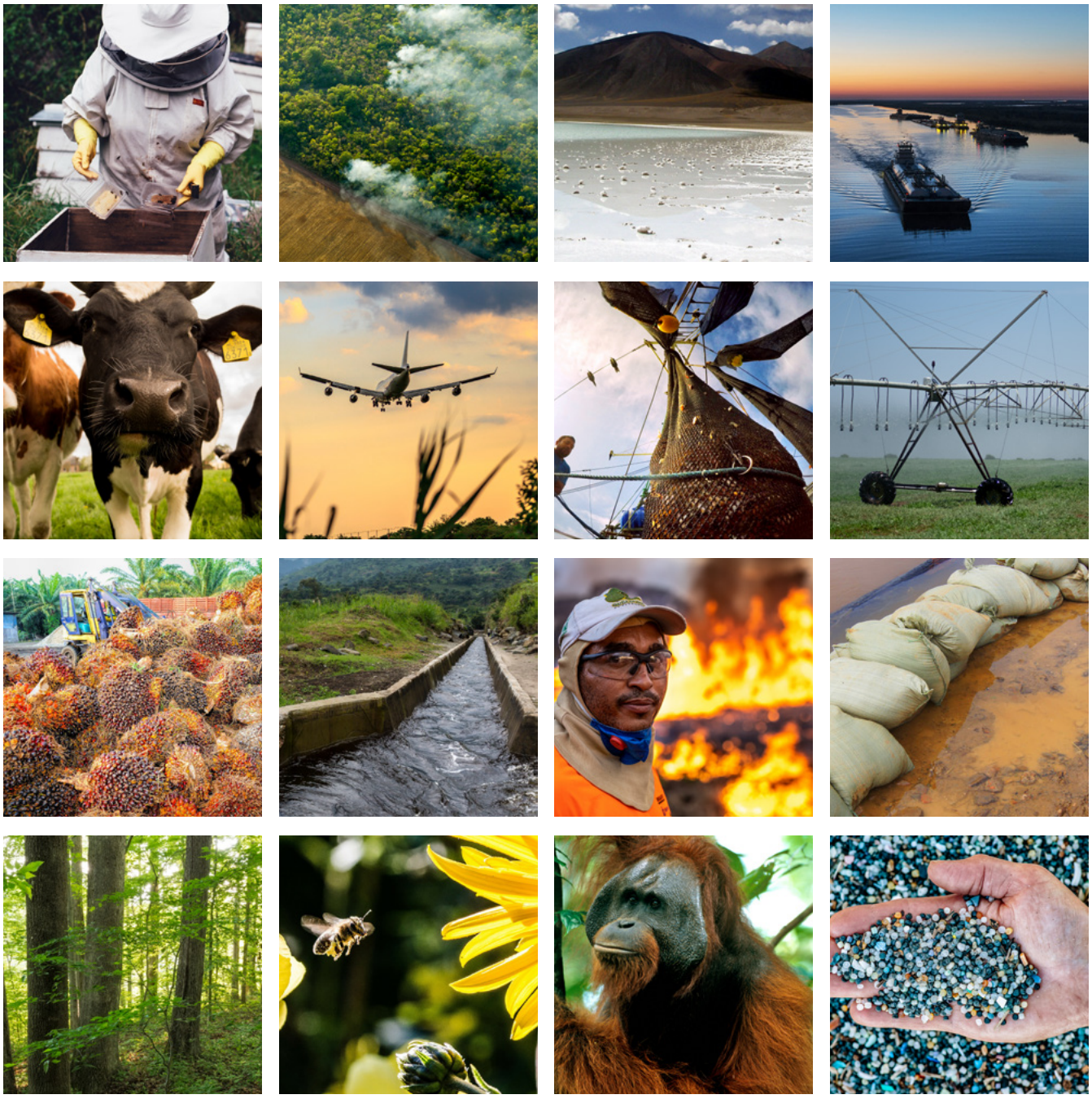

The Nature of Risk

A Framework for Understanding Nature-Related Risk to Business

WWF

Authors
Samantha McCraine, Christa Anderson, Christopher Weber, M. Rebecca Shaw

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The Nature of Risk

A Framework for Understanding Nature-Related Risk to Business

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Executive Summary

The case for considering environmental degradation as a risk—to business, finance, and society as a whole—is constantly getting stronger.

The recent Global Assessment released by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) supplied clear indicators of the loss of nature and the decline of ecosystem services—valued in the hundreds of trillions of dollars—which provide the basic building blocks of the global economy, from water to energy, and food to carbon sequestration.

This decline in ecosystem services is even more important as climate-related risk becomes a growing concern for business and finance: In organizations from central banks[1] to individual businesses,[2] climate-related risks have quickly risen to the top of the corporate mindset.[3] Climate-related risk and nature-related risk are not separate entities; the loss of nature decreases climate resilience, and climate change exacerbates drivers of nature loss.[4,5]

However, action on nature-related risk has been fragmented, in part because of an array of competing concepts and frameworks for understanding the financial materiality of nature and its services. This report provides a synthesis framework for nature-related risk, consolidating work from over 70 sources. We build on the years of study done by environmental economists, corporate risk managers, and climate scientists, as well as the momentum fueled by the Task Force on Climate-related Financial Disclosures (TCFD). As attention grows around climate change-related risk to business, there is a need for nature-related risk to be considered in parallel.

Together, the loss of nature and climate change are the "twin emergencies" facing humanity;[6] turning a blind eye to either can leave businesses vulnerable and exposed to risks.

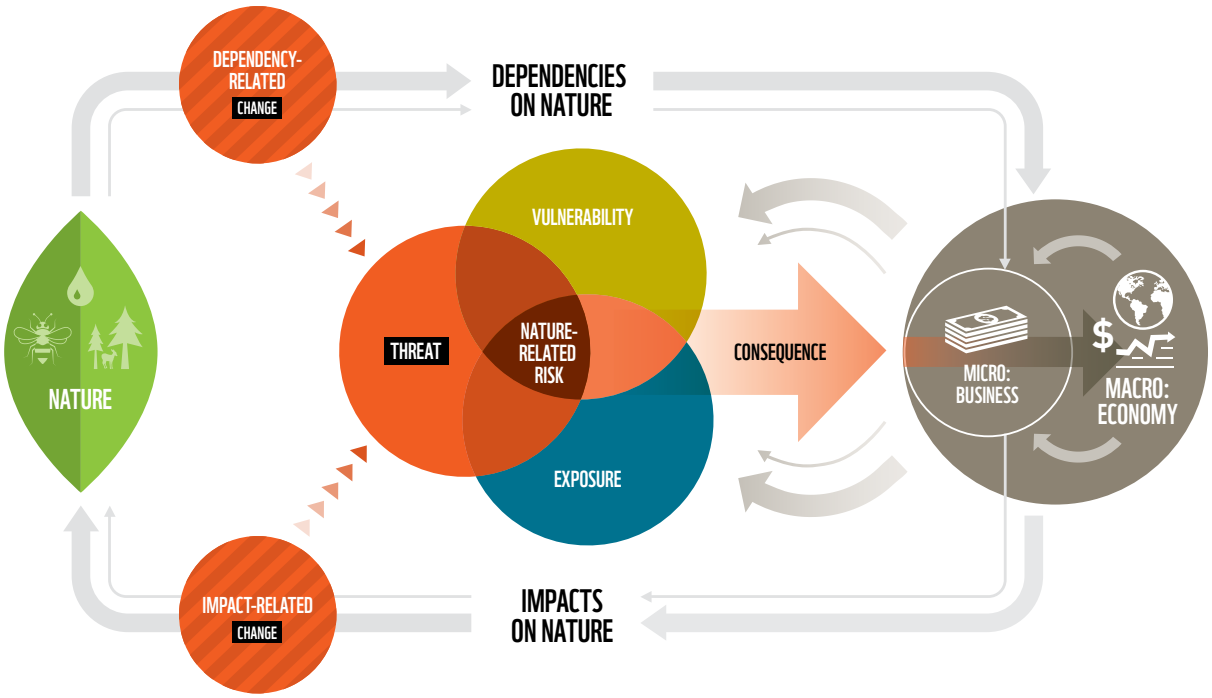
Framework for Understanding Nature-Related Risk to Business

This framework brings together concepts related to its two constituent terms: **nature** and **risk** (Figure ES1). Within our framework, businesses connect to nature in two primary ways: Through their **dependencies on nature**—businesses' reliance on ecosystem services and natural capital; and through their i**mpacts on nature**—the positive or negative effects of businesses' activity on nature. For businesses, a **change** in these dependencies and impacts can become **nature-related risk (NRR)** when that change creates a threat. Threats become financially material or consequential if the company also has some degree of exposure and vulnerability to the threat. At the business level, **exposure** is a function of factors like the business's sector and industry (the practices of these, and proximity to consumers and regulators), the geographic spread of their value chain (with implications for their legal jurisdictions and their sociopolitical contexts of operation), and finally their (degree of) reliance on ecosystem services or natural capital. **Vulnerability** of individual businesses to nature-related threats can generally be thought of as the (in) ability of the business to adapt to the threat at hand; this includes factors like size, expendable capital (or cash on hand), risk management practices along the value chain, risk awareness (including definitions of materiality), degree of operational and managerial resilience, value chain and/or product diversification, and influence on the market/within the sector (including pricing power and brand value). Where a threat, vulnerability, and exposure are all present, a financial **consequence** to the business may materialize. At the business level, this consequence can take the form of operational disruption, an increase in costs, a decrease in sales, or an increase in the cost of capital. Many times, these costs may be borne in part by other actors, such as investors, nearby communities, and other companies in their industry.

These dynamics of risk creation are common to nature-related risks and climate change-related risks. That is, both are concerned with the consequences of a threat becoming material due to exposure and vulnerability in the face of an (unexpected) change in operating conditions.

Factoring nature-related risks into decision-making can help companies anticipate threats and prepare for consequences by reducing their exposure and vulnerability. In a changing world, this preparedness enables better response times, resource availability and efficiency, optimization of products, and decreases in additional fines or costs.

Figure ES1. High level framework illustrating nature related risk to business



Framework of nature-related risk. This framework for nature-related risk combines two ideas. The first is how businesses and the economy both impact and depend on nature (outer gray arrows). The second is that nature-related risk arises from not just the change to impacts and dependencies on nature (striped circles), leading to a threat (orange circles), but also from a business's exposure and vulnerability (blue and yellow circles) 8. When a nature-related risk is realized, there may be a consequence to the business and to the broader economy. These consequences may trigger feedbacks on the company's vulnerability and exposure or may create further threats related to its impacts and dependencies on nature.

Adopted and integrated from NCFA & UNEP-WCMC 2018, Field et al. 2014

Types of Nature-Related Risk to Business

In addition to considering the components that make up nature-related risk, we assess different types of nature-related risks that are of concern for business. This review of the most commonly mentioned threats and consequences provides an indicator of which risks are most likely to be material for businesses (further details in Annex 1).

Based on our review of 30 frameworks, we group nature-related risk into five major types: **physical**, **regulatory & legal**, **market**, **reputational**, and **financial** risks. While the first four risk types can be further separated into **threats** and **consequences**, financial risks are almost always consequences of concern rather than threats.

Separating risk into threats and consequences highlights two elements of risk for businesses: 1) how a risk might arise (the threat, Table ES1a), and also 2) how it becomes material to the business or investors (the consequence). This is a simple distinction largely missing from the current conversation.

Our data indicates that twice as many threats are being assessed as compared to consequences, and that consequences on average receive slightly more attention per specific type than threats.

Table ES1a. Top cited examples of nature-related threats across reviewed sources

RISK TYPES	THREAT TYPE	TOTAL
Physical Risk		**11**
	Acute events; damage from natural/man-made hazards	11
	Biodiversity loss and decreasing species richness	7
	Scarcity of water	4
	Availability, reliability, and security of energy	4
	Habitat loss	2
	Air pollution	2
	Water pollution	2
Regulatory & Legal Risk		**14**
	Litigation, damages, and/or compensation	11
	Pricing or other regulations for emissions (GHG*/other)	10
	Restrictions on land and ES access	6
	Air pollution regulation	6
	Non-hazardous waste management	6
	Soil pollution regulation	6
	Resource quotas for ES use	4
	Unsustainable practices	4
	Changing liability regimes	3
	Hazardous waste management	3
	Water pollution regulation	3
	Changes in disclosure requirements	2
Market Risk		**10**
	Changing consumer preferences	7
	Inability to attract co-financiers due to uncertainty	2
	Purchaser requirements	2
Reputational Risk		**13**
	Negative press coverage	3
	Divestment or other stakeholder campaigns	3
	Impacts on World Heritage Sites or protected areas	2
	Impacts on species on IUCN** Red List	2

*GHG – Greenhouse gas

** IUCN – International Union for Conservation of Nature

Table ES1b. Most cited consequences of nature-related risks across reviewed sources

RISK TYPES	CONSEQUENCE TYPE	TOTAL
Physical Risk	Disruptions to business operations	7
	Labor shortages	5
Regulatory & Legal Risk	Unexpected costs of compliance/fines for noncompliance	9
	Stranded assets	4
Market Risk	Changes in the cost and availability of resources	4
Reputational Risk	Lost sales due to negative perceptions of the institution	3
Financial Risk	Increased cost of capital or lending requirements	5
	Write-downs of asset value and write-offs of assets	5
	Increased insurance claims	4
	Higher premiums; loss of insurance value	4
	Increased risk of default	3
	Loss of investment value related to reputational risks	2
	Changes in market value of the business	2

Physical Risk Regulatory & Legal Risk Market Risk Reputational Risk Financial Risk

Case Studies of Nature-Related Risk

While case studies of nature-related risk to businesses do exist, they are limited in number, in part because business are reluctant to voluntarily share risk information. Those published by business typically showcase positive actions (of companies proactively assessing their natural capital dependencies). In this report, we include cases which are emblematic, instances in which an actual risk event occurred. We outline these cases using the framework outlined in the paper.

Table ES2. Summary of selected case studies of nature-related risk and consequences for business

BUSINESS	CHANGE IN DEPENDENCIES OR IMPACTS	THREAT	VULNERABILITY	EXPOSURE	CONSEQUENCE(S)
BP	Impacts of the oil spill	Damage to surrounding environment	Risk assessment (-); brand value (+)	Types of activities undertaken (e.g., deepwater drilling); operations in marine environment	Legal costs at around USD 62.59–144.89 billion; loss of USD 3.7 billion in revenue; drop in market cap and share prices; increased insurance rates across the industry
Vale	Growing awareness about the dangers of "upstream" tailings dams	Collapse of the tailings dam	Risk assessment (-); brand reputation (-)	Environmental conditions	Suspension of operations; USD 2.3 billion in assets frozen; employees arrested; drops in share value and bond prices; down-graded credit ratings
German exporters	Depletion of South African water sources; drought	Crop failures	Diversification of suppliers and diversified products (+)	Distance from primary production; geography of supply chain; sociopolitical mood in home and host countries	EUR 70 million in forgone sales/profits
PG&E	Increased dryness in the environment; malfunctioning equipment	Sparks on the power lines	Risk assessment (-)	Types of activities under-taken (e.g., power trans-mission); environmental conditions of operation	Over USD 30 billion in liabilities; bankruptcy

This report focuses primarily on nature-related risks to businesses, analyzing recent gray literature on nature-related risk, categorizing and explaining nature-related risks to businesses. Future work is needed to address nature-related risks to society and the entire economy, to review academic literature on nature-related risk, to quantify the financial impact of nature-related risks to business and to discuss nature-related opportunities for businesses in detail. As well, key areas of interest for further research include the nexus of nature-related and climate change-related risks, in addition to the dynamics of systemic risk creation across micro and macro scales and between nature and climate.

List of Abbreviations

CCRR	Climate Change-Related Risk
CSR	Corporate Social Responsibility
ENCORE	Exploring Natural Capital Opportunities, Risks, and Exposure
ESG	Environment, Society, and Governance
FI	Financial Institution
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	The Intergovernmental Panel on Climate Change
NCC	Natural Capital Coalition
NCFA	Natural Capital Financial Alliance
NRR	Nature-Related Risk
TCFD	Task Force on Climate-Related Financial Disclosures

List of Definitions

Consequence – to businesses and other actors occur only if threats or risks are not managed. Consequences affect a business's cash flow and profitability by disrupting its operations directly or affecting its costs, sales, and/or cost of capital (i.e., credit rating, equity value).

Dependency – a business's reliance on or use of nature where nature functions as an input, or if it enables, enhances, or influences environmental conditions required for successful corporate performance.[11, 7]

Ecosystem Services (ES) – the flows of beneficial and detrimental contributions that people derive from nature.[4]

Exposure – the presence of a company's operations in places and settings that could be adversely affected by a threat.[8]* For a business, determinants of exposure include factors like the business's sector and industry (the practices of these, and proximity to consumers and regulators), the geographic spread of their value chain (with implications for their legal jurisdictions and their sociopolitical contexts of operation), and finally their (degree of) reliance on ecosystem services or natural capital. Exposure is the sum of "elements at risk" to any given threat occurring within a business's operating conditions.

Financial Risk – these risks are most often an outcome of the four primary risk types. This risk can be broken into two subsets, depending upon whether it accrues to businesses or financial institutions—we use financing risk for the former and financier risk for the latter.

Impacts – a positive or negative effect of business activity on the quantity or quality of NC stocks or ES.[11, 7]

Market Risk – risks that "relate to product and service offerings, customer preferences, and other market factors that can affect corporate performance."[11]

Materiality – is any information which is capable of making a difference to the evaluation and analysis at hand;[12] any definition of materiality should correspond to the information needs of the stakeholders for the report or publication in question. Material issues in this context are those that can threaten profits and may potentially lead to losses for shareholders.

Natural Capital (NC) – is a "way of thinking about the relationship between nature and the economy/society."[9] It refers to the stock of renewable and nonrenewable natural resources—e.g. plants, animals, air, water, soil, and minerals—that directly or indirectly might have the ability to yield a flow of benefits to people under specific conditions of management.[10]

Nature – refers to "all non-human living entities and their interaction with other living or non-living physical entities and processes."[4] We use this term to encompass both NC stocks and ES flows.

Nature-Related Risk (NNR) – refers to risks which arise when a change in a business's impacts or dependencies on nature become a threat to that business's operations and profitability due to factors of exposure and vulnerability.

Physical Risk – risks that arise from material destruction—such as damage to infrastructure and disruption of operations—causing economic and financial losses for businesses and investors. Physical risk can be further classified into those that are event-driven ("acute") or longer-term in nature ("chronic"), following the Financial Stability Board.[10]

Regulatory & Legal Risk – risks relating to laws, policies, regulations, and court actions that affect the operations of businesses.[11, 7]

Reputational Risk – risks that relate to a company's brand, image, and relationship with customers, the general public, and other stakeholders.[11, 7]

Risk – refers to a probabilistic concern with the consequences to business of a threat arising from a change.[8]*

Threat – the result of an event or change in the business's operating conditions that may jeopardize business value or profitability.[8]*

Vulnerability – the propensity or predisposition of a business to be adversely affected by threats in its operating conditions.[8]* For a business, determinants of vulnerability include size, expendable capital (or cash on hand), risk management practices along the value chain, risk awareness (including definitions of materiality), degree of operational and managerial resilience, value chain and/or product diversification, and influence on the market/within the sector (including pricing power and brand value). A business's vulnerability can mediate both threats and exposure.

*All definitions from Field et al., 2014 were adapted to reflect a focus on nature-related risks to business, in contrast to the original paper's focus on climate-related risks to society.

This list is paired with extended discussion of key terms in Annex 2.

1. Context of the Report

The case for considering environmental degradation as a risk—to business, finance, and society as a whole—is constantly getting stronger.

Earlier this summer, the Global Assessment released by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) made waves when it announced that "much of nature has already been lost, and what remains is continuing to decline."[4] To date, 70% of land systems, 50% of freshwater, and 40% of oceans and seas have been significantly altered.[4] As for the value of that loss, previous estimates of nature's value in monetary terms put it at USD 125-145 trillion/year in 2011.[13]

For example, agriculture is at the core of the global economy and human life, yet the pollination that allows crop production to continue is one of the ecosystem services found to be in decline globally. Currently, "USD 235-577 billion worth of annual global food production relies on direct contributions by pollinators."[14] The loss of pollinators—which is already observed and predicted to increase—"would result in an estimated annual net loss in welfare of USD 160-191 billion globally to crop consumers, and an additional loss of USD 207-497 billion to producers and consumers in other markets."[15,4] Without a reliable supply of food, increases in disease and deficiency can be expected to slowly erode the labor force in many parts of the world, threatening development gains and the stability of economic growth.[a] This example points toward the reality that different business sectors' *impacts* on ecosystem services have effects across the economy.

At the same time, so do businesses' *dependencies*—the ways in which businesses rely on nature and nature's services. With a growing population demanding ever greater supplies of Earth's resources, corporations' impacts and dependencies on nature are likely to continue to expand. Demands on nature will require trade-offs; for example, most scenarios predict that continued increases in the production of food and feed will occur at the expense of clean water, pollination, and climate regulation.[4] Already, 9 out of the 16 categories of ecosystem services surveyed by IPBES show a decline in output over the past five decades.[4] Most models, including business as usual and those with moderate policy intervention, predict a continued decrease in biodiversity across marine, freshwater, and terrestrial ecosystems, trends that have direct negative implications for agriculture, aquaculture, global fisheries, and the tourism industry as well as indirect implications for other sectors of the economy.

This decline in ecosystem services is even more important in a context of growing concern with climate-related risk: In organizations from central banks[1] to individual businesses,[2] climate-related risks have quickly risen to the top of the corporate mindset.[3]

Climate-related risk and nature-related risk are not separate entities; nature loss decreases climate resilience, and climate change exacerbates drivers of nature loss.[4,16] Not only can changes in land use exacerbate climate change (by transforming greenhouse gas "sinks" into "sources"), but climate change can also challenge the provision of ecosystem services through desertification and flooding.[5]

Together, the loss of nature and climate change are the "twin emergencies" facing humanity;[6] turning a blind eye to either can leave businesses vulnerable and exposed to risks posed by changes just over the horizon.

Drawing on the momentum of efforts to understand and address nature-related risk from OECD, NCFA, NCC, UNEP FI, and UNEP-WCMC, this report provides an overview of nature-related risk (NRR). We show how nature loss and degradation can materially affect businesses and present a systematic way of thinking through nature-related risk. In doing so, we address some of the complications that may otherwise stall improvements in corporate risk management.[b]

[a] The health dimension of nature-related risks is not included in this report; however, some attention is given in Annex 2. See UNEP-WCMC, 2019 (in prep), "Exploring the potential of ENCORE as a tool for planetary health: characterizing the relationships between economic sectors, natural systems and human health and well-being."

[b] It is not uncommon to find a passage in a report alluding to the disincentives to corporate action posed by the complexity of nature-related issues. See: https://www.cusp.ac.uk/wp-content/uploads/2017-11-Increasing-investment-in-natural-capital.pdf.

Based on a review of over 70 sources, the following sections present 1) a framework of nature-related risk (Section 3; Annex 2); 2) a typology of nature-related risk (Section 4), as well as a frequency assessment of these types; and 3) an evidence base of case studies to illustrate the framework and experience of nature-related risk (Section 5). Opportunities for further work are discussed in Section 6.

This report focuses specifically on understanding nature-related risks to businesses, leaving further work on analyzing academic literature and quantifying risks for individual businesses for future endeavors (see summary table below).

What this report does

- Focuses primarily on nature-related risks to *businesses*
- Analyzes recent *gray literature* on nature-related risk
- *Categorizes* and *explains* nature-related risks to businesses
- Discusses nature-related *risk* to businesses in detail

What this report doesn't do

- Focuses primarily on nature-related risks to s*ociety or the entire economy*
- Analyzes recent *academic literature* on nature-related risk
- Q*uantifies* financial impact of nature-related risks to businesses
- Discusses nature-related *opportunities* for businesses in detail

2. Literature Summary

This report was compiled from a desk review of relevant literature focused on non-academic reports. These comprise a significant share of what exists on nature-related risk for businesses. A separate literature review focused on academic literature on nature-related risk is forthcoming from WWF.

A large number of reports have been published in recent years on nature-related risk to businesses. This literature falls into three main groups: 1) reports focusing on natural capital, ecosystem services, or biodiversity; 2) reports focusing on climate-related risk; and 3) reports that cover environmental risk broadly, as a component of businesses' environment, social, and governance (ESG) considerations.

Across these categories, most of the literature has been written by nonprofits and multilateral organizations that are specifically interested in nature-related risk, many of which are either nature focused[17,9] or focused on the nature-business intersection.[7] A much smaller group of reports have been written by businesses or financial institutions interested in nature-related risk.[3,18]

A number of reports focus on methods for identifying nature-related risks to businesses[19,7] or on proposing options for businesses to report on their nature-related risks.[20, 9] Many also categorize types of nature-related risk[21,10] and include frameworks detailing how nature-related risks accrue to businesses.[11]

Most of the sources surveyed were concerned with nature-related risk across business sectors rather than focusing on one sector. Many sources rank sectors against one another,[18,19,22–27] providing useful information for investors and regulators, as well as for businesses eager to understand the risks posed to themselves and their competitors. Our survey of sources with sector-specific data revealed the following sectors to face the greatest nature-related risk: food and beverage, metals and mining, oil and gas, utilities, forestry, construction, and transportation (See Annex 1.2 for data). Although different sources qualify high-risk sectors with different terms, common elements include the number of material issues a sector has related to nature, the number of processes which have material dependencies on ecosystem services, the number of ecosystem services that are highly material to business

and the amount of proactive risk mitigation undertaken. The only sector consistently identified as low risk for nature-related issues was telecommunications. However, all sector-level studies pointed to a range of responsible behaviors and risk management practices within as well as across sectors. Not only certain sectors but also companies are more active at mitigating risk and others more active at disclosing risk.[23]

At the business level, most case studies focus on proactive risk management practices. Conducting such studies can help increase brand value (see our collection of case studies). Approaches to nature-related risk at the business level include assessing the value of nature where a business is located;[28] environmental profit and loss accounting;[29] assessments of businesses' natural capital dependencies and impacts; integrating indicators into corporate performance objectives;[30] and strategically selecting risk management options.[31,32]

Many different actors have attempted to **value** and measure the worth and availability of natural capital. This may be done at the micro/company level,[33] on a regional[19] or geographic level,[34] on a macro/global level,[35,13] or as a cross-scalar analysis.[36,c] The primary complications for such exercises are the location-specificity of biodiversity (data limitations), natural capital values and the inherent diversity of values attributed to nature/natural capital (diversity of uses), and the complexity of ecosystem components (natural complexity). Nonetheless, systematic attempts to value nature include Total Ecosystem Valuation[35,13,37] and the Corporate Ecosystem Service Review.[11] Multiple groups have worked to quantify the value of nature-related risks to business,[38–40] but further work remains in this area for bridging valuation and decision-making.

The literature that is focused on climate-related risk has made greater progress in quantifying the costs of these risks,[41,42] particularly those which are *physical risks.* Climate-related transition risks, or the risks to businesses associated with decarbonizing the economy, are more difficult to address. More broadly, *transition risks* "encompass the risks from large-scale adjustments triggered by policymaking, new institutional and/or technical settings, and market structure."[10] While transition risk has so far been associated with climate-related risk, potential may exist for a similar ecological transition risk. The scientific literature is strengthening the case for addressing climate-related risks and nature-related risks in unison;[4,16] to date, the non-academic literature on the intersection of these two realms is sparse.

3. Framework for Understanding Nature-Related Risk to Business

We provide a framework for understanding nature-related risk (NRR) to business based on our review. Given that NRR deals with multiple fields of study and expertise, we briefly define its key elements in order to provide common ground for addressing nature-related risks to business.

The concepts constituting our framework of nature-related risk are strategically selected as the most authoritative terms to communicate key concepts. Additional details on these terms, including distinctions between similar terms, are available in Annex 2.

3.1 Nature

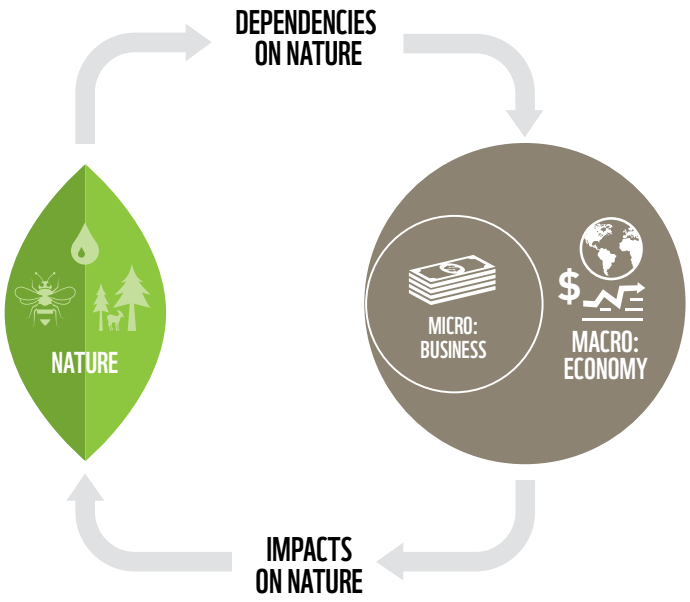
As a concept, **natural capital (NC)** is a "way of thinking about the relationship between nature and the economy/society."[43] It refers to the stock of renewable and nonrenewable natural resources (including plants, animals, air, water, soil, and minerals) that directly or indirectly might have the ability to yield a flow of benefits to people under specific conditions of management.[10] Given that NC is the primary building block of all other capital stocks—financial, manufactured, social/relational, human and intellectual—and economic activity,[44] degradation of NC can threaten all elements of the economy.

In contrast to NC, ecosystem services (ES) can be thought of as the flows of beneficial and detrimental contributions that people derive from nature.[4] These are commonly categorized in terms of provisioning (e.g., food and fiber), regulating (e.g., climate), supporting (e.g., soil quality) and cultural (e.g., sense of place) ES.[45] There may be negative associations between different ES and the sectors of the economy that rely on them; for example, more fiber for textiles or other consumer goods could result in less habitat or shelter availability for species that are critical for industries reliant on biodiversity, like tourism.[4]

Together, natural capital and ecosystem services underpin the economy; they also collectively constitute nature. This report uses the term nature to refer to "all non-human living entities and their interaction with other living or non-living physical entities and processes."[4] Biodiversity is another term commonly used in considering nature and nature-related risk to businesses; see Annex 2 for details.

[c] Coming later in 2019, the Water and Value (WAVE) tool will help bolster cross-scalar analysis. See: https://waterriskfilter.panda.org/en/Value/ValuePotentiallyAffectedTool.

Figure 1. The relationship between nature and business



Adopted from NCFA & UNEP-WCMC, 2018

As highlighted in Figure 1 (adopted from NCFA & UNEP-WCMC, 2018), the relationship between nature and business is one of impacts and dependencies. A **dependency** is a business reliance on or use of nature where nature functions as an *input*, or if it *enables, enhances,* or *influences* environmental conditions required for successful corporate performance.[11,7] An **impact** on nature is a positive or negative effect of business activity on the quantity or quality of NC stocks or ES flows.[11,7] In this way, nature-related risks to business arise from their dependencies or impacts on nature.

3.2 Business Risk

Our understanding of nature-related risks to business is also shaped by the literature on climate-related risks[8] and corporate risk management. Recognizing that the nature-related risks which corporate actors focus on in any given reporting period are a byproduct of issue materiality,[d] we employ the following terms to understand the creation of nature-related risks more broadly.

Given that nature-related risks to business arise from their dependencies or impacts on nature (Figure 1), it follows that a business's concern with risk is centered on the consequences of a threat resulting from a dependency or impact of their value chain.

The **threat** consists of an event or change in the business's operating conditions, which may jeopardize business value or profitability. However, in order for the consequence to materialize, businesses must be both exposed and vulnerable to that threat, and also must have an insufficient response to the threat.

Figure 2. Risk arises from the combination of three factors: a threat, an exposure to that threat, and vulnerability to that threat

Adopted from Field et al., 2014

Threats become financially material or consequential if the company also has some degree of exposure (blue circle) and vulnerability (yellow circle) to the threats. At the business level, **exposure** is a function of factors including the business's sector and industry (the practices of these, and proximity to consumers and regulators), the geographic spread of their value chain (with implications for their legal jurisdictions and their sociopolitical contexts of operation), and finally their (degree of) reliance on ecosystem services or natural capital. **Vulnerability** of individual businesses to nature-related risk can generally be thought of as the (in)ability of the business to adapt to the threat at hand; it is a function of determinants like size, expendable capital (or cash on hand), risk management practices along the value chain, risk awareness (including definitions of materiality), degree of operational and managerial resilience, value chain and/or product diversification, and influence on the market/within the sector (including pricing power and brand value).

Consequences affect a business's cash flow and profitability by disrupting its operations directly or affecting its costs, sales, and/or cost of capital (such as credit rating or equity value). A change in the cost of capital also implies that risk is likely to be felt by the company's investors and creditors, since it affects the value of the company's equity or debt.

[d] See an extended discussion on materiality in Annex 2.

3.3 Nature-Related Risks to Business

Taking together this understanding of risk (Figure 2) with that of businesses' and society's relationship with nature (Figure 1), we present the following way of thinking through the emergence of nature-related risk (Figure 3).

Starting from the outside (right side of figure), businesses, and the economy as a whole, both are dependent on and impact nature (left side of figure). These dependencies and impacts on nature vary across the micro and macro scales; the difference in these impacts is illustrated in the size difference of the gray causal arrows.

Nature-related risk emerges from changes in these dependencies and impacts, which may be **threats** (red circles). **Dependency-related changes** (upper striped circle) emerge from a combination of natural variability in ecosystem services and environmental change—including climate change, nature loss and degradation, and the combination of the two—that humans add to nature. **Impact-related changes** (lower striped circle) may emerge from changes in policies, consumer preferences, adverse media coverage of a company's impacts, and other sources, as detailed below.

When threat, vulnerability, and exposure are all present, a nature-related risk can materialize and lead to consequences for the business and/or the economy. These dynamics of risk creation are common to both nature-related risks and climate change-related risks. That is, both are concerned with the consequences of a threat becoming material due to exposure and vulnerability in the face of an (unexpected) change in operating conditions.

Factoring nature-related risks into decision-making can help companies anticipate potential threats and prepare for potential consequences, thereby reducing their exposure and vulnerability. In a changing world, this preparedness enables better response times, resource availability and efficiency, optimization of products, and decreases in additional fines or costs.

Figure 3. High-level framework illustrating nature-related risk to business

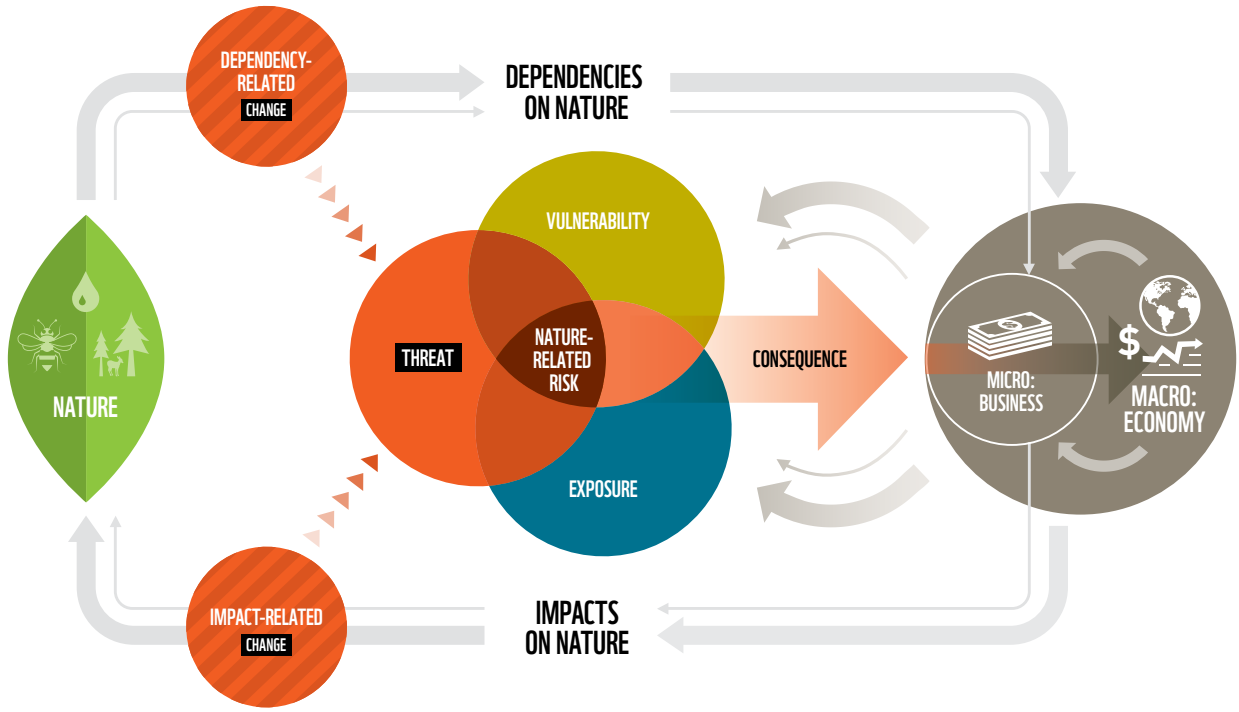


Figure 3: High level framework illustrating nature-related risk to business, adopted and integrated from NCFA & UNEP-WCMC 2018, Field et al., 2014. The framework illustrates how businesses and the economy both impact and depend on nature (outer gray arrows). As well, it conveys how nature-related risk arises from not just the change to a business's impacts and dependencies on nature (striped circles), leading to a threat (orange circles), but also from a business's exposure and vulnerability (blue and yellow circles). When a nature-relate risk is realized, there may be a consequence to the business and to the broader economy. These consequences may trigger feedbacks on the company's vulnerability and exposure, or on further threats related to its impacts and dependencies on nature.

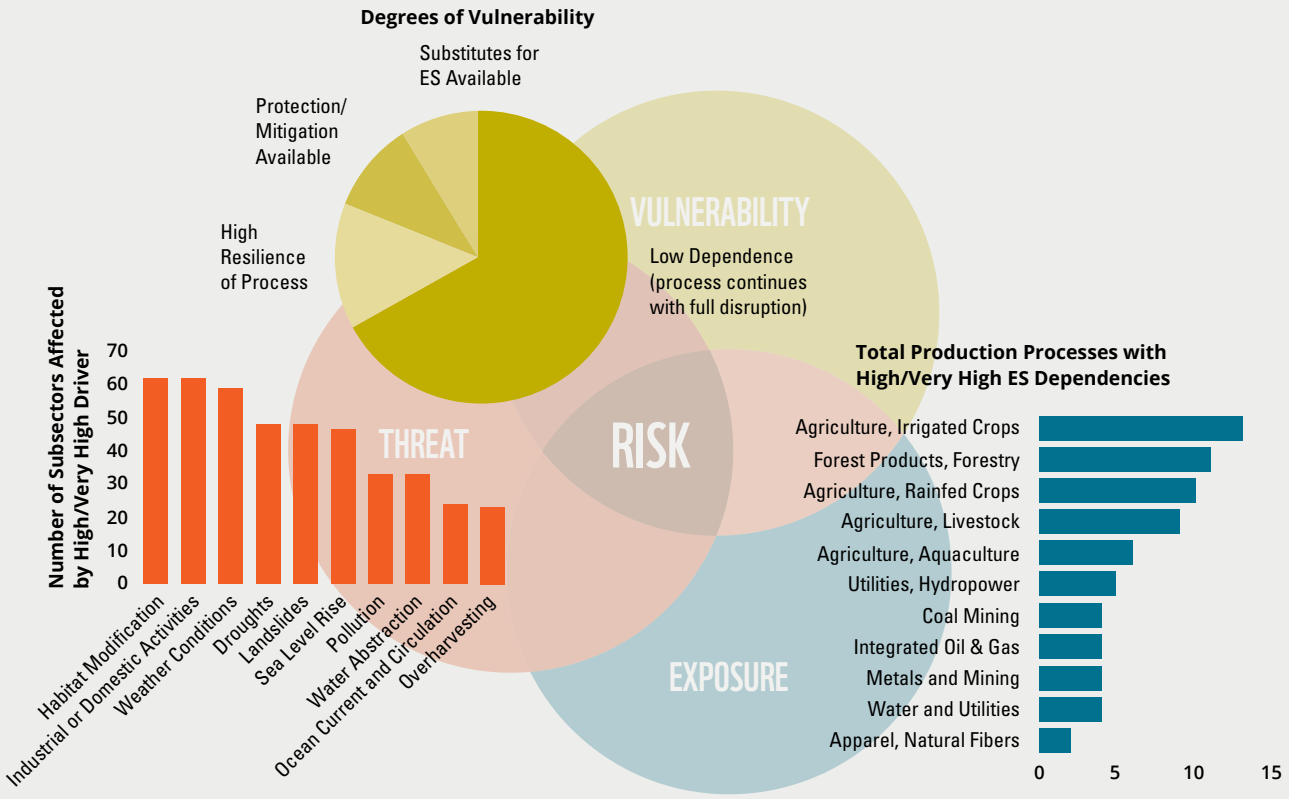
Nature-related risks are emergent: While we know of some nature-related risks that may have impacts for companies in the near term and others that may have impacts in the long term, many nature-related risks remain unknown. To hedge against these, businesses must be proactive.

The ENCORE tool (profiled below) can be used for unpacking nature-related risks to businesses. This tool employs one of the most extensive sets of risk indicators we encountered across tools and disclosure frameworks surveyed.

Illustrating Nature-Related Risk with the ENCORE Database

The ENCORE tool was developed by the Natural Capital Finance Alliance in partnership with UNEP-WCMC to help users understand and visualize the impact of environmental change on the economy. Specifically, it connects the goods and services that nature provides with the idea of business risk if environmental degradation disrupts such dependencies. By connecting businesses' dependencies on nature and rating their potential materiality (from very low to very high), ENCORE illustrates some of the main concepts of nature-related risks. ENCORE's further development over the next year will see the inclusion of impact-related risks as well.

Figure 4. ENCORE data, provided by Natural Capital Finance Alliance and UNEP-WCMC



The figure above shows how ENCORE's data can clarify where businesses' dependencies on nature may lead to nature-related risk. The tool provides data on:

- Material **threats** (red bar chart; top 10 drivers of environmental change across all production processes)
- Sectors with high **exposure** to nature-related risk, based on their material dependencies (blue bar chart; production processes with the greatest number of high/very high material dependencies)
- High **vulnerability** or low resilience of the production processes to disruption (yellow pie chart; most commonly cited reasons why a process would have low vulnerability or high resilience to disruption)

4. Types of Nature-Related Risk for Business

In addition to considering how nature-related risk emerges, it is necessary to understand the variety of types of nature-related risks that are of concern for business.

This work directly parallels WEF's annual Global Risk Reports. For selecting the types of risk presented in our typology of risks and throughout the paper, we conducted a frequency analysis of reports, disclosure frameworks, and risk analysis tools. We used frequency of mention across sources as a proxy indicator for the expected importance and materiality of different types of nature-related risks across sectors. The five most common risk types identified from our survey were *physical, regulatory & legal, market, reputational,* and *financial risk.* Although there were discrepancies in terms used among the sources we reviewed,[e] our objective in harmonization is to help facilitate corporate risk management in this space.[f]

Physical risks arise from material destruction—such as damage to infrastructure and disruption of operations—causing economic and financial losses for businesses and investors. Physical risk can be further classified into event-driven ("acute") or longer-term in nature ("chronic").[2,10] **Regulatory & legal risks** relate to laws, policies, regulations, and court actions that affect the operations of businesses.[9,11] **Market risks** "relate to product and service offerings, customer preferences, and other market factors that can affect corporate performance."[4] **Reputational risks** relate to a company's brand, image, and relationship with customers, the general public, and other stakeholders.[9,11] In addition to the four main risk types—*physical, regulatory & legal, market* and *reputational risk*—**financial risk** was also commonly mentioned across the sources surveyed. We propose a division of financial risk into financing and financier risk to be precise about whether the risk accrues to businesses (financing risk) or to financial institutions (financier risk). We treat this risk type separately given that it typically occurs as an outcome of the risks and may be considered most often as a consequence (see Section 4.1).

Each of the four major types of NRR can accrue to businesses (directly or indirectly) due to either their dependencies or their impacts on nature. For instance, regulatory and legal risks could affect a business through new regulation on the extraction of raw materials (a **dependency-related change**) or through an improved regulatory or liability regime targeting the business's pollution (an **impact-related change**). See examples below, in Section 4.2 and Section 5.

Nature-related risk management approaches vary depending on the specific risk and include operational changes (such as increased resource efficiency, input substitution or diversification away from high-impact or high-dependency production processes) as well as traditional corporate social responsibility (CSR) and marketing strategies.

4.1 Risk Type Frequencies

As introduced above, we assessed the most commonly cited concerns regarding nature-related risk in order to present a harmonized high-level typology on nature-related risk, and also to highlight the risks emerging in this space.

Although at least 70 unique risk types, drivers of risk, and consequences were identified, we included only those that appeared in two or more sources. See Annex 1 for details and full results.

The five risk types above can be further separated into 'threats' and 'consequences' by asking whether what is being described as a risk pertains to a *potential event/change* or the *result of that event/change.* We see the analytical value of this difference in its ability to highlight two elements of risk for businesses: 1) how a risk might arise (the threat), but also 2) how it becomes material to the business or investors (the consequence). This is a simple distinction largely missing from the current conversation.

Table 1a summarizes the most commonly cited nature-related threats to business, followed by Table 1b, which summarizes the consequences of these nature-related risks.[h]

[e.] For instance, physical risk is often spoken of as "operational risk." The key difference between physical and operational risk is the inclusion of value chains in the former. Although reviewers expressed preference for operational risk, our frequency analysis resulted in a higher count for physical risk. Physical risk also aligns with the TCFD typology, which is quickly gaining traction in the climate space. However, in the TCFD context, physical risks are limited to those caused by acute or chronic manifestations of climate change; the categories of specific risks we include under physical nature-related risks are broader; see Annex 1. From this data, we note that "environmental risk" was actually the high-level type with the most hits; this was due to using this term as the default (e.g., for ESG frameworks). Ultimately, we view environmental risk as the over-arching type to categorize both nature-related risks and climate change-related risks.

[f.] See footnote c.

[g.] For example, if a flood causes a power outage and damage to for a utilities company, this physical risk can lead directly to financial consequences in the form of damage costs and potential increases in insurance premiums. This flood represents an interruption of the business's reliance on the buffering and attenuation of water flows or water regulation (a specific type of ES). On the other hand, if a business's operations generate an environmental impact (e.g., through an oil spill or dam collapse—see examples below), this may become a financial consequence to business indirectly, accruing instead through the responses of regulators, society, and the market.

[h.] Notably, some risks – like litigation, compensation and damages – can fall under either category of threats or consequences, depending on the stage in the risk cycle at which they emerge.

Threats were split relatively evenly across the first four major risk types: There were 11 mentions for physical, 14 for regulatory & legal, 10 for market and 13 for reputational risk. However, there were only 5 mentions for financial risk, and these were only listed as what could be considered consequences.

For threats, those which appeared in 25% or more of the sources surveyed include litigation, damages, and compensation (11 mentions); acute events and damage from hazards (11); pricing or other regulation of externalities (10); biodiversity loss (7); and changing consumer preferences (7). Interestingly, a greater number of specific threats were mentioned for the regulatory & legal and physical risk categories; lesser attention to market and reputational risks may be due to the routine nature of risk management for these types. Compared to the other types, regulatory & legal risks may have been overlooked in the past, but the large array of specific types identified in our review suggest that businesses and other actors are broadening their scope of concern in this domain. High-level risk type counts are included in Table 1a to communicate the relatively even spread of concern across these major categories, despite variation in attention to the specific threats identified.

Table 1a. Top cited examples of nature-related threats across reviewed sources

RISK TYPES	THREAT TYPE	TOTAL
Physical Risk		**11**
	Acute events; damage from natural/man-made hazards	11
	Biodiversity loss and decreasing species richness	7
	Scarcity of water	4
	Availability, reliability, and security of energy	4
	Habitat loss	2
	Air pollution	2
	Water pollution	2
Regulatory & Legal Risk		**14**
	Litigation, damages, and/or compensation	11
	Pricing or other regulations for emissions (GHG*/other)	10
	Restrictions on land and ES access	6
	Air pollution regulation	6
	Non-hazardous waste management	6
	Soil pollution regulation	6
	Resource quotas for ES use	4
	Unsustainable practices	4
	Changing liability regimes	3
	Hazardous waste management	3
	Water pollution regulation	3
	Changes in disclosure requirements	2
Market Risk		**10**
	Changing consumer preferences	7
	Inability to attract co-financiers due to uncertainty	2
	Purchaser requirements	2
Reputational Risk		**13**
	Negative press coverage	3
	Divestment or other stakeholder campaigns	3
	Impacts on World Heritage Sites or protected areas	2
	Impacts on species on IUCN** Red List	2

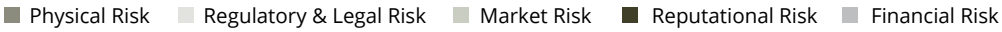
Physical Risk Regulatory & Legal Risk Market Risk Reputational Risk

*GHG – Greenhouse gas

** IUCN – International Union for Conservation of Nature

Table 1b. Most cited consequences of nature-related risks across reviewed sources

RISK TYPES	CONSEQUENCE TYPE	TOTAL
Physical Risk	Disruptions to business operations	7
	Labor shortages	5
Regulatory & Legal Risk	Unexpected costs of compliance/fines for noncompliance	9
	Stranded assets	4
Market Risk	Changes in the cost and availability of resources	4
Reputational Risk	Lost sales due to negative perceptions of the institution	3
Financial Risk	Increased cost of capital or lending requirements	5
	Write-downs of asset value and write-offs of assets	5
	Increased insurance claims	4
	Higher premiums; loss of insurance value	4
	Increased risk of default	3
	Loss of investment value related to reputational risks	2
	Changes in market value of the business	2



For consequences, those that appeared in 25% or more sources include costs and fines related to compliance (9 mentions) and disruptions to business operations (7). The full data on this review can be found in Annex 1. Notably, the routine management mentioned above may skew the data on risks of concern: Those that are contained or are not considered sufficiently material for businesses may not have been included by the sources we surveyed.

Our data indicates twice as much assessment of threats (Table 1a) than of consequences (Table 1b), and that consequences on average receive slightly more attention per specific type than threats. Greater variety in the number of threats being mentioned correlates with the need of businesses to assess the full array of potential risks, and slightly greater weight to each consequence may correlate with their direct connection to financial materiality.

4.2 Connecting Threats and Consequences

As acknowledged by many others, the five high-level risk types (physical, regulatory & legal, market, reputational, and financial) are not mutually exclusive. Instead, they may feed one another.[11] In many cases, physical risks may be precursors or bring the threat of other nature-related risks, e.g., those that are regulatory, financial, or reputational risks, and which may in turn result in financial consequences. For example, a physical risk related to the scarcity of water may create a regulatory and/or operational risk related to access to that resource and to the profitability of operations (see Case Study 3 in Section 5). If that input is not easily substitutable, a cascade of risks may pose a serious threat to the economic profitability of operations, resulting in financial consequences.[i]

Nature-related risks may also arise through multiple pathways: The physical risk of ecosystem degradation may become a risk to companies as a consequence of new regulations coming into place requiring companies to restore the land they have used, or, due to an assessment revealing a company's dependence on ecosystem services. Ecosystem degradation may also be a threat to reduced output and productivity for the company. Some specific threat-consequence pathways were identified across sources, including regulatory risk leading to increased compliance costs and physical risk leading to disruption of operations. Future work elaborating these connections can improve the understanding of nature-related risks within the corporate risk management community.

[i] Notably, these cascading risks and consequences may be felt by one business, or may also be passed vertically–along a supply chain, or horizontally—throughout an industry.

The proposed typology of nature-related risks—physical, regulatory & legal, market, reputational, and financial—can help organize corporate risk analysis within the framework of nature-related risk consisting of change, threat, exposure, vulnerability, and consequence. See Table 2 on the following page to understand how the framework and typology come together.

Ultimately, risk managers must think about the connections among these elements of risk, their drivers, and the other economic, social, and governmental factors across scales of economic activity that put their operations and profits at risk. They should remain cognizant of the ever-changing context in which risk unfolds; the prevalence of different risks can be expected to change over time. Should scientific evidence and policymaking keep pace, a broader subset of ecological transition risks could begin unfolding once a global target is set on ecosystem service protection or natural capital maintenance, having threats and consequences that can ripple throughout supply chains and networks of trade.

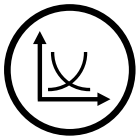
Table 2. Major types of nature-related risks, including how each maps to the risk framework through threat, exposure, vulnerability, consequence, and management approaches

PHYSICAL RISK

Dependency on Nature	Impact on Nature
Change: Drought	**Change:** Infrastructure failure
Threat: Water shortage	**Threat:** Contamination of surrounding watershed
Exposure: Water intensity of business; value chain geography; natural variability	**Exposure:** Characteristics of area of operation – e.g., biodiversity, indigenous communities
Vulnerability: Production process resilience to disruption; alternative water sources; concentration of operations in exposed area	**Vulnerability:** Risk management practices; reputation of company and industry; cash on hand
Financial Consequence: Production process disrupted → operations impacted	**Financial Consequence:** Legal costs, operations stalled (forgone sales), market value of company at risk
Nature-Related Risk Management Approaches: Improve water efficiency; collaborative water conservation with surrounding communities	**Nature-related Risk Management Approaches:** Engage in remediation; payments to affected communities; CSR and stakeholder engagement; compliance with regulation/penalties

REGULATORY & LEGAL RISK

Dependency on Nature	Impact on Nature
Change: New regulation on natural resource extraction limits	**Change:** New liability regime
Threat: Lack of access to inputs	**Threat:** Higher levels of enforcement; liability for environmental contamination
Exposure: Sector; geography of production assets	**Exposure:** Pollutive production processes, jurisdiction of operation
Vulnerability: Production process flexibility	**Vulnerability:** Previous record; expendable capital; legal expertise
Financial Consequence: Input costs rise	**Financial Consequence:** Legal suit for environmental contamination → increased legal costs, higher cost of capital
Nature-related Risk Management Approaches: Lobbying; research and development on substitutes; relocation	**Nature-related Risk Management Approaches:** Compliance; stakeholder engagement



MARKET RISK

Dependency on Nature	Impact on Nature
Change: Resource scarcity (from depletion or new regulations)	**Change:** Increasing environmental awareness
Threat: Increased price of goods	**Threat:** Change in consumer preferences toward low-impact goods
Exposure: Source markets; degree of reliance on scarce goods; availability of alternatives	**Exposure:** Sales markets
Vulnerability: Production process flexibility	**Vulnerability:** Brand value; competition
Financial Consequence: Higher input costs	**Financial Consequence:** Change in consumer preferences → decreased sales
Nature-related Risk Management Approaches: Advertising; CSR activities	**Nature-related Risk Management Approaches:** Engage in remediation; payments to affected communities; CSR and stakeholder engagement; compliance with regulation/penalties

REPUTATIONAL RISK

Dependency on Nature	Impact on Nature
Change: Growing social awareness around risks presented by industry	**Change:** Media investigation of company's operations
Threat: Loss of social license to operate	**Threat:** Protests
Exposure: Environmental awareness in home and host country; production processes	**Exposure:** Environmental awareness in home and host country; production processes
Vulnerability: Risk management practices; reputation of company and industry; relations with stakeholders	**Vulnerability:** Risk management practices; reputation of company and industry; relations with stakeholders; size of company; proximity of investors/shareholders to protestors
Financial Consequence: Loss of social license to operate → operations affected	**Financial Consequence:** Boycotts and protests → decreased sales
Nature-related Risk Management Approaches: Stakeholder engagement; press releases	**Nature-related Risk Management Approaches:** Stakeholder engagement; press releases

5. Case Studies of Nature-Related Risk to Business

Case studies clarify how nature-related risks become material for business. Below we present examples using the framework and terminology introduced in the sections above.

To reiterate, nature-related risk results from a change in an organization's impacts and/or dependencies on nature. A nature-related risk becomes *consequential* to business only if it is sufficiently *exposed, vulnerable,* and has an insufficient response to the *change* or *threat* driving that risk.

The case studies below show the connections between types of risk and the messiness of these in the real world. We include cases that are emblematic instances in which an actual risk event occurred. Elements of the framework and typology are bolded to highlight how these emerge in context. As part of this work, we have also compiled a selection of illustrative nature-related risk case studies, available here.

Note that the cases below only represent a portion of the risks experienced by businesses, many of which go undisclosed. For the most part, other case studies focus on positive actions by business to manage and reduce risk. This approach helps to boost corporate value rather than raise flags for shareholders, investors, and auditors. In comparison to other cases, the cases below focus on disastrous events that clearly signal corporate failure to manage risks.

Below, we summarize each of the cases within the framework of nature-related risk. Note that listed elements of vulnerability and exposure can have either a positive or a negative effect on the consequences incurred by the company (Table 3).

Table 3. Selected case studies of nature-related risk and consequences for companies

BUSINESS	CHANGE IN DEPENDENCIES OR IMPACTS	THREAT	VULNERABILITY	EXPOSURE	CONSEQUENCE(S)
BP	Impacts of the oil spill	Damage to surrounding environment	Risk assessment (-); brand value (+)	Types of activities undertaken (e.g., deepwater drilling); operations in marine environment	Legal costs at around USD 62.59–144.89 billion; loss of USD 3.7 billion in revenue; drop in market cap and share prices; increased insurance rates across the industry
Vale	Growing awareness about the dangers of "upstream" tailings dams	Collapse of the tailings dam	Risk assessment (-); brand reputation (-)	Environmental conditions	Suspension of operations; USD 2.3 billion in assets frozen; employees arrested; drops in share value and bond prices; down-graded credit ratings
German exporters	Depletion of South African water sources; drought	Crop failures	Diversification of suppliers and diversified products (+)	Distance from primary production; geography of supply chain; sociopolitical mood in home and host countries	EUR 70 million in forgone sales/profits
PG&E	Increased dryness in the environment; malfunctioning equipment	Sparks on the power lines	Risk assessment (-)	Types of activities under-taken (e.g., power trans-mission); environmental conditions of operation	Over USD 30 billion in liabilities; bankruptcy

5.1 Case Study 1: BP Oil Spill

The damage to BP's reputation and market share as a result of the Deepwater Horizon oil spill shows how a company's negative impact on nature can cause socio-economic harm, eventually translating into risk to the company's bottom line (i.e. **financial consequences**).

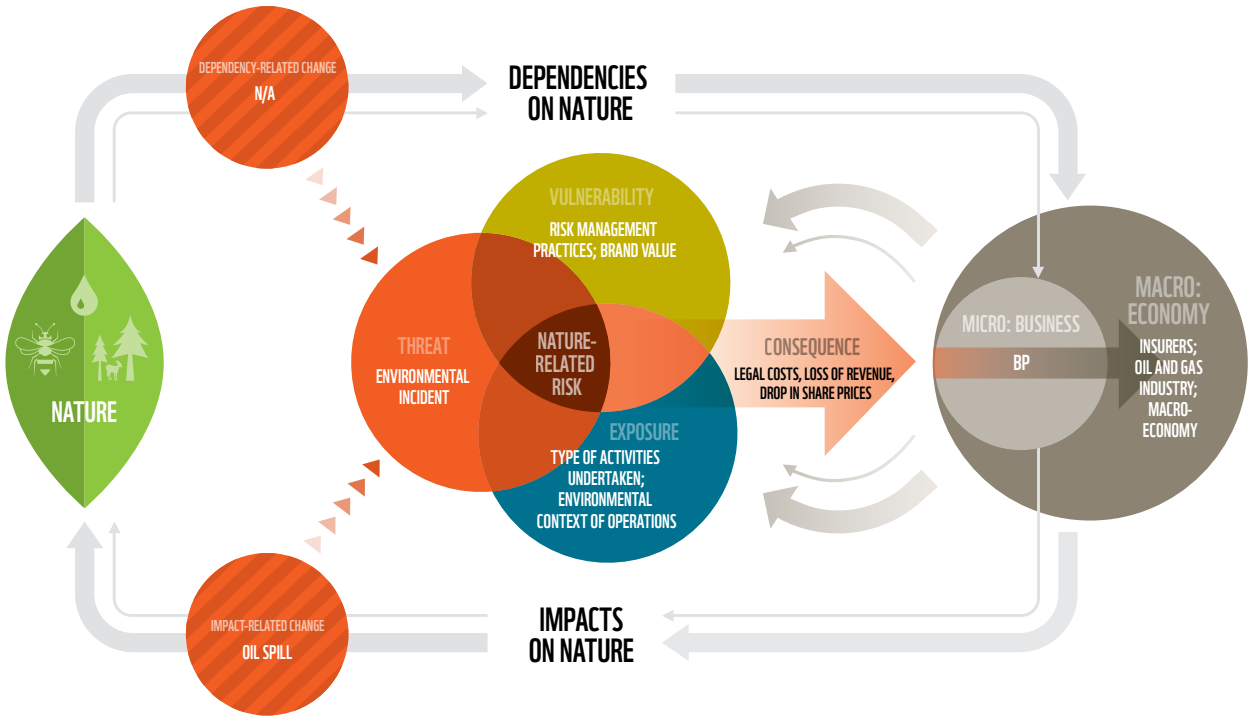
Leading up to the Deepwater Horizon spill, BP's US refineries had 760 "egregious and willful" safety violations from the Occupational Safety & Health Administration, compared to 19 such violations for all other US oil operators combined. A culture of prioritizing profits over safety made BP especially vulnerable to the threat of an environmental incident. When this threat came as an oil spill in April 2010, it became a **physical risk**—due primarily to the **vulnerabilities** posed by poor management and the **exposures** entailed in marine oil drilling—as BP's Deepwater Horizon rig in the Macondo well exploded, burned for 36 hours, and sank. Eleven workers died, and over 200 million gallons of oil gushed into the Gulf of Mexico.

As the largest oil spill in US history, the incident led to consequences which accrued not just to BP, but also to communities along over 1,100 miles of impacted coastline and to economies dependent on the 68,000 square miles of contaminated water. For the local tourism industry, the spill also imparted **financial consequences** to the tune of some USD 22.7 billion in lost revenue by 2013. By 2020, the local fishing industry is expected to have lost USD 8.7 billion in revenue and 22,000 jobs. This example shows how the threat of NRR generated by one company can become consequences for others.

BP suffered most from the **regulatory & legal risk** that arose out of the spill's macro-level impacts. Claims are still rolling in, but recent estimates show BP's ultimate fine from society in the USD 62.59-144.89 billion range.

BP also faced profound **financing consequences,** posting a loss of USD 3.7 billion in 2010, down from a USD 16.6 billion profit the prior year. Market cap plummeted by half after the spill, and share prices never recovered to pre-spill levels. After BP's spill, insurance companies raised premiums on deepwater drilling to alleviate **financier risk** even as oil companies ramped up demand for coverage, ballooning insurance costs industry-wide to over 100%.

Figure 5. High-level framework illustrating nature-related risk to BP



5.2 Case Study 2: Collapse of Vale's Brumadinho Dam

In January 2019, over 200 people were killed, 270 hectares of land were destroyed, and 300 km of rivers were impacted by the largest environmental disaster in Brazilian history. The collapse of Vale's Brumadinho tailings dam at Córrego de Feijão mine released toxic mudflow into native vegetation and protected forests, as well as into rivers where the waste—composed of metals and chemicals—can last for decades.[46] In addition to ecosystem and species disturbances, this can have a critical impact on the well-being of thousands of Brazilians living near the disaster: The contaminated Sao Francisco river is a source of drinking water for hundreds of municipalities.[47]

For Vale, the mining company operating the faulty dam, the consequences of the physical risk posed by its collapse are still playing out. Key consequences to date include the suspension of Vale's operations at several mines (due to its responsibility for both the 2019 Brumadinho disaster and the 2015 disaster at Samarco Mineracao);[48] the freezing of USD 2.3 billion of its assets under a court order;[49] and the arrest of a handful of employees, including executives, on suspicion of murder after being found aware of significant safety problems.[50] Other executives have since resigned in the wake of legal, regulatory, and reputational consequences.

Further market and financial consequences have followed: Within weeks of the disaster, the company suffered the *largest single-day loss in the history of the Brazilian stock market,*[51] falling by USD 19 billion on Brazil's B3 stock exchange. Further consequences include *drops in Vale's bond prices and downgrades in its credit ratings from both Fitch and Standard & Poor.*[51]

Beyond the company, consequences are ricocheting among investors and others involved in Brazil's metal and mining sector. There are emerging concerns about the security of a nearby mine, also operated by Vale; the risks of the Brumadinho disaster remain present for the company, investors, regulators, and local communities.[52]

Risky practices are coming under closer scrutiny, with expected financial consequences to follow. In addition to a new ban on new 'upstream' tailings dams and requirement for decommissioning all those in operation by 2021, there are expected adjustments to national laws regarding external auditors and auditing. The failings in Brazil have raised an alarm globally—a demand for disclosure emerged from global investors (including the Bank of England and Swedish pension funds)[53] in April. This group—managing USD 10.3 trillion in assets—demanded that 683 mining companies, including Vale, provide details of every tailings dam under their control. More stringent regulations could impose greater financial burdens on this industry.

5.3 Case Study 3: German exporters in South Africa

Agricultural producers directly *depend* on access to water resources (quality and quantity) and associated ecosystem services like water regulation. Changes in the supply of these inputs can lead to **cascading risks** throughout the food sector. In this case, we attend to the different risks accrued to farmers in South Africa verses the German exporters and retailers further down the supply chain.

Since 2017, the drought in South Africa has resulted in economic losses of over USD 510 million to farmers alone.[54] Food exporters (buyers for overseas clients) have lost at least USD 75 million from crop failures of high-priced items like wine and fruit. Outside the export sector, staple crops like maize have gone up in price and down in supply. High food prices and food insecurity will increase the amount of food South Africa needs to import from overseas. These **financial consequences**, accumulated at various levels of the economic activity, through farmers to financiers and up to the state, are a massive setback to the country's economy and to its development goals.

In Germany, food and beverage retailers have been cited as "importing water risk" through their supply chains.[55]

Relying on South Africa and other water-scarce nations, German food exporters, distributors, and retailers are at risk of **threats** related to their water *dependence*, passed along supply chains, and potentially leading to **consequences** in terms of the availability and price of goods (in other words, **market and financial consequences**); they are also at risk of **threats** related to their water impacts linked to their use of agrochemicals, overfertilization, and salinization of soil. Each of these threats can further lead to **reputational threats**.

To date, German retailers and exporters have been dealt a lesser blow by the drought—in comparison to their South African suppliers—given the diversification of their supply chains. This factor of reduced **vulnerability** may become overwhelmed by changes in the sociopolitical mood of both their home and host country if societal woes in South Africa continue to grow (increasing retailers' **exposure**). Already, the **physical risks** experienced by the food sector are creating water shortages which may result in restrictions on access or loss of social license to operate for some companies (otherwise understood as **regulatory risk**). If the quality of farmland continues to degrade, it may also become financially devalued, posing a **financing risk** to asset holders who may be left with temporarily illiquid assets.

5.4 Case Study 4: PG&E Bankruptcy

The events surrounding Pacific Gas & Electric Company's (PG&E) 2019 bankruptcy56 illustrate how climate change translates into risk through business operations, as well as how risk feeds back into legal, market, and natural systems to perpetuate additional risks.

In recent years, PG&E repeatedly neglected to maintain faulty equipment prone to sparks, creating **vulnerability** for itself through haphazard risk management practices. This vulnerability was exacerbated by dry conditions in the company's service area due to anthropogenic climate change. The **exposure** of PG&E to the physical risk of fire arose from its operations: transmitting energy in a fire-sensitive landscape. Ultimately, these factors of negligence and environmental context resulted in homes and lives consumed by fire across hundreds of thousands of acres in Northern California.

Though society bore much of the consequence of this physical risk, it eventually translated into **financial consequence** to the business in early 2019 when PG&E faced over USD 30 billion in liabilities and filed for Chapter 11 bankruptcy in January.

PG&E was not the only affected company, however, as its bankruptcy proceedings cleared the path for PG&E to relieve itself of over USD 42 billion in power-purchase agreements (PPAs), and renewable energy providers then found that they suddenly faced **market risk** if PG&E's bankruptcy were to lead it to rewrite power contracts at lower prices. In the face of this impending change and uncertainty, renewable energy growth has slowed, stunting the transition away from fossil fuels and continuing the increase of greenhouse gas emissions. Ironically, these outcomes exacerbate the exposure of society and other businesses to these risks and others associated with a changing climate, like landslides, fire, and drought.

5.5 Case Study Summary

Case Studies 1, 2, and 4 are emblematic of businesses ignoring nature-related risk. Although in each case the companies were aware (at some level) of the risks, they were not compelled to take action to reduce or manage threats. This self-assessment of vulnerability (or lack thereof) is in part what allowed these risks to materialize with significant consequences. These examples also show how physical risk generated by a company might not translate directly into consequences for business operations; instead, the consequences of risk need recognition from society, markets, and regulators in order to create consequences for the business.

Case Study 3, on German exporters in South Africa, differs from the rest in a number of ways. It illustrates how risks are spread over supply chains (with differential risk exposure for each actor) and trade relationships between countries, showing how the consumers of goods in one country can create or ameliorate dependency-related risks in other countries. This case also exemplifies how risks to companies can emerge from changes in their *dependencies*, whereas the other cases exemplify how risks can emerge from changes in their impacts. Finally, Case Study 3 is an example of how changes in the climate can intersect with human patterns of resource use. Although the El Niño event that has been linked to the drought is a relatively standard pattern, drought is expected to intensify, creating dependency-related risks for water-reliant businesses operating in South Africa and other semi-arid regions. When compounded with impact-related risks linked to nature degradation, the consequences may become more severe.

6. Opportunities and Future Work

This report offers a consolidated framework for understanding nature-related risk, reviews types of nature-related risk from existing literature and offers case studies on company consequences of nature-related risk. With this final section, we seek to highlight 1) needs for future research and 2) opportunities available in addressing nature-related risk.

1. Future research
   - Further incorporating ideas from climate-related risk management to nature-related risk, and vice versa, building on TCFD's climate risk work to increase businesses knowledge of nature-related risk. Critically, more work is needed on understanding the potential synergies that can be attained when businesses and other actors tackle climate change and nature loss in unison.
   - Additional study on the connection between macro-level and micro-level nature-related risk is needed. Understanding how macroeconomic risk and microeconomic risk feed into one another at different spatial and temporal scales is a critical question for further research and action, since private-sector materiality concerns may be both short-term and damaging to common pool resources like natural capital.
   - New thinking and analysis are needed on the potential for systemic risk to emerge, especially if regional- or large-scale ecosystem collapse occurs.
   - Collaboration between businesses, finance institutions, credit rating agencies, independent auditors and regulators is necessary to harmonize the frameworks through which businesses' impacts and dependencies on nature are assessed and disclosed.

Improving companies' understanding of nature-related risks allows them to manage those risks, and also to capitalize on *opportunities* associated with proactively addressing the loss and degradation of nature. Now is the time for early movers to address the unprecedented risk posed by changes in nature.

2. The following are opportunities for businesses in addressing NRR highlighted by Finance Watch, TCFD, and the Natural Capital Coalition, among others:
   - **Resource efficiency** – Real-time decreases in costs can come from improvements in material efficiency, and in the future cost reductions may arise from the sustainable use of resources.
   - **Product, service and market opportunities** – Companies can gain first-entrant advantage in nature-friendly markets for products and services and have the ability to develop brand value in this space. To replace carbon- and nature-intensive assets, innovation will be necessary.
   - **Financing opportunities** – By conducting nature-related impact and dependency assessments, businesses can demonstrate their understanding and management of nature-related risks, allowing them to improve their credit ratings and access funds which are targeted toward 'impact,' 'responsible' and 'green' investment. These self-assessments are key in a context of improved green investment classification schemes (e.g., ongoing work within the European Commission).[57]
   - **Opportunities for collaborative action** – self-assessments of corporate impacts and dependencies on nature can feed into collective action by those actors who are mutually reliant on the same ecosystem services or natural capital within a discrete region. This elevates the ability of businesses to manage emerging nature-related risks.
   - **Reputational opportunities** – A strong reputation on nature-related risk can be associated with a higher selling power and greater advantages in the hiring process.
   - **Leadership opportunities at the Convention on Biological Diversity (CBD) 2020** – Companies can demonstrate leadership and gain first-entrant advantage with strong participation in addressing common drivers of ecosystem service erosion.

7. Annexes

Annex 1: Data on Nature-Related Risk Counts

A1. Table 1. Full Data on Types, Threats and Consequences Mentioned in Review (Section 4)

Risk Type	Type, Driver, Threat or Consequence*	Specific Threat or Consequence	Total Mentions
Environmental Risk	Type	N/A	13
Operational Risk	Type	N/A	6
Physical Risk	Type	N/A	8
Physical Risk	Consequence	Disruptions to business operations	7
Physical Risk	Consequence	Labor shortages	5
Physical Risk	Driver	Climate change	13
Physical Risk	Driver	Ecosystem degradation	12
Physical Risk	Driver	Invasive species	2
Physical Risk	Threat	Acute events; (damage from) natural or man-made hazards, extreme events	11
Physical Risk	Threat	Scarcity of raw materials (quantity, quality)	9
Physical Risk	Threat	Biodiversity loss and decreasing species richness	7
Physical Risk	Threat	Reduced output or productivity of land/resources	5
Physical Risk	Threat	Scarcity of water	4
Physical Risk	Threat	Availability, reliability and security of energy	4
Physical Risk	Threat	Habitat loss	2
Physical Risk	Threat	Air pollution	2
Physical Risk	Threat	Water pollution	2
Physical Risk	Threat	Soil pollution	1
Legal & Regulatory Risk	Type	N/A	14
Legal & Regulatory Risk	Consequence	Unexpected costs of compliance & fines for non-compliance	9
Legal & Regulatory Risk	Consequence	Stranded assets (as a result of changes in land access, asset prices, waste generation or other operational regulations)	4
Legal & Regulatory Risk	Threat	Litigation, damages and/or compensation	11
Legal & Regulatory Risk	Threat	Pricing or other regulations for carbon, GHG emissions or other externalities	10
Legal & Regulatory Risk	Threat	Restrictions on land and ES access	6
Legal & Regulatory Risk	Threat	Air pollution regulation	6
Legal & Regulatory Risk	Threat	Non-hazardous waste management	6
Legal & Regulatory Risk	Threat	Soil pollution regulation	6
Legal & Regulatory Risk	Threat	Resource quotas for ES use	4
Legal & Regulatory Risk	Threat	Unsustainable practices	4
Legal & Regulatory Risk	Threat	Changing liability regimes	3
Legal & Regulatory Risk	Threat	Hazardous waste management	3
Legal & Regulatory Risk	Threat	Water pollution regulation	3
Legal & Regulatory Risk	Threat	Changes in disclosure requirements	2
Legal & Regulatory Risk	Threat	Changes in subsidy regimes	1
Legal & Regulatory Risk	Threat	Changes in international regulations or standards of behavior	1
Legal & Regulatory Risk	Threat	Changes in labeling and certification requirements	1
Market Risk	Type	N/A	10
Market Risk	Consequence	Changes in the cost and availability of different resources on the market	4
Market Risk	Threat	Changing consumer preferences	7
Market Risk	Threat	Increased uncertainty (about market trends, values); inability to attract co-financiers due to uncertainty	2
Market Risk	Threat	Purchaser requirements	2
Reputational Risk	Type	N/A	13
Reputational Risk	Consequence	Lost sales due to negative perceptions of the institution	3
Reputational Risk	Threat	Damage to brand or social license to operate	7
Reputational Risk	Threat	Negative press coverage	3
Reputational Risk	Threat	Divestment or other stakeholder campaigns	3
Reputational Risk	Threat	Impacts on World Heritage Sites or protected areas	2

Annex 1: Data on Nature-Related Risk Counts *continued*

A1. Table 1. Full Data on Types, Threats and Consequences Mentioned in Review (Section 4)

Risk Type	Type, Driver, Threat or Consequence*	Specific Threat or Consequence	Total Mentions
Reputational Risk	Threat	Impacts on species on IUCN Red List	2
Reputational Risk	Threat	Protests	1
Societal Risk	Type	N/A	4
Sustainability Risk	Type	N/A	3
Transition Risk	Type	N/A	6
Transition Risk	Threat	Falling technology costs	1
Transition Risk	Threat	Disruptive technologies	1
Financial Risk	Type	N/A	5
Financial Risk	Consequence	Increased cost of capital or lending requirements	5
		Write-downs of asset value (due to increased costs for ES, irremediable contamination, increased risks of litigation or obsolescence of equipment) and write-offs of assets (due to difficulties in obtaining permits and licenses)	5
Financial Risk	Consequence	Increased insurance claims	4
Financial Risk	Consequence	Higher premiums; loss of insurance value	4
Financial Risk	Consequence	Increased risk of default (due to lower crop yields or	3
Financial Risk	Consequence	due to higher costs related to regulations on water treatment and disposal)	
Financial Risk	Consequence	Loss of investment value (related to reputational risks)	2
Financial Risk	Consequence	Changes in market value of the business	2

*'Type' indicates and overarching risk type. 'Driver' indicates an upstream driver of risk. 'Threat' and 'Consequence' are used as defined in this report.

Sources surveyed: For this research, we surveyed reports, disclosure frameworks, and risk analysis tools. These included: NCFA & PWC 2018, NCFA & UNEP-WCMC, NCC 2018, IPBES 2019, TCFD, OECD 2019, Bonner et al. 2012, Hanson et al. 2012, Finance Watch 2019, UNEP/PSI 2019, Bank of England (Batten 2018), Schellekens & van Toor 2019, ERBD 2014, Caldecott et al. 2013, ELD Initiative 2013, GFSG 2017, Collins 2019, WWF & AXA 2019, Trucost 2013, PWC 2012, SASB Materiality Map 2018, S&P 2019, Moody's Investors Service 2018, GRI 300 Series, CDP Forest, Climate, and Water Questionnaires 2019, Water Risk Filter, SCRIPT, GMAP

A1. Table 2. Sectors with High Nature-related Risk, as Mentioned in Review

Sector*	% of Sources** Ranking Sector as High Risk	Number of Processes with VH/H Material ES identified in ENCORE	Number of Processes with Other Material ES identified in ENCORE
Food & Beverage	86%	76	85
Metals & Mining	86%	4	39
Oil & Gas	71%	5	29
Utilities	57%	16	54
Forestry	43%	25	12
Construction	43%	5	22
Transportation	43%	8	30

The numbers in the table above convey the consistent perception across the sources surveyed that these seven sectors face a high degree of nature-related risk. Looking at the ENCORE data on these specific sectors, the number of production processes which rely on ecosystem services are highest for Food & Beverage, Utilities and Metals & Mining. However, those sectors with the highest number of VH/H ES dependencies (as a proportion of their overall ES dependencies) are Forestry (67.5%), Food & Beverage (42%), Utilities (23%) and then Transportation (21%). While this first measure is an indicator of the potential for production process disruption with changes in ecosystem services, the second is a measure of that sector's vulnerability to ecosystem service disruption; when ES materiality is higher, production processes are more reliant on ES to continue normal functioning.

*Note that ENCORE uses the following sector categorizations: Consumer Staples for Food & Beverage, Materials for both Metal & Mining and Forestry, Utilities for Utilities, Energy for Oil & Gas, Industrials (and Materials) for Construction and Consumer Discretionary for Transportation.

**Sources surveyed: Bonner et al.; Bonnet & Morozova 2018, ELD 2013, ENCORE; Moody's Investors Service 2018; SASB Materiality Map 2018; S&P 2019; Trucost 2013.[j]

[j] Definitions of risk vary across the sources surveyed. Bonner et al. (2012) define high risk as most high risk materialities, whereas Bonnet & Morozova (2018) define it as a combination of risks and mitigation.

Annex 2: Terminology Use

Below we elaborate on a number of key terms used in the paper to address debates and confusion surrounding these words.

Nature and Biodiversity

This report uses the term nature-related risk, while other use environmental risk and biodiversity risk. We understand environmental risk to be the over-arching category capturing nature-related and climate change-related risks (see below), and biodiversity risk can be understood as a subset of nature-related risks.

The connection between nature and biodiversity has been framed in a number of different ways. For instance, within the planetary boundaries concept[58,59] and the Living Planet Index (WWF),[60] biodiversity is seen as a barometer of planetary health. Where indicators of biodiversity (such as species richness) are in decline, it follows that the wellbeing of natural systems are at risk. In relation to our report's other key concepts—natural capital (NC) and ecosystem services (ES)—biodiversity has been defined as a fundamental component of NC, underpinning nature's products and services.61 Indeed, biodiversity is seen as central to the functioning of ES and ensuring the delivery of ES which are critical to society.[15,20,62] For example, healthy, biodiverse marshes and mangroves can fulfill flood protection services to coastal businesses and communities. Because of the role of biodiversity in maintaining critical ES like food provision and climate regulation, many have also drawn connections between this biodiversity and global goals related to sustainable development and climate change.[4,15]

While this report recognizes the significance of biodiversity, it focuses on 'nature' in its broadest sense, including biodiversity, natural capital, and ecosystem services.

Nature's Contributions to People

The recent IPBES report uses a new term, nature's contributions to people (NCP), to refers to "All the beneficial and detrimental contributions that we obtain from and with nature."[4] This builds on previous work by the Millennium Ecosystem Assessment (2005) on ecosystem services, as well as on IPBES's own regional and thematic assessments. According to the IPCC and IPBES, the two terms—nature's contributions to people and ecosystem services—should be seen as interchangeable rather than mutually exclusive.[16]

Below, we present a table of preliminary matches across the categories of NCP from IPBES (2019) and ES listed in the MEA (2005) and in ENCORE's database (2019). Boxes which are matched with a dash were found to have no direct parallel in the other assessed categorization. As emphasized in the report, harmonizing this terminology is critical for improving businesses' ability to assess and manage nature-related risks; common language facilitates data collection and risk communication.

A2. Table 1. Crosswalk of NCP and ES Categories MEA 2005, IPBES 2019, ENCORE 2019

	MEA (2005)		IPBES (2019)		ENCORE (2019)
ES1	Food	NCP 12	Food and feed	ES7	Fibers and other materials
ES2	Fresh water	NCP 6	Regulation of freshwater quantity, location and timing	ES11	Ground water
				ES18	Surface water
ES3	Fuelwood	NCP 11	Energy	ES1	Animal-based energy
-	-	NCP 3	Regulation of air quality	ES5	Dilution by atmosphere and ecosystems
-	-	-	-	ES19	Ventilation
ES4	Fiber	NCP 13	Materials, companionship and labor	ES7	Fibers and other materials
ES5	Biochemicals	NCP 14	Medicinal, biochemical and genetic resources	ES10	Genetic materials
ES6	Genetic resources				
ES7	Climate regulation	NCP 4	Regulation of climate	ES4	Climate regulation
		NCP 9	Regulation of hazards and extreme events	ES13	Mass stabilization and erosion control
-		-	-	ES14	Mediation of sensory impacts
ES8	Disease regulation	NCP 10	Regulation of detrimental organisms and biological processes	ES2	Bio-remediation
				ES6	Disease control
				ES15	Pest control
ES9	Water regulation	NCP 7	Regulation of freshwater and coastal water quality	ES3	Buffering and attenuation of mass flows
				ES9	Flood and storm protection
				ES20	Water flow maintenance
				ES21	Water quality

Annex 2: Terminology Use *continued*

A2. Table 1. Crosswalk of NCP and ES Categories (MEA 2005, IPBES 2019, ENCORE 2019) *continued*

MEA (2005)		IPBES (2019)		ENCORE (2019)	
ES10	Water purification	-	-	ES8	Filtration
-	-	NCP 5	Regulation of ocean acidification	-	-
ES11	Pollination	NCP 2	Pollination and dispersal of seeds and other propagules	ES16	Pollination
ES12	Spiritual and religious	NCP 17	Supporting identities	-	-
				-	-
ES17	Sense of place	NCP 17	Supporting identities	-	-
ES18	Cultural Heritage	NCP 17	Supporting identities	-	-
ES13	Recreation and ecotourism	NCP 16	Physical and psychological experiences	-	-
ES14	Aesthetic	NCP 16	Physical and psychological experiences	-	-
ES15	Inspirational	NCP 15	Learning and inspiration	-	-
ES16	Educational	NCP 15	Learning and inspiration	-	-
-	-	NCP 1	Habitat creation and maintenance	ES12	Maintain nursery habitats
ES19	Soil formation	NCP 8	Formation, protection and decontamination of soils and sediments	ES17	Soil quality
ES20	Nutrient cycling	-	-	-	-
ES21	Primary production	-	-	-	-
	-	NCP 18	Maintenance of options	-	-

Value

Value is another commonly used and important term to clarify for nature-related risk. According to IPBES, "beyond monetary worth, **value** conveys the relative importance or usefulness of natural capital to others."[15] Value is always defined in the context of a given worldview and cultural context and can refer to a preference someone has for a particular state of the world, the importance of something for itself or for others, or simply a measure.[63] This reflects what it means to 'value' something and hints at the diversity of values: e.g. bequest value, non-use value, monetary value, option value. Therefore, although many have advocated for modelling the benefits/value of nature, notorious characteristics of the task have limited progress to date (e.g., availability of data, diversity of nature's uses, complexity of both nature and value, and the scientific limitations of measurement). This has left some elements of NC/ES 'model-able' and others not (such as ground and surface water versus bioremediation or pest control). Ultimately, the inability to capture the full picture renders efforts at valuing nature incomplete.

Dependencies versus Impacts

Framing of risks and business relationships to the environment in terms of dependencies and impacts is relatively widespread. For instance, it can be found in the work of the Organization for Economic Cooperation and Development,[15] Finance Watch,10 the Natural Capital Finance Alliance,[7,64] the Biodiversity Consultancy,[65] the Natural Capital Coalition,[9] the Association of Chartered Certified Accountants,[22] and in the work of the World Resources Institute.[11] Widespread uptake may be in part linked to strong overlaps with the otherwise widely recognized 'input-output' and 'source-sink' understandings of the economy's relationship to nature and of nature's contributions to welfare. The high value contribution of the framework is maintaining a focus on business dependencies on nature, without which some businesses could not function (e.g. the paper industry without water). If dependencies are not included, the conversation around businesses and environmental risks tends to focus on businesses' impacts on the environment (e.g. the focus of the ESG community on pollution, regulatory and reputational risks).

This framing requires balancing scales of analysis. Society and the macroeconomy have dependencies and impacts on nature as much as individual businesses do. These dependencies may be through their consumptive demands on businesses, or through their own extractive and pollutive activities. Businesses must consider in their risk analysis who or what may be leading to changes in the ecosystem services or natural capital stocks on the business depends or may be held accountable for impacting.

Annex 2: Terminology Use *continued*

Climate Change-Related Risk versus. Nature-Related Risk

Although the lines between climate change-related risk and nature-related risk are still being drawn, this report holds them as analytically distinct in order to further understanding of *nature-related risk* as another category of significant environmental risk, alongside climate *change-related risk*. As stated in the presentation of our framework (see Section 2 above), the terms we use for describing nature-related risk—change, threat, exposure, vulnerability and consequence—are drawn from the literature on climate change-related risk, particularly, the work of the IPCC.

There are several overlaps between the climate and nature-related risk. Connections include the loss of nature as a driver of climate change (e.g. deforestation and land conversion releasing greenhouse gases into the atmosphere) on the one hand, and climate change as a driver of loss/degradation on the other (e.g. warmer oceans leading to the bleaching of coral reefs).[4] Conversely, a healthy environment may improve societal resilience in the face of climate change, with the latest IPCC report on climate change and land emphasizing conservation and restoration as positive courses of action for adaptation and mitigation. As outlined in the case studies in this report, changes in the global climate – for instance increased desertification and dryness in semi-arid regions – can lead to disruption in the provision of ecosystem services that businesses rely on (e.g. water availability) and create new risks to operations (e.g. flammability).

Materiality and Externalities

Materiality and externality are the focal points of many discussions of nature-related and climate change-related risk. Even across the third-party agencies which monitor and report on business activities, definitions of corporate or financial materiality diverge. There are three primary issues separating corporate definitions of materiality: 1) timeframe, 2) scope of issues, and 3) stakeholders covered in assessments and reports.[66] As the Corporate Reporting Dialogue emphasizes in its work,[12] the context of corporate activities is decisive for considerations of materiality. Therefore, sociopolitical and environmental changes can come to bear on corporate reporting practices.

The issue of timeframe related to materiality was best reflected by Mark Carney's pivotal speech proclaiming that climate change is the "tragedy of the horizon."[67] Carney explained that the costs of climate change will fall on future generations because the current generation has no direct incentive to bear these costs themselves. Beyond climate change, this analogy extends to nature loss and degradation, which is a similarly on a longer timeframe than businesses often plan for. In part because business operate on a shorter time horizon than climate change and nature loss, businesses don't fully consider their dependencies, impacts and consequences. However, given that materiality is rooted in context—what is material in one context may be immaterial in another.[12] As contexts change, the threshold of materiality will shift and risks which were initially considered immaterial may demand greater attention.

Although businesses are the focus of this report, the actors involved in managing nature-related risk include investors, insurers, state banks, and government regulators. These actors are concerned with a wider suite of potential risks beyond the risks of concern to businesses. Some of these concerns which may in fact derive from businesses' operations in the form of externalities, and some of which may extend beyond businesses' scope of financial materiality.[k] Differences in mandates between businesses and society yield different agendas of action.

For socially oriented actors, issues of concern may include those which are **'environmentally material.'** Environmentally material issues are those involving environmental impacts or dependencies on nature which are thought to have the potential to alter decisions being taken by businesses.[21] More specifically, NCFA defines materiality as pertaining to the importance of an ecosystem service to a business's production process, considering two main aspects: loss of functionality (in the case of ecosystem service disruption) and financial loss (due to that loss of functionality).[7] For businesses and other actors, considering and disclosing issues with environmental materiality depends on considerations like the mandatory and voluntary codes of conduct to which a business subscribes, and their mission statement and principles. For businesses operating within the European Union, disclosure was influenced by the European Commission's 2017 Non-Binding Guidelines on Non-Financial Reporting, under which businesses must account for the impact of their activities when assessing the materiality of non-financial information. A communication from the Commission states that this "in effect" establishes a **"double materiality"** perspective, such that businesses should disclose information which is both financially material in the classic sense, i.e. potentially consequential for the value of the company, and also information which is environmentally and socially material.[68]

[k] Financial materiality refers to aspects that influence the revenue generation, costs, capital efficiency or risks that a company faces today or in the future. Financially material issues will affect the value of the company's equity or borrowings.

Annex 2: Terminology Use *continued*

This extension of materiality and corporate accounting is a direct result of an increase in attention to climate and other environmental issues from both investors and society at large.

Although a number of corporations do still report solely on issues which are financially material, the growing number of those engaging in CSR and ESG reporting indicates that firms are beginning to acknowledge their impacts—positive and negative—on issues of social and environmental materiality to society at large. Most companies now acknowledge ESG issues in their reports[69] and CEOs repeatedly rank nature-related risks at the top of their concerns.[3,70–73] Conservation finance and sustainable and responsible investing are growing, and are expected to continue growing.[10] The relationship of governments, consumers, financiers, and other actors to nature shapes the incentives to which businesses respond; changes in preferences and values within these groups can create risks and pressures on businesses to act. For instance, whether or not corporate actors disclose and manage nature- and climate change-related risks, credit rating agencies and other third-party actors can still release information on businesses and sectors, which may have material impacts on their ability to access loans or attract financing.

The question of materiality parallels discussions on externalities. Externalities such as air pollution can impose health burdens on communities near and far from a company's operations. When compounded by the effects of other polluters, these impacts become severe enough to result in decreased productivity of laborers or even labor shortages. This secondary effect may be felt more distantly in the economy or market in which a corporation operates, or even within its own labor supply.[74] For institutional investors, economy and market-wide impacts of externalities are a major concern. When they are examined, negative externalities may (partially) offset the benefits associated with production, and are often seen to erode profits across a standard portfolio (i.e., of a universal investor).[75] The inability of balance sheets and market prices to capture the environmental costs paid by society at large is a well-known a market failure. When businesses fail to fully internalize the negative impacts of their operations, trillions of dollars' worth of environmental benefit are lost.[19] Troublingly, prior studies have found that no high impact sector studied was currently generating sufficient profit to cover their environmental impacts.[19] Externalities are not only of concern for citizens who rely on unpriced ecosystem services for services like climate regulation, potable water and recreational benefits, but also for their governments, institutional investors and companies generating these costs themselves. For governments, the cost felt by citizens is tied to their subsidy policies. Hundreds of millions of dollars in government subsidies fuel potentially harmful agriculture and other pollutive industries.[10] For universal investors managing a wide portfolio of companies, the failure of markets and balance sheets to capture externalities can cause residual negative impacts across their investments.[75] For companies generating the costs, externalities may eventually become financial risks should regulatory, market and/or social forces require internalization of these costs in the future.

Annex 3: Literature Summary

More details available here.

Title/Link	Author/Group	Year	Brief summary	Nature or Climate Risk	Intended Audience	Risk Framework Used
A Call for Action: Climate change as a source of financial risk	NGFS (Network for Greening the Financial System)	2019	Network for Greening the Financial System presents a set of recommendation for integrating climate change risks into financial systems. Among these is disclosing in line with TCFD and developing a taxonomy of economic activities.	climate	central banks; policymakers	physical and transition risks
Biodiversity: Finance and the economic and business case for action	OECD	2019	OECD report linking biodiversity loss to socio-economic and business concerns. Prepared for the G7 Environment Ministers' Meeting, 5-6 May 2019	nature	G7 Environment ministers; framing for CBD 2020	ecological, liability, regulatory, reputational, market, financial
Global assessment report on biodiversity and ecosystem services	IPBES Diaz, Settle, & Brondizio	2019	Global assessment based on existing academic literature on biodiversity and ecosystems services	nature	policymakers	NA
Into the wild: Integrating nature into investment strategies	AXA and WWF-France	2019	Report summarizing risks to the finance sector due to loss of nature; focused on laying out categories of risks, and possible approaches to risk report and assessment. Section 2.3 lays out opportunities to be had in facing risks.	nature	G7 Environment ministers; finance institutions	operational, legal & regulatory, markets, reputational, societal
Making finance serve nature	Finance Watch (Ludovic Suttor-Sorel)	2019	proposes moving away from finance that ignores nature to finance that supports nature, including accounting of natural capital; risks and opportunities; and supportive of 'mission-oriented' finance	nature	policymakers	references multiple frameworks, primarily TCFD for risk framework
Underwriting environmental, social and governance risks in non-life insurance business	UNEP & PRI	2019	Byline: The first ESG guide for the global insurance industry developed by UN Environment's Principles for Sustainable Insurance Initiative.	nature	insurance industry	ESG --> environment
Values at risk? Sustainability risks and goals in the Dutch financial sector	Schellekens & van Toor	2019	Bank-produced report identifying and addressing management of 'environmental and social risks' related to water, biodiversity, resource loss, and human rights	nature	finance institutions	water risk, biodiversity risk, resource scarcity risk
Measuring and managing environmental exposure: A business sector analysis of natural capital risk	Allianz	2018	analysis of 7 natural capital risks that businesses face, across 12 sectors. Data from literature review, MSCI, and interviews.	nature	businesses	Sectors are categorized as high, medium, or low risk. Risk process is elaborated in 3 steps: awareness, preparation, and management
Aiming higher to bend the curve of biodiversity loss	Mace et al.	2018	Frame-setting Nature Sustainability comment paper calling for new a new goal, targets, and metrics to restore biodiversity. Linked to larger New Deal for Nature and People.	nature	academics	NA
Climate change and the macro-economy: a critical review	Bank of England (Batten, Sandra)	2018	outlines "key theoretical and empirical modelling issues in the analysis of the macroeconomic risks deriving from climate change" and discusses the increasing need to quantify climate risks	climate	economists, central banks	physical risk and transition risk; unpredictable shocks versus predictable long-term impacts
Climate change challenges for central banks and financial regulators	Campiglio, Dafermos, Monnin, Ryna-Collins, Schotten & Tanaka	2018	Argument for the need for developing a framework to assess the impact of climate change on financial stability and to incorporate such assessment into regulation and policy	climate	researchers, banks	calling for development of a framework dependencies and impacts;
Connecting finance and natural capital: A supplement to the natural capital protocol	Natural Capital Coalition & Natural Capital Finance Alliance	2018	Focused on ways to assess the finance sector's impacts and dependencies on natural capital (1 of 3 interrelated reports)	nature	ESG analysts,	operational, legal & regulatory, markets, reputational, societal

Annex 3: Literature Summary *continued*

Title/Link	Author/Group	Year	Brief summary	Nature or Climate Risk	Intended Audience	Risk Framework Used
Exploring natural capital opportunities, risks and exposure: A practical guide for financial institutions	Natural Capital Finance Alliance and UN Environment WCMC	2018	Report focused on detailing the ENCORE tool (Natural Capital Finance Alliance, 2019) (2 of 3 interrelated reports)	nature	finance institutions	dependencies and impacts (species, water, disease, drought, fire, etc)
Global Risks 2018: Fractures, fears and failures	World Economic Forum	2018	Annual report on global risks: cites loss of biodiversity and climate change risks to private sector Annual assessment of 20+ global risks, not exclusive to climate change, but ranking climate change high	nature	businesses	rating
Integrating natural capital in risk assessments: A step-by-step guide for banks	Natural Capital Finance Alliance & Pricewaterhouse Coopers	2018	Brief report framing assessing risk of natural capital loss or impairment for banks. Examples are at the scale of a sector/industry within a country (3 of 3 interrelated reports)	nature	finance institutions	dependencies and impacts; risks are credit, environmental, market, reputational, operational, compliance, liquidity
Making Waves: Aligning the financial system with sustainable development	UNEP Inquiry (Zadeck and Robins)	2018	Part of the broader UNEP FI 'Inquiry' on sustainable finance which makes the case for "aligning the financial system with sustainable development"	nature	policymakers	discusses risk, but not specially focused on identifying risk types
S&P Global Ratings' Proposal for Environmental, Social, And Governance (ESG) Evaluations	S&P	2018	Separate from credit ratings, these are entity-specific evaluations, based on a "cross-sector, relative analysis of an entity's ability to operate successfully in the future and optimize long-term stakeholder value in light of its natural and social environment and the quality of its governance."	nature	businesses, FIs	all ESG, not specific to environment/ nature only
Stranded Assets and the Environment	Caldecott, Ben	2018	"edited collection [which] provides a comprehensive assessment of stranded assets and the environment"	nature	researchers	stranded assets as a framing for environmental risks
The private sector's climate change risk and adaptation blind spots	Goldstein, Turner, Gladstone, & Hole	2018	Review of corporate adaptation strategies indicates that risks of climate change should be better assessed and incorporated	climate	researchers	NA; review of risk approaches
Environmental Risks Global Heatmap Overview	Moody's	2018	Rating of the level of environmental risks (high/med/ low) across five environmental risks (air pollution, soil/water, carbon regulation, water shortage, natural hazards) and across many sectors (eg: shipping, power generation, agriculture), including the value of the current debt holdings for that sector	nature	investors	risk level: high/ med/low risk timeframe: immediate v. emerging 5 environment categories: air pollution, soil/ water, carbon regulation, etc
Advancing TCFD guidance on physical climate risks and opportunities	Four Twenty Seven and Acclimatise for EBRD	2018	focused on climate risk, following TCFD work; "lay the foundations for a common conceptual framework and a standard set of metrics for reporting physical climate risks and opportunities"	climate	regulators	building on TCFD
Enhancing environmental risk assessment in financial decision-making	Green Finance Study Group [GFSG]	2017	i) Understanding practice via case studies; ii) Categorizing existing ERA practices; iii) A desk review evaluation of effectiveness through case analysis; iv) Identifying barriers to effective usage of ERA methodologies; and v) developing options to promote wider adoption of ERA practices	nature	public institutions	Environmental risk factors (e.g. Physical, transition risk) and Financial Risks (Business, Legal, Market, Credit). See diagram of this on page 10
Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures (Annex to 'Recommendations of the Task Force on Climate-related Financial Disclosures)	TCFD	2017	Practical implementation suggestions for the 'recommendations' report on how to include material financial risks due to climate change in a company's required annual financial filings	climate	businesses and finance institutions	transition risks (policy & legal, technology, market, reputation); physical risks (acute, chronic)

Annex 3: Literature Summary *continued*

Title/Link	Author/Group	Year	Brief summary	Nature or Climate Risk	Intended Audience	Risk Framework Used
Recommendations of the Task Force on Climate-related Financial Disclosures)	TCFD	2017	Recommends financial disclosures done by companies for climate-related issues. Risks of climate change to companies, but especially regarding transition to a low-carbon economy	climate	businesses	transition risks (policy & legal, technology, market, reputation); physical risks (acute, chronic)
Biodiversity and ecosystem services: the business case for managing risk and creating opportunity	The Biodiversity Consultancy	2017	Brief summary of the business case for managing biodiversity risk.	nature	businesses	Biodiversity risk; social license to operate, access to capital, litigation, permitting, disrupted operations or supply chain
Net Positive Impact on biodiversity: The business case	IUCN	2016	Introduces the concept of Net Positive Impact (NPI) on biodiversity for businesses, including the business case for applying NPI	nature	businesses	NA
'Climate value at risk' of global financial assets	Dietz, Bowen, Dixon, & Gradwell	2016	Risk of climate change to the financial sector "Estimate the impact of twenty-first-century climate change on the present market value of global financial assets...." At $2.5 trillion	climate	researchers, businesses	using IAM to quantify risk in $
Let's talk about the weather: the impact of climate change on central banks	Bank of England (Batten, Sowerbutts and Tanaka)	2016	identification and description of physical risks and transition risks for climate change impacting central banks and the economy	climate	economists, central banks	physical risk and transition risk
Natural Capital Protocol Principles and Framework	Natural Capital Coalition	2016	Further elaboration on Natural Capital Protocol on how to apply the natural capital framework in 9 steps	nature	organizations, businesses	impacts and dependencies; risks and opportunities
Natural Capital Protocol	Natural Capital Coalition	2016	Protocol (framework) for organizations and businesses to include consideration of natural capital in their decision making	nature	organizations, businesses	impacts and dependencies; risks and opportunities
Statement of Common Principles of Materiality of the Corporate Reporting Dialogue	Corporate Reporting Dialogue	2016	This document overviews the common foundational principles of the CRD, for instance, the principle that "material information is any information which is reasonably capable of making a difference to the conclusions reasonable stakeholders may draw when reviewing the related information." Comparison of materiality definitions used by different organizations included on pages 5-8.	nature	investors, regulators	NA
Stranded Assets in Palm Oil Production: A case study of Indonesia	UNEP/SSEE Morel, Friedman, Tulloch, Caldecott	2016	"focus on the environment-related risk factors that can cause asset stranding in the national context of Indonesia's oil palm industry"	nature	researchers, practitioners	Caldecott 2013. Risks are applied to asset types: physical, financial, social, human; natural risk factors: likelihood, timing, and potential scale
A Framework for Protected Area Asset Management	UNEP/SSEE Paul Jepson, Caldecott, Milligan, Chen	2015	assessment and literature review on how to consider protected areas as an asset class, including case examples from Brazil and Tanzania; includes risks to PA assets and how to manage risks	nature	decision-makers, investors	not a risk framework; instead an 'asset framework for Protected Areas with five typologies: investment, situated assets, forms of value, value capture, and risk factors
Breaking the tragedy of the horizon – climate change and financial stability	Carney, Mark (Bank of England; with Phillips, Rhys and Weymarn, Ian de)	2015	outlining a 'tragedy of the horizon' for climate risk, in which most risks are on a time horizon outside of the scope of businesses, FIs, and politics; calls for climate risk disclosure and framework of physical, liability, and transition risks	climate	insurance/ finance institutions	physical, liability, transition risks
Linking forest ecosystem services to corporate sustainability disclosure: A conceptual analysis	D'Amato, Li, Rekola, Toppinen, & Lu	2015	Focus on conceptual options for the forest sector to evaluate/value ecosystem services	nature	researchers	Ecosystem services linked to dependencies, impacts, and responses

Annex 3: Literature Summary *continued*

Title/Link	Author/Group	Year	Brief summary	Nature or Climate Risk	Intended Audience	Risk Framework Used
The cost of inaction: Recognising the value at risk from climate change	Economist Intelligence Unit	2015	Risk of climate change to the financial sector. Modelling finds that "risk to current manageable assets from climate change is $4.2 trillion" from ~2015-2100	climate	FIs	quantifying risks
Toward a risk register for natural capital?	Mace et al	2015	proposes a risk register to monitor natural capital assets that are at risk of being unable to continue to provide expected benefits	nature	policymakers, researchers	assigns high/med/low risk to asset & benefit relationships in the UK
Environmental and Social Risks	ERBD	2014	Focus on environmental risks from business's impacts; putting forward risk framework for implementation by its financial intermediaries	nature	ERBD's financial intermediaries	Financial, Legal, Reputational risks (as a result of company's actions)
IPCC AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability	IPCC	2014	Builds upon the risk concept set forward in SREX to include feedbacks between risk, climate and socioeconomic processes. Provides evidence on impacts, adaptation and vulnerability around the world.	climate	policy makers, governments, researchers, other stakeholders	IPCC: risk as a function of hazard, vulnerability, exposure, socioeconomic process and natural variability/change
Financial Dynamics of the Environment: Risks, Impacts, and Barriers to Resilience Working Paper for the UNEP Inquiry	UNEP/SSEE Caldecott and McDaniels	2014	reporting to summarize why finance sector should care about environmental risks; to identify barriers that would prevent managing risks; and to identify the groups working in this realm; "how environmental-related risks could affect the financial sector and what financial institutions can do to manage such risks"	nature	finance sector	physical, legal, technological, reputational, credit
Risky Business: The economic risks of climate change in the United States	Gordon	2014	Economic risks of climate change in the US. Uses risk assessment approach, economy wide and by sector.	climate	policy makers, governments, stakeholders	risks categorized by region and impact
The New Climate Economy Better Growth, Better Climate	The New Climate Economy	2014	It is possible to have economic growth and address climate change risks together	climate	government, businesses	NA
Opportunity Lost: Mitigating risk and making the most of your land assets. An assessment of the exposure of business to land degradation risk and the opportunities inherent in sustainable land management	ELD Initiative	2013	assessment of business exposure to land degradation risk, including mitigation measures / opportunities	nature	businesses	risks categorized as reduced productivity, decreasing raw materials, political instability/social issues, regulatory/legal
Identifying natural capital risk and materiality	Hewitt et al.	2013	Overviews materiality debate around scope, stakeholders and time frame. Provides table of materiality definitions used by ratings/disclosure agencies on page 2.	nature	organizations	ESG
Natural Capital at Risk: The Top 100 Externalities of Business	Trucost	2013	Concentration is on costs to the economy and society from private businesses in the form of environmental externalities.	nature	companies, investors, governments, TEEB business coalition	Some mix of risk frameworks is applied; ultimately, they're concerned with risks as businesses'
Private-sector adaptation to climate risk	Surminski	2013	Some companies are now addressing adaptation climate risks, but many aren't, due to various barriers	climate	researchers	environmental costs focused on private-sector adaptation to climate risks

Annex 3: Literature Summary *continued*

Title/Link	Author/Group	Year	Brief summary	Nature or Climate Risk	Intended Audience	Risk Framework Used
Weathering the storm: Building business resilience to climate change	Center for Climate and Energy Solutions	2013	Analysis of (mostly) traditional risk assessment approaches of 100 companies; recommends proactive risk assessment and management, especially for climate risks	climate	policy makers, organizations	framework for managing climate risk: build awareness, assess vulnerabilities, manage risks, review
Harnessing nature to help people adapt to climate change	Jones, Hole, & Zavaleta	2012	Policy Perspective at intersection of ecosystem service and climate change: advocates using ecosystem-based approaches for climate change adaptation	nature	researchers	NA
Is natural capital a material issue?	Bonner et al.	2012	Early study on materiality of natural capital as an issue for business. Barriers to action identified at that time: lack of a standardized business case, low and lacking market values for biodiversity and ES, and [appropriate] accounting principles. Given its focus on measurement/accounting, the report includes trends and current practices on valuation of biodiversity and ecosystem services in section 6.	nature	CFOs and accountants	Impacts and dependencies as overall framework. 5 types: operational, regulatory & legal, reputational, markets & products, financing.
Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX report)	IPCC Field et al eds.	2012	IPCC special report on managing the risks of extreme events/disasters for climate change adaptation, including grounding in disaster risk management and approaches to vulnerability and exposure, and addressing uncertainty	climate	policymakers, researchers	main framework is understanding disaster risk through vulnerability, exposure, and climate events
Risk ready: New approaches to environmental and social change	PwC	2012	Frames concerns with environmental lens through threats to economic stability. Focus is on business-level risk management practices.	nature	Businesses and finance institutions	Operational/ value chain risks, 'exposures in the landscape' (i.e. hazards)
The Corporate Ecosystem Services Review: Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change. Version 2.0. [ESR]	Hanson, C., J. Ranganathan, C. Iceland, and J. Finisdore / WRI, Meridian Institute, WBCSD	2012	Promotes the use of an ecosystem services review (ESR) in order to protect against risks and exploit opportunities related corporate impacts and dependencies on ES. Full suite of ES which can be considered are taken from TEEB, corp narrows these down. Step by step guide provided on how to use the ESR, tests this on 5 WBCSD companies: BC Hydro, Sygenta, Rio Tinto, Mondi and Akzo Nobel.	nature	businesses	Operational, regulatory and legal, reputational, market and product, financing
The Economics of Ecosystems and Biodiversity in Business and Enterprise	TEEB	2012	"the global economic benefit of biological diversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation" for the business community	nature	businesses and finance institutions	dependencies and impacts
Universal Ownership: Why environmental externalities matter to institutional investors	UNEP FI & PRI	2011	Provides estimates of the current and future estimated monetary value of environmental degradation (via Trucost), in order to create a basis for large institutional investors (i.e. universal owners) to address externalities that have the greatest financial implications. Focus is on unpriced externalities, both the positive (e.g. ecosystem services) and negative (e.g. pollution) -- premise that the failure to price these appropriately will erode future benefits.	nature	Institutional investors	quantifying financial risks
Biodiversity and Business Risk	WEF	2010	2010 briefing on biodiversity and risk for WEF. Identified biodiversity loss as a major economic risk. includes a list of biodiversity risks in classic risk typology (physical, regulatory, market, other), and includes some limited case studies	nature	produced for participants in biodiversity discussions at WEF annual meeting	physical, regulatory, market, other risks
The cost of policy inaction	Braat & ten Brink	2008	2008 assessment of the "social and economic costs to mankind as a consequence of the losses of biodiversity"	nature	European Commission, for Review on the Economics of Biodiversity Loss	quantifying costs of loss of biodiversity
The value of the world's ecosystem services and natural capital	Costanza et al. *	1997	Classic review paper assessing the value of ecosystem services. 17 services; 16 biomes; $16-54 trillion per year		researchers	researchers quantifying the value of ecosystem services globally

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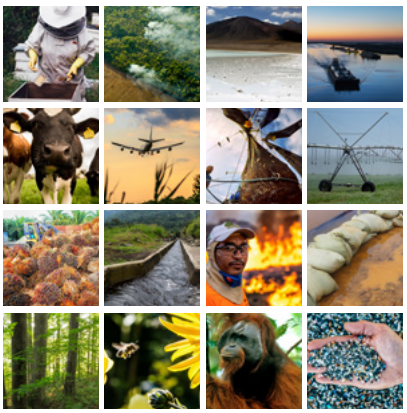

The Nature of Risk

A Framework for Understanding Nature-Related Risk to Business

WWF