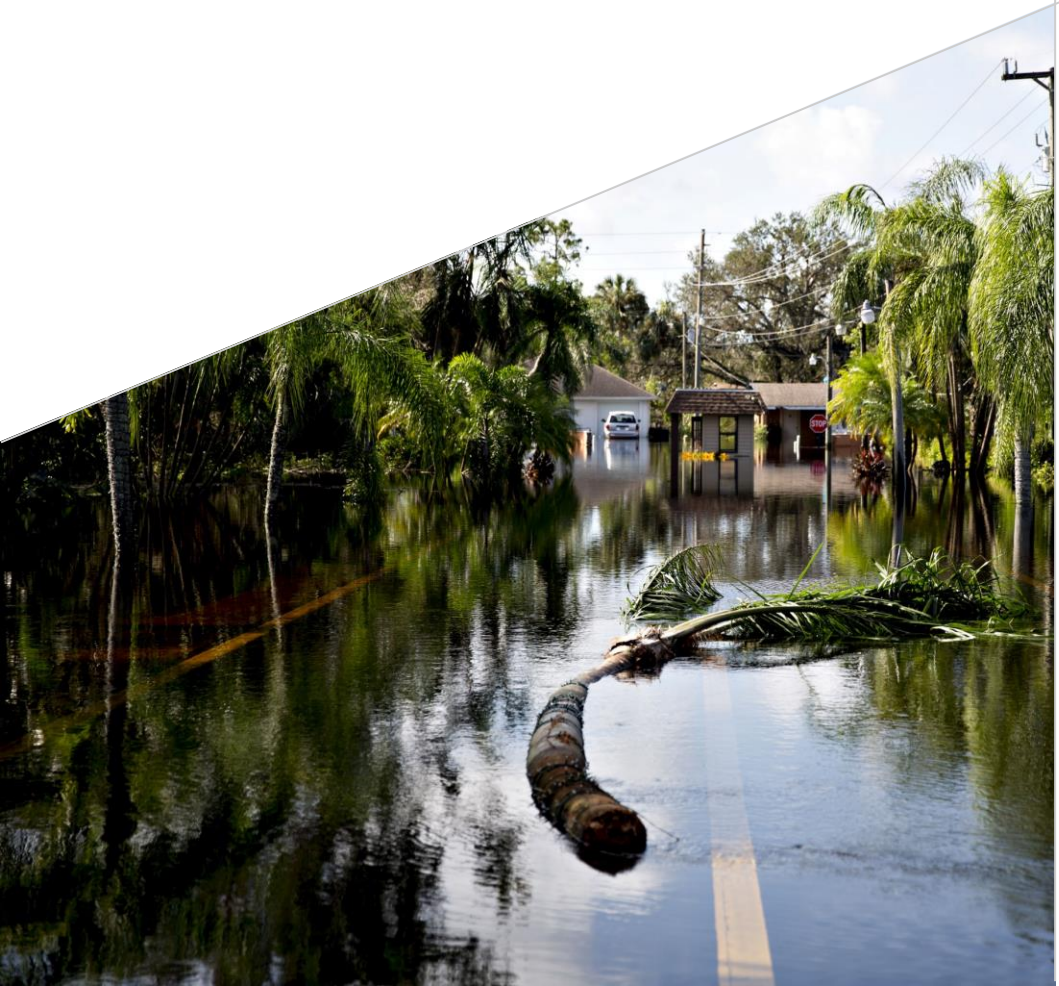
When the Bee Stings

Counting the Cost of Nature-Related Risks

December 9, 2023



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Section 1. Executive summary

10

Number of case studies accompanying this research note

$83.2 billion

Total financial impact on the 10 firms profiled, excluding strategic delays

55%

Share of global GDP moderately or highly dependent on nature

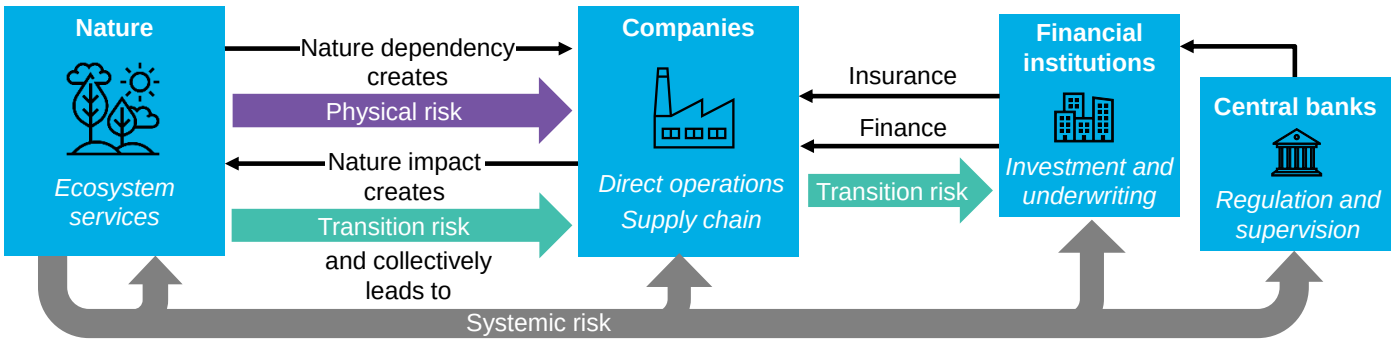
Mismanaging nature risk has burned billion-dollar holes in many corporate balance sheets. In collaboration with the Taskforce on Nature-related Financial Disclosures (TNFD) and aligned with its newly released recommendations, BloombergNEF has examined 10 instances of companies suffering material financial losses, the threat of such losses and share price pressure from poorly handled interactions with nature. The case studies demonstrate the financial importance of a business understanding and managing its impacts and dependencies on the natural world.

- All sectors are exposed to nature risk. Even within this small sample, companies include those operating in materials, consumer staples, transport, energy, industrials and utilities, with further diversity within sectors.
- Spanning a range of geographies and company sizes, the organizations each handled their interactions with nature differently, creating various forms of nature risk that amounted to at least $80 billion in financial impacts.
- The cases of Bernard Matthews and Tesla detail how nature *dependency* manifested into *physical* risk. For the poultry producer, inadequate biosecurity measures enabled avian influenza to enter and spread throughout its supply chain, costing tens of millions of pounds in lost sales, hundreds of jobs and tainting its brand. Meanwhile, though Tesla Chief Executive Officer Elon Musk downplayed the threat of declining groundwater levels, these concerns delayed completion of the electric vehicle giant's $5.7 billion Berlin gigafactory.
- *Transition* risk arises through the *impacts* of a company on nature, manifesting as legal and policy risk in five of the cases. Chemicals producer 3M, plastics manufacturer Formosa and copper and gold miner Freeport-McMoRan each released harmful materials into watercourses proximate to their operations, resulting in over $10 billion in combined legal liabilities, revocation of production permits and obstacles to planned equity transfers.
- Chevron's expansion plans in the Gulf of Mexico faced uncertainty as environmental groups mounted a legal challenge to protect an endangered whale in the region. Shipping giant CMA CGM incurred fines for non-compliance with ballast water treatment rules intended to limit the spread of invasive species.
- Specialty oil and fats manufacturer AAK and the world's largest meat producer, JBS, were impacted through market and reputational risk – further forms of transition risk – as a result of practices linked to deforestation. Despite AAK's commitment to sustainable sourcing of palm oil, media reports tying its operations to a protected national park in Indonesia hit its share price, while ongoing criticism of JBS' practices in the Amazon has imperiled its long-planned listing in the US, jeopardizing up to $20 billion in unlocked value.
- There is clear overlap between nature and climate risk, as highlighted by electric utility PG&E. After being found liable for a series of California wildfires from 2015-18, the company paid over $5 billion in settlements and filed for bankruptcy (a state it has since emerged from).
- As the unprecedented decline in nature continues to accelerate, business models and ultimately cash flows, are increasingly vulnerable. Physical and transition risk is becoming more material to companies across all sectors. Initiatives such as the TNFD provide resources and guidance to assist companies in managing this risk by identifying and assessing their dependencies, impacts, risks and opportunities associated with nature.

Section 2. A framework for nature-related risk

All economic activity is dependent on nature to some degree. Global GDP growth is underpinned by a reliance on the stock of natural capital and the ecosystem services that flow from it. At the same time, business operations, supported by the financial sector, have driven a rapid decline in nature and biodiversity. These nature-related dependencies and impacts, alongside long-term system collapses, create risks to companies that fall into three categories, in line with the categorization used by the Taskforce on Nature-related Financial Disclosures (TNFD): physical risk, transition risk and systemic risk (Figure 1).

Figure 1: Nature impacts and dependencies create nature-related risks



Source: BloombergNEF, TNFD.

Businesses depend on ecosystem services to operate[1]. For example, forests provide wood for timber producers, growers depend upon insects and birds to pollinate crops, and an airport or nuclear power plant may depend on the erosion control and flood protection offered by mangrove swamps. These dependencies can present physical risk to business operations, manifesting through degradation of nature and the resulting loss of ecosystem services. Physical nature risks are either acute or chronic, broadly referring to short- and long-term nature-related events.[2]

Companies also impact nature through their operations, including the release of pollutants, extraction of resources and conversion of land. When these production processes are misaligned with changing regulation, market dynamics or community expectations, the firm becomes exposed to transition risk that can lead to financial costs[3]. Impacts and dependencies on nature can also spread through the entire natural or economic system, hitting tipping points and creating systemic risk for companies.

Each of these three forms of nature-related risk manifest differently, contingent on the source of the risk (Figure 2, additional information contained in Appendix C). It is important to note that risks

[1] Ecosystem services provide a range of tangible and intangible benefits to humans valued at $125 trillion per year. They are categorized as provisioning, regulating, supporting and cultural services.

[2] Acute risks are short-term events that change the state of nature and are typically location-specific, such as wildfires destroying infrastructure, crop diseases affecting harvest yield, or oil spills reducing ocean fish stocks. Chronic risks are long-term, incremental changes to the state of nature, with consequences that are not anticipated to recede. Examples include climate change and ocean acidification.

[3] This note adapts BNEF's approach to climate risk when defining nature transition risk: the loss of revenues, valuation, access to capital or increased costs to a company because of the shift to a nature-positive economy. See: *Climate Risk Sector Homepage* (web).

do not exist in isolation: Companies with significant dependencies on nature will also impact its condition, while each risk type can contribute to systemic effects. This report is primarily concerned with physical and transition risk.

Figure 2: Nature-related risks manifest in a variety of ways

Physical risks		Transition risk				Systemic risk	
Acute	**Chronic**	**Legal and policy**	**Market**	**Technlogy**	**Reputational**	**Ecosystem stability**	**Financial stability**
Short-term events that change the state of nature	Long-term incremental changes to the state of nature	Changes in policy or regulation impact the company	Movement in market prices creates losses for the company	New technology financially affects the company	Consumers move away from brand tied to harmful practices	Collapse of entire natural system	Collapse of financial system

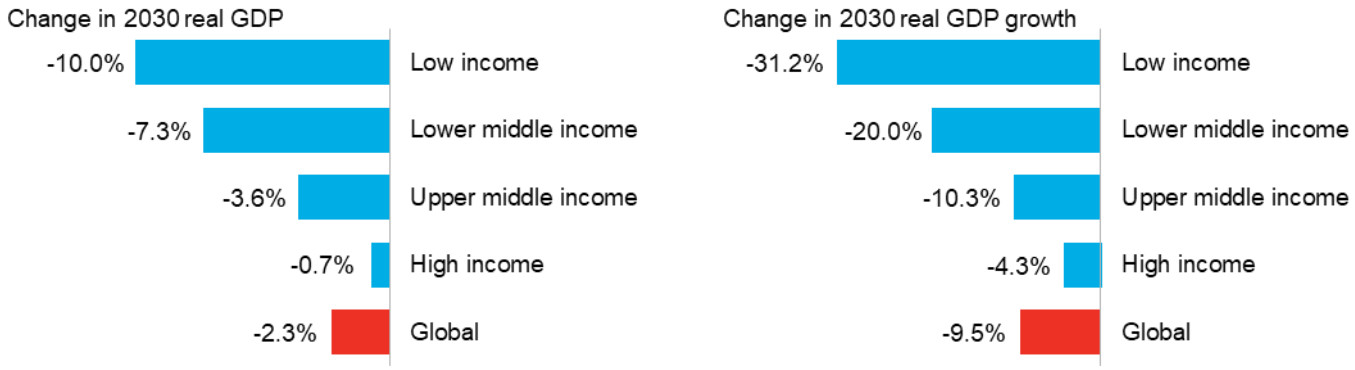
Source: BloombergNEF, TNFD. Note: Further detail in Appendix C.

Nature risk presents financial threats to companies and the economy

The continuing decline in the state of nature affects the global economy. According to the World Bank's 2021 report *The Economic Case for Nature,* global GDP could fall by 2.3% – equivalent to $2.7 trillion – in 2030 under a partial ecosystem collapse scenario, relative to a baseline scenario with no change in the state of nature (Figure 3). Such a collapse would slow the rate of GDP growth by 9.5% relative to the baseline[4]. The impacts are not felt equally across regions – areas with lower incomes are significantly more affected than their wealthier counterparts. These estimates are somewhat limited as they do not account for transition risk, merely the decline in value generated from the disrupted ecosystem services.

Fewer studies have considered the financial cost incurred by individual companies due to the mishandling of nature risks. The remainder of this report details nature-related risks through the experiences of 10 impacted companies.

Figure 3: The financial impact of a partial ecosystem collapse would be unevenly distributed



Source: BloombergNEF, World Bank (2021). Note: GDP impact relative to a baseline scenario with no change in the state of nature

[4] GDP, or gross domestic product, is a measure of the total monetary value of all goods and services produced in a year. A change in GDP refers to an increase or decrease in this total, while a change in GDP growth is an increase or decrease in the rate of change in GDP.

Nature risks are transposed on the financial sector

Central banks have already started to follow climate stress testing with an equivalent for nature. The Dutch central bank was the first to do so. The European Central Bank published a paper on physical nature risk in November 2023. The Network for Greening the Financial System (NGFS), a group of central banks and financial supervisors, has also started to consider the implications of nature loss for the global financial system.

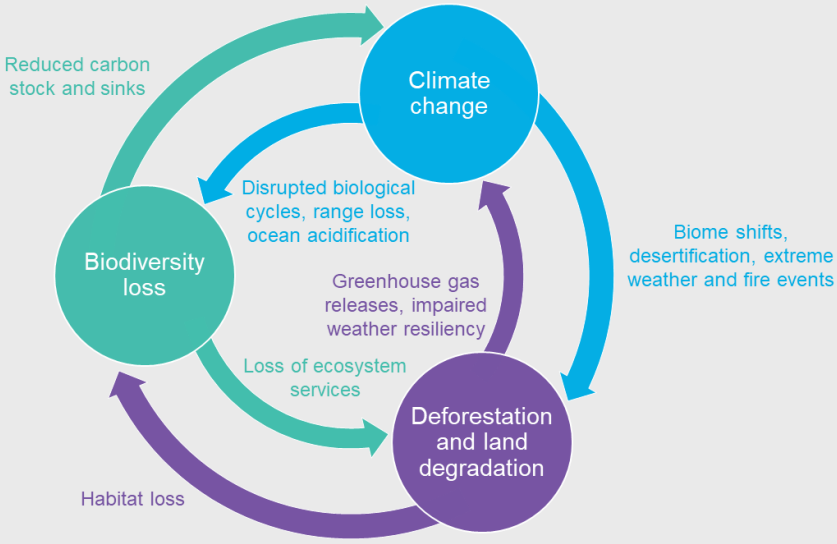
The UK and French central banks have also released statements on the need for more research into nature risk, which will likely happen apace as investors, regulators and banks begin to price the risk from nature loss into their calculations.

Nature loss and climate change are inextricably linked

Nature and climate are interlinked, as represented by Figure 4. Increasing temperatures hasten the decline in the state of nature. Land and ocean use change, the primary driver of nature loss, also contributes significantly to climate change, reducing the resiliency of the biosphere and exacerbating further impacts. Likewise, deforestation and habitat loss release stored carbon that amplifies temperature increases.

All natural systems play a regulating or supporting role in the global climate to some extent, be it in terms of mitigation or adaptation.

Figure 4: Relationship between natural systems and climate change



Source: BloombergNEF, United Nations Environment Programme.

This report does not attempt to draw a separation between nature and climate risks due to the close relationship between the two. While some events, such as heatwaves, may appear to be climate-related phenomena, they can also be seen as part of a larger breakdown in the operation of the biosphere. Temperature extremes precipitate droughts, floods, storms and various other meteorological phenomena, which in turn hinder ecosystem services.

Section 3. Exposing the financial costs of nature-related risk

Following the nature-related assessment approach outlined by the TNFD, BNEF has profiled 10 companies that incurred financial losses as a result of poorly handled interactions with nature. The cases span a variety of sectors and geographies and demonstrate how various types of nature-related risks manifest. Each case study follows a similar structure to enable comparison.

The cases are diverse, covering a wide range of industries, geographies, risks and financial impacts – Table 1 provides a high-level overview. Each of the companies profiled is a major player in its respective sector. Excluding container shipping company CMA CGM and poultry producer Bernard Matthews – which are privately held – the total market capitalization of these firms amounts to over $1.1 trillion (though a substantial share of this comprises Tesla).

Table 1: Case studies included in this report

Company	Sub-sector	Event	Costs	Risks exposed	
				Physical	Transition
3M	Specialty chemicals	Since 2016, its US facilities have released toxic per- and polyfluorinated substances, or 'forever chemicals', into watercourses*	At least $10.5 billion in legal liabilities, layoffs		
AAK	Grain and oilseed milling	Reported** to have sourced palm fruit from protected plantations in Indonesia, contrary to its sustainability claims	5.5% fall in share price in the 24 hours after the newspaper investigation was published		
Bernard Matthews	Packaged food	Inadequate biosecurity measures enabled the avian influenza virus to enter its UK facilities in 2007 according to DEFRA***	£20 million ($25 million) loss of brand value, layoffs		
Chevron	Oil and gas exploration and production	Faced legal challenges to protect an endangered whale threatened by oil and gas activities in the Gulf of Mexico****	Legal costs and development delays, which threatened up to $49.6 million in revenue		
CMA CGM	Container shipping	Discharge of untreated ballast water without authority or adequate reporting spread invasive alien species	$165,000 in fines		
Formosa Plastics	Basic and diversified chemicals	Discharged billions of plastic pellets from the wastepipes of its Texas facilities into waterways	$50 million settlement, $9.4 billion plant construction suspended		
Freeport-McMoRan	Metals and mining – base metals	Polluted water and forests in Indonesia through its disposal of vast quantities of mining waste	18% share price fall in two days after CEO reacted to tighter environmental laws		
JBS	Packaged food – meat products	Repeatedly sourced cattle raised on illegally deforested land in the Brazilian Amazon*****	$7.7 million in fines, potential loss of $20 billion valuation gain if US listing blocked		
PG&E	Electric transmission and distribution	Sparking transmission lines ignited untrimmed tree branches, leading to a series of deadly wildfires in California	91% share price fall from September 2017 to January 2019, $5.36 billion settlement		
Tesla	Automotive	Planned Berlin gigafactory's extraction of declining groundwater led to court complaint	3.1% share price fall in 24 hours after court complaint, $5.7 billion facility delayed		

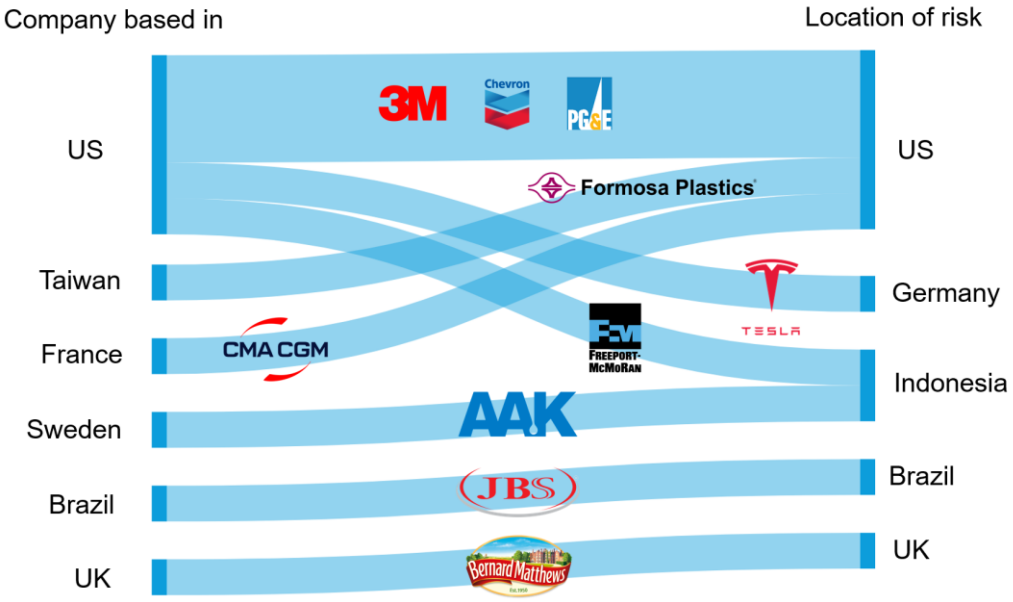
*Source: BloombergNEF. Note: *3M did not admit liability in the settlement. **AAK investigation reported by newspaper Sveriges Natur. Company noted that sustainable sourcing is important but did not deny allegations. ***UK's Department for Environment, Food and Rural Affairs. Bernard Matthews disputed these allegations in 2007. ****A November 2023 hearing ruled that the lease sale could proceed without further protections for the endangered whale. *****According to a Bloomberg investigation.*

Transition risk features more prominently than physical risk, with policy and legal risk manifesting in five of the 10 cases, though there is significant variability. The examples of chemical giant 3M and CMA CGM are the simplest – the companies violated environmental regulation and were deemed liable by authorities, incurring penalties and fines, or agreeing to settlements, though 3M did not admit liability. Court documentation and extensive media reporting ensured that the key events in these stories are well-documented. However, policy and legal risk is not always this apparent.

The cases of AAK, Chevron, Formosa and Freeport-McMoRan each saw the protagonist's impacts on nature translate into share price falls or hurdles for major strategic projects, such as multi-billion-dollar factories or expansion into new territories. JBS, the world's largest meat producer, saw its impacts on nature lead to efforts to block its listing in the US, potentially costing billions of dollars in enterprise value that it expected to unlock. Bernard Matthews and Tesla bore losses in brand value and a decline in share price, respectively, as a result of their dependencies on nature and the manifestation of acute physical risk. In each of these cases, the impact of the firm's operations also played a role, reflecting the difficulties of entirely separating dependency from impact. PG&E, a California power utility, was impacted by a combination of acute physical risk, legal and reputational risk.

The cases are also geographically diverse. The profiled companies are headquartered in six countries across four continents. Their impacts and dependencies materialize as risk in the same number of continents – though often not the companies' domicile. This demonstrates that nature risk is not constrained by national boundaries. Rather, location-specific risk can transcend jurisdictions, and strategies designed for one market may not be appropriate for another.

Figure 5: Company's origins do not necessarily align with the location of risk



Source: BloombergNEF

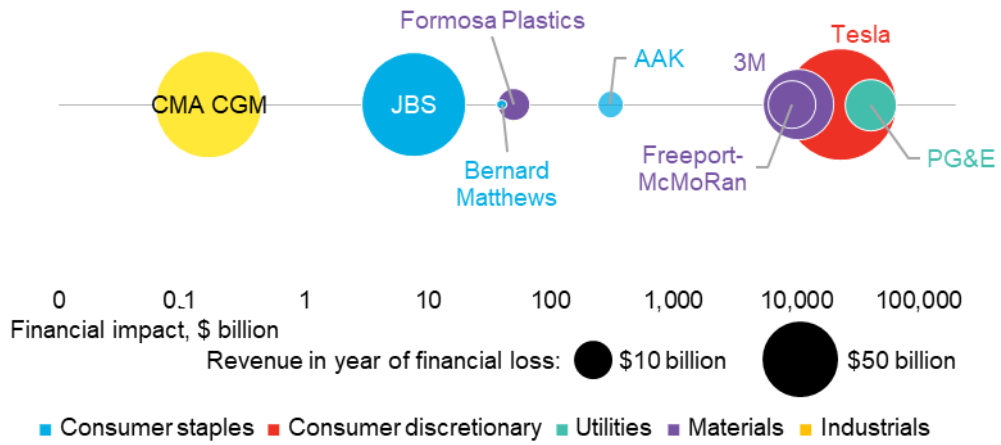
The cases exhibit both commonalities and differences in the type of natural impact or dependency. Eight of the 10 case studies detail instances of companies incurring loss from transition risk. Half relate to water, although in different ways. Formosa, 3M and Freeport each

released some form of chemical contaminant into watercourses proximate to their facilities, while untreated ballast water unloaded by CMA CGM vessels could have potentially released invasive species to vulnerable marine ecosystems. Tesla's vast water requirements challenge the planned expansion of its European "gigafactory", while simultaneously contributing to local water stress, according to local environmental groups. Three cases – JBS, AAK and Freeport – featured deforestation as an impact that led to financial repercussions for the firm. The remainder relate to disease transmission and biosecurity (Bernard Matthews), wildfires (PG&E) and endangered species (Chevron).

The predominance of water is no surprise. Surface and groundwater are two of the most salient natural assets that companies rely on or impact through their operations. Likewise, deforestation features prominently throughout nature-risk mitigation efforts across various sectors of the economy. Despite each case being location-specific, their findings can be applied across sectors and geographies.

The size of financial impact incurred in each case likewise shows significant variation, highlighting how risk can manifest relatively trivially, such as through CMA CGM's six-figure fines and public rebuke from the US Environmental Protection Agency, to the more substantive $10 billion settlement agreed by 3M for its dumping of toxic chemicals into local water systems. Several of the cases saw risk manifest through share price declines, ranging from 3% intraday for Tesla, to 91% over 16 months for PG&E. Figure 6 shows the magnitude of the financial impact and each firm's revenue in the year that nature risk materialized.

Figure 6: Magnitude of financial impact and company revenue in year of loss



Source: BloombergNEF. Note: Logarithmic x-axis.

There appears little evidence of correlation between the sector and type of nature-related risk faced. This is due to the wide range of interactions that global firms have with the natural world. Shifting regulation can bring exposure to any firm, as every form of economic value generation is to some extent dependent on nature. This highlights the need for both vigilance in overseeing the firm's operations and in the design of its strategy. Companies that have operated without regard for environmental regulations may find those freedoms swiftly curtailed, while unexpected technological shifts, resource scarcity, or shifting climate can induce physical and transition risk.

The role of reporting and disclosure in managing nature risk

The case studies together highlight the importance of managing nature-related dependencies, impacts, risks and opportunities (DIROs) to minimize financial impact on the company. The first step in doing so is building awareness of the organization's interface with nature. The recommendations of the TNFD, released in September 2023, enable companies to better identify, assess and disclose DIROs. Consisting of a four-pillar approach to disclosure first recommended by the Taskforce on Climate-related Financial Disclosures (TCFD) and now incorporated into the global baseline sustainability standards of the International Sustainability Standards Board (ISSB) and the European Union's sustainability reporting regulation (CSRD), the recommendations require companies to describe and report how they consider nature in terms of governance, strategy, risk and impact management, and metrics and targets.

Figure 7: Recommendations of the TNFD

Organizations are encouraged to describe and report how they consider nature-related dependencies, impacts, risks and opportunities along the following four pillars:

Governance	The organization's governance of DIROs

- Board oversight
- Management's role in assessing and managing DIROs
- Organization's human rights policies and engagement activities, with respect to indigenous peoples and local communities

Strategy	Effects of DIROs on business model, strategy and financial planning

- Short-, medium- and long-term DIROs that the organization has identified
- Effect of these DIROs on strategy and business model
- Resilience of the organization to different scenarios
- Identify priority locations in operations or value chain

Risk and impact management	Processes used to identify, assess, prioritize and monitor DIROs

- Process for identifying and assessing DIROs in its direct operations
- Process for identifying and assessing DIROs in value chain
- Process for managing these DIROs
- Processes for identifying, assessing, prioritizing and monitoring are integrated into risk management

Metrics and targets	Metrics and targets used to assess and manage material DIROs

- Metrics used to assess and manage risks and opportunities to the organization
- Metrics used to assess and manage dependencies and impacts on nature
- Targets and goals used to manage DIROs and organization's performance against them

Source: BloombergNEF, TNFD. Note: DIROs are nature-related dependencies, impacts, risks and opportunities.

Beyond the recommended disclosures, the TNFD has also published additional guidance to help organizations identify and assess their nature-related DIROs. This assessment methodology is called the LEAP approach – locate, evaluate, assess and prepare – and has been aligned to help organizations assess and identify their impact materiality aligned with the EU's CSRD requirements, as well as their financial materiality aligned to the IFRS ISSB requirements. Specific guidance for financial institutions encourages firms to examine portfolio risk exposure. While the TNFD is a market-led voluntary initiative, its work will inform future nature-related regulation and bring together various other standard setters, metrics and targets providers, and governments.

Further details on the TNFD, including its recommended disclosures and LEAP assessment approach and other guidance can be found here: www.tnfd.global Bloomberg clients can access further research on nature reporting here: web | terminal.

3M Incurs $10.5 Billion Liability for Polluting Waterways with 'Forever Chemicals'

3M's liability in the US for damages caused by "forever chemicals" serves as a prime example of the financial risk facing a company improperly managing its impacts on nature. The multinational conglomerate, while not admitting liability, reached a tentative $10.5 billion settlement with US municipal water authorities in June 2023 to resolve water pollution claims resulting from its introduction of harmful substances, also known as PFAS, into watercourses to the detriment of human and environmental health. Liability for remediations and other solutions could total $25 billion.

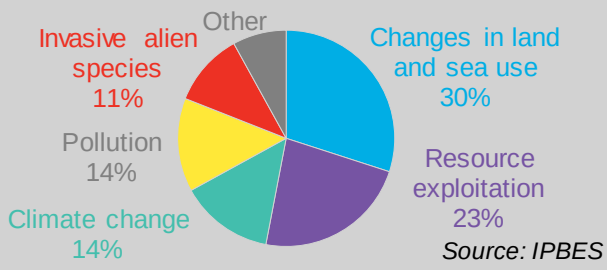
53% Share of gross value added in the direct operations of chemical companies that is moderately or highly dependent on nature

66% Decline in 3M's share price from high in January 2018 to October 2023, in part due to liability concerns

$10.5 billion Settlement by 3M to resolve claims of water pollution, possibly rising to $12.5 billion

Drivers of nature loss

Five drivers account for over 90% of nature's decline relative to pre-industrial levels:



Source: IPBES

Companies with exposure to these drivers have higher nature-related transition risks, as they are the most vulnerable to shifting regulation and customer preferences.

Manifestation of nature risk

3M Co. (NYSE: MMM) is a US-headquartered diversified technology company operating across 70 countries that derives 40% of its revenue from specialty chemicals. These include PFAS, a group of synthetic chemicals used to make coatings and items that resist heat, water and oils, and feature in a myriad products from adhesives to cookware and firefighting foams. Dubbed "forever chemicals" as they do not easily break down, PFAS manufactured by 3M and its peers have contaminated the natural environment, particularly soils and groundwater, since the 1950s.

The EPA describes these per- and polyfluoroalkyl substances as persistent, bio-accumulative and toxic, with pollutants linked to environmental damage and negative human health impacts, such as cancer and infertility. Chemical waste has been found in high concentrations around multiple 3M facilities in the US, including its 1,750-acre factory in Minnesota, where the state claims there is a 100-square-mile underground plume of leaked PFAS.

3M's Minnesota headquarters

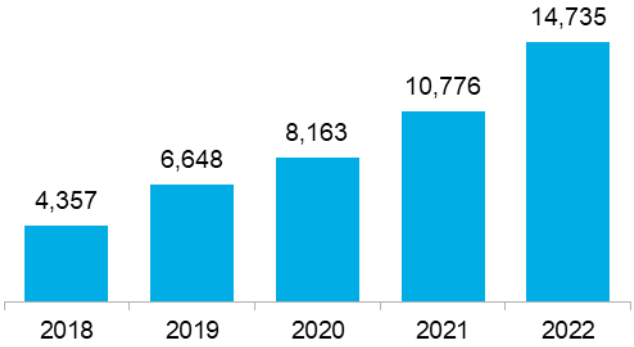
Source: Bloomberg

According to retired 3M toxicologist John Butenhoff, in a pre-trial video deposition taken in 2023, 3M is more than likely the source of PFAS contamination around the globe, including in air, water, soil, humans, and various animals. The Minnesota plant is the largest point source of this pollution, though the company operates 70 chemical facilities throughout the US, according to Bloomberg asset mapping data. The US Environmental Protection Agency (EPA) has called PFAS an "urgent public health and environmental issue". The company admits no wrongdoing and says the chemicals pose no significant threat to public health and welfare, according to Bloomberg News.

In addition to environmental damage in the US, the emission of PFAS into ambient air surrounding production facilities led Belgian authorities to repeatedly halt 3M's operations in the country through 2021 to 2023, asserting that the airborne particles eventually enter groundwater, negatively impacting ecosystem health.

Managing nature risk

Cumulative number of PFAS chemicals listed with the US EPA



Source: US Environmental Protection Agency, BloombergNEF.

Recognizing the harmful environmental impacts of PFAS, the EPA formulated an action plan to tackle the crisis, creating new rules to enhance measurement, reporting and enforcement. In March 2021, the agency announced it would more stringently regulate the two most harmful PFAS chemicals in watercourses – called PFOA and PFOS – with Congress later introducing dozens of bills to monitor the scope of contamination, ban non-essential uses of the substances, address ongoing contamination, and clean up legacy pollution. After intensive lobbying from the chemicals industry, only three of the 50 bills have passed the Senate.

Three categories of PFAS chemicals

Category	Definition	PFAS example
Non-essential	Uses that are not essential for health and safety	Consumer textiles, cosmetics, ski waxes
Substitutable	Regarded essential, but alternatives have been developed	Firefighting foams, floor coverings
Essential	Uses considered essential because they are necessary for health or safety	Medical devices, protective clothing

Source: Global PFAS Science Panel, BloombergNEF.

Despite some categories of the chemicals being deemed essential, 3M has pledged to exit PFAS manufacturing by the end of 2025, acknowledging in a press release the shifting regulatory landscape and changing stakeholder expectations.

Financial and reputational impacts on 3M

In June 2023, 3M settled lawsuits brought by US water authorities in 2018 for an estimated $10.5 billion to $12.5 billion, to be paid to various municipalities over 13 years. According to Bloomberg Intelligence, 3M's liability risk could total $25 billion, the lion's share of which will contribute to the restoration of natural resources and water treatment.

The US Chamber of Commerce estimates that a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) designation – which provides a federal "Superfund" to clean up uncontrolled environmental pollution – could create costs of $17 billion for non-water authority sites for 3M. This supports the prediction that $10 billion is unlikely to be the final remediation tally. As part of the claim, the state of Minnesota settled its lawsuit against 3M for

$850 million for damaging natural and ecological resources, and contaminating drinking water.

Prior to US authorities bringing the claim for damages, 3M shares had peaked at $258 in January 2018, before dropping to $178 later that year, though it is difficult to separate demand-side impacts from the fallout of the settlement. However, the company's shares fell further as more lawsuits emerged and, at the time of writing, were priced at around $88 – a 66% decline from five years ago. 3M later accepted a change in the 2023 settlement that removed an indemnity clause following pushback from attorneys general from 22 states, who urged the trial's judge to reject the deal for its perceived leniency.

Even with annual revenue surpassing $30 billion and a market capitalization of $57 billion in 2023, 3M is cutting costs, faced with multi-billion dollar settlements, against a background of macroeconomic headwinds stymying demand and a concurrent mass tort litigation over its manufacture of allegedly defective earplugs. Since January 2023, the firm has announced a 10% cut to its workforce and plans to spin off its healthcare business by 2024. Buyside analysts on Wall Street note that 3M's generous 6.1% dividend is also at risk.

In addition to financial losses, 3M incurred reputational damage. According to Minnesota's attorney general, despite possessing knowledge about the harmful impacts of PFAS, the company kept this information from regulators, local residents, and its client DuPont. The attorney general released a trove of documents online to back up the allegations, though a 3M spokesperson later called them misleading.

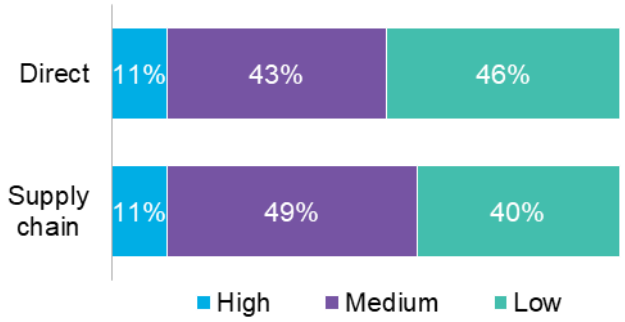
As local communities became aware of the environmental impacts, those surrounding the Minnesota facility switched to bottled water, while others threw away products containing PFAS, such as Scotchgard stain and water repellants, and Teflon pans.

3M remains exposed to risks from ongoing environmental damage, as it continues to manufacture various types of PFAS until 2025. Even if it does halt production, 3M will be hard pushed to escape further PFAS liabilities, as the chemical does not degrade and has complex interactions with the environment that are still being uncovered. In 2022, the EPA warned that forever chemicals could be dangerous even at undetectable levels. As a result, 3M will continue to face thousands of lawsuits over PFAS contamination, with over 4,000 lawsuits filed between January 2020 and October 2023 that mention 3M as a defendant.

Nature risk across chemical industry

The chemical sector's production operations expose companies to significant natural risks. These range from physical (for example, loss of natural inputs as ingredients in the manufacturing process) to transition (such as the tightening of environmental protection laws) and systemic (macroeconomic changes shifting consumer demand).

Nature dependency of gross value added across chemical companies' direct operations and supply chain



Source: World Economic Forum, BloombergNEF. Note: 3M is categorized as a chemical company in the report as it obtains over 40% of its revenue from the manufacture of specialty chemicals.

While all of the direct and supply chain value generation of chemical companies is to some extent dependent on nature, only 11% is classified as highly dependent, with over one-third being moderately reliant, according to the World Economic Forum. The ENCORE materiality matrix offers detail specific to specialty chemical companies such as 3M, identifying 10 ecosystem services that production processes

depend on, though only two of these are given a high materiality rating.[5]

The nature *impacts* of the sector are much larger. For seven out of 11 impact drivers, which assess the impacts of production processes on ecosystem services and natural capital, chemical companies' operations are deemed highly material, covering water, greenhouse emissions, pollutants and waste.

The interactions that chemical companies have with nature mean that the case of 3M is not an exception. Even as awareness of the environmental effects of PFAS has increased, many companies continue to manufacture the harmful substances at scale.

In early June 2023, days before 3M's $10.5 billion settlement, DuPont, Chemours Co. and Corteva Inc. together agreed to pay $1.185 billion to resolve hundreds of municipal water pollution claims. Under a cost-sharing agreement, Chemours will cover approximately half of the settlement, DuPont one-third, and Corteva the remainder. Total costs for these PFAS-related liabilities are estimated at $3 billion to $5.5 billion.

Bayer, which acquired Monsanto in 2018, provides another example of legal risk manifesting through poor management of nature impacts. The company reached a $650 million settlement with the state of Oregon to resolve claims over environmental damage resulting from its PCBs production.[6]

In May 2023, fire protection company Kidde-Fenwal filed for Chapter 11 bankruptcy protection in a New York court, unable to bear the weight of lawsuits alleging that its firefighting foam products contaminated water sources around US airports and military bases, claiming that its total liability was highly likely to "substantially exceed" its ability to pay.

Similar risks and opportunities for chemical companies

Company	Risk type	Description
Bayer AG	Legal and reputational	Bayer finalized a $698 million settlement with the US state of Oregon to resolve claims over PCBs' environmental pollution. The company did not admit liability.
DuPont, Chemours, Corteva	Legal and reputational	Total costs for PFAS-related liabilities for DuPont, Chemours and Corteva estimated at $3.5 billion to $5.5 billion. Currently $110 million has been settled.
Kidde-Fenwal Inc	Legal	A subsidiary of Carrier Global Corp, it filed for bankruptcy after lawsuits alleged that forever chemicals in its firefighting foam products contaminated water sources around US airports and military bases.

Source: BloombergNEF

Pollution of watercourses and farmland will continue, and with it the associated legal and reputational risks for companies. As of August 2023, some 3,186 sites across locations in all 50 US states are known to be contaminated with PFAS, according to a report by the Environmental Working Group, a non-profit organization. Regulation is shifting rapidly – chemical companies that learn from the 70-year history of PFAS will be better placed to mitigate the risks resulting from their own impacts and dependencies on nature.

More from BNEF:

Corporate Net-Zero Assessment Tool (web | terminal)

Technology Radar: Advanced Conductors (web | terminal)

What Policy Levers Get the World to 1.5C and Net Zero? (web | terminal)

[5] ENCORE is an ongoing collaboration between Global Canopy and UNEP to help companies understand potential nature-related risk exposure through sector-level generalizations. It collates information on the production processes of 177 sub-sectors, enabling sector- and industry-level comparison. More detail can be found on the tool's methodology page.

[6] PCBs, or polychlorinated biphenyls, are classed as persistent organic pollutants. Their history – innovative chemicals with a myriad of applications across many sectors, followed by growing awareness of environmental harm and a subsequent production ban – appears to be a precursor to the story of PFAS.

Deforestation Allegations Trigger Share Selloff of Swedish Oils and Fats Firm AAK

Swedish specialty oils and fats manufacturer AAK AB is highly exposed to nature-related risk through the import and use of plant-based oils in many of its products. Despite its claims to source palm fruit only from sustainable sources, in June 2023, a news report emerged alleging that the company knowingly engaged with mills supplied by Indonesian palm plantations that had been illegally cleared.

AAK experienced a 5% decline in its share price the day after the news broke, reflecting investor concern over the credibility of sustainable palm oil initiatives in the industry.

100% Share of gross value added by the food and beverage sector that is moderately or highly dependent on nature

5.5% Decline in AAK's share price across June 13-14, 2023, following the publication of an article alleging exposure to illegal palm oil

23% Potential downside for AAK shares in the month following the news, according to buy-side analysts

Materiality of nature impacts and dependencies

'Materiality' refers to the influence some factor, event or information has on a company's valuation, the omission of which in a financial statement could mislead investors or other stakeholders.

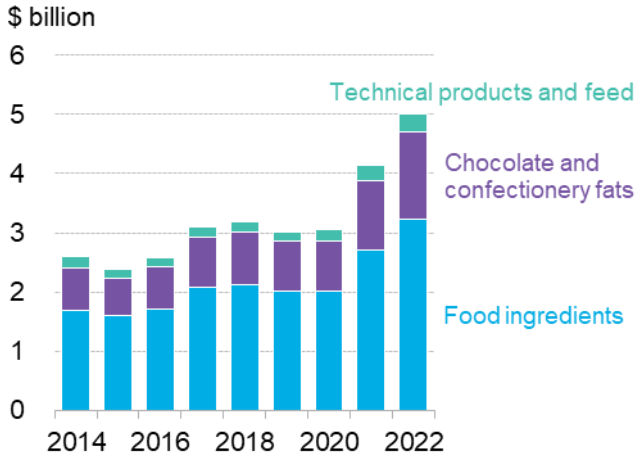
'Single materiality' is conventionally used in accounting. For nature, it captures only how a firm's valuation can be affected by changes in the ecosystem services that production depends on.

'Double materiality' also considers the impacts of the firm on nature, capturing how production processes change the state of nature.

Manifestation of nature risk

Founded in 2005 as the result of a merger and later becoming the eighth-largest palm oil company globally, AAK (STO: AAK) and its antecedents have more than 150 years of experience processing and manufacturing plant-based oils. The company now sells chocolate and confectionary fats, food ingredients, feed and other products globally. It imports raw shea, soybean and palm oils from Southeast Asia and West Africa, refining them at facilities around the world and exporting to food manufacturers globally. Its revenue and market cap are each around $5 billion.

AAK's revenue is derived from three product groups linked to food and agriculture



Source: BloombergNEF, Bloomberg Terminal. Note: Technical products include fatty acids and glycerine.

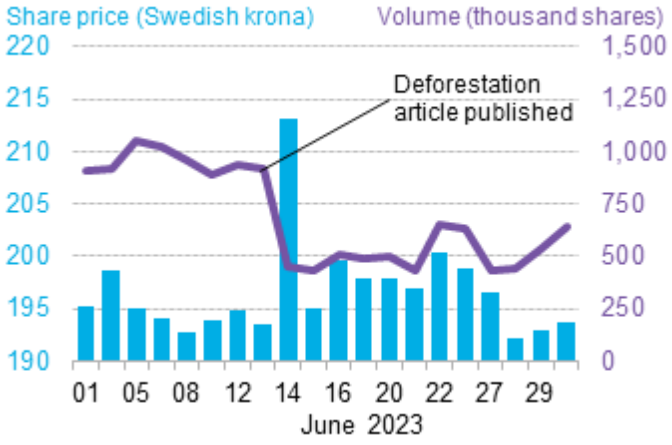
Indonesia's rainforests are among the most biodiverse areas on the planet, home to 10% of the world's mammal species, including orangutans, tigers and rhinos, and identified by BNEF as a priority region for biodiversity finance. The World Resources Institute places palm oil second on a list of commodities that

drive deforestation, behind beef. AAK has striven to build a sustainable palm sourcing practice, co-founding a voluntary industry standards initiative in 2003 and implementing a suite of initiatives to improve traceability and transparency.

Against this backdrop, on June 12, 2023, Swedish newspaper *Sveriges Natur* published the results of its investigation into 20 mills that extract oil from illegally grown palm fruit in Tesso Nilo, a national park in Sumatra, Indonesia, in which land clearance and deforestation are explicitly prohibited. Citing plantation owners and local workers, it reported that AAK knowingly purchased from all 20 mills. The investigation followed a similar story by another Swedish newspaper three years earlier.

Oil sourced from palm fruit illegally grown within the protected Tesso Nilo is extracted by nearby mills, mixed with oil from legitimate palm plantations, and sold into a complex global supply chain, making it difficult for downstream manufacturers and retailers to trace its origin.

The allegations triggered a selloff of AAK's shares, with five times usual trading volumes and a 5.5% price decline over June 13-14, 2023



Source: BloombergNEF, Bloomberg Terminal. Note: X-axis spacing due to trading data.

Financial and reputational impact on AAK

For a sustainability-focused oils and fats company, the palm oil supply chain brings inextricable reputational risks. News of practices seemingly in violation of its zero-deforestation ambitions spooked equity investors, sending daily trading volumes to over five times their usual average and precipitating a 5.5% fall in the company's share price over June 13-14, 2023.

The article, which received media coverage outside of Sweden, quickly attracted attention from buy-side research analysts, who estimated a potential 23% downside to the company's share price for the month. AAK published a press release in response to the allegations, emphasizing the importance of palm oil and the company's commitment to its sustainable sourcing policy, though not directly addressing the situation in Tesso Nilo or admitting wrongdoing.

AAK's share price took four months to recover, returning to its early-June level in the second week of October, when third-quarter results showed operating profit exceeded analysts' estimates. This suggests that there has not been a long-lasting reputational impact for the company. Nor have there been significant changes in management. Swedish asset managers saw the need to react to the news investigation, affirming their backing of AAK, while noting that they were continuing to monitor the situation.

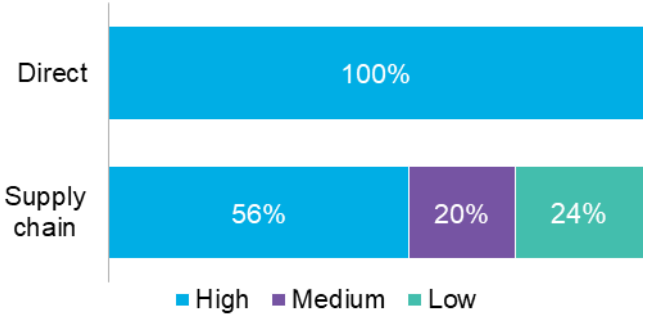
Despite the short-lived impact, the incident heightens AAK's future risk exposure, as the increasing prevalence of deforestation and sustainable soft commodities in the climate dialogue is fueled by growing global demand for palm oil. In this context, a repeat of June's allegations and a failure to establish fully traceable and deforestation-free palm oil sourcing by its 2025 target may have lasting financial and reputational impacts, while also exposing its investors to similar risks.

Nature risk across the food and beverage sector

The food and beverage sector is highly exposed to nature risk. The World Economic Forum estimates that 100% of the industry's direct economic value generation is moderately or highly dependent on nature, as is 76% of the value generated by the food

and beverage supply chain. This risk manifests in a myriad of ways: physical dependencies on ecosystem services such as pollination are foremost, though transition risk is already emerging as policy and investor expectations begin to shift; systemic risk is likewise becoming more material as the possibility of large-scale ecosystem collapse increases.

Nature dependency of gross value added across the food and beverage sector's direct operations and supply chain



Source: World Economic Forum, BloombergNEF. Note: AAK is classed as a food and beverages company as it derives most of its revenue from such products.

The sector also has considerable impacts on nature. According to the ENCORE nature tool's impact drivers, which assess the impacts of production processes on ecosystem services and natural capital, the sector has a high materiality rating for water use and greenhouse gas emissions, among others. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) notes that changes in land and sea use, 80% of which are caused by agriculture, are together the biggest drivers of nature and biodiversity loss. The next-largest driver is resource exploitation, with agriculture again being the industry most responsible.

Due to the scale of nature impacts and dependencies across the sector, examples of nature-related risks are plentiful. The newspaper investigation that alleged AAK's connection to mills processing palm oil also cited Mondelez International, Unilever and Colgate-Palmolive, alleging that they all source palm oil in a similar manner to AAK. Three further examples relating to deforestation are presented below.

Similar risks and opportunities for adjacent firms

Company	Risk type	Description
Cadbury	Reputational and market	Cadbury New Zealand and Cadbury Australia were forced into an about-turn on their decision to substitute palm oil for cocoa butter in pursuit of cost savings, after consumer outcry in 2009.
PT Kallista Alam	Legal and reputational	In 2014, the Indonesian palm oil company was ordered to pay $30 million in fines and reparations for its illegal clearance and burning of protected forest, a violation of a newly enacted moratorium on plantation concessions.
BNP Paribas	Legal and reputational	The bank was sued in February 2023 by a Brazilian non-governmental organization, which claimed the bank did not conduct sufficient due diligence on the companies to which it provides financial services, despite BNP Paribas' commitment to cease financing activities associated with deforestation.

Source: BloombergNEF

Regulatory shifts present a new frontier of transition risk for companies operating in the food and beverage sector. The most prominent example of this is the EU Deforestation Regulation, which is causing firms that trade food products within the bloc to consider their exposure to deforestation.

EU Deforestation Regulation

The EU Deforestation Regulation on Deforestation-free Products, also known as the EUDR, came into force on June 29, 2023, and requires companies trading in seven at-risk soft commodities to conduct extensive due diligence in their supply chains. This is to ensure that their production does not result from recent deforestation, forest degradation or other breaches of environmental laws. The seven commodities are beef, cocoa, coffee, palm oil, rubber, soya and wood. From

December 30, 2024, it will be illegal to trade these products in the EU market or to export them from the EU if they are tied to deforestation, punishable by fines proportionate to the environmental damage caused, though limited to 4% of the firm's EU turnover. For more, see: *Supply Chains Will Be Challenged By EU Deforestation Rules* (web | terminal)

Managing nature risks in the food and beverage sector

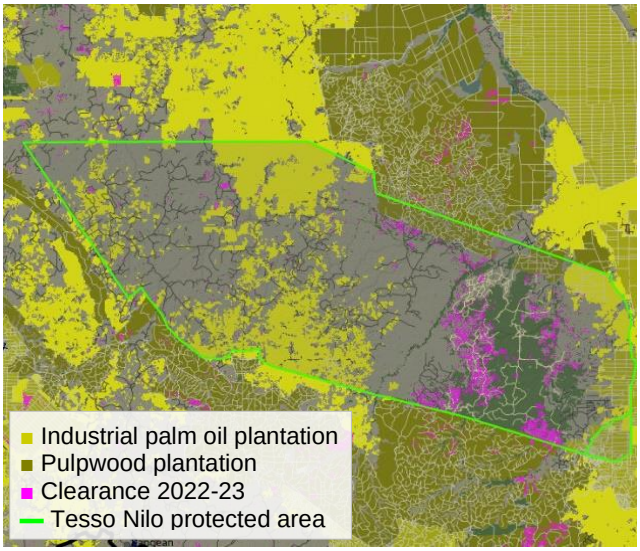
AAK is well placed to mitigate similar risks in the future as an early pioneer of deforestation-related commitments – a point that its management appears to appreciate, touting zero-deforestation and full-traceability pledges for palm oil by 2025. Its biggest challenge is ensuring that these commitments translate into timely execution. It is making significant progress: in 2022, some 71% of its palm supply was verified to be deforestation-free and 87% was traceable to plantation, representing respective gains of 4% and 7% from the previous year. Its 3Q 2023 earnings report saw these figures reach 77% and 91% respectively, although that still leaves a substantial portion from indeterminate origins.

Other companies in the sector can learn from the progress of AAK. Its internal and external verification of palm sourcing, including the use of technology, and membership of industry groupings such as the Roundtable on Sustainable Palm Oil (RSPO), provide examples of good practice. Making zero-deforestation pledges remains an important first step for firms concerned about their palm sourcing, though as of October 2023, only 26 out of the 319 packaged food companies tracked by Bloomberg have done so. As global policies tighten, the risk of financial impacts on firms exposed to deforestation increases.

To minimize the financial costs stemming from impacts and dependencies on nature, firms whose supply chains are exposed to deforestation should actively target full traceability to legal plantations. This will help them avoid market and legal risk from changing investor preferences and regulatory pressure.

Understanding nature-related impacts and dependencies can be enhanced by using the existing reporting and disclosure architecture and its supporting suite of relevant metrics and targets. These commitments are not enough, however, as demonstrated by the ongoing destruction of the Tesso Nilo rainforests over the past two years.

Tesso Nilo continues to experience deforestation despite its protected area status



Source: BloombergNEF, Nusantara Atlas.

Financial institutions also have an opportunity to minimize exposure to potential risks from the sector. Understanding how recipients of their debt and equity finance interface with nature, then implementing and enforcing tighter restrictions, will better insulate them against the market and reputational risks that impacted companies such as AAK in recent months.

More from BNEF:

Supply Chains Will Be Challenged by EU Deforestation Rules (web | terminal)

Biodiversity Finance Factbook: COP28 Edition (web | terminal)

Sustainable Agriculture: 10 Things to Watch in 2023 (web | terminal)

Bernard Matthews' Balance Sheet and Reputation Struck by Bird Flu

Animal production and processing operate at the intersection of the natural and anthropogenic worlds. This brings heightened and persistent nature risks, as evidenced by the financial and reputational losses incurred by UK poultry producer Bernard Matthews due to an avian influenza outbreak in 2007. Vulnerabilities in the company's biosecurity enabled the virus to enter its UK facilities from abroad, resulting in the mass culling of turkeys. A substantial decline in sales and subsequent brand damage demonstrate the importance of managing meat producer and processers' impacts and dependencies on nature.

100% Share of gross value added in the direct operations of the food and agriculture sector that is moderately or highly dependent on nature

£20 million Estimated decline in the brand value of companies owned by Bernard Matthews

165 Number of employees laid off by the company in the four weeks following the outbreak

Physical risk

Nature dependency exists when the operations of an organization rely on the presence of an ecosystem service to function. These dependencies can present a physical risk to business operations, manifesting through degradation of nature and the resulting loss of ecosystem services.

Acute risks are short-term events that change the state of nature and are typically location specific.

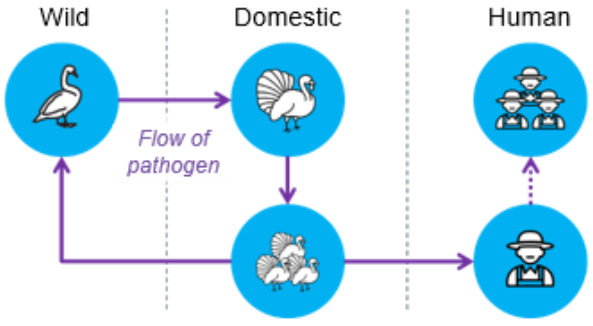
Chronic risks are long-term, incremental changes to the state of nature, with consequences that are not anticipated to recede or revert to their prior condition.

Manifestation of nature risk

Bernard Matthews Foods is a privately held, UK-based farming and food company. The vertically integrated producer and processer specializes in turkey products, which account for 90% of its sales.

On January 30, 2007, an outbreak of the H5N1 subtype of the Influenza A virus was detected at a Bernard Matthews-owned farm in Suffolk. This avian influenza – or bird flu – likely originated in partially processed poultry meat imported from Bernard Matthews' Hungarian subsidiary Saga Foods, according to the UK government's Department for Environment, Food and Rural Affairs (Defra). A third-party abattoir in Hungary used by Saga Foods and other meat companies was also suggested as a candidate for disease transmission. The company denied these allegations at the time. Regardless of its precise origin, a strain of H5N1 99.96% genetically similar to that in Hungary reached Bernard Matthews' UK facility.

Transmission pathway of H5N1



Source: BloombergNEF. Note: H5N1 is an avian disease. Evidence of human-to-human transmission is limited.

Government investigations were unable to unequivocally confirm the path of avian influenza,

though familiarity with previous outbreaks of the virus suggests that the strain originated in Hungarian wild birds, whose flocks acted as a disease reservoir. Transmission to poultry stocks then occurred through direct contact with an infected wild bird, its droppings or a contaminated water source. From a single infected farm animal, the pathogens spread quickly to others in the flock, accelerated by the high density of poultry in Saga's farming facilities.

Having entered the processing system, the virus would likely have been able to reach Bernard Matthews' UK facility through its trade in partially processed animals. The Observer reported back in 2007 that the virus' entry may have been associated with a 38-metric-ton shipment of chicken breasts received in the days before the first turkeys exhibited symptoms. Farm workers claimed that scraps produced in meat processing were not hygienically disposed of and were left uncovered in bins open to rats and wild gulls. These scavengers could have provided a vector for the virus to then move into adjacent turkey sheds.

Early tests suggested that avian influenza was responsible for the deaths of 2,600 turkeys. On February 3, following official identification of the highly pathogenic variant, the government imposed a three-kilometer exclusion zone and 10-kilometer monitoring zone around the farm to constrain movement of poultry and wildfowl, and began a cull of all birds on site the same day. Veterinarians dispatched a total of 159,000 turkeys in a slaughterhouse adjacent to the premises.

Financial and reputational impacts on Bernard Matthews

Consumer perception of Bernard Matthews nosedived in the aftermath of the outbreak. A YouGov BrandIndex survey conducted shortly after the cull deemed Bernard Matthews Britain's least trusted company, ranking last among 1,150 businesses. Another annual assessment of top UK grocery brands saw it fall 38 places, to 98 out of 100. Factors beyond the influenza outbreak, including alleged animal rights violations in 2006 and negative media coverage of its processed food in 2005, also contributed to this perception.

Sales declined sharply. The company posted losses of £77 million ($159 million in 2007 nominal terms) in the 2007-08 financial year and was forced to begin laying off workers – 165 by February 27. Impacts on the privately held firm's valuation were not readily available, though a consultants' report estimated a £20 million fall in the company's brand value at the time.

The once iconic brand was unable to recover its reputation after 2007, despite engaging turnaround specialist Rutland, a private equity house, which injected £25 million ($40.7 million) into the business in 2013, the first outside investment in the firm's 60-year history. Further cash injections did little to stem the financial losses.

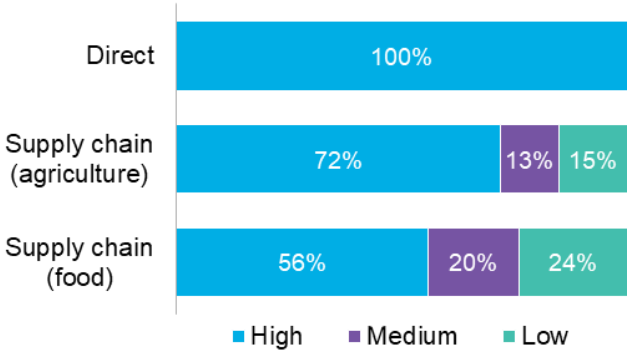
In July 2016, Bernard Matthews agreed to sell its German operations to pork and poultry producer Sprehe Gruppe, with the proceeds used to reduce group debt. Two months later, the remainder of the company was acquired by the Boparan Private office in a pre-pack administration deal, strengthening the private investment vehicle's position in the UK poultry market.

Nature risk across the food and agriculture industry

Food and agriculture companies derive revenue by extracting value from biotic resources, be it through crops, livestock or processing further downstream. Through this direct interface with the natural world, it is the industry most exposed to nature-related risks. These risks can be physical (such as damage to farmer assets from increased incidence of wildfires), transition (the introduction of more stringent environmental regulation), or systemic (global ecosystem collapse, for example).

Food and agriculture are among the most nature-dependent industries, according to the World Economic Forum. The entirety of the gross value added in the direct operations of both the food and agriculture industries is highly dependent on nature, while 83% of value added in the supply chain is moderately or highly dependent.

Nature dependency of gross value added in direct operations and supply chain of food and agriculture



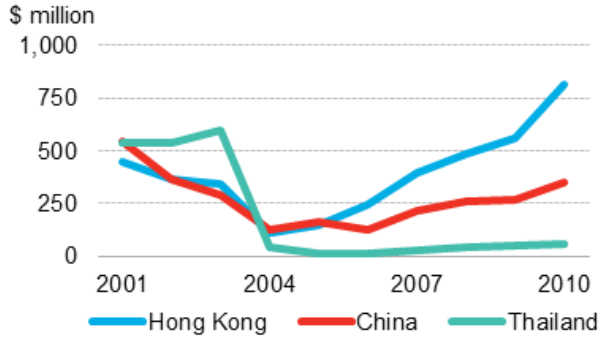
Source: World Economic Forum, BloombergNEF. Note: Food includes beverages and tobacco.

The ENCORE nature materiality matrix likewise emphasizes the depth and breadth of the sector's reliance on nature. It identifies 19 areas on which livestock production depends, covering almost all aspects of nature. The sector also *impacts* the natural world, with operations deemed highly material to water and terrestrial ecosystem use, greenhouse gas emissions and water and soil pollutants.

For poultry producers, avian influenza continues to be a particularly potent source of risk, with repeated outbreaks in recent decades attributed to the H5N1 variant. Before the 1990s, highly pathogenic strains caused mortality in poultry but were sporadic and well contained. In more recent times, increased animal density and larger trade volumes have enabled the virus to spread more quickly, making detection and containment more challenging.

Consumers are highly sensitive to reports of outbreaks. The World Organisation for Animal Health (WOAH) notes that avian influenza engenders devastating consequences for the poultry industry, impacting farmers' livelihoods and international trade. Following the 2003-04 H5N1 crisis in East Asia, exports from three major poultry producing economies – China, Hong Kong and Thailand – fell to almost zero.

Decline of chicken meat exports in selected Asian economies following the 2003 H5N1 outbreak

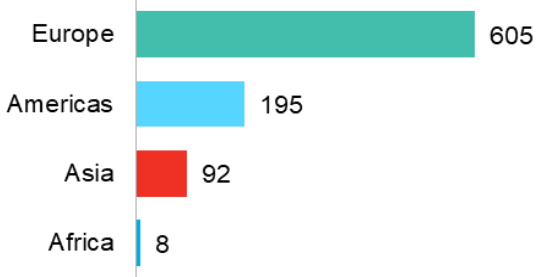


Source: BloombergNEF, FAOSTAT.

A 2014-15 outbreak in the US was one of the largest in history, with significant financial impacts on poultry and egg producers. A total of 51 million birds were culled to limit the spread of the disease, costing the sector $3 billion with a further $879 million in public expenditures.

Since 2020, the incidence of avian influenza has become more frequent. Major cases across Europe, the US and Africa have all required large-scale culling of flocks, leading to supply chain issues and subsequent spikes in the prices of meat, eggs and products using them as ingredients. A September 2023 analysis by FAIRR estimated that the most recent outbreak in the US resulted in animal losses of 40 million and an overall economic cost of $2.5 billion to $3 billion.

Number of new avian influenza outbreaks, September 2022 to May 2023



Source: BloombergNEF, World Organisation for Animal Health.

Other forms of disease likewise present a considerable source of risk to agriculture. Three of the most prominent outbreaks in recent decades are African swine fever (ASF), foot and mouth disease (FMD), and bovine tuberculosis (bTB), each attaining household name status. No single livestock species is immune to the risk of disease, and new diseases have the potential to emerge at any time. Human encroachment on nature and the intensification of agriculture have led to the increasing incidence of livestock disease.

Other diseases presenting nature risk to livestock

Disease	Description	Example impact
African swine fever (ASF)	Pig virus spread by ticks	A 2009 global ASF outbreak affected tourism activities. Research calculated the losses incurred by companies in the tourism sector in the UK to be close to £1 billion ($1.5 billion*).
Foot and mouth disease (FMD)	Viral cattle and sheep disease	The disease spread across the UK in 2001 and remained a threat for seven months, requiring mass culls and enforcement of containment zones. Later estimates placed the total financial impact on the private sector at £5 billion ($7.2 billion*).
Bovine tuber-culosis (bTB)	Bacterial cattle respiratory disease	Controlling bTB cost British farmers £50 million ($65 million*) in 2018. Losing bTB-free status had a median cost per farmer of £6,600.

*Source: BloombergNEF. Note: *Exchange rates presented in 2009, 2001 and 2018 nominal terms, respectively.*

Avian flu, FMD and bTB all exhibit zoonotic potential – the ability to jump from animal hosts to humans. Zoonotic diseases can cause loss of human life and cost to the wider economy. Many zoonotic disease outbreaks originated in the food and agriculture system. The WHO estimates the global economic cost of zoonotic disease Covid-19 to be between $8.1 trillion and $15.8 trillion. The bat-borne virus was transmitted to humans, likely following evolution in nature or an as yet unidentified second animal host.

Managing nature risk in the poultry industry

Best practices for managing risks in the livestock sector are well established. Several supranational groups and public health agencies, including the World Health Organization, World Bank, Centers for Disease Control and Prevention and WOAH have collaborated to compile disease control guidelines for poultry producers:

1. Effective vaccine implementation
2. Improved disease monitoring and surveillance measures
3. Stringent biosecurity procedures
4. Better zoning and compartmentalization
5. Stronger communication mechanisms between health authorities and industry

Proper implementation of these recommendations first requires companies to fully understand and disclose their interactions and touchpoints with nature.

FAIRR's Emerging Disease Risk Ranking, published in 2022 with updates in September 2023, benchmarks protein companies' exposure to disease risk. Results show that none of the 60 companies assessed attained best practice rankings, while 34 were deemed to operate at high risk. The report analyzed strategies across six risk indicators, including deforestation and biodiversity loss, antibiotics, waste and pollution, working conditions, food safety and animal welfare. It also finds that across the protein production industry, the poultry sector is the worst-performing on pollution and biosecurity. Monitoring and reporting these nature risks are key steps in limiting further outbreaks of disease and minimizing financial loss.

More from BNEF:

Climate-Tech Innovations: Building a Net-Zero Food System (web | terminal)

Meat Producers Contemplate an Alternative Future (web | terminal)

Alternative Proteins: Fake It Till You Make It (web | terminal)

Chevron's Gulf of Mexico Plans Caught in Legal Battle Over Protecting Rare Whale

Legal challenges to oil and gas development in the Gulf of Mexico demonstrate the increasing risks faced by the sector as nature losses mount. A lawsuit filed by environmental groups to protect a newly discovered, critically endangered species – the Rice's whale – delayed lease sales that are key to Chevron's growth plans in the region. While no financial penalties have been imposed on the supermajor and the lease sales are now set to proceed, the case highlights the nature-related uncertainties that could impact future expansion opportunities.

41% Share of gross value added in the oil and gas industry's direct operations that is moderately or highly dependent on nature

23 Number of environmental lawsuits involving Chevron and its subsidiaries in the past three years

300,000 Number of barrels of oil equivalent per day Chevron is targeting in the Gulf of Mexico, home to the critically endangered Rice's whale

Nature risk explained

Nature-related risks are the **physical**, **transition** and **systemic** threats posed to an organization as a result of its dependencies and impacts on the natural world. Each comprises specific risk types:

- Physical: Acute, chronic
- Transition: Policy, market, technology, reputational, legal
- Systemic: Ecosystem stability, financial stability

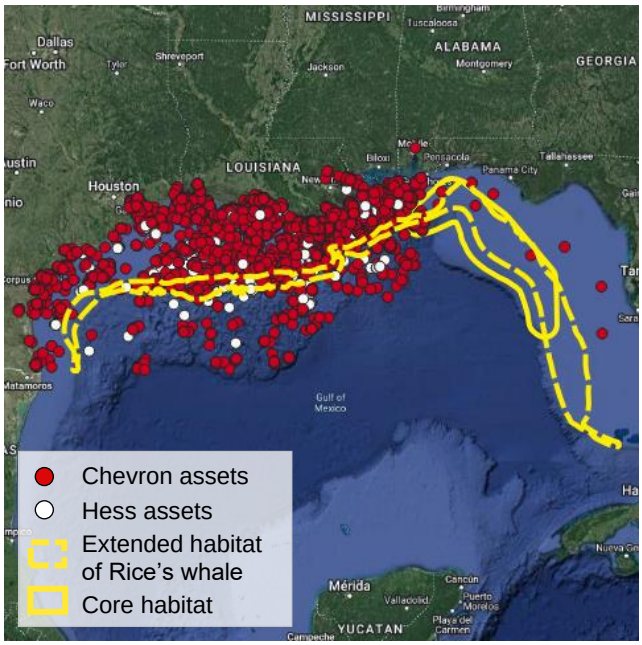
These dependencies and impacts are explored in depth in the accompanying report (web | terminal).

Manifestation of nature risk

Chevron Corporation (NYSE: CVX), a $270 billion oil and gas company, has global operations across many major oil producing regions. In October 2023, it announced the buyout of Hess, an independent energy company in an all-stock, $53 billion transaction, increasing its footprint in the Gulf of Mexico. Chevron plans to consolidate its operations in the region, having placed the highest number of bids in the most recent licensing round, at the end of 1Q 2023.

The Gulf of Mexico is also home to the Rice's whale, a critically endangered species that was only formally identified as having diverged from other baleen species through isolation in the Gulf in 2021.

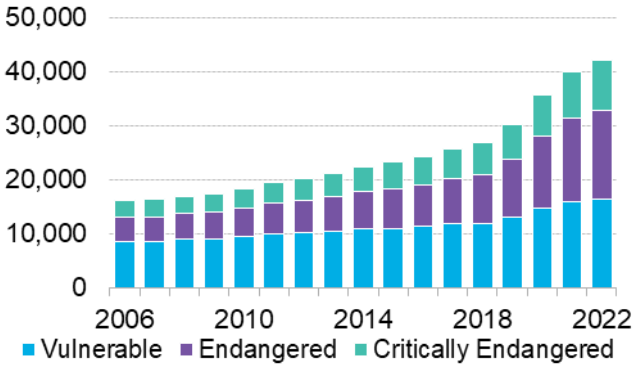
Proximity of Chevron and Hess' upstream assets to Rice's whale habitat areas in the Gulf of Mexico



Source: BloombergNEF, US Bureau of Energy Ocean Management.

The Rice's whale is one of a growing number of threatened species. As these species' numbers dwindle – and awareness of their threatened status grows – projects that interfere with them face increasing risk. By the end of 2022, over 42,000 species were listed as threatened, an IUCN category that covers critically endangered, endangered or vulnerable species.

Number of threatened species continues to grow



Source: International Union for the Conservation of Nature, BloombergNEF. Note: Threatened species include those that are critically endangered, endangered or vulnerable.

The Rice's whale is endemic to the Gulf of Mexico; only 51 individuals are believed to now exist. Oil and gas extraction has a major impact on Rice's whales, exemplified by a 20% decline in the population following the BP Deepwater Horizon spill. Effects of the spill itself on the species include reproductive failure and disease. Vessel collisions also negatively impact the marine mammals, as they rest at night in the shallowest surface waters, and noise from industry interferes with their communication.

Some 5% of the wells currently operated by Chevron fall directly within the whale's habitat area, while 8% require traversal of this area as they are located in the deep and ultradeep parts of the Gulf. All of the areas Chevron is targeting for growing its Gulf portfolio are also in these deep and ultradeep regions – those with water depths greater than 1,000 feet (305 meters) and 5,000 feet, respectively – with associated vessel movements likely to impact whale habitats. Chevron is aiming to reach production of 300,000 barrels of oil equivalent per day (boe/d) by 2026 in the Gulf, a 50% increase from its current output levels.

Managing nature risk

Regulators have long been aware of the environmental impacts of oil and gas development. To analyze the impacts of new activity in the Gulf of Mexico, the National Marine Fisheries Service (NMFS), a US federal agency, released a biological opinion in 2020 concluding that development of new oil rigs would threaten endangered whales given the risk of collision, and proposed recommendations to mitigate this risk. Several environmental groups sued NMFS in 2020 as they deemed the study did not properly assess the environmental impact. They reached a settlement with the agency in August 2023, following which the US government implemented a variety of measures to protect the whales, including withdrawing acreage from the license area, a vessel speed limit of 10 knots and a requirement to maintain a minimum 500 meters distance from any sighted Rice's whale.

In response to these changes, Chevron, Shell, the state of Louisiana and the American Petroleum Institute (API) sued the Department of the Interior and were granted an injunction that would allow the lease auction to take place on November 8. Later, the court granted an order indefinitely staying the injunction, but a hearing on November 13 determined that the sale could proceed without added the protections for the Rice's whale, such as vessel traffic restrictions. Lease Sale 261 is scheduled to take place on December 20.

Financial impacts on Chevron

With the sale now set to proceed, Chevron is unlikely to incur any immediate financial losses aside from court fees and costs from delays. But the economic impact of vessel restrictions could have led to a potential drop of 620,000 boe/d in the entire region's supply on average between now and 2040, according to industry analyses. Depending on commodity prices, this supply shortage could have translated into reduced revenue of $31 million to $49.6 million (assuming $50 per barrel for the low case and $80 for

the high case) for the oil and gas industry, as those volumes would have otherwise been produced and sold by operators. Chevron accounts for almost half of this total.

In the long term, Chevron's assets in the Gulf of Mexico may be at risk of becoming impaired or incurring costs if environmental laws to protect the critically endangered whale are strengthened. This could be instigated by an increase in litigation around climate change and biodiversity. Gulf of Mexico primary lease terms can range from at least five to 10 years based on water depth, and offshore projects usually have lifespans of 20 to 30 years before being decommissioned. Were Chevron's project to become uneconomical due to environmental restrictions, the company may decide to relinquish its licenses, leading to tens of millions of dollars in additional losses.

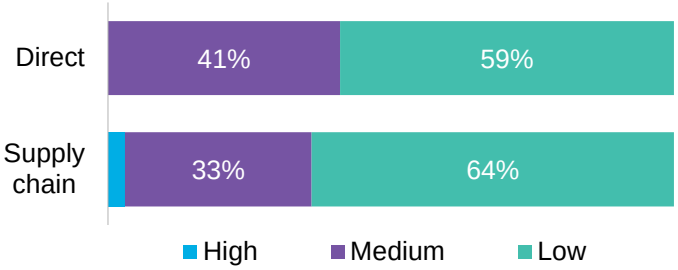
Chevron declined to comment on this case study.

Nature risk across the oil and gas sector

The extractive operations and global footprint of the oil and gas sector expose companies to significant nature risks. These risks are physical (such as oil spills), transition (non-compliance with shifting environmental regulation) or systemic (macroeconomic changes tied to nature moving global demand away from fossil fuels). According to the World Economic Forum, 41% of the sector's gross value added through direct operations – and 36% through its supply chain – is moderately or highly dependent on nature.

The ENCORE nature materiality matrix highlights 10 ecosystem services on which production processes are dependent, with three deemed to be of very high materiality and covering direct physical inputs, water quality, and flood and storm protection. ENCORE further classifies the sector as having one of the largest impacts on nature – 10 impact drivers are deemed to be of at least moderate materiality, with eight considered high or very high. Careful management of these impacts and dependencies is needed to contain nature risk for the sector.

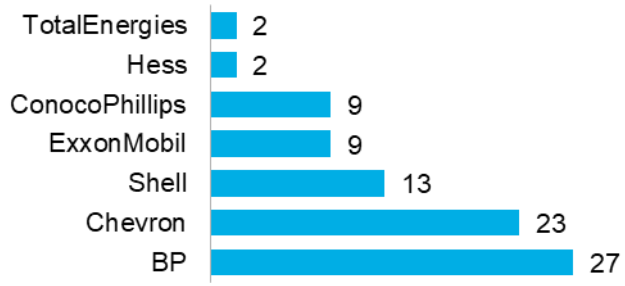
Nature dependency of gross value added across oil and gas sector's direct operations and supply chain



Source: World Economic Forum, BloombergNEF.

The legal wrangling Chevron was involved in over oil extraction in the Gulf of Mexico is not an anomaly. Other oil and gas majors have likewise been subject to recent environmental lawsuits, with BP and Shell among the most frequently involved. Such cases are more likely to occur in offshore licensing instances rather than onshore exploration – except in environmentally sensitive areas such as the Arctic – but are nonetheless highly location-specific. It is likely that environmental groups will continue pursuing lawsuits against operators in the Gulf, amplifying litigation risk for the sector.

Environmental lawsuits involving oil majors in the last three years



Source: BloombergNEF. Note: Includes subsidiaries.

The US Bureau of Ocean Energy Management has considered options for 10 further potential lease sales by 2029 in its proposed program, as well as one in Alaska's Cook Inlet region, where compounds from fossil-fuel production have been found to be an underlying cause of a decline in the Beluga whale population. The growing legal risk to the sector is in spite of regulatory attempts to minimize ecological

damage: for decades, the industry has had to undertake environmental assessments prior to the development of new projects. The cases of BP, Shell and ConocoPhillips demonstrate the legal risks and the deficiency of these assessments to account for nature loss.

Risks and opportunities for adjacent firms

Company	Risk type	Description
BP	Legal, physical, and reputational	BP's Deepwater Horizon spill released 3.19 million barrels of oil into the Gulf of Mexico and was subject to a Clean Water Act penalty. The company paid $63.4 billion in clean-up costs and legal fees linked to the spill.
Shell	Legal and reputational	In September 2023, the state of California sued several oil majors, including Shell, on the grounds of downplaying fossil-fuel-induced climate risks and biodiversity loss. The company said that it does not believe the courtroom is the right venue to address climate change.
Conoco Phillips	Legal and systemic	Conoco's $8 billion oil and gas Willow Project in Alaska was imperiled by a lawsuit brought by environmental groups over its potential climate and biodiversity impact. The company stood to lose the $100 million it had invested into project development, before the lawsuit was dismissed by a federal judge in November 2023. Environmental groups are considering a potential appeal, which could cause further delays.

Source: BloombergNEF.

Biodiversity is starting to be factored into oil and gas company strategies, though large US players, such as ExxonMobil, ConocoPhillips and Chevron, lag their peers in terms of target-setting, managing oil spills and forgoing footprint expansion.

Colombia's Ecopetrol, a TNFD Taskforce member, was the first to indicate it will start disclosing against the TNFD recommendations.

Petrobras, TotalEnergies and Repsol are leading majors, establishing short- and long-term nature targets and providing better disclosure of biodiversity metrics. Petrobras discloses metrics of capital allocated to biodiversity projects.

Major oil companies' biodiversity strategies and risk exposure metrics

	Year for biodiversity targets*	Spills	Assets/ area affected	Mining expansion
PETROBRAS	2025	9	114km^2	No
TotalEnergies	2025	49	282	Yes
Shell	2025	129	14	No
ExxonMobil	-	171	30%	Yes
equinor	2030	111	27	Yes
eni	2026	280	155	No
REPSOL	2050	24	13	Yes
bp	2025	108	9	Yes
ConocoPhillips	-	178	8	No
Chevron	-	71	-	Yes

*Source: BloombergNEF, company reports. Note: Colors represent BNEF assessment of metrics. *Includes water targets. Assets/area affected refers to number of sites of area coverage located in nature-sensitive areas or intersecting conservation units.*

Oil majors will likely continue exploring and drilling in sensitive environmental areas. As they do, an awareness around integrating biodiversity and ecosystem services management to better manage and mitigate the impacts on biodiversity could prove to be expedient.

More from BNEF:

BNEF Oil and Gas Transition Scores 2023: Results and Analysis (web | terminal)

Theme: Decarbonizing Oil Refineries (web)

Theme: Fossil Fuels Flourish Despite Energy Transition Push (web)

CMA CGM Penalized for Nature Threats Posed by Untreated Ballast Water

The world's third-largest container shipping company, CMA CGM, received $165,000 in penalties from the US Environmental Protection Agency in August 2023 over risks its operations presented to local waterways. Four ships operated by the Marseille-based company were found to have violated the Clean Water Act by discharging untreated ballast water without authority or adequate reporting, as well as other recordkeeping, inspection, monitoring, and reporting infringements.

While the penalty imposed is far smaller than other case studies, the CMA CGM case is indicative of tighter environmental regulation of the shipping industry and scrutiny of the threats it presents.

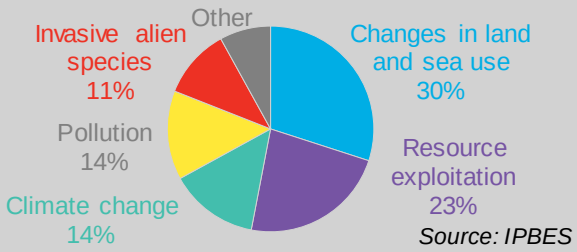
100% Share of gross value added in the direct operations of the transport sector that is moderately or highly nature-dependent

$165,000 Penalties for violations involving ballast water discharge, inspection, monitoring and reporting

30% Share of company's fleet now fitted with a ballast water treatment system

Drivers of nature loss

Five drivers account for over 90% of nature's decline relative to pre-industrial levels:



Source: IPBES

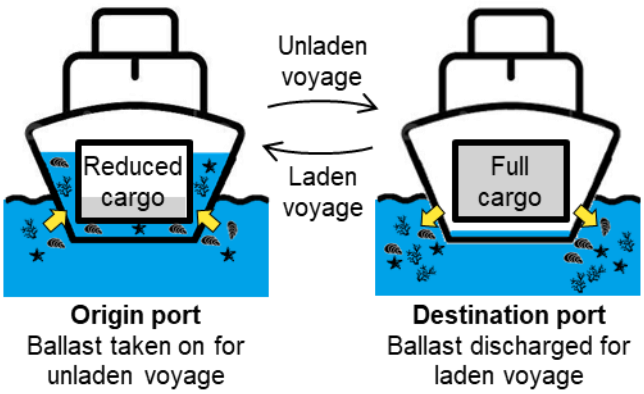
Companies with exposure to these drivers have higher nature-related transition risks.

Manifestation of nature risk

CMA CGM is an industry giant, operating almost 600 vessels across 435 ports, in addition to its smaller land and air logistics services. Like all global shipping companies, CMA CGM operates in natural environments where conditions are often hostile. Its vessels expose marine ecosystems to contamination risks from ballast water discharge, oil or fluid spills, or cargo lost at sea, impacts that can result in costly legal action and remediation, reputational damage, and physical loss or damage of vessels and cargo.

Ballast – water that is pumped into the ship's hull to steady the vessel in open seas then released at the destination port – is essential to safe navigation, but can introduce invasive species and may be contaminated with oil, paint chips, rust, sediment, and toxins that damage marine life.

Ballast water moves marine life and contaminants from one port to another



Source: BloombergNEF

The movement of contaminated ballast water from one port to another has been linked to the spread of invasive species such as Asian kelp, the European

green crab, North Pacific seastar and the zebra mussel, a native to the Caspian and Black Seas that has proliferated across European and US waterways. These mussels accumulate on surfaces such as rocks, docks and boats, outcompeting native species, other invertebrates and young fish until they eventually overwhelm the water system.

In addition to the ecological damage, the US Geological Survey estimates invasive mussels cause $1 billion in damage to infrastructure each year, including clogging exhaust pipes and heat exchangers of power plants and industrial facilities. There are no control mechanisms once an outbreak has occurred.

Invasive zebra mussels attached to native mussel

Source: US National Oceanic and Atmospheric Administration climate.gov

Managing nature risk

The risk of introducing invasive species through ballast water is managed through international conventions and local laws, which like the marine environments, can vary significantly. Some jurisdictions including the US have mandated that ship operators install biological control devices to treat ballast water and monitor and report shipping activities that present risk to nature.

In the case of CMA CGM, the company was found to be in numerous breaches of the Vessel General Permit (VGP), a key element of the US Clean Water Act which relies on industry self-reporting of potential spills, untreated ballast discharge and faulty pollution prevention equipment.

In August 2023, the shipping giant was handed $165,000 of penalties relating to multiple infringements by four vessels. These infringements included two untreated ballast water discharge events in the waters around Los Angeles and Norfolk, Virginia. The two offending vessels were each capable of holding almost 33,000 cubic meters of ballast water, enough to fill 13 Olympic swimming pools.

Both ships were required by law to have a ballast water treatment system fitted from the time of launch in 2015, according to a mandatory technology deployment schedule outlined in the VGP that applied to all large vessels constructed after December 2013. Older ships needed to be retrofitted with a treatment system at the first scheduled drydocking after January 2014 or January 2016, depending on ballast capacity. It is unclear why these vessels were not fitted with the technology. The company also failed to conduct the necessary calibration of a ballast water treatment system, adequately monitor and sample ballast discharges, and properly report the results of annual vessel inspections. CMA CGM did not respond to BNEF's request for comment.

Penalties issued to CMA CGM for Clean Water Act infringements

Vessel	Alleged violations	Penalty
Fidelio	Multiple inspection, calibration, sampling, and reporting violations over 2018-2020	$52,197
A. Lincoln	Untreated ballast water discharge near a port in Norfolk, Virginia, in 2021, multiple reporting violations over 2018-2020	$48,277
T. Jefferson	Untreated ballast water discharge near a port in Los Angeles in 2018, and multiple reporting and sampling violations in 2020	$48,233
Columbus	Multiple reporting violations over 2017-18	$16,293

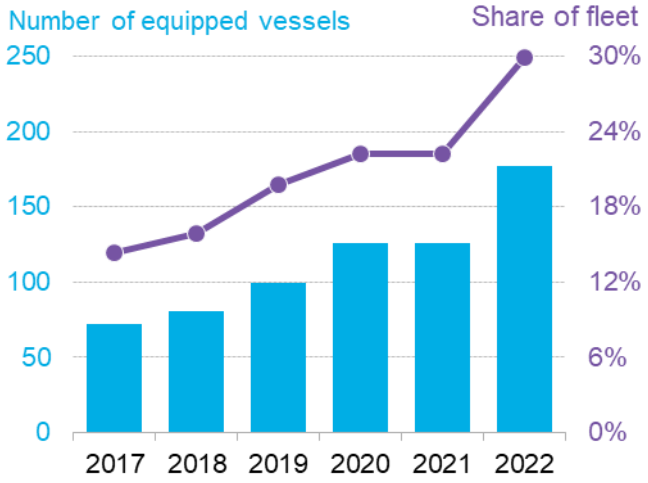
Source: BloombergNEF, US EPA.

Financial and reputational impacts on CMA CGM

The dollar value of the penalty imposed on CMA CGM is trivial relative to the industry leader's $74.5 billion in revenue and $76 billion in assets in 2022. However, it comes on top of compliance costs to meet conditions of the Vessel General Permit.

CMA CGM has been steadily adding ballast water treatment systems to its ships past the US deadlines. As of 2022, almost 30% of CMA CGM's global fleet had been fitted with the technology. The company chose to use ultraviolet radiation ballast water treatment systems, instead of chemical options which have negative impacts on local biodiversity. Treatment systems typically cost $1 million to $5 million per ship, according to the International Chamber of Shipping.

CMA CGM is deploying ballast water treatment across its vessel fleet



Source: CMA CGM, BloombergNEF.

The US EPA's practice of publicizing infringements and settlements could further impact CMA CGM by diminishing its reputation as a sustainable shipping company.[7] The fines and non-compliance undermine the shipper's climate and nature stewardship. It is a signatory of the United Nations Sustainable Ocean Principles and was recently certified Green Marine Europe, a voluntary industry initiative requiring companies to review their environmental performance annually, submit to external verification and publish the results, and commit to a process of continual improvement. It also works with IFREMER (French Research Institute for Exploitation of the Sea) to help preserve marine ecosystems, three NGOs to support coral reef regeneration projects around the world, and with the WWF to prevent illegal trade of endangered wildlife.

The company has also pledged not to facilitate the export of certain products linked to deforestation, such as timber from Gambia, and has set a target of "zero loss" of containers at sea.[8]

In addition, the privately held firm has set a target to reach net-zero carbon emissions by 2050. It is investing in bio-methanol-powered ships and investigating future fuel options including hydrogen and ammonia.

Nature risk across the shipping industry

The interaction of global shipping operations with marine ecosystems exposes companies to significant risks. These risks can be physical (for example, stranding a vessel on a coral reef), transition (for non-compliance with environmental protection laws), or systemic (if trade flows of deforestation-linked commodities are halted, for example).

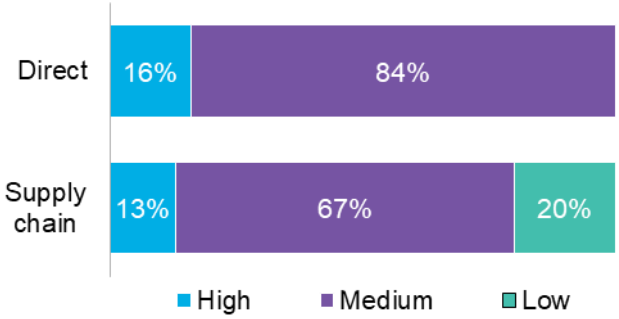
The broader supply chain and transport sector is among the most nature-dependent sectors according to the World Economic Forum, with 100% of direct economic value generation, and 80% of supply chain value generation, being moderately or highly dependent on nature. Likewise, the ENCORE nature materiality matrix identifies five areas where marine shipping has a high impact: marine ecosystem use, greenhouse gas emissions, water pollutants, soil

[7] Containership companies are under pressure from their customers to be more sustainable; for example, nine leading multinationals, including Amazon, Unilever and Ikea, have committed to only using zero-emission ships to transport their cargo by 2040.

[8] The target was missed in 2022 after the APL Vanda lost 69 containers in heavy weather near the entry to the Gulf of Aden, off Yemen.

pollutants, and disturbances such as noise pollution. These impacts and dependencies mutate into nature risks when inadequately managed.

Nature dependency of gross value added across supply chain and transport sector



Source: World Economic Forum, BloombergNEF.

The nature risks associated with shipping are increasing as enforcement agencies bolster their efforts to address climate change and nature loss.

The US EPA has ramped up enforcement of the inspection, reporting and technology deployment requirements of the VGP.[9] The agency pursued only a handful of enforcement actions in the decade after the rules were first implemented in 2008, but is now routinely issuing five-figure penalties. Just five weeks before the CMA CGM settlement, the EPA issued $137,000 in penalties to Singaporean-headquartered Swire Shipping for various Clean Water Act violations relating to three vessels, and $200,000 in penalties relating to two ships operated by Tokyo-based MMS.

Shipping companies face other nature risks in their regular operations. Grounding of vessels, loss of cargo and pollution of marine ecosystems have each led to legal action against vessel operators and insurers, as well as physical damage to the ships.

Similar risks and opportunities for adjacent firms

Company	Risk type	Description
Swire Shipping	Legal	$137,000 settlement relating to multiple ballast treatment, inspection, calibration, sampling, and reporting violations relating to three vessels operating in American Samoa, the Ports of San Francisco and Long Beach, California.
Shenzhen Energy Transport	Legal and physical	A $39.3 million ($29.6 million) settlement with operator and insurer of coal transport ship which grounded and caused damage to the Great Barrier Reef in April 2010.
Exxon	Legal, criminal, reputational and physical	Two decades of litigation resulting in $507.5 million in punitive damages, $2.2 billion clean-up costs, and $1 billion to settle civil and criminal charges following the Exxon Valdez oil spill in the Prince William Sound, Alaska, on March 24, 1989.
Steamship Mutual	Legal, reputational and physical	Authorities to recover up to A$22.5 million ($14.4 million) in fines and clean-up costs from the insurer of APL England, which lost 50 containers overboard in May 2020.

Source: BloombergNEF

More from BNEF:

Green Methanol Offers Container Ships a Net-Zero Lifeline (web | terminal)

Shipping's Bet on Methanol Raises Supply Concerns (web | terminal)

Maui Wildfires Expose Tourism's Nature Risk (web | terminal)

[9] The Vessel General Permit was scheduled to expire in 2018 and be replaced by the Vessel Incidental Discharge Act (VIDA), signed into law by then-President Donald Trump. Although the successor weakens and removes some of the best practice requirements of the VGP, the specific rules are still being determined by the EPA. The VGP remains in force until the VIDA is officially adopted.

Formosa Penalized Over Plastic Pellets, But Real Risk Is in Shift to New Materials

Formosa Plastics, a vertically-integrated supplier of plastic resins and petrochemicals, agreed to a $50 million settlement with local environmental groups in October 2019 to redress damage caused by the discharge of plastic pellets from its Texas facility. This incident, and penalties imposed by the US Environmental Protection Agency, inspired further citizen-led lawsuits against the company in Louisiana, culminating in the court's suspension of permits for a proposed $9.4 billion complex in the state.

Formosa's case is emblematic of the transition risk facing the materials sector. Regulators are becoming more attuned to the environmental impacts, and governments, consumer packaged goods companies and supranational organizations are developing plans to transition away from consumer plastics.

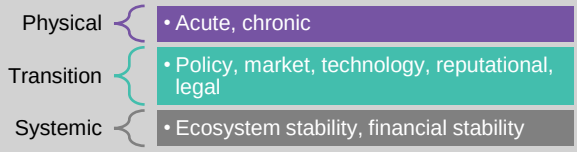
50% Share of gross value added in the direct operations of the materials sector that is moderately or highly nature-dependent

$50 million Settlement paid by Formosa Plastics to clean up plastic-pellet pollution

$9.4 billion Value of Formosa manufacturing facility suspended by citizen lawsuit

Nature risk explained

Nature-related risks are the **physical**, **transition** and **systemic** threats posed to an organization as a result of its dependencies and impacts on the natural world. Each comprises specific risk types:



Manifestation of nature risk

Established in Taiwan in 1954, Formosa Plastics Corporation (TPE: 1301) is one of the largest polyvinyl chloride (PVC) resin manufacturers globally, operating a large facility in Point Comfort, Texas since 1983. By 2016, residents of the surrounding area had grown concerned about the number of small plastic resin pellets in the nearby San Antonio Estuary.

Known as 'nurdles', these pellets are the building blocks of almost all plastic products. They are produced by refining oil and natural gas, then transported by truck, rail and ship to plastics manufacturers who melt and mold them into myriad consumer items. The pellets are persistent pollutants, degrading into microplastics. Animals mistake them for prey, and ingestion can result in stomach ulcerations and bioaccumulation of the toxic substances and pathogens that can be carried by microplastics.

It takes 600 nurdles to make one small plastic bottle. Over 11 trillion are estimated to enter oceans each year. In Formosa's case, from 2016 (or before) until the time of writing, nurdles have flowed out of the wastepipes of its Texas plant, entering adjacent Cox Creek and Lavaca Bay to the detriment of various marine and coastal species.

In April 2017, a group of San Antonio volunteers sued Formosa under the US Clean Water Act. Evidence in the 2019 trial included 2,428 samples of over 46 million nurdles collected from the estuary over a three-year period and alleged to have originated from the Formosa facility. While the Clean Water Act made allowances permitting Formosa Plastics to discharge "trace amounts" of plastics into US waterways, this

evidence indicated the company's impact on the environment was significantly larger. The court found Formosa guilty of violating its permit conditions, largely based on the evidence presented by activists.

The penalties were not the first time Formosa had come under fire for mishandling its environmental impacts. The company had previously been fined for a number of infringements including improper disposal of wastewater, leaks of air pollutants, hazardous waste, and poor risk management. Other facilities – notably a comparable plant in Louisiana – similarly failed to manage their nature impact. The EPA's Enforcement and Compliance History database houses details of past cases - access by searching "Formosa".

Selected penalties issued to Formosa by the EPA for violations at its Texas Point Comfort plant

Date	Alleged violations	Penalty
Feb 1991	Land disposal and treatment, permit violation, container requirements	$3.375 million
Jan 2022	Multiple pollution releases and inadequate risk management plan, discovered in 2015 audit	$2.85 million
Feb 2010	Failure to regulate leaks of air pollutants, hazardous waste, and wastewater discharge	$600,000
May 1997	Failure to meet standards for hazardous air pollutants	$150,000

Source: BloombergNEF, US EPA. Note: Date refers to the "final order entered" date from EPA records.

Financial and reputational impacts on Formosa Plastics

Formosa agreed to mitigation payments totaling $50 million over five years to support rehabilitation projects and undo damage to waterways, public beaches, and local marine life. It also committed to reach "zero discharge" of plastic pellets from the Point Comfort facility by 2024, requiring deployment of technology costing up to another $50 million, on top of monitoring and other enforcement costs. While the direct impact of the settlement was negligible relative to the firm's $6.7 billion revenue in 2019, the incident signaled the onset of a more difficult period for Formosa.

Analyses from Bloomberg Intelligence and the Institute for Energy Economics and Financial Analysis project slow growth for Formosa Plastics revenues to 2025. While this is a trend across the broader plastics sector due to higher input costs squeezing margins, the fallout from Texas has spotlighted the company's exposure to nature-related risks.

A $9.4 billion industrial complex announced in 2018 in St. Louis Parish, Louisiana, was intended to be a key part of Formosa's North America growth plans. Comprising 14 plastic manufacturing plants over 2,300 acres, it immediately attracted strong local opposition over potential pollution. Despite these concerns, the Louisiana Department of Environmental Quality (LDEQ) granted the project permits under the Clean Air Act. Inspired by the lawsuit brought against Formosa in Texas, local citizen activist groups appealed the issuance of permits. In 2021, President Biden cited the area in an executive order directing federal agencies to prevent disproportionate harm to communities resulting from climate change and pollution, leading to the revocation of the permits by a Louisiana district court in September 2022.

Nature risk across the materials industry

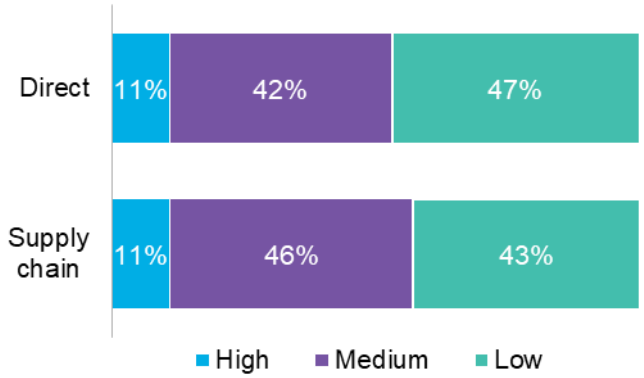
The plastics value chain is complex, entailing interactions with nature at each stage, from extraction of raw materials to processing and waste disposal, and exposing manufacturers to significant risks. These risks can be physical (such as limited access to water sources), transitional (regulation that hampers production), or systemic (global trade flows collapsing due to a breakdown in ecosystem services, for example). These risks stem from companies' impacts and dependencies on nature.

The ENCORE nature tool describes the production of specialty chemicals as having significant impacts on nature. It identifies seven impact drivers of nature loss in the industry, with water use, terrestrial ecosystem use, emissions, waste, and water and soil pollutants

classed as highly or very highly material, as evidenced by the Formosa Plastics case.

Likewise, the materiality matrix finds seven nature dependencies in the industry, though only groundwater and surface water are classed as highly material. Additionally, over 50% of direct and supply chain gross value added in the materials industry is moderately or highly dependent on nature, according to the World Economic Forum.

Nature dependency of gross value added across the chemicals and materials sector



Source: World Economic Forum, BloombergNEF.

Numerous examples of companies impacted by nature risk exist across the plastics value chain. Staying within plastic pellet production, the cases of Frontier Logistics, Ducor, Styropek and ExxonMobil highlight the legal and reputational risks that companies face and demonstrate that the challenges faced by Formosa are not an outlier in the industry.

A study published by the Minderoo Foundation, supported by the UN Environment Programme's Finance Initiative, found pollution litigation against petrochemical companies in the US may cost petrochemical companies, consumer goods producers, and their insurers in excess of $20 billion by 2030.

Regulation in the plastics sector presents a major source of risk to companies as governments and supranational organizations seek to rein in harmful practices. The European Commission has proposed regulation to prevent plastic pellet losses during manufacture, including proposals for mandatory measurement and reporting. The Plastic Pellet Free Waters Act was introduced in the US Senate for the third time in July 2023. If passed, this would require the EPA to prohibit the discharge of plastic pellets into waterways. The UK, Canada and the EU have all set minimum targets for post-consumer recycled content for plastics that will come into force by 2030.

Similar cases of nature risk from nurdle pollution

Company	Risk type	Description
Frontier Logistics	Legal and reputational	$1.2 million settlement to clear up plastic pellet pollution from a facility in Charleston, South Carolina, in 2021. The company also agreed to allow an independent auditor to assess nurdle pollution at the plant and follow its recommendations.
Ducor	Legal and reputational	Found to be contributing to plastic pellet pollution in Rotterdam harbor in 2020, Ducor must now prevent pellet loss or face a €15,000 ($16,000) fine per infringement.
Styropek	Legal and reputational	Received notice of intent to sue in October 2023 due to allegations of plastic pellet pollution violating Pennsylvania's Clean Water Act. The company said that it is evaluating the allegations.
ExxonMobil	Legal, criminal and reputational	Following activist pressure, ExxonMobil agreed to report on plastic pellet spills in 2019. California's Department of Justice is taking legal action against the company, alleging they deceived the public about the harmful effects of plastic pollution.

Source: BloombergNEF.

A legally binding agreement on plastic pollution is expected by 2024, with the backing of 175 UN members. In 2022, the UN announced a $2.6 trillion plastic pollution plan, which laid out a scenario in which "mismanaged plastic waste" could be reduced by 80% by 2040. Notably for plastics manufacturers, this suggests cutting investment in virgin plastic production

by a total of $2.2 trillion by 2040. The UN claims this scenario would avoid $3.3 trillion of externalities such as ocean clean-up and air pollution, suggesting $1.7 trillion should be invested in developing sustainable plastic substitutes. For more information on the UN's plastic proposal, see *UN's $2.6 Trillion Plastic Pollution Plan Still Not Enough* (web | terminal).

Companies are also facing downstream pressure. Brand owners such as Nestle, Danone, Mondelez and Unilever have committed to reducing the amount of virgin plastic in their supply chain and ensuring that 100% of their packaging will be recyclable, reusable or compostable by 2025.

Managing nature risk

With growing awareness of the harmful impacts of plastic production spurring market and regulatory change, companies are beginning to respond, though slowly. BNEF has assessed how 20 of the largest plastic producers have integrated nature and biodiversity into their strategies; a sample of the findings is compiled in the adjacent table. A comprehensive scoring of plastics manufactures based on sustainability and emissions indicators can be found in the *Circular Economy Company Ranking Tool* (web).

Policies are in their infancy. While Borealis and INEOS have set ambitious targets for 100% recyclable, reusable, compostable or recoverable packaging by 2025, only TotalEnergies has set a tangible biodiversity protection target – net-zero deforestation at its new sites – and only Lotte Chemical has committed to zero water pollution. Neither has provided a date by which these targets will be reached.

Lyondell Basell, INEOS, Dow and Borealis have committed to zero plastic pellet discharge targets, but none have provided a date for achieving this target. Formosa Plastics did not mention its commitment to zero plastic pellet discharge in Texas in its 2022 annual report. It is unclear whether they intend to achieve this by 2024, as promised in the settlement.

The slow progress of companies in the sector suggests that not enough is being done to mitigate risk. Better identification, assessment and disclosure of nature-related impacts and dependencies will inform business and investor understanding of nature-related risks in the industry and increase the likelihood of preventative actions being taken.

Water pollution, waste and nature targets of selected large plastics manufacturers by revenue

Company	Water pollution reduction target	Zero plastic pellet discharge target	Nature protection target
TotalEnergies			■
SINOPEC			
sabic			
lyondellbasell		■	
ExxonMobil			
INEOS		■	
Braskem			
DOW		■	
LOTTE CHEMICAL	■		
BOREALIS		■	
Formosa Plastics			
Hanwha			

Source: BloombergNEF. Note: Blue indicates target in place. Applies to company-wide commitments, not individual projects.

More from BNEF:

Theme: Decarbonizing Petrochemicals (web)

Research Series: Circular Economy (web)

Sustainable Materials Market Outlook 4Q 2023 (web | terminal)

Freeport's Share Price and Divestment Deal Spoiled by Tighter Tailings Rules

The case of mining company Freeport-McMoRan demonstrates how abruptly transition risk can materialize. Following allegations that that the firm's vast mining and mineral operations – and specifically waste from copper and gold processing – had resulted in water pollution and forest degradation in Papua, the Indonesian environment ministry tightened regulations on tailings disposal.

The company's initial failure to comply with these standards delayed a divestment deal with a state-owned metals producer, hitting Freeport's share price and reputation.

100% Share of gross value added in the direct operations of the mining sector that is moderately dependent on nature

18% Decline in Freeport's share price immediately following the announcement of new mining waste regulations

$12.95 billion Estimated cost of environmental damage caused by Freeport in Indonesia

Materiality of nature impacts and dependencies

Materiality refers to the influence some factor, event, or information has on a company's valuation, the omission of which in a financial statement could mislead investors or other stakeholders.

'Single materiality' is conventionally used in accounting. For nature, it captures only how firm valuation can be affected by changes in the ecosystem services that production depends on.

'Double materiality' also considers the impacts of the firm on nature, capturing how production processes change the state of nature.

Manifestation of nature risk

Freeport-McMoRan Inc. (NYSE: FCX) is a major producer of copper, gold and molybdenum, a trace mineral used in steel alloys. The Phoenix-based firm operates Grasberg Mine in Papua, Indonesia, through PT Freeport Indonesia (PT-FI), a joint venture between Freeport and the Indonesian government. With some of the world's largest reserves of gold and copper, the 11,100-hectare mine yielded 711,000 tons of copper and 55.9 tons of gold in 2022. Freeport has run operations at the rainforest-flanked complex since 1988, including a one-mile-wide open pit mine, an underground mine and four concentrators. Grasberg accounted for 47% of Freeport's operating income in 2017.

Extraction at Grasberg is followed by primary crushing on site before delivery to a nearby mill complex for further processing. The milling and concentrating facility is the world's largest, generating enormous volumes of tailings – the materials left over in the process of separating the valuable fraction of an ore from the gangue, or uneconomic fraction.

Freeport-McMoRan's Grasberg copper and gold mining complex in Papua province, Indonesia

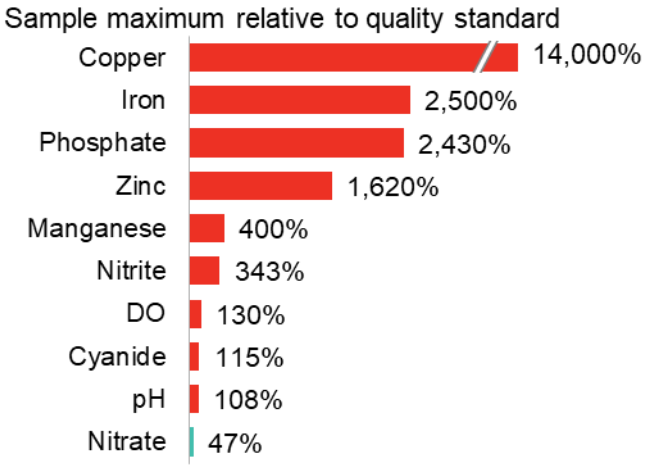
Source: Free West Papua.org

In line with a 1990s agreement with the Indonesian government, PT-FI has dumped up to 300,000 tons of tailings per day directly into the nearby river system, where it flows downstream to the Ajkwa deposition area (ADA). A 2018 Bloomberg News article cited data from mining watchdog-group Earthworks, which suggested Freeport sent over 76 million tons of tailings into Indonesian rivers annually, though the company puts the 2017 figure at 50 million tons.

According to scientific journal Nature, as discharge levels into the river increased, so did heavy metal-rich tailing deposition, dramatically raising the riverbed and reducing channel capacity. Sediment buildup restricted the movement of fish, and chemical particles covered their gills, leading to the suffocation of over 200,000 fish in April 2016. Tailings not deposited in the ADA flow onward to the Arafura Sea, increasing suspended particulate matter and heavy metal concentrations.

A 2018 water quality survey conducted by Indonesian environmental group Walhi indicated that the rivers into which PT-FI dumped tailings contained harmful levels of toxic chemicals. In all three samples across two rivers, concentrations of copper, iron, phosphate, zinc and cyanide were far in excess of those permitted. Two samples showed elevated levels of nitrate and chlorine solids, while high concentrations of manganese were found in another.

Water quality survey in the Papua Province in 2018



Source: Walhi Papua. Note: Three samples taken from the Yamaima and Okorpa Rivers. Red denotes concentration beyond permitted level. DO is dissolved oxygen.

Satellite images reveal vegetation disturbance in the region directly correlated with the rate of Grasberg tailings production. Between 1987 and 2014, some 138 square kilometers of rainforest, mangroves, and agricultural land experienced substantial vegetation loss, a result of flooding from the aggraded riverbed.

In 2017, the Indonesian Financial Audit Agency, BPK RI, published an assessment report on the extent of the ecological damage caused by PT-FI, putting the figure at 185 trillion Indonesian rupiah ($12.95 billion in 2017 real terms). Though it does not represent a penalty payable by Freeport, future liability could arise, and the firm asked the government to recalculate its estimate.

With growing awareness of the mine's environmental impact, on April 5, 2018, the Indonesian environment ministry released new standards requiring that over 90% of tailings deposits must be stored on land, a significant step up from the previous 50%. The percentage represents the proportion of tailings recovered from water downstream after dumping into rivers to move them to the ADA.

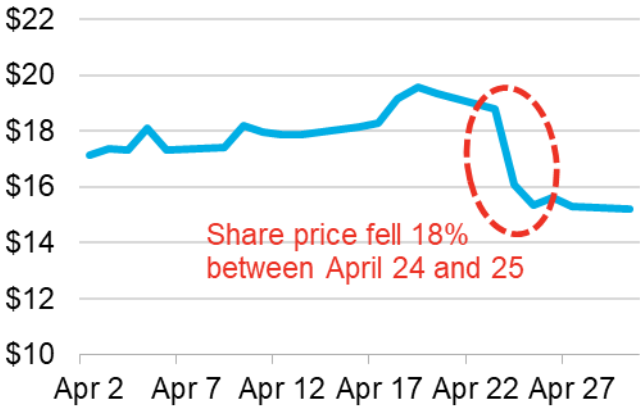
Freeport Chief Executive Officer Richard Adkerson described the ministry's demands as "shocking and disappointing", telling analysts in earnings call several weeks later in April 2018 that "nobody could mine this ore body in consistency with these decrees" and that it "is so far out of bounds it cannot be done". Bloomberg News reported in June of that year that "[al]most every other miner in the world has been forced or has elected to stop discarding tailings in rivers".

Financial and reputational impacts on Freeport-McMoRan

In the two days following Adkerson's response to the tighter regulations, Freeport's shares dropped by 18.2%, to below $16. It was the company's largest share price decline since January 2016, and rendered Freeport the day's worst performer in the S&P500 index. Investors were concerned that the company's inability to meet the new standards would further stall plans to increase government ownership in PT-FI.

As part of a 2009 law, all foreign mining companies in Indonesia were required to divest at least 51% of their shares to government entities. After years of disagreement, in December 2018, Inalum, a national mining holding company and aluminum producer, was selected as the new majority stakeholder as part of a $3.85 billion equity transfer. Disagreement between Freeport and the government over who should bear responsibility for ecological damage at Grasberg held up completion of the deal.

Freeport-McMoRan's share price fell 18% in 2018 on the CEO's response to the tailings regulation



Source: BloombergNEF, Bloomberg Terminal.

Reuters reported in June 2018 that Indonesia's mining minister said that his office would need approval from the environment ministry before permits could be issued to extend PT-FI's operations until 2031. Inalum's CEO informed parliament in July that, "regarding the environment, we told Freeport 'the past problems are your sins,'" and "the [$13 billion] from tailings damage still needs to be cleared up". In December 2018, the two sides reached a compromise after Freeport agreed to a roadmap to manage tailings disposal at Grasberg through 2030. No agreement has been made public on how the $13 billion historical damage is to be redressed.

Institutional investors had earlier taken note of the ecological concerns. Norway's sovereign wealth fund, GPFG, which controls over $1 trillion in assets, excluded Freeport from its investment universe in 2006, citing Grasberg's use of rivers for tailings disposal. The fund also sold $850 million of Rio Tinto shares in 2008, due to an agreement that gave the company the rights to 40% of the mine's output above specific levels.

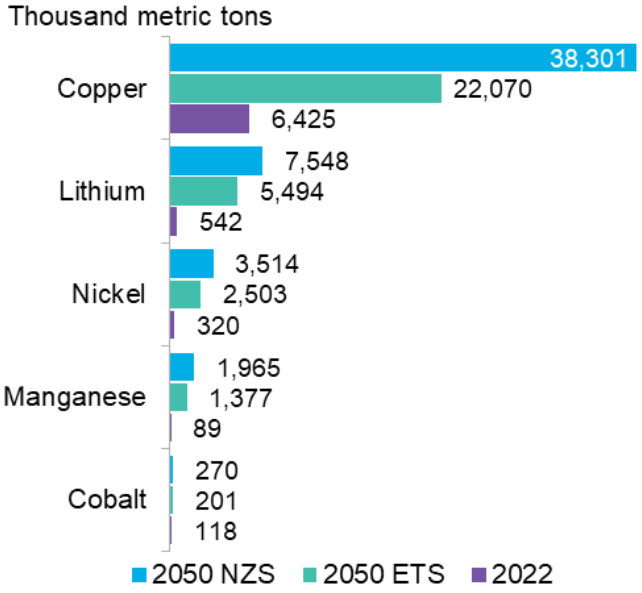
To compensate for the impacts of ecological damage on local economies and community health, Freeport created the Partnership Fund for Community Development, committing $55 million in 2018.

Nature risk across the mining value chain

The mining sector operates at the intersection of different facets of nature risk – particularly geological degradation, water and air pollution, and biodiversity loss. According to CDP, an environmental non-profit organization, mining operations and mineral extraction account for around 7% of tropical deforestation.

The acceleration of the energy transition will spur the buildout of more physical assets to supply the required joules, increasing the extraction of metals and critical minerals globally. The energy transition includes power generation, battery storage, power grids and transport sectors.

Demand for energy transition metals in 2022 and outlook for 2050, covering power generation, battery storage, power grids and transport sectors

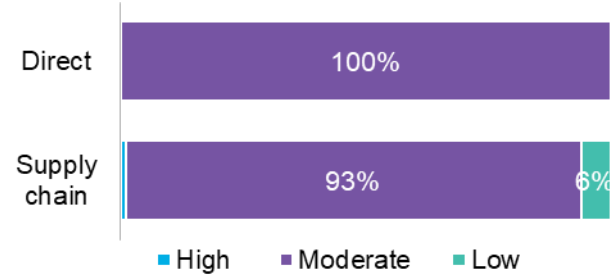


Source: BloombergNEF. Note: 2050 NZS and ETS refer to the Net Zero Scenario and Energy Transition Scenario in BNEF's New Energy Outlook report.

Metals required for the transition (and their demand drivers) include copper (wind, solar, EVs), aluminum (solar, EVs), cobalt (energy storage, EVs), nickel (EV batteries, stationary storage, wind) and lithium (EV batteries). This presents a significant future source of physical and transition risk as approximately 350 mines used for energy transition metals are located within key biodiversity areas – sites contributing significantly to the global persistence of biodiversity. For more BNEF analysis on energy transition metals, see: *Transition Metals Outlook 2023* (web | terminal).

The metals and mining sector is moderately dependent on nature. According to the World Economic Forum, 100% of gross value added in its direct operations is classified moderately reliant on nature, while 93% of its supply chain value generation is moderately or highly dependent.

Nature dependency of gross value added across mining and metal companies' direct operations and supply chain



Source: World Economic Forum, BloombergNEF.

Global Canopy and UNEP's ENCORE nature tool provides further detail on these nature interactions. The precious metals and minerals subsector is dependent on five ecosystem services: groundwater, surface water, water flow maintenance, climate regulation and erosion control. Four of the five are deemed to be of at least high materiality. The nature impacts of the subsector are more significant than its dependencies. The ENCORE materiality matrix identifies nine impact drivers of nature loss, which assess the impacts of production processes on ecosystem services and natural capital that result from the operations of the sector. Of these, water use and terrestrial ecosystem use are rated very highly material to nature loss, while the rest are deemed highly material.

There are a myriad of cases of nature risk translating to financial impacts in mining. The table below highlights the examples of BHP, Anglo American and Vale.

Similar risks faced by other large mining companies

Company	Risk type	Description
BHP	Legal and reputational	Fined $8.2 million in 2022 by Chile's environmental regulator for damage from water extraction in the Sakar de Atacama salt flat.
Anglo American	Legal and reputational	The British miner was fined $37.7 million in 2018 for a burst pipeline in Brazil that spilled 313 metric tons of iron ore slurry into a nearby river.
Vale	Legal and reputational	Fined $16.8 million in 2022 after failing to present adequate information on tailings disposal at its Brumadinho dam, following the 2019 collapse of nearby Corrego do Feijao iron mine.

Source: BloombergNEF

Managing nature risks in the mining sector

Several technologies that could help mitigate the industry's nature impact have been developed. These include deployment of reclamation, water and oil treatment, and digital tools in both mining and smelting operations to reduce emissions and minimize production errors. Lower-impact mining techniques and exploring circularity for mining waste can boost sustainability and reduce nature-related risks for the sector. Over the short term, identifying and disclosing sources of risk remains the most effective approach.

More from BNEF:

Sector page: Metals and Mining (web)

Transition Metals Outlook 2023 (web | terminal)

Series: Industrial Metals Monthly (web)

JBS Links to Amazon Deforestation Imperil US IPO as Banks and Customers Cut Ties

JBS, the world's largest processor of animal protein, has incurred millions of dollars in penalties for purchasing cattle from illegally deforested land in the Amazon. The company is attempting to strengthen its sourcing process, in the face of growing pressure from its corporate customers, investors and regulators to expunge illegal land clearance from its supply chain. While zero-deforestation commitments and traceability initiatives may appear to address these concerns, a Bloomberg News investigation found JBS is only taking superficial action. NGOs, unsatisfied with JBS' progress, are attempting to block its long-planned listing in the US.

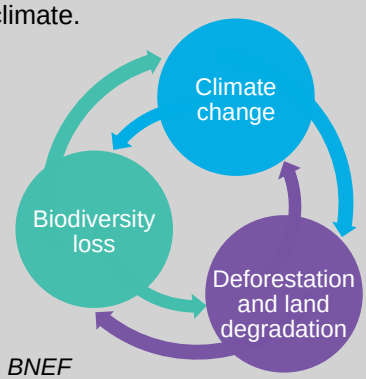
100% Share of gross value added in the direct operations of agriculture that is highly dependent on nature

$7.7 million Fine from the environment agency in 2017 for buying cattle from illegally deforested land

$20 billion Potential gain in market capitalization if JBS is able to list on the New York Stock Exchange

Climate change and nature loss

The natural systems, land use and climate change are interlinked. Increasing temperatures and deforestation hasten the decline in nature, which impairs the ability of natural systems to regulate the global climate.



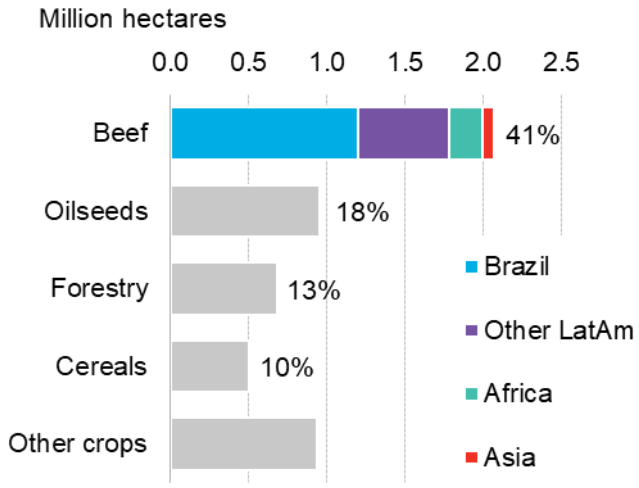
Source: BNEF

Manifestation of nature risk

The Brazilian beef supply chain is among the most complex in the world, beginning with 2.5 million ranchers and ending with corporate buyers across 80 countries. In the middle sits JBS (BVMF: JBSS3), the world's largest meat producer. It operates slaughterhouses in dozens of locations throughout Brazil. Estimates suggest that cattle ranching is responsible for between 70% and 90% of deforestation in the Amazon. An investigation by the Bureau of Investigative Journalism concluded that about 800 million trees were destroyed across 17,000 square kilometers of forests near meat processing plants in the region between 2017 and 2022.

The beef industry is the largest driver of deforestation globally, responsible for over 40% of tropical rainforest loss. Operations in Brazil account for more than half of the industry's total deforestation impact.

Drivers of tropical deforestation

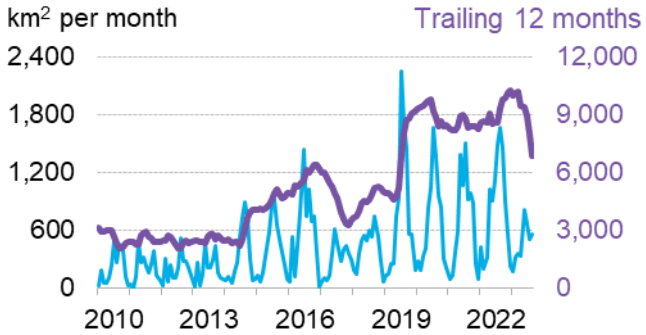


Source: BloombergNEF, Our World in Data, Pendrill et al. (2019). Note: Data covers 2005-2013. Recent observations suggest that drivers have not changed significantly since 2013. Gray bars represent commodities other than beef.

A 2022 Bloomberg News investigation, referenced throughout this case study, found that JBS slaughters a third of all cattle in the Brazilian Amazon, sourcing from ranchers throughout the region.

JBS was purchasing cattle from suppliers entrenched deep in the Amazon, where forests have been razed to accommodate growing herds. After attention was first drawn to the beef industry's role in driving nature loss in the Amazon by a 2009 report, major Brazilian supermarket chains pledged to suspend contracts with suppliers tied to Amazon deforestation, and a Brazilian federal prosecutor filed a billion-dollar lawsuit against the cattle industry for environmental damage. JBS responded by agreeing, in a settlement with the federal government, to a moratorium on buying livestock from land cleared after October 2009.

Amazon deforestation between January 2010 and August 2023, monthly and trailing 12 months



Source: BloombergNEF, Brazil National Institute for Space Research (INPE). Note: Data from INPE's DETER system.

To assess how this commitment translated to on-the-ground action, Bloomberg analyzed the coordinates of 1 million now-restricted cattle shipments between 2009 and 2021, finding that though JBS had indeed ramped up its monitoring, it also aggressively expanded its Amazon footprint over the period. Its base of direct suppliers in the region, from whom JBS sources cattle first-hand, more than doubled to 16,900 from 7,700, while it purchased from a total of over 60,000 Amazon ranchers cumulatively, including indirect suppliers.

JBS stresses that for the last decade it has complied with the 2009 settlement, purchasing only from ranches not tied to illegal land clearance and checks thousands of suppliers daily. "One hundred percent of our suppliers in the biome abide by those criteria, which is to say, zero deforestation," said the company's global president of operations in Latin America and Oceania in a 2020 press conference.

The company is forthright in its assertions of a deforestation-free supply chain. However, a major caveat exists – JBS only verifies the provenance of cattle from direct suppliers to ensure their legality. Despite cattle in Brazil moving on average between two and three – and sometimes up to six – ranches before slaughter JBS registers only the location immediately before purchase. The Bloomberg News investigation said this enables the early stages of a cow's lifecycle to take place in deforested areas, before the animal is sold to land-intensive pasture and then fattening stages. It is the latter ranches that are certified as deforestation-free – and on which JBS' provenance claims rest.

Financial and reputational impacts on JBS

Allegations of deforestation have followed JBS since 2009, resulting in legal penalties, termination of supply contracts with downstream customers and divestment by financiers.

In 2017, JBS was fined 24.7 million Brazilian reais ($7.7 million) by Ibama, the Brazilian Institute of Environment and Renewable Natural Resources, for purchasing 49,000 cattle from illegally deforested areas in the Amazon state of Pará between 2013 and 2016. JBS pointed to independent audits by DNV.GL, which showed no irregularities relating to deforestation in over 7,000 of its transactions in 2018. The following year, DNV.GL added a note stating that its comments only applied to JBS' direct dealings and that verifications were not in place for its indirect supply chain.

For a company with over $72 billion in revenue in 2022, a seven-figure fine does not present an existential threat. Of more significance is access to capital. In July 2023, JBS moved ahead with a long-

delayed plan to list its shares on the New York Stock Exchange, filing a registration request with the US Securities and Exchange Commission (SEC). JBS "sees the move as key to accessing a broader pool of institutional investors […] potentially slashing its capital costs and boosting stock valuation relative to US competitors such as Tyson Foods," according to Bloomberg News. As of November 2023, the company had a market capitalization of $9.5 billion, which it expects to increase to almost $30 billion, if the listing closes the valuation gap with its main rival Tyson Foods Inc., according to an internal presentation in July.

Previous attempts to list in the US fell apart following allegations of corruption that resulted in JBS incurring a $3.2 billion fine. This time, deforestation and climate change have prompted various environmental organizations to contact the SEC, urging it to block the listing or investigate claims in the company's IPO prospectus, such as increased transparency. In response, the SEC said that the concerns "will be given careful consideration in view of the Commission's overall enforcement responsibilities under the US federal securities laws". An excoriating Bloomberg Opinion piece in September 2023 argued that permitting the listing to go ahead would be "an ESG nightmare".

The SEC has form in investigating environmental issues, particularly greenwashing, which is how NGOs and standard setters such as CDP have described JBS's proposed "zero illegal deforestation" approach. It recently set up a Climate and ESG task force and investigated mining company Vale and electric truck maker Nikola over making misleading environmental and governance claims to investors. A run of subpoenas sent to asset managers relating to ESG marketing likewise suggests a possible future crackdown on greenwashing. Vale and Nikola paid $55.9 million and $125 million in settlements respectively, but Vale did not admit or deny the claims.

European supermarkets have also reacted to the allegations of illegal deforestation against JBS. Six chains, including Sainsbury, Aldi and Carrefour, said in December 2021 that they would commit to either stop selling specific JBS products or sourcing Brazilian beef entirely. Despite accounting for only $5.6 billion, or 7.5%, of the company's revenue in 2022, the shifts in retailer sourcing policy highlight future market risk for JBS. The EU's Regulation on Deforestation-free Products, which applies to all companies that trade within the bloc, places further pressure on European food retailers and service providers to examine their supply chains or face penalties up to 4% of revenue.

Response from the financial sector and risks of engagement with JBS

Financial institutions are beginning to reconsider their positions, cognizant of the growing legal, market and transition risk that accompanies debt and equity finance of activities tied to deforestation. In 2018, Norway's Government Pension Fund Global (GPFG) – the world's largest pension fund – sold its 1.78% equity stake in JBS, while Nordea Asset Management, the investment arm of northern Europe's largest financial services group, divested from the company in 2020, selling €40 million ($46 million) in shares. Each cited "unacceptable risk" stemming from continued association with the company. In March 2023, the NL Times reported that several of the largest Dutch pension funds are expecting to soon step away from investments in JBS over environmental concerns.

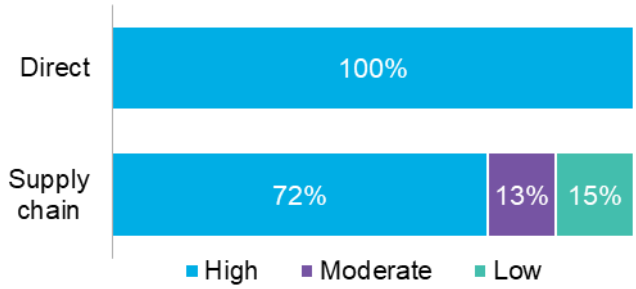
According to Bloomberg Terminal data, banks have provided or underwritten over $60 billion of finance to JBS and its subsidiaries since 2013 in the form of bonds and loans; Barclays alone extended $10 billion. After numerous media and NGO reports highlighted its involvement with JBS, Barclays rewrote its forestry and agricultural commodities statement to exclude engagement with companies whose operations or supply chains involve illegal deforestation. As of March 2023, no JBS share or bondholding data can be found for Barclays, suggesting that it has ceased financing the company. Similarly, analysts at HSBC have warned of the potential risks of investing in JBS due to deforestation concerns.

Increasing awareness of transition and systemic risk stemming from deforestation not only impacts JBS, but also its financiers, who open themselves to new avenues of legal risk. In November 2023, Paris-based NGO Sherpa filed a criminal complaint against French financial institutions, including BNP Paribas, Credit Agricole and Axa, to the French financial prosecutor's office alleging the banks abet illegal deforestation through their provision of finance to JBS. Bank representatives either did not respond immediately for comment or said that their firms' policies on climate abide by international laws and standards.

Nature risk across protein companies

The agriculture sector is one of the most highly dependent on nature, according to the World Economic Forum, with 100% of direct economic value generation and 85% of supply chain value generation being moderately or highly dependent.

Nature dependency of gross value added across agriculture companies' direct operations and supply chain



Source: World Economic Forum, BloombergNEF. Note: JBS is categorized as an agricultural company due to its live animal supply chain contributing to deforestation.

The ENCORE nature tool identifies 19 ecosystem services that large-scale livestock production processes are dependent upon. Of these, three direct physical inputs are deemed be to be of very high materiality, including ground and surface water, and plant material for fodder. Livestock production also has major nature-related impacts, with impact drivers of nature loss across water and terrestrial ecosystem use, greenhouse gas emissions, and water and soil pollutants each deemed impactful, according to the materiality matrix.

JBS is far from an outlier among meat processing companies. Among peers of JBS operating in the Amazon, a cursory search yields legal and reputational risks for Cargill, Minerva and Marfrig, with selected cases summarized below.

Similar risks faced by soft commodities companies operating in the Amazon

Company	Risk type	Description
Cargill	Legal and reputational	Fined $29 million for growing soya on deforested land in the Amazon, alongside four other grain firms.
Minerva	Legal	Ibama filed a public civic action against the meat producer in September 2023, alleging illegal clearance of almost 200,000 hectares of rainforest in Brazil.
Marfrig Global Foods	Legal and reputational	Brazilian authorities found links between the meat producer's indirect suppliers and embargoed land, drawing a 1.19 million reais ($290,000) fine and criticism from fast food chains.

Source: BloombergNEF

Managing nature risks in the protein sector

Companies producing beef on land tied to tropical rainforest destruction face some of the largest nature-related risks. Increased scrutiny from regulators, consumers and finance providers is resulting in pressure to tighten supply chains and trace agricultural goods from their origin to retail outlet. Technology including blockchain-based sourcing and satellite monitoring can help with managing impacts and dependencies. In the short-term, disclosure on *indirect* supply chains remains the most meaningful step.

More from BNEF:

Banking on Nature: Lending Policy and Risk Exposure (web | terminal)

Boycotts, Buycotts, Lifestyle Choices, and Discursive Acts (web | terminal)

Theme: Sustainable Food Systems (web | terminal)

PG&E Liabilities for California Wildfires Led to Bankruptcy

Power companies interact with the natural world in ways that bring existential threats. This is exemplified by the bankruptcy of PG&E Corp, the parent of regulated power and gas utility Pacific Gas and Electricity Company. The Northern California utility was forced to file for Chapter 11 bankruptcy after a federal court found PG&E liable for a series of forest fires from 2015 to 2018 that were started by sparking lines and poorly maintained infrastructure. It later paid out billions of dollars in settlements and was required to invest heavily in upgraded transmission and distribution equipment, as well as monitoring systems.

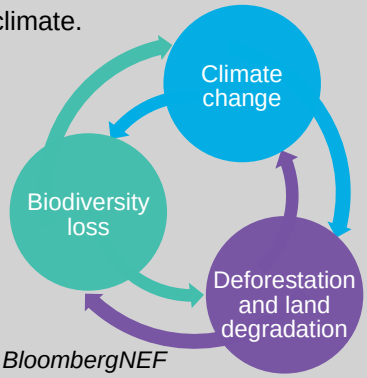
100% Share of gross value added by power utilities that is moderately or highly dependent on nature

91% Decline in PG&E's share price in the 15 months following the 2017 Napa Valley fire

$5.36 billion Amount paid by PG&E in settlements to compensate for the impacts of the wildfires

Climate change and nature loss

The natural systems, land use and climate change are interlinked. Increasing temperatures and deforestation hasten the decline in nature, which impairs the ability of natural systems to regulate the global climate.



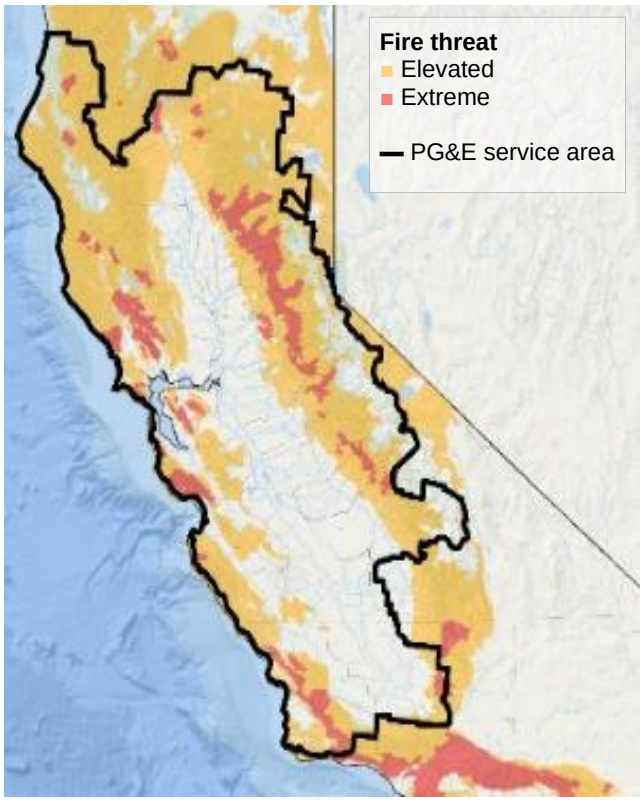
Source: BloombergNEF

Manifestation of nature risk

PG&E's (NYSE: PCG) service territory extends through urban, rural and wild settings. It covers approximately 70,000 square miles – almost twice the size of South Korea or Portugal – including some of the most forested areas of the state, in Northern California and the Sierra Nevada mountains.

Severe and prolonged drought – exacerbated by climate change – has made these natural settings more vulnerable to wildfire.

PG&E's service territory is smothered with high fire-threat areas



Source: PG&E, California Public Utilities Commission, BloombergNEF.

Throughout the early 2000s, several Californian wildfires were attributed to the state's utilities. However, it was the Napa Valley and Camp Fires in 2017 and 2018, respectively, together causing over 100 fatalities and destroying an area almost the size of Los Angeles, that garnered global attention. Across California, the proximity of electrical transmission lines to drought-affected vegetation significantly increased the risk of wildfires. According to a federal judge, PG&E's liability for damage caused since 2010 stemmed from failures to properly trim trees in the forest regions north of San Francisco, resulting in fires when branches hit the lines.

Sparking transmission and distribution lines also caused fires, as with 2018's Camp Fire, where a live wire broke free of a 99-year-old tower that PG&E's own guidelines deemed to be a quarter-century past its "useful life". The company's total liabilities for fires between 2015 and 2018 amounted to some $30 billion, far in excess of its insurance limits.

PG&E contractors trim trees around distribution lines in California in June 2019, in preparation for anticipated wildfires

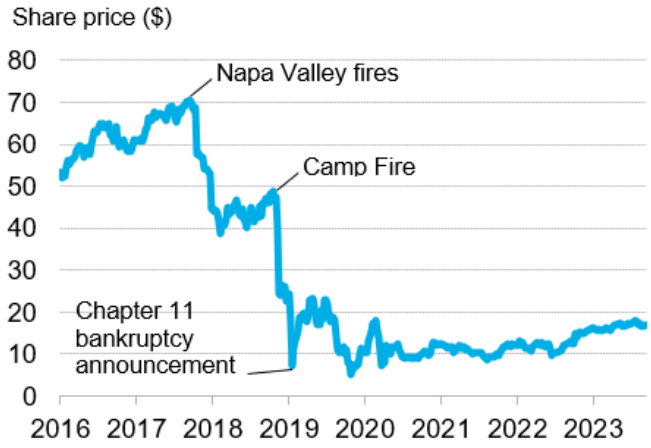
Source: Bloomberg

Financial and reputational impacts on PG&E

On January 14, 2019, the company announced it was filing for Chapter 11 bankruptcy and was looking to sell its natural gas unit, following negative media coverage and major harm to its reputation. This was the culmination of almost two years of turbulence for PG&E: prior to the Napa Valley fires, its share price had peaked at $71, before tumbling to $6 when news of its bankruptcy filing was revealed. For more BNEF analysis of PG&E wildfires, see: here, here and here.

Since the company emerged from bankruptcy in July 2020 and completed its court-ordered reorganization, its share price hasn't climbed above $20. Nor has PG&E been able to fully recover its reputation. However, following a large public share offering to partially fund the bankruptcy exit, PG&E's market capitalization returned to its pre-wildfire level of $36 billion in 2022 after reaching lows of $3 billion in 2019.

PG&E Corp share price fell 91% from September 2017 to January 2019



Source: BloombergNEF, Bloomberg Terminal.

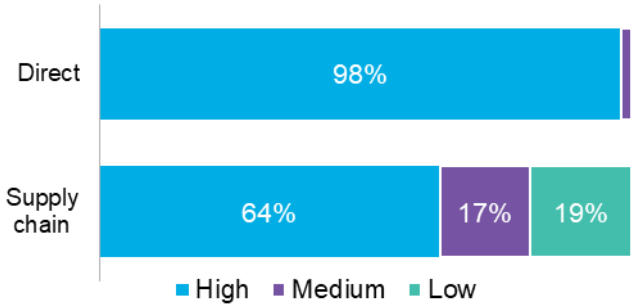
In addition to financial loss and reputational damage, PG&E underwent management upheaval: its longtime CEO stepped aside after the company pleaded guilty to 84 counts of manslaughter. Patti Poppe succeeded interim CEO Bill Johnson, who had guided it through the implementation of the $59 billion reorganization plan. In March 2023, Poppe pledged $18 billion in wildfire prevention through 2025, which includes shoring up PG&E's infrastructure to reduce the risk of sparking lines and restore investor confidence in the utility.

PG&E remains highly exposed to future wildfire risk. Rising temperatures and less frequent rainfall render Northern California more prone to drought, creating the conditions for forest fires to ignite and spread quickly. While moving a portion of its transmission infrastructure underground and requiring more stringent equipment inspections have helped mitigate this risk, the scale of its transmission and distribution network across the state means that wildfires will remain a key consideration in the company's long-term strategy. Nonetheless, its restructuring has played an important role in convincing investors, consumers and regulators that the company is better insulated from nature risk.

Nature risk across electric utilities

The electric utilities sector is one of the most highly dependent on nature, according to the World Economic Forum, with 100% of direct economic value generation and 81% of supply chain value generation being moderately or highly dependent.

Nature dependency of gross value added across electric utilities' direct operations and supply chain



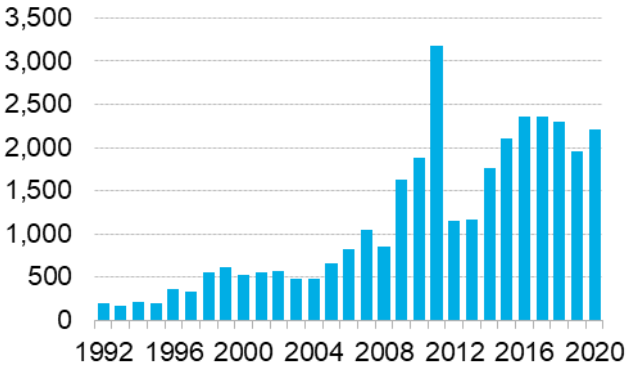
Source: World Economic Forum, BloombergNEF. Note: PG&E is categorized as an electric utility as it is the main part of the company and most relevant to the wildfires.

Global Canopy and UNEP's ENCORE nature tool provides further information on these nature interactions, providing information specific to electric power transmission and distribution, as well as infrastructure holdings. The production processes entailed in these operations are dependent on four ecosystem services, across climate regulation, flood and storm protection, and soil stabilization and erosion control. Flood and storm protection is deemed to be of very high materiality to companies in the sector.

The impacts of electric transmission and distribution on nature are more significant than the dependencies. The ENCORE materiality matrix identifies seven impact drivers of nature loss, which assess the impacts of production processes on ecosystem services and natural capital, that result from the operations of the sector. Of these, water use and pollution, greenhouse gas emissions, and soil pollutants are rated highly or very highly material to nature loss.

The number of wildfires in the US tied to the operations of electric utilities has increased in the last decade. A California state audit found that electrical power caused 10% of all wildfires and was responsible for 20% of the total area burned from 2016 to 2020.

Annual incidences of US wildfires caused by power generation, transmission or distribution



Source: US Forest Service, BloombergNEF.

Carbon dioxide released by wildfires contributes to climate change, in turn making future fires more likely and introducing a new set of climate risks for the utilities sector, including less resilience to natural disasters. An October 2023 article in Nature found that anthropogenic warming has enhanced the expected frequency of extreme daily wildfire growth by 25%, on average, relative to pre-industrial conditions.

To address this issue, California has started a public safety power shutoff (PSPS) program, under which

utilities suspend local electricity services when weather conditions carry a high risk of electrical equipment igniting wildfires. The subsequent outages can leave thousands of customers without power.

Despite observing the financial collapse of PG&E, several other US utilities are facing legal and reputational loss related to wildfires. In June 2023, an Oregon jury found PacifiCorp liable for the 2020 wildfires in the state, which the company is appealing. As of October 2023, Xcel Energy is engaged in court cases from insurance companies seeking to ascribe to it responsibility for wildfires in Colorado in 2021, though Xcel denies liability. According to Wall Street analysts, Hawaiian Electric is facing potential bankruptcy for its possible role in the 2023 Maui wildfires, among the deadliest in US history, after Maui county filed a lawsuit against the utility company in August 2023. Hawaiian Electric denies liability.

For more BNEF analysis, see: *Hawaiian Electric Is Latest Utility Scorched by Wildfires* (web | terminal).

Similar risks and opportunities for electric utilities

Company	Risk type	Description
Hawaiian Electric	Legal and reputational	After Maui fires, HE is facing a financial crisis and litigation over accusations from Maui county that its power lines played a role in igniting fires. It denies liability.
PacifiCorp	Legal and reputational	Embroiled in litigation for failure to shut off power in extreme weather conditions that led to wildfires in Oregon, the company has already paid out almost $100 million to farmers, though it could be liable for $11 billion.
Xcel Energy	Legal and reputational	Facing litigation for its alleged failure to implement a shut-off as conditions worsened in the build-up to Colorado's 2021 wildfires. Xcel denies liability.

Source: BloombergNEF.

Beyond causing wildfires and incurring the resulting liabilities, electric utilities in California are also at risk of sustaining asset damage from wildfires ignited naturally or by human activities other than their own. A 2018 assessment by California's Energy Commission found that between 2000 and 2016, wildfires in California cost utilities more than $700 million in transmission- and distribution-related damage; including data from recent years brings total costs to over $1 billion.

Managing nature risks in the utilities sector

While PG&E's wildfire risk is location-specific, it serves as a prime example of a firm not fully appreciating its impacts and dependencies on the natural world and how those impacts and dependencies inform an understanding of nature-related risks to the business and investors. Better identification, assessment and disclosure of these would have increased awareness and the likelihood of preventive actions being taken.

With growing awareness of potential liabilities facing utility companies, the issue has become far more financially material for stakeholders. Managing risk and by extension ensuring safety, particularly in relation to wildfires, should be a top priority for utilities operating in the western US. To achieve this, the first step is understanding nature dependencies and impacts, achievable through the use of reporting and disclosure frameworks, and the selection of relevant metrics and targets.

Better wildfire prediction would also help the industry. Several startups and companies, including Kettle, Zesty.AI and Cape Analytics are building increasingly accurate modeling tools that harness AI technology. Insurance and reinsurance companies are availing themselves of the nascent services to better manage financial risk. For companies such as PG&E, these offerings could enable improved preparations in the run up to future wildfire outbreaks.

More from BNEF:

Wildfire Victims Draw the Short Straw in PG&E Exit Plan (web | terminal)

Theme: Power Grids Struggle to Cope with Extreme Weather (web | terminal)

Storm-Battered US Power Grids Need Intervention Now (web | terminal)

Tesla's Reliance on Groundwater Hinders Brandenburg Gigafactory Development

Water provision services create nature-related risk across a wide number of industries, some non-obvious. Electric vehicle giant Tesla faced months of delays to its flagship Berlin-Brandenburg 'gigafactory' after environmental campaigners attempted to halt construction over the area's declining groundwater and the water demands of the facility's full-scale production.

Investors interpreted these delays as a threat to Tesla's aggressive expansion plans, worsening falls in the firm's share price and posing questions over the viability of its long-term operations in the region.

$5.7 billion Cost of Brandenburg gigafactory delayed by groundwater concerns

3.1% Decline in company's share price between NGOs' complaint about water licensing and stock market opening

39% Share of gross value added in the direct operations of the automotive sector is moderately nature-dependent

Physical risk

Nature dependency exists when the operations of an organization rely on the presence of an ecosystem service to function. These dependencies can present a physical risk to business operations, manifesting through degradation of nature and the resulting loss of ecosystem services.

Acute risks are short-term events that change the state of nature and are typically location specific.

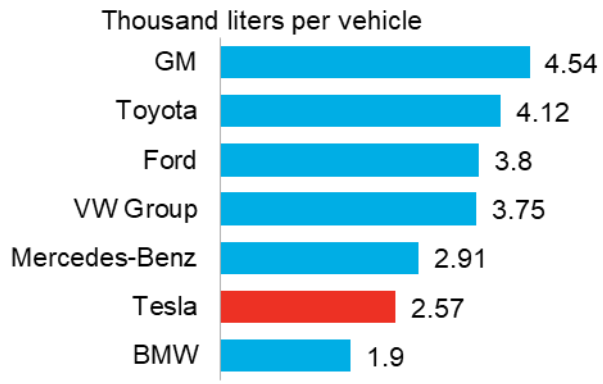
Chronic risks are long-term, incremental changes to the state of nature, with consequences that are not anticipated to recede or revert to prior condition.

Manifestation of nature risk

Multinational automotive and clean energy company Tesla (Nasdaq: TSLA) manufactures and sells electric vehicles, battery energy storage and solar equipment, attaining a $700 billion market capitalization and almost $100 billion revenue in 2023. A key factor in the company's rapid growth has been the speed at which it increased its production capacity, typified by the construction of its first 'gigafactory' in Nevada in 2016, followed by another five in North America, Asia and Europe in subsequent years.

Despite requiring less water withdrawal per vehicle than most of its competitors, Tesla uses an average of over 2,500 liters of water for each car it produces. Much of this is as a paint diluting agent, coolant for production machinery and an input in power-washing equipment. This water is sourced from utilities supplied by surrounding rivers, lakes and groundwater, depending upon local hydrogeological conditions.

Water withdrawal intensity in global vehicle manufacturing



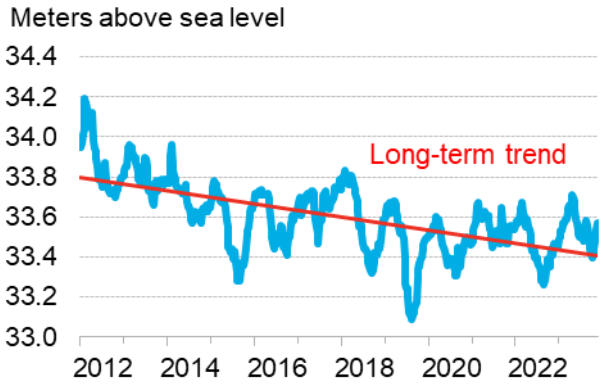
Source: Company reports, BloombergNEF

The company announced plans for the construction of its fourth gigafactory – the Gruenheide facility in Brandenburg, on the outskirts of Berlin, Germany, in November 2019. With initial foundation work beginning in May 2020, production of the firm's Model Y vehicles was widely expected to be underway in late 2021, an extremely rapid timeline.

In August 2021, as reported by Bloomberg News, when Tesla CEO Elon Musk was questioned about whether the facility would deplete the area's water supply, he broke out in laughter, describing the notion as "completely wrong", adding, "It's like water everywhere here. Does this seem like a desert to you? It's ridiculous. It rains a lot."

Groundwater levels in the area surrounding the plant have been declining over the past three decades, exacerbated by climate change, with droughts in 2018, 2019 and 2020. Despite this, the Brandenburg state environment ministry granted a 30-year license to utility Wasserverband Strausberg-Erkner (WSE), to supply 1.4 million cubic meters of groundwater to the Tesla plant annually, roughly doubling the total volume of water extracted from the area.

Groundwater levels declining in area surrounding the Brandenburg plant



Source: BloombergNEF, Germany Ministry for the Environment's Information Platform.

Local environmental groups filed a complaint to the Frankfurt Oder administrative court challenging the license on the grounds that the ministry did not conduct sufficient checks on the impact that the factory's operation would have on groundwater levels, failing to factor in climate change in its estimates. After the court allowed the issue of the license to proceed, WSE released a statement in late March 2022, noting that the overall situation in the area among communities and businesses remains tense and that the new arrangement would lead to full exploitation of existing groundwater reserves, precluding further development.

This poses problems for Tesla's plans to ramp up production at the factory. The facility reached a run rate of 1,000 vehicles per week in June 2022, rising to 5,000 per week in March 2023, equivalent to 250,000 annually, or half of the plant's maximum capacity. The company is now seeking permission to expand further, to one million vehicles at the facility per year, but is again facing opposition from local environmental groups over its water use.

Managing nature risk

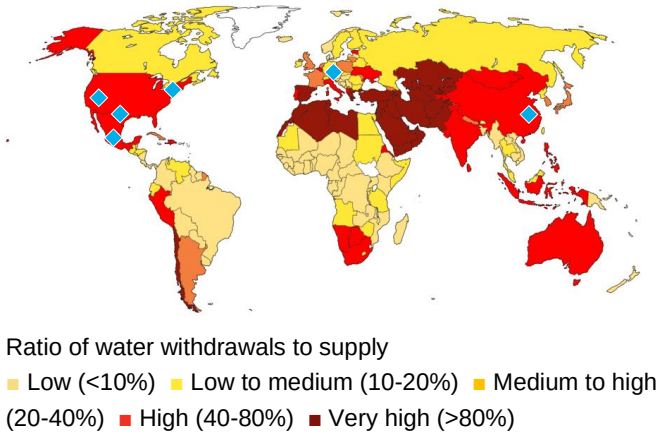
Tesla is well aware of the importance of managing water risk. Its 2022 Impact Report notes that "water is becoming increasingly scarce as the climate changes" and outlines a number of initiatives being taken at its factories. These include water-intensive process optimization and elimination, such as the installation of hybrid cooling towers, removal of quench tanks in casting and introduction of cascade rinsing systems in its paint shop and battery can wash process. It also plans to capture roof runoff in central underground storage, recycle rainwater to cool manufacturing equipment, and capture condensed moisture for use in cooling towers. Tesla estimates that the introduction of these processes at its Texas facility in 2023 will save 320 million gallons of groundwater use annually.

The company does not appear to consider water availability a priority when selecting locations for its facilities. Other factors, including production and tax incentives, skilled labor and market access have taken precedence. Its Nevada, Texas, Berlin and Shanghai facilities are all in (or directly adjacent to) water stressed areas, as will be its sixth gigafactory, currently

under construction in Santa Catarina, Mexico. Among the six, the underutilized Buffalo, New York factory inherited from SolarCity is the only one not proximate to water risk.

Tesla's experience in Germany has shown the need for the company to be more aware of the importance of water availability, even in areas where many (such as its polarizing CEO) may not expect it to be an issue. The World Resources Institute expects water scarcity to become increasingly more severe, raising the water risk that the company's operations are exposed to and requiring more stringent mitigation and adaptation.

Water stress by region in 2040 and location of Tesla gigafactories



Source: World Resources Institute, BloombergNEF.

Financial and reputational impacts on Tesla

After environmental groups filed the licensing complaint on February 21, 2022, the Nasdaq-listed shares of the company fell 3.1% in the hours before trading opened. This was part of a broader 19% decline over the first two months of 2022, though isolating the precise contribution of the complaint is challenging.

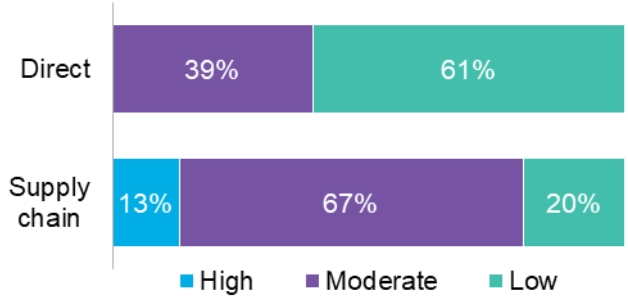
Investors saw the eight-month delay as an obstacle to the company's strategy of rapid expansion, particularly in providing its Model Y SUV to the European market. Bloomberg notes that the primary reason for analysts to raise the company's share price target in early 2022 was optimism over its ability to get its Brandenburg facility operational quickly. If the firm is unable to expand its current operations to its target level due to groundwater concerns, it stands to miss out on up to $36 billion in revenue annually, assuming sufficient demand and a base price of $48,725 for the Model Y.

Neither of these financial impacts present existential threats to Tesla. Rather, the strategic delays have disrupted a longer-term road map for the company and brought minor uncertainty to investors.

Nature risk across the automotive industry

The automotive industry is one of the most globalized, with supply chains covering many countries across material sourcing and assembly. As a whole, it is moderately dependent on nature. According to the World Economic Forum, just under 40% of gross value added in the direct operations of the automotive sector is moderately dependent on nature, though 80% of its supply chain value is highly or moderately reliant.

Nature dependency of gross value added across the automotive sector



Source: World Economic Forum, BloombergNEF.

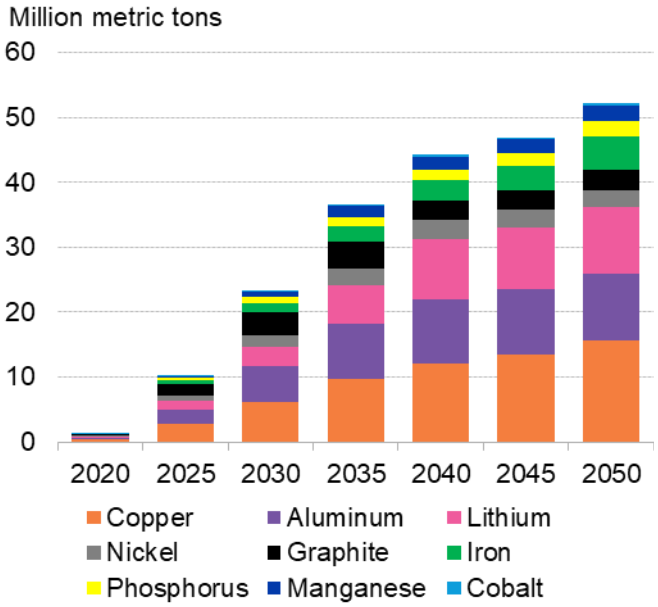
The ENCORE tool offers more specific information, though does not draw a distinction between internal combustion engines and electric vehicles incorporating battery metals. The manufacture of automotive parts and equipment is deemed to be dependent on 11 ecosystem services, with those related to water and water use being the most relevant. The use of ground and surface water as inputs, water flow maintenance, mediation of sensory impacts and flood and storm

protection are of moderate materiality to manufacturers.

Water features prominently in the nature impacts of the sector. The materiality matrix identifies seven impact drivers of nature loss, of which water use, greenhouse gas emissions, water and soil pollutants, and solid waste are each classified as highly or very highly material.

The EV sub-sector will be exposed to more nature-related risks as the energy transition accelerates. Lithium-ion battery manufacture will increase significantly to 2050, following BNEF's Net Zero Scenario and Electric Vehicle Outlook. This will require 29 times more manganese, 26 times more iron and 22 times more lithium than 2022 levels. Evaporitic technology currently used to extract lithium carbonate requires 100 to 800 cubic meters of water per metric ton and brings a suite of other environmental harms. Cobalt mining contaminates soil and water, phosphorous mining impacts landscapes and biodiversity, while nickel extraction is particularly carbon intensive.

Annual metals demand from lithium-ion batteries under BNEF's Net Zero Scenario



Source: BloombergNEF. Note: Lithium is expressed in million metric tons lithium carbonate equivalent.

The situation faced by Tesla in Brandenburg is not unique. Climate change and the increasing frequency of droughts have exposed more companies to water risk in recent years. Volkswagen, Toyota and Tesla were affected by a 2022 drought in China after depleted reservoirs used for hydropower led to power shortages, while falling water levels in the Rhine river led to supply chain disruptions for many companies in the same year. Examples of water related risks across three other sectors are presented in the following table:

Droughts have created water-related risks for other companies in various sectors

Company	Sector	Description
TSMC	Technology	In Taiwan, persistent droughts in 2021 led the government to further tighten restrictions on water supply, putting the output of the world's biggest contract chipmaker at risk.
Cargill	Food and agriculture	Prolonged droughts across the US in 2013 reduced crop yields and added costs to meat processing operations for the world's biggest agricultural trader by volume, reducing quarterly revenue 42%.
Uniper SE	Energy	The utility company warned that droughts in Germany in August 2022 would require it to cut production at two key coal-fired power plants, as depleted Rhine river levels hindered transport of fuel supplies.

Source: BloombergNEF

More from BNEF:

Electric Vehicle Outlook 2023 (web)

2023 Lithium-Ion Battery Price Survey (web | terminal)

Theme: EVs Are on Their Way to Price Parity With Gas Cars (web)

Appendix A. Glossary of terms

The definitions used throughout this report align with those used by the TNFD and are drawn from a range of organizations

Table 2: Glossary of nature-related terms

Term	Definition	Source
Biodiversity	The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.	Convention on Biological Diversity
Climatological	Relating to the atmosphere and weather patterns over a time period, focused on the natural and artificial forces that influence long-term weather patterns. In the context of natural disasters, climatological phenomena cover drought, glacial lake outburst flood and wildfire.	World Bank
Ecosystem	A dynamic complex of plant, animal and microorganism communities and the non-living environment, interacting as a functional unit.	CBD, IPBES
Ecosystem service	The contributions of ecosystems to the benefits that are used in economic and other human activity.	UN
Geophysical	Referring to physical processes and properties of the Earth, particularly its composition. Geophysical phenomena in this report include earthquakes and volcanic activity.	IPCC
Hydrological	Relating to the hydrologic system – Earth's closed water system, including land and terrestrial ecosystems, evaporation, precipitation, transpiration, among others. Hydrological phenomena in this report refer to floods.	National Oceanic and Atmospheric Administration
Meteorological	Relating to weather. In this report, meteorological phenomena are short-term events that occur in the troposphere and stratosphere, including extreme temperatures, fog, and storms.	European Environment Agency
Natural Capital	The stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.	Capitals Coalition
Nature	The natural world, with an emphasis on the diversity of living organisms (including people) and their interactions among themselves and with their environment.	IPBES
Risk	Risk refers to consequences for human or ecological systems. It is not used as a substitute for probability or chance, nor is it a generic term for something bad.	IPCC

Source: BloombergNEF, TNFD.

Appendix B. Ecosystem services

Defined as the contributions of ecosystems to the benefits that are used in economic or other human activity. The four groups of ecosystem services are:

- Provisioning services: Material benefits obtained from nature, including food, raw materials, freshwater and medicines.
- Regulating services: Maintenance of biosphere integrity resulting from the functioning of ecological processes, providing stability and allowing other flows of value to continue. Examples include regulation of air, water and soil quality, carbon sequestration and storage, pollination, moderation of extreme natural events, and erosion prevention.
- Supporting services: Ecosystem services that provide habitats or maintain diversity of life, influencing survival and covering living spaces for species and genetic diversity.
- Cultural services: Non-material benefits that people obtain from ecosystems, including recreation and mental health, aesthetic appreciation and tourism.

Appendix C. Further information on the types of nature risk

Physical risks

Physical nature-related risks arise due to a decline in the state of nature disrupting the ecosystem services on which a firm's operations depend. They are classed as either acute or chronic, broadly referring to short- and long-term nature-related events:

- Acute risks are short-term events that change the state of nature and are typically location specific, such as wildfires destroying infrastructure, crop diseases affecting harvest yield, or oil spills reducing ocean fish stocks.
- Chronic risks are long-term, incremental changes to the state of nature, with consequences that are not anticipated to recede or revert to their prior condition. Examples include climate change and ocean acidification.

In some instances, isolating the precise form of physical risk becomes arbitrary. While a short-term drought is clearly an acute risk, it can progressively mutate into a chronic risk without any substantive change to its characteristics. In this way, a long-term drought can be seen as having attributes of both acute and chronic risk. Likewise, an oil spill initially presents acute risk to the operations of nearby fisheries, though its more persistent effects can also be considered chronic.

Both acute and chronic nature-risk are becoming more severe due to the underlying decline in natural systems. This is well established. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) notes in its most recent global assessment report that the current rate of nature decline is unprecedented. Natural ecosystems have declined by 47% on average, relative to their earliest estimated states, while approximately 25% of species are threatened with extinction, and the abundance of naturally present terrestrial species has fallen by 23% since prehistory. BNEF clients can access further analysis on nature loss in the *Biodiversity Finance Factbook: COP28 Edition*.

There are varying degrees of dependency on nature, rendering ecosystem services of low, moderate or high *materiality* to the company (see box below). The extent of materiality is derived from the scale and scope of a firm's interactions with nature, the resilience of the associated ecosystem, and risk mitigation efforts employed by the firm.

Dependencies occur both in companies' direct operations and supply chains – risk upstream can propagate downstream through second-order dependencies. For example, steel producers use substantial volumes of water for cooling in the steel production process. Depletion or degradation of the water sources on which they rely would put continued operations at risk and open the sector to financial loss. Downstream companies that use steel as an input would likewise face risk as their supply chain is disrupted. Financial institutions also have indirect dependencies on ecosystem services, as their business model is predicated on engagement with companies that interact, in some form, with nature.

Materiality

Materiality refers to the importance of some factor when making a decision. In accounting and finance, it is the importance of an event or information influencing a company's valuation, the omission of which in a financial statement could mislead investors or other stakeholders. Given that exposure to nature risk has financial implications for the firm, it follows that investors ought to be apprised of this information.

Single materiality is conventionally used in accounting. For nature, it captures only how firm valuation can be affected by changes in the ecosystem services that production depends on. For example, in the case of a large-scale horticulture producer highly reliant on water, investor decisions are likely to be influenced by changes related to this dependency. If local ground and surface water are expected to be significantly depleted or degraded, the firm's future earnings and valuation will be affected, and this should be made known to financially involved stakeholders

Double materiality also includes the impacts of the firm on nature. While single materiality refers to "outside-in" effects, i.e., how changes external to the firm affect its valuation, double materiality is also "inside-out", capturing how production processes change the state of nature. Continuing the horticulture example above, if pesticide run-off from farming operations pollutes nearby watercourses, causing eutrophication and harming wildlife, this information should also be disclosed, lest potential financial penalties or regulatory tightening impact cashflow.

Costs of physical risk

There are three types of loss associated with physical nature risk, covering both direct and indirect costs to the firm. While short-term asset damage and economic costs are significant, research on climate risk indicates that the longer-term impairment from lost productivity and stalled economic growth can be up to six times as much.

Acute physical risks tend to affect firms directly, particularly in the form of asset damage, and are inherently easier to calculate. Chronic risk manifests more insidiously, stymying productivity and hitting supply chains.

Table 3: Types of losses from acute and chronic physical nature risks

Type of loss	Impact of physical nature risk	Examples
Asset damage	Destruction of physical asset	Farmland destroyed by wildfires
Productivity loss	Output loss from nature	Decline of pollinators reduces crop yield
	Supply chain disruptions	Droughts create shipping bottlenecks
Economic costs	Cost of remediation and clean up	$16B to rebuild after 2022 Pakistan floods
	Price surge of suppliers	Water scarcity increases input prices
	Losses borne by other sectors	Alien species impact water security

■ Direct costs ■ Indirect costs

Source: BloombergNEF

Transition risk

Nature-related transition risk comprises four subcategories:

- Policy and legal risks: Changes in policy, regulation or legal precedent constrain the operations of firms whose production processes impact nature, incurring costs either through legal challenges or the imposition of penalties. For example, more stringent environmental impact assessments (EIAs) add costs and limit the scope of potential future offshore wind developments, or a government's environment agency introduces more stringent standards for chemical companies extracting surface water close to production facilities.
- Market risks: Movements in market prices, particularly in financial markets, create losses for companies. For example, uncertainty over impacts of an emerging zoonotic disease can suppress demand for a company's products, or stock markets can react negatively to a firm's environmental impacts, reducing its valuation.
- Technology risks: Technological developments enable consumers to purchase new products with lower nature impacts than their current choices, curtailing demand for the incumbent product. Biodegradable packaging offers an alternative to single-use plastics and lab-grown meat could offer a source of protein with fewer nature impacts than cattle.
- Reputational risks: Consumer perception of companies and products with a (reputed) high nature impact can suppress demand and brand value. For example, a campaign against unsustainably sourced palm oil by a cosmetics brand leads consumers to competitors using coconut oil in lieu of palm.

Estimating which sector is exposed to transition risk requires analysis of nature impacts. The 2019 IPBES global assessment report identifies five drivers of nature loss, accounting for over 90% of nature's decline relative to pre-industrial levels: land and ocean use change, resource exploitation, climate change, pollution and invasive alien species. The industries and commodities which underpin these drivers are shown in Table 4. It follows that companies operating within these sectors are more likely to have higher exposure to nature-related transition risks, as they are the most vulnerable to shifting regulation and customer preferences.

Table 4: Drivers of nature loss

Pressure	Industries	Commodities or services	Nature loss contribution %
Changes in land and sea use and conversion of natural habitats to other uses	Agriculture, forestry, fishing, mining, energy	Beef, palm oil, soy, timber, rubber, pulp	30%
Resource exploitation Extraction of living and non-living material from nature	Agriculture, materials, energy, fishing, forestry	Crops, beef, timber, seafood, coal, oil, gas	23%
Climate change Long-term alteration of temperature of weather patterns	Energy, materials, agriculture, transportation	Coal, oil, gas, beef	14%
Pollution Introduction of harmful substances into the environment	Agriculture, industry, transportation, energy, metals	Crops, packaging, textiles	14%
Invasive alien species Introduction of species without natural competitors to new ecosystems	Trade, tourism, agriculture, forestry, aquaculture	Shipping, aviation, tourism, exotic species	11%

Source: BloombergNEF, IPBES.

Systemic risks

Systemic risks arise from the breakdown of entire systems, rather than declines in their component parts. While their causes can be multifaceted, stemming from issues with supply chains, infrastructure, climate change, economics or politics, they are generally characterized by tipping points, where one loss triggers a chain of others, preventing the system returning to its equilibrium. Two categories of systemic risk exist for nature, in line with the approach of the TNFD and others:

- Ecosystem stability risk: Destabilization of a key natural system, such that it is no longer able to provide ecosystem services as before. Examples include global collapse of pollinators or desertification across entire previously fertile regions.
- Financial stability risk: Collapse of an entire financial system prevents basic economic activities, such as lending or insurance to function as normal.

Each of these systemic risks can manifest from the build-up of individual physical or transition risks, passing a threshold and growing to affect entire systems. While this form of risk cannot be prevented by individual companies, it is nonetheless necessary to factor into long-term strategic planning to minimize negative financial impacts. Such calculations are commonly undertaken by insurance providers and credit risk analysts at financial institutions. Systemic risk is unpredictable, and can result from different interactions between business and nature – both complex systems. This form of risk is slow to materialize and has not yet had evident, verifiable financial impacts on companies.

Further information on nature-related risks and the relationship to impacts, dependencies and opportunities can be found in the conceptual foundations section of the Recommendations of the TNFD. BNEF clients can access further research on nature reporting, markets and finance here: web | terminal.

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