagement was carried out?** No external consultation **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?** Environmental specialists were consulted to better understand the impacts associated with raw materials used in the supply chain. **What criteria were used to compare relative materiality?** Societal materiality to understand and communicate the extent of positive impact delivered **What data were gathered?** An external consultant was hired to provide high-level appraisal of impacts over key products lifecycle.	**What stakeholder engagement was carried out?** Some engagement with local government. **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?** A selection of leading domestic companies were consulted to understand their dependencies. Specialists were consulted to understand impacts in countries that are imported from. **What criteria were used to compare relative materiality?** Financial and operational materiality of the dependencies incorporated to best understand the country's import dependency risks. **What data were gathered?** Corporate procurement data requested from companies and analyzed.
	List the material impact drivers and/or dependencies that will be brought forward to the Measure Value Stage	Water use and provisioning deemed most material impact, as well as disturbances (noise and odor) and air pollution.	Impacts around carbon sequestration and greenhouse gas emissions found to be most material.	Impacts around GHG emissions and carbon sequestration most material.	Dependencies on wood fiber. Impacts on carbon sequestration and biodiversity.	Consumptive dependencies on wood fiber and water and energy are most material.	Consumptive dependency on foreign wood fiber most material.

Steps 05-09 of the hypothetical examples are not included in this draft guide for consultation but will be included after feedback and pilot testing.

Appendix 2.a:
Justification for colour coding in Figure 4.3

PRE-ESTABLISHMENT		
Zoning sensitive areas and practicing low impact management		
Carbon sequestration**		Protecting high conservation value (HCV) areas as reserves may have a positive impact on carbon sequestration over time
Water pollutants		The establishment of buffer zones has repeatedly been shown to be highly effective for protecting water quality
Fiber		Protecting natural habitats may increase the availability of fiber for local communities depending on access
Food and fuel		Protecting natural habitats may increase the provision of food and fuel types for local communities depending on access
Fresh water (groundwater)		Protecting natural habitats can secure the watershed protection function of forests
Fresh water (surface water)		Protecting natural habitats can secure the watershed protection function of forests
Biochemicals, natural medicines, and pharmaceuticals		Protecting natural habitats can allow for the protection of important naturally occurring biochemicals, natural medicines, pharmaceuticals, etc.
Regulation of air quality		Protecting high conservation value forested areas may help to clean polluted air by filtering and trapping pollution particles with attendant benefits for local flora and fauna
Regulation of local, regional, and/or global climate		Protecting natural habitats will likely facilitate the role of the natural landscape regulation of local climate
Regulation of water timing and flows (groundwater)		Protecting natural habitats can secure the watershed protection function of forests
Regulation of water timing and flows (surface water)		Protecting natural habitats can secure the watershed protection function of forests
Erosion control		Protecting natural habitats can secure the erosion control function of forests
Water purification and waste treatment (groundwater)		Protecting natural habitats can secure the watershed protection function of forests
Water purification and waste treatment (surface water)		Protecting natural habitats can secure the watershed protection function of forests
Regulation of soil quality		Protecting natural habitats can maintain the natural soil quality in these areas
Regulation of pests and diseases		Protecting natural habitats can maintain the natural heterogeneity required to regulate pests and disease in these areas
Pollination		Protecting natural habitats can maintain the natural heterogeneity required to regulate pollination in these areas
Regulation of natural hazards		Protecting natural habitats can maintain the functionality of natural hazard regulation in these areas (e.g., protecting against mudslides)
Recreation and ecotourism/educational and spiritual values		By protecting areas of high conservation value, areas particularly valuable to tourists are also likely to be conserved.
Change in habitat/biodiversity: Flora		Native and natural habitats zoned for protection will increase undisturbed area available for species
Change in habitat/biodiversity: Fauna		Native and natural habitats zoned for protection will increase undisturbed area available for species

Transportation for sourcing trees		
GHG emissions		Increased GHG emissions due to transportation impacts; this will vary according to both the distance travelled and the mode of transport used
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
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
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

Constructing roads and railroads		
GHG emissions		The industrial processes required to construct roads and railroads may lead to the release of GHG emissions
Non-GHG air pollutants		The industrial processes required to construct roads and railroads may lead to the release of non-GHG air pollutants
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, diesel spillages, construction debris
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, diesel spillages, and construction debris)
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)
Erosion control		Poorly designed roads and railroads may lead to soil erosion
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
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

Use of nurseries for seedling production		
Carbon sequestration**		Seedling production may lead to an increase in carbon sequestration

Carrying out 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)
Non-GHG air pollutants		Burning leads to the release of non-GHG air pollutants

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
Non-GHG air pollutants		Non-GHG air pollution could likely take place via the machines used to till soils
Water pollutants		Tilling soils may cause sediment leaching into water ways
Fresh water (groundwater)		Tilling soils may impact the way water moves through a forestry system
Erosion control		Tilling soils may disturb soil compaction and lead to erosion and sediment leaching

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
Non-GHG air pollutants		Non-GHG air pollution could likely take place via the machines used to establish the drainage systems (if mechanized)
Water pollutants		Establishing drainage systems may cause sediment leaching into water ways
Fresh water (surface water)		Establishing drainage systems for plantations can redirect water away from natural surface water routes that serve local communities

Appendix 2.a continued:
Justification for colour coding in Figure 4.3 continued

ESTABLISHMENT		
Planting native tree species		
Carbon sequestration**		Planting, especially fast growing species, can increase forest carbon sequestration rates
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
Change in habitat/biodiversity: Flora		Native species may provide habitat for local biodiversity
Change in habitat/biodiversity: Fauna		Native species may provide habitat for local biodiversity
Planting non-native tree species		
Carbon sequestration**		Planting, especially fast-growing species, can increase forest carbon sequestration rates
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, Robina pseudo-accacia in Europe)
Change in habitat/biodiversity: Flora		Non-native species are less likely to provide a good habitat for local biodiversity compared to native species
Change in habitat/biodiversity: Fauna		Non-native species are less likely to provide a good habitat for local biodiversity compared to native species
Planting mixed-species plantations		
Carbon sequestration**		Planting, especially fast-growing species, can increase forest carbon sequestration rates
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
Change in habitat/biodiversity: Flora		Will depend to a large extent on the composition and ratio of native and non-native trees
Change in habitat/biodiversity: Fauna		Will depend to a large extent on the composition and ratio of native and non-native trees
Planting - By hand		
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
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
Soil pollutants		Mechanized planting is likely impactful by causing soil pollution via the mechanisms required to plant
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)
Disturbances (e.g. noise and odor)		Mechanised 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
Regulation of soil quality		Mechanized planting is impactful to soils by disturbing compaction and quality

MANAGEMENT		
Thinning and pruning		
GHG emissions		If mechanized, thinning activities are likely to release some GHG emissions via machinery used
Non-GHG air pollutants		If mechanized, thinning activities are likely to release some non-GHG air pollutants via machinery used
Disturbances (e.g. noise and odor)		Some noise-related disturbance could result from thinning and pruning activities, depending on level of mechanization
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
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
Regulation of pests and diseases		Maintaining proper stand density has been shown to reduce susceptibility to pests and diseases

Fertilizing soils		
Carbon sequestration**		Increased tree growth may lead to an increase in carbon sequestration
GHG emissions		Intensive fertilizer 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
Water pollutants		Fertilizers which are drained in the water (leached) can lead to water pollution and eutrophication
Disturbances (e.g. noise and odor)		Some odor-related disturbance could be the result of extensive fertilizing
Fiber		Fertilizing soils improves the growth rate of commercial trees and surrounding vegetation increasing the availability of fiber for local communities
Change in habitat/biodiversity: Flora		Fertilizers may negatively impact flora adapted to nutrient-poor conditions, or conversely benefit other types of flora negatively affected by nutrient-poor soils

Irrigation (may also apply to Pre-Establishment and Establishment)		
Water use (groundwater)		Irrigation may lower levels of ground water BIOME VARIATION: Boreal forests and forests in North America are typically not irrigated
Water use (surface water)		Irrigation may lower availability of surface water BIOME VARIATION: Boreal forests and forests in North America are typically not irrigated
Fiber		Drought and moisture stress can result in stunted tree growth rates or mortality
Regulation of pests and diseases		Irrigation may reduce drought that increases susceptibility to insect pests and pathogens
Change in habitat/biodiversity: Flora		Water from irrigation systems may benefit flora that are negatively impacted by dry or arid conditions or seeds lying dormant due to water stress

Controlling pests: Pesticide		
Carbon sequestration**		An infestation of pests may reduce the ability of the forest to sequester carbon
GHG emissions		Application of pesticide (if mechanized) may release GHG emissions
Water pollutants		Pesticides can be leached from the forest floor during rain storms and pollute water ways
Soil pollutants		Overuse of pesticides can lead to pesticides acting as a soil pollutant, reducing soil quality
Disturbances (e.g., noise and odor)		Some odor-related disturbance could be the result of extensive pesticide spraying

Appendix 2.a continued:
Justification for colour coding in Figure 4.3 continued

Controlling pests: Pesticide continued		
Fiber		Uncontrolled pest outbreaks can stunt tree growth or result in outright tree mortality
Food and fuel		Uncontrolled pest outbreaks can stunt tree growth, result in outright tree mortality, and destroy crops
Regulation of pests and diseases		The use of pesticide can be highly effective in regulating the presence of pests and diseases
Pollination		A number of pesticides have been linked to a decrease in pollination services
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
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

Controlling pests: Bio-control		
Carbon sequestration**		The planting of beneficial cover crops may lead to increased carbon sequestration
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
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

Fire prevention and suppression		
Change in habitat/biodiversity: Flora		Potential impacts on biodiversity through habitat fragmentation
Change in habitat/biodiversity: Fauna		Potential impacts on biodiversity through habitat fragmentation

HARVESTING		
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
Non-GHG air pollutants		Machinery used will result in the release of non-GHG air pollutants
Water pollutants		May cause water pollution via sediment leaching
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)
Erosion control		May result in soil erosion and subsequent sedimentation/leaching
Regulation of soil quality		May result in soil erosion and subsequent sedimentation/leaching

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)
GHG emissions		Mechanized felling will have GHG emissions impacts
Non-GHG air pollutants		Mechanized felling will likely release non-GHG air pollutants via the machinery used

Harvesting: Selective logging continued		
Soil pollutants		Harvesting can lead to soil pollution via the machinery used
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)
Disturbances (e.g., noise and odor)		Harvesting by selective logging is likely to be mechanized but likely less disturbing both visually and audibly compared to clear-felling
Fiber		Harvesting of wood fiber provides fiber to local and global communities
Fresh water (groundwater)		Harvesting can be highly impactful on soil erosion, reducing the soil's productivity and ability to retain water
Erosion control		Is likely to lead to erosion via disturbance of soil during tree removal. Damage will not be as impactful as clear-felling.
Change in habitat/biodiversity: Flora		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type
Change in habitat/biodiversity: Fauna		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type

Harvesting: Clear-felling		
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).
GHG emissions		Mechanized felling will have GHG emissions impacts
Non-GHG air pollutants		Mechanised felling will likely release non-GHG air pollutants via the machinery used
Soil pollutants		Clear-fell harvesting can lead to soil pollution via the machinery used
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)
Disturbances (e.g., noise and odor)		Harvesting by clear felling is likely to be highly mechanized. Large-scale land clearing will cause disturbances both visually and audibly.
Fiber		Harvesting of wood fiber provides fiber to local and global communities
Fresh water (groundwater)		Harvesting can be highly impactful on soil erosion, reducing the soil's productivity and ability to retain water
Regulation of air quality		Clear-felling 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
Erosion control		Is very likely to lead to erosion via disturbance of soil during tree removal. Damage will be more impactful than selective logging
Change in habitat/biodiversity: Flora		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type
Change in habitat/biodiversity: Fauna		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type

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)
GHG emissions		Mechanized felling will have GHG emissions impacts
Non-GHG air pollutants		Mechanized felling will likely release non-GHG air pollutants via the machinery used
Water pollutants		The nature and practice of underwater harvesting may lead to water pollution
Disturbances (e.g., noise and odor)		Harvesting underwater is likely to be highly mechanized and will cause disturbances both visually and audibly

Appendix 2.a continued:
Justification for colour coding in Figure 4.3 continued

Harvesting: Underwater continued		
Fiber		Harvesting of wood fiber provides fiber to local and global communities
Change in habitat/biodiversity: Flora		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type
Change in habitat/biodiversity: Fauna		Likely to negatively impact biodiversity via disturbance and removal of continuous habitat but dependant on species type

Restoring lands		
Carbon sequestration**		Restoring forests after harvesting replenishes carbon stores and increases carbon sequestration rates
Regulation of air quality		Restoring forests helps to clean polluted air by filtering and trapping pollution particles
Regulation of soil quality		Restoring land to its pre-harvest state should improve the overall quality of the soil
Change in habitat/biodiversity: Flora		Restoring land to its pre-harvest state should lead to an overall increase in biodiversity
Change in habitat/biodiversity: Fauna		Restoring land to its pre-harvest state should lead to an overall increase in biodiversity

KEY:

POSITIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT
NEGATIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

* This is the view taken in carbon accounting methodologies. However, the net carbon sequestration over a whole forest concession within a year may well be positive even taking into account the stock removed by harvesting.
** 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 colour coding in Figure 4.4

TRANSPORTATION FROM FELLING SITE TO PRIMARY PROCESSING		
Use of roads		
GHG emissions		Use of heavy duty trucks on road may release significant GHG emissions
Non-GHG air pollutants		Use of heavy duty trucks on road may release significant non-GHG air pollutants
Disturbances (e.g., noise, odor)		Noise and odor disturbances of trucks in rural forested areas may be significant
Change in habitat/biodiversity: Fauna & Flora		Heavy traffic may result in animal fatalities and frighten species away from the area
Use of railroads		
GHG emissions		May release significant GHG emissions although comparatively less than on road
Non-GHG air pollutants		May release significant non-GHG air pollutants although comparatively less than on road
Disturbances (e.g., noise, odor)		Noise and odor disturbances may be significant
Change in habitat/biodiversity: Fauna & Flora		Heavy traffic may result in animal fatalities and frighten species away from the area
Use of waterways		
GHG emissions		Will release GHG emissions, but much less than train or road transport
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
Water pollutants		Shipping through inland waters can cause the release of untreated blackwater, greywater and bilge water.
Disturbances (e.g., noise, odor)		Poorly planned logdriving can impact the movement of inward and outward migrating fish and other marine species as well as disrupting sensitive spawning grounds
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
Recovery of process chemicals		
GHG emissions		Chemical recovery (e.g., in pulping processes) avoids GHG emissions associated with the production of new 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
Water pollutants		Chemical recovery (e.g., in pulping processes) can reduce the potentially negative water pollution impacts of manufacturing
Water use (groundwater)		Chemical recovery (e.g., in pulping processes) avoids water use impacts associated with the production of new chemicals
Water use (surface water)		Chemical recovery (e.g., in pulping processes) avoids water use impacts associated with the production of new chemicals

Appendix 2.b continued:
Justification for colour coding in Figure 4.4 continued

Recovery of process water		
Water use (groundwater)		Water recovery (e.g., in pulping processes) can reduce the potentially negative water use impacts of manufacturing
Water use (surface water)		Water recovery (e.g., in pulping processes) can reduce the potentially negative water use impacts of manufacturing

Use of residues as energy		
GHG emissions		Potential reduction in GHG emissions relative to using alternative fuel sources
Non-GHG air pollutants		Potential reduction in non-GHG air pollutants relative to using alternative fuel sources
Solid waste		Prevents wood residues being sent to landfill

Manufacturing		
GHG emissions		GHG emissions vary according to the processing technique employed (e.g., handwork vs. mechanization)
Non-GHG air pollutants		Non-GHG air pollutants vary according to the processing technique employed (e.g., handwork vs mechanization)
Water pollutants		Water pollutants vary according to the materials or chemicals used in the manufacturing process and their disposal
Soil pollutants		Soil pollutants vary according to the materials or chemicals used in the manufacturing process and their disposal
Solid waste		Solid waste vary according to the materials used in the manufacturing process and their disposal
Disturbances (e.g., noise, odor)		Noise or odor pollution (e.g., around pulp mills) may impact neighbouring communities.
Water use (groundwater)		Some manufacturing processes can have high water use impacts (e.g., pulp and paper mills require substantial amounts of water)
Water use (surface water)		Some manufacturing processes can have high water use impacts (e.g., pulp and paper mills require substantial amounts of water)
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		
(Non-electric) Road and 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
Non-GHG air pollutants		Air pollutants released from petrol, diesel, and alternative-fuel engines include carbon monoxide, nitrogen oxides, un-burnt hydrocarbons, and particulate matter
Disturbances (e.g., noise, odor)		Heavily travelled road and rail routes can cause significant noise pollution depending on the location
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

SHIPPING AND TRANSPORT TO USER		
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)
Non-GHG air pollutants		Shipping may release high quantities of sulphur dioxide and nitrogen dioxide that causes acid rain, if heavy fuel is used
Water pollutants		Shipping may release untreated blackwater, greywater, and bilge water
Disturbances (e.g., noise, odor)		Marine noise pollution can disrupt and harm marine species who may rely on sound for communication, orientation, and feeding
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		
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
Water pollutants		Certain toxic chemicals may be used to treat finished wood fiber products (e.g., creosote on wooden fences and sheds) to significantly prolong their valuable lives, which can be a source of pollution to waterways if they run off

RE-USE AND RECYCLING		
Reuse of product		
GHG emissions		This avoids GHG emissions in the stages prior to use and at end of life
Non-GHG air pollutants		This avoids the emission of air pollutants in the stages prior to use and at end of life
Water pollutants		This avoids the release of water pollutants in the stages prior to use and at end of life
Soil pollutants		This avoids the potential release of soil pollutants from poorly designed and/or maintained landfills
Solid waste		This avoids the generation of solid waste across the value chain, but particularly at the end-of-life stage
Disturbances (e.g., noise, odor)		This avoids disturbance impacts across the value chain
Water use (groundwater)		This avoids the water use impacts associated with many upstream processes (e.g., tree production, primary and secondary processing)
Water use (surface water)		This avoids the water use impacts associated with many upstream processes (e.g., tree production, primary and secondary processing)
Change in habitat/biodiversity: Fauna & Flora		This avoids biodiversity impacts across the value chain

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
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

Appendix 2.b continued:
Justification for colour coding in Figure 4.4 continued

Recycling continued		
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
Soil pollutants		This avoids the potential release of soil pollutants from poorly designed and/or maintained landfills
Solid waste		This avoids the generation of solid waste across the value chain, but particularly at the end-of-life stage
Disturbances (e.g., noise, odor)		Recycling can cause disturbances, but it avoids other more significant disturbances across the value chain
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)
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)
Change in habitat/biodiversity: Fauna & Flora		This avoids biodiversity impacts across the value chain

Incineration for energy (e.g., biomass pellets, [forest] waste wood residues)		
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
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
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
Disturbances (e.g., noise, odor)		Smoke from the incineration process can cause smog and haze, while the odor may affect local/downwind communities

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
Non-GHG air pollutants		If the landfill is not well designed or maintained, a variety of potentially harmful non-GHG pollutants may be released
Water pollutants		If the landfill is not well designed or maintained, there is a likelihood that harmful chemicals will leach into groundwater
Soil pollutants		If the landfill is not well designed or maintained, there is a likelihood that harmful chemicals will leach into the soil
Solid waste		If products that could be recycled or reused are sent to landfill, this is a negative solid waste impact
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
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:

POSITIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT
NEGATIVE: LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

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 colour coding in Figure 4.5

POTENTIAL DEPENDENCIES IN THE FOREST PRODUCTS VALUE CHAIN		
Tree production		
Energy (non-photosynthetic)		Energy will be required by a number of mechanized processes, including transport, site preparation, maintenance and restoration, and harvesting
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
Nutrition		Trees primarily may require the application of fertilizers depending on a number of factors including current health and soil type and quality
Materials		Tree production may rely on the use of machinery and other inputs (e.g., fertilizer)
Land use		Forests usually require large areas and can be in competition with urban areas, agricultural land use, natural forests, or protected areas
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
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.
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

Primary and 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)
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)
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 fibre 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 artefacts such as instruments and furniture)
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
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
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

Appendix 2.c continued:
Justification for colour coding in Figure 4.5 continued

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)
Materials		Glue needed for the use of cross-laminated timber (CLT) wood panels for construction

End of life		
Energy (non-photosynthetic)		This will depend on the process: incineration and recycling are heavily dependent on energy, unlike landfill
Water		This will depend on the process: recycling can require high quantities of water
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
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
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
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:
LIKELY TO BE SIGNIFICANT POTENTIAL TO BE SIGNIFICANT UNLIKELY TO BE SIGNIFICANT

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.
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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Pilot testing companies will be appropriately acknowledged in the final version of the guide

About The Natural Capital Coalition

The Natural Capital Coalition brings together the different initiatives and organizations working in natural capital to find solutions and create opportunities through collaboration. Its membership is global and includes research, science, academia, business, advisory, membership, accountancy, reporting, standard setting, finance, investment, policy and governments, conservation bodies, and civil society. Its strength comes from this diversity, which is brought together through a common vision of a world where business conserves and enhances natural capital to create thriving societies and prosperous economies.

www.naturalcapitalcoalition.org

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