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Biodiversity

Costing the Earth: measuring corporations' impact on biodiversity

MISTRA FinBio

About this paper

This paper has been produced in collaboration with researchers at the MISTRA Finance to Revive Biodiversity (FinBio) programme. Pictet Asset Management, as a founding partner to the FinBio project, is providing investment expertise and contributing to research that can help bring about nature-positive changes in the financial system. For more details, please see Appendix.

Contributors

STEVE FREEDMAN
Head of Research and Sustainability, Thematic Equities, Pictet Asset Management

GABRIEL MICHELI
Senior Investment Manager, Thematic Equities, Pictet Asset Management

VIKTORAS KULIONIS
Investment Manager & Senior Environmental Economist, Thematic Equities, Pictet Asset Management

PROF BEATRICE CRONA
Science Director at the Stockholm Resilience Centre, Senior Scientific Advisor to MISTRA Finance to revive Biodiversity programme

GIORGIO PARLATO
Researcher, Royal Swedish Academy of Sciences

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship

Stockholm University

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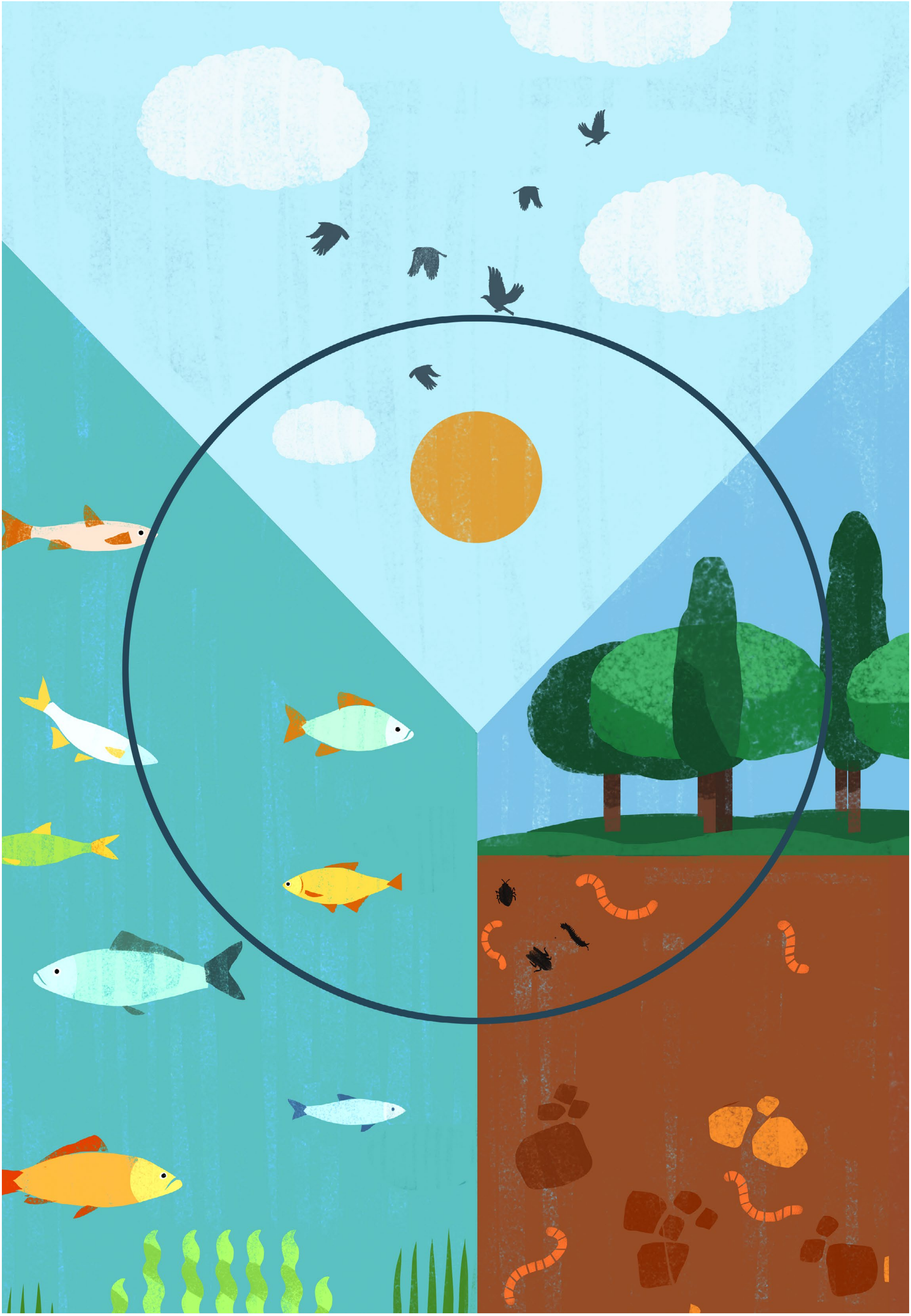


Foreword

The world can't afford to lose any more of its natural capital.

In its first serious attempt to analyse the economic impact of dwindling ecosystems, the European Central Bank estimates that more than 70 per cent of euro zone companies and three quarters of all bank loans are exposed to biodiversity loss.[1]

The World Bank, meanwhile, finds that by as soon as 2030, further ecological degradation could cost the economy almost USD3 trillion per year in lost output.[2]

Financial markets are beginning to discount such risks, too. Research conducted in both the US and Europe has uncovered the existence of a "biodiversity risk premium" in bonds, stocks and derivatives.

In other words, evidence shows that the companies most dependent on natural resources – whether that's the plants used to develop medicines or the insect pollination essential for agriculture – face the prospect of higher capital costs.

Yet even these evaluations are unlikely to reflect the economy's true vulnerability to the degradation of the natural world.

Biodiversity systems are fiendishly complex. They can shift suddenly from one equilibrium to another, crossing tipping points with devastating consequences.

The business world's singular focus on reducing carbon emissions threatens to make matters worse. Some well-intentioned net zero efforts risk speeding up biodiversity loss. If solar and wind farms are situated in the wrong locations, they could cause irreparable harm to natural habitats and, in turn, adversely affect weather patterns.

1 "The economy and banks need nature to survive" https://www.ecb.europa.eu/press/blog/date/2023/html/ecb.blog230608~5cffb7c349.en.html

2 https://openknowledge.worldbank.org/server/api/core/bitstreams/9f0d9a3a-83ca-5c96-bd59-9b16f4e936d8/content

3 Tanner, K., Moore-O' Leary, K, Parker, I, Pavlik, B., Haji, S., Hernandez, R, 'Microhabitats associated with solar energy development alter demography of two desert annuals', Ecological Applications 31(6):e02349. 10.1002/eap.2349

Take the building of utility-scale solar farms in California's Mojave Desert. This once rich ecosystem – home to a wide variety of flora and fauna – is fast becoming a lifeless wasteland.[3]

The upshot of all this is that sustainable investment will inevitably demand a more extensive approach.

Portfolios with environmental objectives will need to look beyond carbon emissions data and take into account the complex interactions between the Earth's natural systems.

Doing so won't be straightforward. The tools currently available to assess and monitor such risks – all of which have the potential to affect investment returns – are not advanced enough.

This is where the research undertaken by scientists in the MISTRA Finance to Revive Biodiversity Programme – of which Pictet Asset Management is a founding partner – could provide some useful guidance (see Appendix).

The team has devised a prototype biodiversity loss measurement tool – the Earth System Impact (ESI) model – that seeks to give a far broader assessment of environmental impacts. While still in development, the framework can be applied to the activities of industries and individual companies wherever they are located.

This paper describes the mechanics of the ESI tool and also demonstrates how it can be deployed to analyse the biodiversity impact of the mining industry – a sector that has a pivotal role to play in the green transition.

The final section of this report discusses the ways in which Pictet Asset Management will seek to draw on the insights from the ESI tool to augment its own biodiversity risk models.

Analysing the economic and financial effects of biodiversity loss is a time-consuming and costly exercise. But it is an essential one too. Without self-sustaining natural capital, the world's future economic development is at serious risk.

STEVE FREEDMAN
Head of Research
and Sustainability,
Thematic Equities

CHAPTER 1

Prologue: financial markets are beginning to discount biodiversity risk

Biodiversity loss has long concerned scientists and conservationists. But new research shows it has now started to become a material financial risk for listed companies and their investors.

Several studies published this year have found that biodiversity-related risks are beginning to affect company valuations and their financing costs.

One study, published by the Swiss Finance Institute, showed that the risk premium investors demand from stocks of companies with larger biodiversity footprints has risen in the past two years.[4]

Based on an analysis of share returns for more than 2,000 firms from 32 countries, the researchers found that stocks experienced an additional monthly rise in risk premium of 23 basis points, or an annualised increase of 2.8 per cent, for a one-standard deviation increase in the value of their corporate biodiversity footprint.[5]

Companies with the largest negative impact on biodiversity were those operating in industries such as retail and wholesale, paper and forestry, and food.

Among the sectors with the smallest footprints were leisure, services and education.

Tellingly, the increase in the premium occurred around the time of the Kunming biodiversity summit in October 2021, which was the initial part of the COP15. While the final agreement on a Global Biodiversity Framework (GBF) was reached later in Montreal in December 2022, the Kunming meeting is considered to have laid the groundwork and contributed to increasing both investor awareness about the loss of biodiversity and the prospect of future intervention by authorities.

"Our findings suggest that investors anticipate that new regulations will target business activities whose biodiversity footprint is large. As a result of the associated policy uncertainty, a biodiversity footprint premium starts to emerge," the study reads.

"We confirm (previous research papers) that ESG risks are increasingly getting priced, and demonstrate this for what is now, next to climate change, the focal ESG topic among institutional investors."

The GBF includes a target that requires large companies and financial institutions to monitor and disclose their impact on biodiversity, as well as the risks they face from biodiversity loss.[6]

4 Garel, A. et al, Do Investors Care About Biodiversity? (May 26, 2023). Swiss Finance Institute Research Paper No. 23-24, European Corporate Governance Institute – Finance Working Paper No. 905/2023 https://ssrn.com/abstract=4398110

5 The biodiversity footprint was calculated using a metric based on a species-based indicator of biodiversity intactness.

6 https://www.cbd.int/article/cop15-cbd-press-release-final-19dec2022

These requirements will apply across the entirety of a business' value chain. For financial institutions, the provisions will extend to portfolio investments.[7]

The Europe-based researchers also found that companies with large biodiversity footprints experienced a cumulative stock price decline of 1.18 per cent relative to small-footprint stocks in the three days following the Kunming meeting, compared with the three days before (see FIGURE 1).

Emergence of a risk premium

Other research suggests the biodiversity risk premium may have existed as far back as 2010.

A working paper published by the National Bureau of Economic Research analysed financial statements and corporate annual reports from 2010 to 2020. It found that companies that were more exposed to biodiversity risk saw their stock prices underperform compared with others when biodiversity risk increased.[8]

To determine the extent to which biodiversity risks were being incorporated into equity prices, researchers performed a two-part study.

First, they constructed a news-based measure of biodiversity risk using a natural language processing model.

They then built model equity portfolios along sector lines, grouping them according to what the researchers judged as their exposure to biodiversity risk.

The model portfolios featured long positions in industries with low biodiversity risk exposure – such as semiconductor, software and communication services – and short positions in industries with high biodiversity risk exposures – including energy, utilities and real estate.

Researchers assumed that if biodiversity risk is priced, the return on these portfolios should move together with their aggregate biodiversity news index, effectively behaving like a hedge for biodiversity risk.

The correlations between the return of this hedging portfolio and the biodiversity risk index were positive at up to 0.2 – a link researchers said was comparable to those obtained by climate hedging portfolios when evaluated against aggregate climate news , as well as to the hedging performance of portfolios built to hedge other macro risks such as consumption or GDP. This reflects the fact that biodiversity is becoming as important a risk factor as climate change.

7 For more, please read our related article: https://am.pictet/en/globalwebsite/global-articles/2023/expertise/thematic-equities/cop15-and-investors.

8 Giglio, S. et al, Biodiversity Risk (April 4, 2023). https://www.nber.org/papers/w31137

Biodiversity premium: case study

These aggregate results can be illustrated with a few representative examples. Keep in mind that when considering individual company cases, other factors may well have been at work in explaining performance during the selected period. This is why statistical results across a multitude of companies constitute a more powerful evidential basis. Nonetheless, individual cases can serve as illustration.

The selected companies were chosen from the Nature Action 100 list. The list is made up of companies which the Finance for Biodiversity Foundation think are deemed to have a "high potential impact on nature", i.e. a high biodiversity footprint.

We consider three such companies: Nutrien (agricultural chemicals), Rio Tinto (mining), and McDonald's (fast food restaurants). We look at the time before and after October 13, 2021, the pivotal date at the Kunming biodiversity summit. One version considers each stocks excess return over the period from October 11 to October 15 (once over the relevant local stock market, once over the global market as captured by the MSCI All countries world index). The second treatment considers the excess return during the month following October 13 (from October 13 to November 13) and compares it to the excess return during the month before October 13 (from September 13 to October 12). Here too, the results are provided both in excess of the local and global equity benchmarks.

FIGURE 1
Relative performance of selected companies around Kunming biodiversity summit

	EXCESS RETURN Oct 11 to 15, 2021		EXCESS RETURN DIFFERENCE (month after - month before Oct 13, 2021)	
	Excess return over local index	Excess return over global index	Excess return over local index	Excess return over global index
Nutrien Ltd	-2.9%	-2.5%	-26.3%	-24.9%
Rio Tinto Plc	-2.4%	-3.5%	-3.9%	-10.5%
McDonald's Corp	-4.5%	-4.0%	-7.9%	-6.5%

Source: Pictet Asset Management

In all three cases, we find a clear underperformance vs both benchmarks during the short time window around October 13. In addition, in all three cases we find a clear shift in excess performance behaviour for the worst between the month that preceded the pivotal date and the month thereafter.

While these case studies provide anecdotal examples, the systematic analysis in Garel et al. (2023) indicates that this effect is noticeable across a large universe of companies.

Negative return expectations

A separate group of researchers in France examined companies in industries with a large biodiversity footprint. They found that investors require higher compensation for holding biodiversity-impacting firms (see FIGURE 2).

These researchers from Emlyon Business School and the Center for Research in Economics and Statistics, found a "negative and significant" impact on their expected stock returns, or the expected average return from stocks computed from option prices.[9]

"These results demonstrate that, similarly to carbon risk, markets anticipate that biodiversity will become a major risk factor in the years to come, in particular for companies that rely the most on nature-based exploitation," reads the study.

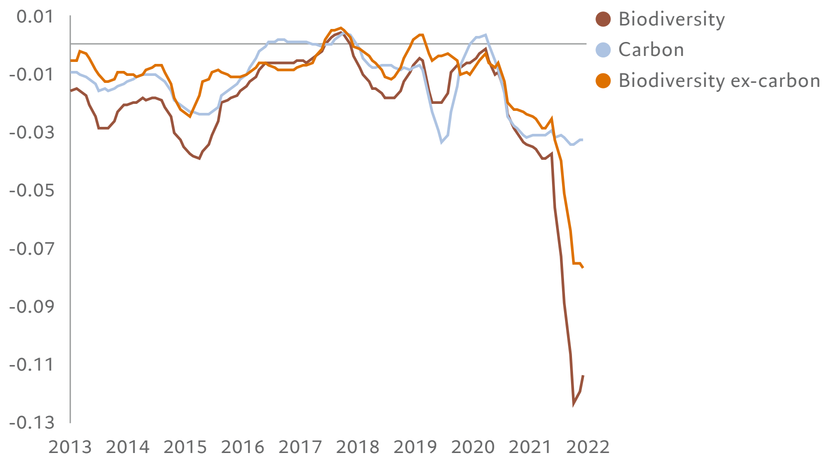
Premium in bond markets

Another study showed the emergence of biodiversity risk in fixed income markets.

FIGURE 2

Expected returns by factor

Impact of carbon and biodiversity-based risk factors on expected returns of companies with large biodiversity footprint (% annualised)



Source: Coqueret and Giroux. Detailed methodology is available Coqueret, Guillaume and Giroux, Thomas, A Closer Look at the Biodiversity Premium (July 21, 2023). Available at SSRN: https://ssrn.com/abstract=4489550

9 Coqueret, G. and Giroux, T., A Closer Look at the Biodiversity Premium (July 21, 2023). https://ssrn.com/abstract=4489550

Researchers from Ireland, France and Switzerland compared the Credit Default Swaps (CDS), or the cost of insuring debt against default, for a term between one and 10 years.[10]

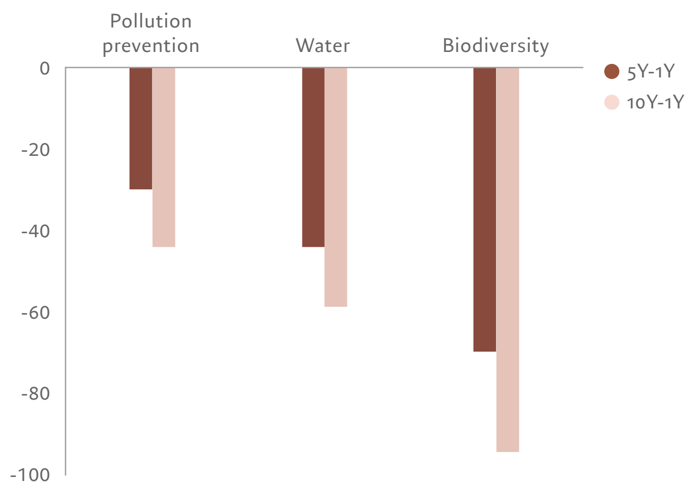
The study focused on the infrastructure industry, which is responsible for nearly 90 per cent of all climate adaptation costs. It is a sector crucial in tackling the triple planetary crisis of climate, biodiversity loss and pollution.[11]

They found that companies that manage biodiversity risks had up to 93 basis points better relative long-term financing conditions those that do not (see FIGURE 3).

What is more, the results show the difference was greater over longer lending periods – the slope showing one to 10 years was steeper than that for one to five years. The CDS curve, the researchers concluded, indicates that investors perceive those risks as long-term issues.

Researchers said legislation that already internalises clean-up costs for companies when they pollute on- or off-site, such as the US Clean Air Act, could be one of the reasons for this phenomenon.

FIGURE 3
Flatter curve
Scale of negative effects on CDS slopes from three environmental variables



Source: Based on monthly regression results from a sample period between December 2007 to January 2018. Source: Hoepner, A. et al

10 Hoepner, A. et al, Beyond Climate: The Impact of Biodiversity, Water, and Pollution on the CDS Term Structure (February 8, 2023). Swiss Finance Institute Research Paper No. 23-10, Michael J. Brennan Irish Finance Working Paper Series Research Paper No. 23-4 https://ssrn.com/abstract=4351633

11 https://www.unep.org/resources/report/infrastructure-climate-action

“To protect endangered species or preserve natural habitats, laws that, e.g., forbid building roads or rails in protected areas, could lead to high additional costs for firms operating in this business,” the study reads.

"BIODIVERSITY RISKS WILL BECOME A MAJOR TOPIC FOR DEBATE ACROSS CORPORATE BOARDROOMS WORLDWIDE."

Biodiversity: not business as usual

The biodiversity risk pricing mechanism is a complex phenomenon that will evolve over time. But this doesn’t mean businesses and investors can afford to disregard biodiversity loss as a risk factor. Research suggest that it has already started becoming a material financial variable. It is likely to increasingly affect the way firms conduct their business and how investors allocate their capital.

Furthermore, the Taskforce for Nature-Related Financial Disclosures (TNFD), an industry body representing financial institutions and companies with assets of over USD20 trillion, has just launched a set of 14 disclosure recommendations aligned with the GBF, and more regulatory changes are sure to follow.

All of this means biodiversity risks will become an increasingly major topic for debate across corporate boardrooms worldwide.

Rapidly developing policy scene

International agreements that were decades in the making are now falling into place. Halting the degradation of nature has become an urgent environmental issue for policymakers.

This cohesion comes eight years after nearly 200 countries agreed in Paris to limit global warming in a sweeping deal that would align finance flows and investment portfolios with climate objectives.[12]

The Montreal agreement of December 2022 is poised to have the same transformative effect on biodiversity, encouraging businesses to accelerate efforts to protect biodiversity, and investors to incorporate biodiversity risks when allocating their capital.

FIGURE 4
List of international agreements

AGREEMENTS	GOAL
Paris Accord on Climate Change (2015)	Limit the rise in mean global temperatures to 1.5°C above pre-industrial levels
The Global Biodiversity Framework (2022, Montreal)	Halt biodiversity loss by 2030 and achieve recovery and restoration by 2050
UN High Seas Treaty (2023, New York)	Protect marine biodiversity and places responsibility on polluters to bear the cost of their pollution
Expected: UN Plastics Treaty (2024, Paris)	Eliminate plastic waste by addressing sources of pollution along the lifecycle – from production to disposal

Source: United Nations

12 https://www.bis.org/publ/bppdf/bispap130.pdf

CHAPTER 2

Assessing biodiversity loss: the Earth System Impact tool

Measuring biodiversity loss accurately is a monumental task. Much of the planet's biological diversity remains "dark matter" – it is poorly understood and unclassified.

So even if a growing number of investors recognise that biodiversity loss is a financial risk – as shown by several studies published this year (see CHAPTER 1) – the tools that currently exist to analyse the erosion of natural capital are deficient.

Such shortcomings do not, however, reflect a lack of effort on the part of the scientific and business community.

The Taskforce for Nature-related Financial Disclosures (TNFD) lists at least 100 data tools designed to measure biodiversity loss.

As FIGURE 5 shows, various measurement approaches exist. All of them apply land use change as their primary frame of reference, while some also look to extend the analysis of corporate biodiversity impacts to different parts of a product's value chain.

FIGURE 5

Overview of selected measurement approaches

	THE BIODIVERSITY FOOTPRINT FOR FINANCIAL INSTITUTIONS (BFFI)	CORPORATE BIODIVERSITY FOOTPRINT (CBF)	EXPLORING NATURAL CAPITAL OPPORTUNITIES, RISKS AND EXPOSURE (ENCORE)
Description of the approach	Provides an overall biodiversity footprint of investment within a portfolio	Measures the impact of corporates on biodiversity	Provides information mainly on dependencies – or how much a company's activity depends on ecosystem services
Developed by	CREM, PRé Sustainability, ASN Bank	Iceberg Datalab	Global Canopy, UN Environment Programme Finance Initiative (UNEP), UNEP-World Conservation Monitoring Centre
Focus area of the approach	Balance sheet, portfolio, index level, company, project/site level	Balance sheet, portfolio, sector, index level, company, project/site level	Portfolio, sector, company, project/site level
Asset category	Listed equity, private equity, corporate bonds, sovereign bonds, mortgages and real estate	Listed equity, private equity, corporate bonds, sovereign bonds, mortgages and real estate	Listed equity, corporate bonds
Biodiversity metric*	PDF	MSA	MSA, STAR
Environmental pressure covered	Land use change, direct exploitation (partial), climate change, pollution	Land use change, direct exploitation (partial), climate change, pollution	Land use change, sea use change, direct exploitation, climate change, pollution, invasive species
Boundaries of what's included	Scope 1, Scope 2, Scope 3 upstream	Scope 1, Scope 2, Scope 3 upstream, Scope 3 downstream	Scope 1, Scope 2
Strengths	• Open access • Covers most drivers for biodiversity loss	• Covers impact throughout value chain	• Open access • Regarded as the most established dependencies assessment tool
Weaknesses	• Sector average data needs to improve • Land use-related impacts are less accurate for tropical regions • Location-specific characteristics are limited	• Licensed • Water use not included • Granularity within sector is limited	• Does not cover impact well • Beyond initial screening, spatially explicit and company-specific assessments are needed for location-specific dependencies assessment

Source: EU Business @ Biodiversity, Finance for Biodiversity Foundation, Pictet Asset Management

* Means Species Abundance (MSA) is an indicator of biodiversity intactness. Potentially Disappeared Fraction of species (PDF) indicates the potential loss of species due to a pressure and often used in the Life Cycle Assessment. Species Threat Abatement and Restoration metric (STAR) quantifies the threats driving species extinction risk.

Measuring impact at Earth level

While many of these frameworks are still in development, a common shortcoming is that they all fail to account for the interactions between the biosphere and atmosphere – a delicate relationship that is essential to planetary health. The effects of climate change, for instance, manifest themselves in several different ways and across several dimensions.

Climate change negatively affects ecosystems by reducing their capacity to take up carbon; it can also lead to changes in rainfall patterns. This, in turn, affects vegetation and its ability to absorb carbon. Research from the Stockholm Resilience Centre shows this feedback loop alone will add an extra 0.4C to the world's temperature by 2100.[13]

In an effort to account for these complexities, scientists at the Royal Academy of Sciences in Sweden – part of the MISTRA Finance to Revive Biodiversity (FinBio) research programme – have developed a new metric that they believe could serve as a better way to gauge the corporate impact on biodiversity.[14]

Known as Earth System Impact (ESI) the measurement tool breaks new ground in several ways. First, it adopts a multi-dimensional view of biodiversity, analysing how changes in land use, water withdrawal and carbon emissions – collectively known in scientific circles as Earth Systems – affect planetary health.

Second, it decomposes these nature-related impacts by region and vegetation type. This is critical because environmental impact is to a great extent determined by the topography of the areas where economic activities take place.

For example, clearing a plot of land in the Amazon, which stores a large amount of carbon, would have a greater environmental impact than doing the same in the grasslands of southeast Australia. Similarly, using water in certain dry areas of North America will disturb the environment more than water withdrawal in the Asian tropical forest.

Third, the model takes into account the complex interactions between climate, water and land, and how changes in one can have knock-on effects on another. For example, the clearing of a forested area for agriculture not only constitutes a change in land use but it can also have a strong bearing on water run-off.

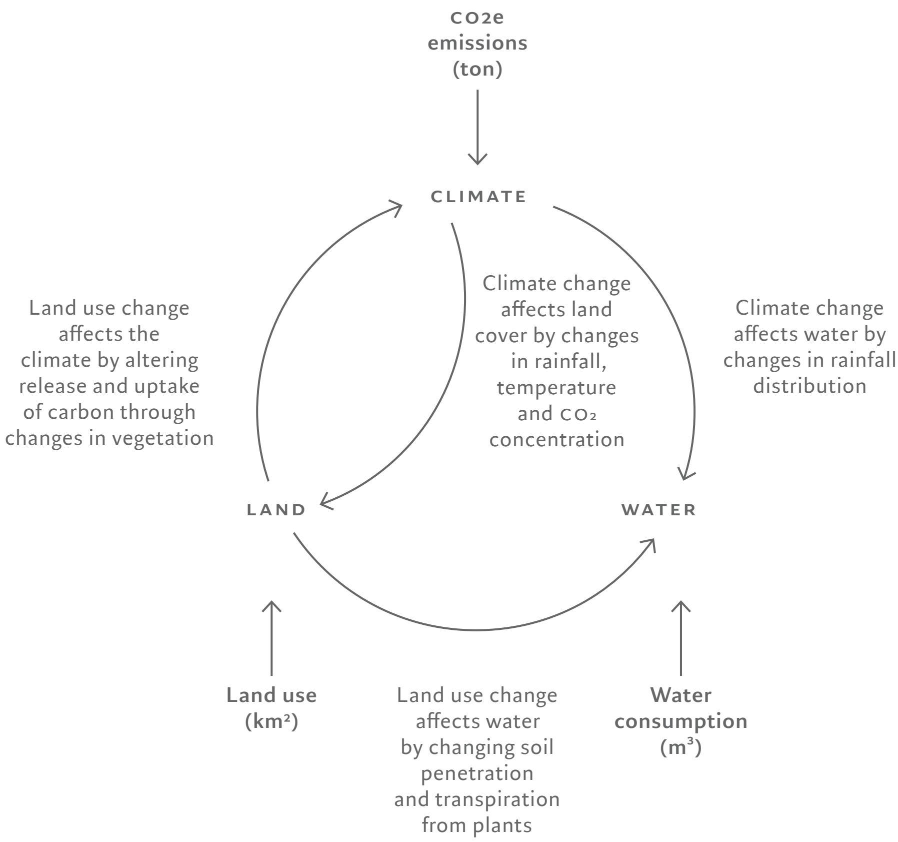
13 Lade., SJ et al. (2019), Potential feedbacks between loss of biosphere integrity and climate change. Global Sustainability, 2, E21. doi:10.1017/sus.2019.18

14 https://doi.org/10.1016/j.jclepro.2023.139523

In analysing how the three systems interact, the model also seeks to capture the strength of those relationships. To that end, it computes "amplification effects" that estimate, say, the extent to which a change in land use in a particular locality will also impact water availability in the same area and climate on a global scale.

What is more, it takes into account the current state of Earth Systems, using the Planetary Boundaries framework as a scientific reference point.[15] This allows users to capture to what extent their activities disrupt the environment in the context of scientific limits as established by the Planetary Boundaries. For example, activities or facilities in already degraded regions will see their ESI score penalised.

FIGURE 6
Earth System interactions asessed by the ESI prototype score



Source: Crona, B. et al (2023)

15 Planetary Boundaries is a globally recognised sustainability framework developed in 2009, that defines the environmental thresholds within which humanity can prosper. For more details, please read: https://am.pictet/en/uk/global-articles/2020/expertise/thematic-equities/planetary-boundaries-and-environmental-footprint-of-businesses

ESI step-by-step

Researchers used the following steps to capture Earth System interactions (Step 1–4):

1. The strength of interaction between climate, land and water are assessed using the dynamic global vegetation model (LPJmL).[16] Interactions (changes in climate affecting water runoff, changes in climate affecting vegetation cover; changes in vegetation cover affecting climate; and changes in vegetation cover affecting water runoff) are quantified through simulations.
2. Interaction strengths are normalised relative to regional guardrails derived from the Planetary Boundaries framework.
3. A feedback model is used to calculate amplification factors, which quantify the extent to which interactions amplify pressures on climate, land or water in a specific location.
4. Amplification factors (see Appendix) are weighted by the current state of the Earth System. This penalises impacts on natural systems that are already degraded. For example, water consumption in regions with severe water shortage will result in a higher ESI score for water use in that area. This step results in a set of ESI "coefficients" for climate (globally) and for land and water in each region.
5. In the final step, businesses and investors can calculate an ESI score for each asset:
    a. Using geo-coordinates, each asset/facility is assigned a vegetation type and region.
    b. Apply relevant ESI coefficients (based on the asset's location) for carbon, land and water to arrive at an overall ESI score for each asset.

16 Lund-Potsdam-Jena managed Land (LPJmL) model is designed to simulate vegetation composition and distribution as well as stocks and land-atmosphere exchange flows of carbon and water, for both natural and agricultural ecosystems for each 0.5 x 0.5 degree grid cells of the Earth's land surface.

FIGURE 7

How to arrive at the Earth System Impact score for an asset

scientist-led (Steps 1–4) | *business- and investor-led* (Step 5)

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5
Dynamic global vegetation model LPJmL	**Planetary boundaries framework**	**Feedback model**	**Normalise for current state**	**Calculating an asset's ESI Score**
Interaction strengths between Climate, Land and Water →	Interaction strengths relative to guardrails →	Amplification factors →	ESI coefficients →	Asset's specific ESI coefficients
↑ Model runs with land use change on/off			↑ Current state of Earth System	↑ Asset's location

Source: Crona, B. et al (2023)

Testing ESI on the mining industry

In what is the first empirical test of ESI, researchers applied the model to a sample of mining companies. It was a deliberate choice for a number of reasons.

First, the quality of the data is high. Because the industry is subject to tight environmental regulations and scrutiny, mining companies routinely provide asset-level reporting on carbon emissions, water and land use, which are outside the scope of standard non-financial disclosures.

Then there's the obvious environmental impact. Mining also exacts a heavy toll on natural habitats by contaminating water and soil.

Just as importantly, mining companies are crucial to the green transition. They supply many of the materials used in net zero technology such as copper, nickel and lithium.

FIGURE 8

ESI score on 10 mines with the highest environmental pressures

FACILITY	COMPANY	VEGETATION TYPE	REGION	PRIMARY COMMODITY	TOTAL EMISSIONS (tCO_2e)	TOTAL WATER CONSUMPTION ($1,000M^3$)	TOTAL LAND USE (KM^2)	CLIMATE ESI	WATER ESI	LAND USE ESI	TOTAL ESI
1	A	Warm climate grass	North America	Copper	621,890	33,719	116	1.74E-06	2.57E-05	7.67E-06	3.51E-05
2	B	Cool climate grass	Africa	Platinum Group Metals	2,107,135	28,831	42	5.90E-06	1.26E-05	4.72E-06	2.32E-05
3	C	Cool climate grass	Africa	Iron	720,000	7,259	139	2.02E-06	3.17E-06	1.57E-05	2.09E-05
4	D	Warm climate grass	North America	Copper	447,892	22,568	15	1.25E-06	1.72E-05	9.86E-07	1.94E-05
5	E	Tropical forest	Asia	Nickel	2,157,207	3,370	88	6.04E-06	0.00E+00	1.01E-05	1.61E-05
6	F	Warm climate grass	Australia	Iron	2,256,212	57,504	256	6.32E-06	1.36E-06	6.86E-06	1.45E-05
7	G	Warm climate grass	Australia	Coal	1,850,164	3,773	309	5.18E-06	8.90E-08	8.29E-06	1.36E-05
8	H	Cool climate grass	Australia	Coal	1,955,625	3,988	36	5.48E-06	4.11E-07	4.23E-06	1.01E-05
9	I	Tropical forest	South America	Iron	508,702	15,494	118	1.42E-06	0.00E+00	7.79E-06	9.21E-06
10	J	Tropical forest	Asia	Copper	2,034,939	44,297	28	5.70E-06	0.00E+00	3.22E-06	8.92E-06

Source: Crona, B. et al (2023)

The table shows the values of direct emissions, water use and land use, alongside the values for each ESI component, where the direct values have been multiplied by the ESI coefficients. The assets are ordered according to descending total ESI. Cells are formatted such that, in the last column (Total ESI), higher values are colored red and lower values green. The formatting for the three ESI components (Carbon ESI, Water ESI and Land ESI), is based on contribution to total ESI, such that the largest component is red, the intermediate yellow, and the smallest green, for each asset/mine.

The dataset includes a total of 201 assets, of which 146 are mining facilities, 33 smelters or refineries, 9 exploration sites and 13 other types of assets, including facilities such as ports, distribution centres and power plants.

FinBio researchers analysed carbon emissions, water consumption and land use for more than 200 assets owned by the world's five largest mining companies in non-precious metals and the five largest in precious metals, using geo-coordinates of each facility (see FIGURE 8).[17]

The results represent a more comprehensive analysis than what would be derived from analysing at the mining industry's own disclosures.

For just over half of the mines analysed, carbon emissions are the main source of environmental damage. Land disruption, meanwhile, emerged as the main source of environmental impact for 40 per cent of all mines (see FIGURE 9).

But the advantage of the ESI is that it reveals important differences depending on where mines are located.

Take mine 6 in FIGURE 8. The analysis shows it withdraws more water than any other facility and uses more land than any other, bar one. This would suggest its environmental impact is among the largest. Yet on closer inspection a different picture emerges. Mine 6 is located in the warm grasslands of Australia, where water is in plentiful supply. This means its water consumption has a less disruptive effect on the immediate environment than that of mines located in areas where water is scarcer, such as the grasslands of North America or temperate forests in Australia.

FIGURE 9
Contribution to total ESI by the three impact drivers

	CO2e EMISSIONS	WATER EXTRACTION	LAND USE
Mean	51.3%	8.5%	40.3%

Source: Crona, B. et al (2023)

17 Researchers used a mix of sources including company websites, publicly available Carbon Disclosure Project reports, the Australian mines Atlas and Google Maps to identify assets' coordinates. For carbon emissions, they gathered disclosed data for Scope 1 and Scope 2 carbon equivalent greenhouse gas emissions, relying on both CDP reports (when publicly available) and corporate sustainability disclosures.

ESI intensity: gauging the relative impact per revenue generated

The ESI score represents the absolute impact of a business activity, which tends to be influenced by the size of a facility or efficiency of production.

Researchers calculated asset-level ESI intensity – which represents relative impacts, emphasising the effect of corporate practices, innovation and the location of the impact – using total revenue.

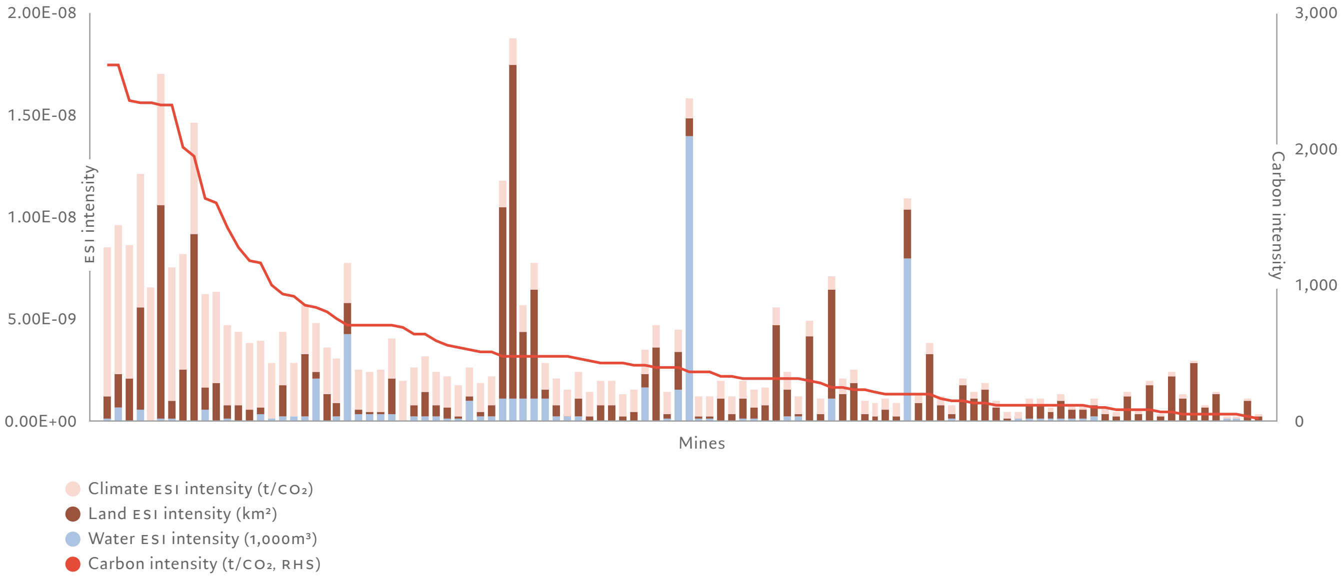
"RELYING ON THE CARBON INTENSITY METRIC ALONE GIVES AN INCOMPLETE PICTURE WHICH COULD EXPOSE BUSINESSES AND INVESTORS TO UNFORSEEN RISKS."

This is similar to carbon intensity, a measure used to calculate the amount of CO_2 equivalent emitted per volume of production produced, or per revenue generated, by a company. It is one of the most common measures companies and investors use to quantify environmental impact; it is also among the variables ESG rating companies use to rank companies.

As FIGURE 10 shows, a number of mines which are ranked among the medium to lowest carbon emitters can be some of the most harmful from the ESI perspective.

As a result, relying on the carbon intensity metric alone gives an incomplete picture, which could expose businesses and investors to unforeseen risks.

FIGURE 10
ESI intensity compared with carbon intensity
Ordered by carbon intensity



Source: Crona, B. et al (2023)
Note: The data sample contains 106 mining assets with revenues above USD100 million. For each mine, the ESI score is broken down to indicate the individual contribution of CO_2 emissions (tCO_2e), land use (km^2) and water consumption ($1{,}000m^3$) to the total ESI score. Superimposed on the ESI intensity plot is the CO_2 intensity measure for each mine (RHS), and mines are plotted from left to right according to their carbon intensity score. Due to the use of normalised units, all values are small and expressed in exponential notation.

ESI in practice

The ESI model is an integrated tool that considers multiple environmental dimensions and their interactions. It can work as a footprinting tool which incorporates regional factors and illustrates how a certain corporate activity disrupts the environment in relation to the current state of the planet.

Companies wanting to reduce the environmental impact of their operations could use the ESI model to identify which of their sites present the biggest problems. They can then set individual site-specific targets for reducing ESI of their operations over time.

Some companies are already taking an integrated approach in seeking to achieve climate and biodiversity goals.

Take Denmark's Orsted, the largest offshore wind farm developer in the world. It has said that choosing a suitable location during the development phase is crucial to protecting marine and coastal ecosystems. The company said it is committed to reducing any significant impacts on sensitive species and ecosystems within predetermined sites; mitigating potential impacts due to underwater noise from piling foundations; and reducing impacts on seabed and coastal ecosystems to a minimum.[18]

Investors, for their part, can use an ESI score to estimate and compare the impacts of potential new energy transition projects and make sure such investments are made in the way that best minimises the biodiversity impact.

What is more, site-specific information from the ESI model could guide shareholder engagement conversations to identify problematic assets and projects, and to enhance efforts to reduce negative impact on biodiversity.

STEVE FREEDMAN
Head of Research and Sustainability, Thematic Equities

18 https://www.financeforbiodiversity.org/ffb-foundation-launches-biodiversity-climate-nexus-guide-ahead-of-ebns/

CHAPTER 3

Pictet AM Thematic Equities' biodiversity impact model

Analysing the interaction between nature and economic activities is a complex undertaking. At Pictet Asset Management, we recognise this complexity. This is why we work with scientists in organisations such as those at the Stockholm Resilience Centre and partners at the FinBio programme. Our aim is to draw on scientific insights and adapt them for use in portfolios.

Pictet AM's thematic equity team has developed a proprietary biodiversity impact measurement tool that provides investment managers with an estimate of the species loss (flora and fauna) that a company risks causing for every dollar of revenue it generates.

We believe the model can be further improved by incorporating insights provided by both the ESI model and other research from the MISTRA FinBio programme.

Our model at a glance

Illustrated in FIGURE 11, our biodiversity impact model has several layers.

First, we construct a prism through which biodiversity loss can be assessed at a regional level.

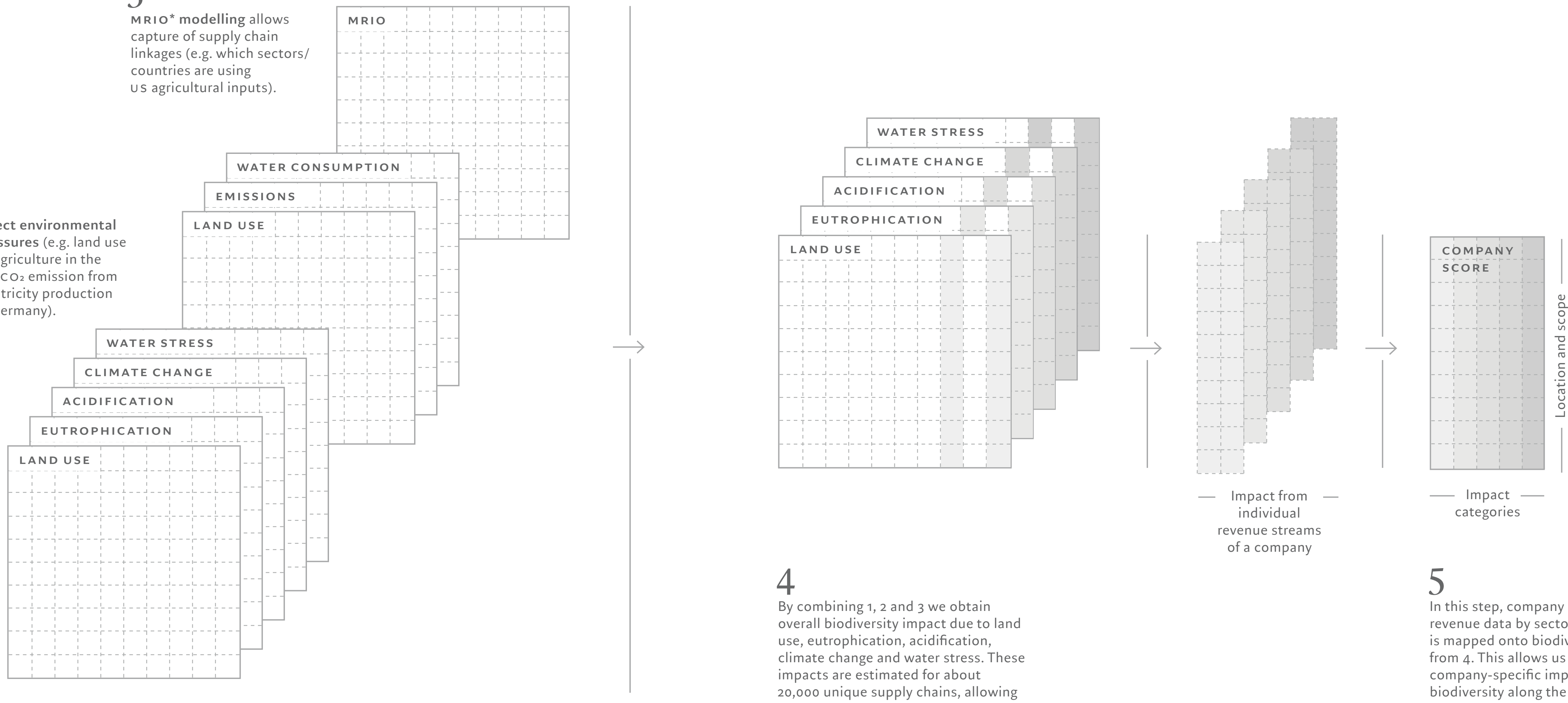
The prism is made up of the five environmental phenomena that have the greatest bearing on species loss across the planet. The aim here is to understand the magnitude of the effect that each of these processes has on species loss globally.

The impact calculations are based on a metric that scientists call Potentially Disappeared Fraction of species (PDF), which approximates how far biodiversity richness has declined as a result of human pressures.

Once the PDF has been determined for each of the five components – for example, the PDF that occurs for every km2 of natural land lost – we then perform calculations that convert them to country, industry and company-level data. In carrying out this conversion, we first need to determine the environmental pressures (water usage, relevant emissions and land use) caused by countries and sectors. The calculations also account for pressures generated by a company's suppliers and customers.[19]

19 This part of the process uses Life Cycle Analysis (LCA). LCA is a technique that measures the environmental impact of corporate activities across the lifecycle of a product, from the extraction of raw materials, manufacturing and distribution through to product use, recycling and disposal. Using LCA is vital as product supply chains become more complex. Manufacturing and production of a product can take place in one country, while its consumption takes place in another, masking the true footprint of emissions, resource extraction and ecosystem degradation.

FIGURE 11
Biodiversity impact



1
Biodiversity impact per direct pressure (e.g. PDF/m² of the land use, PDF/m³ of water use) shows impact on biodiversity per environmental pressure in a specific location.

2
Direct environmental pressures (e.g. land use by agriculture in the US, CO_2 emission from electricity production in Germany).

3
MRIO* modelling allows capture of supply chain linkages (e.g. which sectors/countries are using US agricultural inputs).

4
By combining 1, 2 and 3 we obtain overall biodiversity impact due to land use, eutrophication, acidification, climate change and water stress. These impacts are estimated for about 20,000 unique supply chains, allowing for a thorough company level analysis.

5
In this step, company reported revenue data by sector and region is mapped onto biodiversity impacts from 4. This allows us to estimate company-specific impact on biodiversity along the following dimensions: (a) impact category (how much is due to land use vs climate change); (b) scope (direct vs indirect/scope3); (c) location (where in the supply chain impacts are caused).

*MRIO: multiregional input-output
Source: Pictet Asset Management

The result of these detailed calculations is a data series offering PDF estimates per dollar of revenue generated for some 20,000 supply chains – and the industries and companies that operate within them.

For any given company, the model allows us to estimate any one of a number of impacts. It can, for example, show how a Swedish pharmaceutical firm's US operations are affecting local wildlife, breaking down the impact across several dimensions. Equally, our model can identify the biggest driver of biodiversity loss for a Swiss chemical company, and measure that company's contribution to species loss through water use associated with practices such as sourcing materials from Germany.[20]

"OUR MODEL OFFERS ESTIMATES (BIODIVERSITY LOSS) PER DOLLAR OF REVENUE GENERATED FOR SOME 20,000 SUPPLY CHAINS."

Accounting for Earth System Impact

Our biodiversity impact model incorporates several scientifically established techniques and models.

But it is constantly evolving and will inevitably draw on the research undertaken by our partners at the MISTRA FinBio programme.

There are already several synergies between the ESI model and our own. For example, three of the environmental phenomena we use – land change, water use and climate change – are the same as those contained within the ESI model.

Going forward, elements from the ESI model such as amplification effects – which show how land use, water consumption and climate change could reinforce each other to turbocharge the impact on biodiversity – will be particularly useful for the future development of the model.

20 Currently, we use the environmental impact modelling as a screening tool to identify existing and emerging risks of companies in the investment universe associated with biodiversity loss. We also incorporate calculations on dependencies. This is to measure how strongly a company is dependent on ecosystem services. For example, food companies are highly dependent on pollination for harvesting of cereals; metal processing will be on ground water provision and pharmaceutical companies on wild species. Finally, we also aim to quantify the potential positive impact – or what positive impact an industry or company offers with its goods and services when substituted from those offered by its less sustainable counterparts. For example, a plant-based protein supplier will see its overall score improve over an animal meat counterpart. This is thanks to its future expected positive contribution to the environment by allowing customers to swap resource-intensive meat for a more sustainable alternative.

APPENDICES

Coefficients used to calculate ESI values

FIGURE 12 lists the factors by which any reported value for CO_2 equivalent emissions, water consumption or land use should be multiplied to arrive at an estimated Earth System Impact. Due to the use of normalised units for state variables, all values are small and expressed in exponential notation.

For more details, please refer to refer to the original research paper by Crona, B. et al, which can be accessed at https://www.sciencedirect.com/science/article/pii/S0959652623036818?via%3Dihub

FIGURE 12
ESI coefficients

	BOREAL	COOL CLIMATE GRASS	WARM CLIMATE GRASS	TEMPERATE	TROPICAL
Climate ESI coefficient (tCO_2e)					
2.8E-12					
Land ESI coefficient (km^2)					
Australia	NA	2.68E-08	1.18E-07	1.34E-08	2.10E-21
Oceania	NA	NA	NA	2.18E-07	0.00E+00
South America	NA	4.90E-08	4.52E-08	4.82E-08	6.60E-08
Africa	NA	1.15E-08	1.13E-07	1.09E-07	4.62E-08
Europe	6.38E-08	6.02E-08	NA	5.26E-08	NA
North America	1.40E-08	6.64E-08	8.36E-09	4.12E-08	2.34E-07
Asia	1.07E-08	2.66E-08	4.78E-09	3.34E-08	1.14E-07
Water ESI coefficient ($1,000m^3$)					
Australia	NA	2.36E-11	1.03E-10	1.35E-10	2.61E-12
Oceania	NA	NA	NA	7.92E-11	7.20E-11
South America	NA	1.59E-10	1.75E-10	0	0.00E+00
Africa	NA	3.17E-11	4.36E-10	8E-11	2.95E-12
Europe	0.00E+00	0.00E+00	NA	2.77E-11	NA
North America	0.00E+00	7.62E-10	1.29E-11	0	4.00E-12
Asia	1.31E-11	4.67E-10	5.97E-12	1.35E-11	0.00E+00

Source: Crona, B. et al (2023).

eDNA – an emerging technology for biodiversity impact assessment

As biodiversity loss accelerates worldwide, it is increasingly acknowledged as a risk to society on par with ongoing climate change. Growing awareness of the multi-level risks that environmental degradation poses to the finance industry has led to increased interest in sustainable investment. Investors need reliable data and analytics to predict the biodiversity impact, and associated risks, of their financial decisions.

Traditionally, biodiversity data have been collected using labour-intensive methods, for example through extensive field work and with species identification done by experts. This has resulted in incomplete knowledge of biodiversity as well as data biased towards certain organisms and habitat types that are easily accessible and observable. As an example, biodiversity data on birds are abundant but data on soil fungi are sparse.

In recent years, we have experienced a revolution in biodiversity data collection methods. This includes improved molecular methods, satellite technology and acoustic monitoring. In particular, DNA sequences obtained from environmental samples (eDNA) has revealed an enormous abundance and diversity of hitherto unknown microbes, fungi and small invertebrates.

eDNA is a novel approach that analyses the genetic material released into the environment by different species. Researchers or volunteers collect environmental samples from for example soil, water or air. DNA can then be extracted and chosen parts of the genetic code can be compared with available references in open global genetic databases through a process called metabarcoding.

Our ability to measure biodiversity has also improved dramatically thanks to data from Earth Observation programmes, such as Copernicus – part of the European Union's space programme. Variables that can be measured accurately from satellites include landscape, land use and productivity metrics, such as fragmentation, land surface phenology – or seasonal pattern of variation in land surfaces – and chlorophyll concentration.

While these new methods reveal the inadequacy of current data, they offer a time- and cost-effective and scalable approach to biodiversity monitoring. Combining technologies, for example eDNA and Earth Observation data, would make it possible to estimate biodiversity variables from the genetic to the ecosystem level.

These technologies are applicable across the globe, and with proper method standardisation the data will be comparable. Importantly, these approaches generate massive quantities of verifiable data, suitable for analyses of long-term biodiversity impact using AI, machine learning and big data analytics.

In Work Package (WP) 1 of the MISTRA Finance to Revive Biodiversity research programme, we are exploring the potential of eDNA as a metric for corporate biodiversity monitoring. Currently, we are researching and refining methods to estimate biodiversity from eDNA. Going forward, we will also explore the combination of eDNA and Earth Observation data and aim to propose a new framework of corporate biodiversity impact assessment based on these emerging technologies.

While challenges remain, such as further method development and the need for standardisation, these developments show great potential. Indeed, if corporate biodiversity reporting were based on open eDNA data, it could transform our ability to leverage economic mechanisms for safeguarding biodiversity and ecosystem services.

PROF FREDRIK RONQUIST
Swedish Museum of Natural History and Leader of WP1, MISTRA Finance to Revive Biodiversity

DR EMMA GRANQVIST
Swedish Museum of Natural History, WP1 MISTRA Finance to Revive Biodiversity

DR MATS TÖPEL
Swedish Environmental Research Institute, WP1 MISTRA Finance to Revive Biodiversity

MISTRA Finance to Revive Biodiversity (FinBio) research programme

Pictet Asset Management (Pictet AM) is representing the global asset management industry as an "Impact Partner" in the Finance to revive Biodiversity (FinBio) programme. The FinBio project is designed to help the financial industry develop strategies to protect natural capital and halt biodiversity loss.

The initiative, which receives approximately EUR5 million in research funding from MISTRA (the Swedish Foundation for Strategic Environmental Research), is overseen by the Stockholm Resilience Centre (SRC) at Stockholm University.

Pictet AM is the only asset management company in the FinBio programme, chosen for its track record in "innovative thinking" in sustainable finance. As an Impact Partner, Pictet AM's role is to provide investment expertise and contribute to transdisciplinary research that can help bring about nature-positive changes in the financial system.

Pictet AM is working alongside consortium members including the UN Principles for Responsible Investment, the Finance for Biodiversity Foundation and Stanford University.

The FinBio programme, which kicked off in late 2022, has been devised to integrate the protection and restoration of natural capital into financial and investment decision-making worldwide.

Although biodiversity loss is one of the gravest environmental threats the world faces, monitoring it has proved difficult due to a lack of reliable data and measurement standards. According to the World Wildlife Fund, failure to protect natural ecosystems could wipe USD10 trillion from the global economy by the middle of this century.

Leading the FinBio research programme is SRC Professor Garry Peterson, who was a coordinating lead author for the Millennium Ecosystem Assessment's Scenario Assessment and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services scenarios and model assessment. He is joined by Professor Beatrice Crona, Science Director of the SRC.

This unique collaboration extends Pictet AM's nine-year relationship with the SRC, whose Planetary Boundary Framework provides the analytical underpinning for our Global Environmental Opportunities investment strategy, one of the largest of its kind in the world.

More details can be found at http://finbio.org

GABRIEL MICHELI
Senior Investment Manager,
Thematic Equities

STEVE FREEDMAN
Head of Research
and Sustainability,
Thematic Equities

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship

Stockholm University

MISTRA

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