Swiss Finance Institute Research Paper Series N°23-24

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Finance Working Paper N° 905/2023
March 2023

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Forthcoming, Review of Finance, 2024

Do investors care about biodiversity?

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Abstract

This paper introduces a new measure of a firm's negative impact on biodiversity, the corporate biodiversity footprint, and studies whether it is priced in an international sample of stocks. On average, the corporate biodiversity footprint does not explain the cross-section of returns between 2019 and 2022. However, a biodiversity footprint premium (higher returns for firms with larger footprints) began emerging in October 2021 after the Kunming Declaration, which capped the first part of the UN Biodiversity Conference (COP15). Consistent with this finding, stocks with large footprints lost value in the days after the Kunming Declaration. The launch of the Taskforce for Nature-related Financial Disclosures (TNFD) in June 2021 had a similar effect. These results indicate that investors have started to require a risk premium upon the prospect of, and uncertainty about, future regulation or litigation to preserve biodiversity.

Keywords: Biodiversity, corporate biodiversity footprint, Kunming Declaration, natural capital, nature, stock returns, Taskforce for Nature-related Financial Disclosures (TNFD)

JEL Classification: G12, G30, Q57

*We thank Marcin Kacperczyk (the Editor), an anonymous Associate Editor, an anonymous referee, Marco Ceccarelli, Alberta Di Giuli, Ulrich Hege, Julian Kölbel, Nadya Malenko, José Martin-Flores, Christophe Pérignon, Sébastien Pouget, Stefano Ramelli, and Tingyu Yu, members of the University of Zurich Research Priority Program Global Change and Biodiversity, and conference participants at the AFA 2024 in San Antonio, CUNEF, EDHEC Business School, KEDGE Business School, PRI Academic Seminar Series, Toulouse Business School, Toulouse School of Economics, University of Surrey, and the NYU-LawFin/SAFE-ESCP BS Law & Banking/Finance Conference for helpful comments. We also thank Ming Deng and Amra Hrustanovic for excellent research assistance. We declare that we have no relevant or material financial interests that relate to the research described in this paper. Data on the corporate biodiversity footprint by country and industry are available at https://bit.ly/CBF-ci.

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1 Introduction

Biodiversity, the variety of living organisms in all habitats, is deteriorating at an unprecedented and alarming rate. Between 1970 and 2018, the world has seen a 69% loss of monitored wildlife (WWF 2022), and biosphere integrity has been identified as one of the overstepped planetary boundaries (Rockström et al. 2009; Steffen et al. 2015). Biodiversity collapse jeopardizes the goods and services humans obtain from all ecosystems, with potentially far-reaching economic implications (World Bank 2020).[1] In addition, biodiversity loss may bring about a new "era of pandemics" (IPBES 2020). While the UN Convention on Biological Diversity (CBD) entered into force in 1993, and several Conferences of the Parties (COPs) to the CBD have adopted plans to protect biodiversity, most goals have not been achieved (CBD Secretariat 2020). Recent globally coordinated steps toward protecting biodiversity include the Kunming Declaration (2021) and the Montreal Agreement (2022).

Given the potentially dramatic financial consequences of the loss of biodiversity, firms, investors, and financial market regulators are increasingly paying attention to the topic. For example, the Taskforce on Nature-related Financial Disclosures (TNFD), modeled after the Taskforce on Climate-related Financial Disclosures (TCFD), was launched in 2021 and released its final disclosure recommendations in September 2023 (TNFD 2023a). Also in September 2023, the Network for Greening the Financial System released NGFS (2023), a framework to help central banks and supervisors identify and assess sources of nature-related transition and physical risks, following its earlier report in NGFS and INSPIRE (2022). However, the link between biodiversity and finance has received little attention by academics. As

1. While "biodiversity" is an ecological term, the economic term "natural capital" is often used to emphasize the role of nature in supporting human economic activity and well-being. Indeed, the World Economic Forum (2020) estimates that half of the world's gross domestic product stems from industries that depend on nature and ecosystem services (e.g., construction, agriculture, and tourism).

noted by Karolyi and Tobin-de la Puente (2023), no studies in the top-10 finance journals reference biodiversity.[2] In this paper, we take a step toward filling this gap by introducing to the finance literature a science-based measure, the corporate biodiversity footprint (CBF), and exploring whether investors price this footprint.

Developed by Iceberg Data Lab (IDL), the CBF aggregates the biodiversity loss caused by a firm's annual activities related to land use, greenhouse gas (GHG) emissions, water pollution, and air pollution. To quantify this loss, the CBF builds on the concept of Mean Species Abundance (MSA), which measures the relative abundance of native species in ecosystems, compared to their abundance in undisturbed ecosystems. The CBF expresses this loss in terms of km^2.MSA, and quantifies not only the direct impact of a firm, but also the biodiversity loss along the entire value chain. Thus, the CBF contains scope 1, 2, and 3 components, whereby scope 1 measures the environmental pressure of the firm's direct activities, such as the area artificialized or occupied due to its business activity; scope 2 measures the pressures induced by the purchase of electricity, heat, and cooling; and scope 3 measures all indirect pressures (i.e., products sold or purchased, or investments made).[3]

Our international sample consists of 2,106 listed firms from 34 countries for which CBF data are available from IDL over the years 2018-2021. While the sample period includes only a few years, the most important global policy developments concerning biodiversity are also quite recent. Retail & Wholesale, Paper & Forest, and Food are the sectors with the largest average corporate biodiversity footprints, reflecting these sectors' intensive land

2. By contrast, the economics of biodiversity received early and substantial attention (e.g., Weitzman 1992, 1993; Metrick and Weitzman 1998; Heal 2003, 2004; Dasgupta 2021).

3. Alternative metrics to MSA exist, e.g., Potentially Disappeared Fraction (PDF) and Species Threat Abatement and Restoration (STAR). We discuss these concepts below. As biodiversity receives more attention, more data options are becoming available. For example, data provider ISS ESG launched in 2022Q3, and MSCI plans to launch in 2024, biodiversity impact measures that build on a combination of MSA and PDF. Since 2023, S&P offers a tool utilizing STAR. To our knowledge, these data providers do not offer (yet) a time-series comparable to that of IDL.

use or contribution to air pollution.[4] While there is a sizeable industry component to the CBF, there is large heterogeneity within each industry. This heterogeneity is a strength of the metric, as it allows for the exploration of granular within-industry variation. Capturing such variation is important; several institutional investors have recently started negative screening policies, by which they exclude the laggards within certain sectors (e.g., La Banque Postale Asset Management 2022). The CBF reveals that larger firms, understandably, have a more negative impact on biodiversity. The CBF also relates positively to a firm's carbon emissions, which represent one channel through which firms harm biodiversity.

The CBF correlates with whether firms are targeted by the investor coalition Nature Action 100 (NA100), which in June 2023 released a list of 100 firms to engage with to tackle biodiversity and nature loss. Almost 70% of NA100 targets locate in the top quintile of the CBF distribution. Using textual analysis, we find that terms related to biodiversity are mentioned in only 5.0% of our sample firms' earnings calls. This low number is consistent with Giglio et al. (2023), who find that only 3.8% of U.S. firms' 10-K statements mention biodiversity terms. As a result, the correlation between the CBF and the number of biodiversity terms in earnings calls is just 8.8%. Notably, many large-CBF firms, including many NA100 targets, do not discuss biodiversity at all in their earnings calls.

How can a firm's CBF be expected to correlate with its stock returns? A first possibility is that large-CBF stocks will earn higher returns, as these firms potentially face higher transition risks. These transition risks may result from legal fines or the costs of compliance with an increasingly demanding regulatory environment regarding biodiversity preservation. The theory by Pástor and Veronesi (2012) implies that uncertainty associated with future regula-

4. While the biodiversity impact from land use is mostly indirect for Retail & Wholesale (e.g., because of sold food and beverage products), it is direct for Paper & Forest and Food (e.g., because of deforestation and farming). Retail & Wholesale has a high negative air pollution impact because of pollution related to shipping activities in the value chain.

tion or litigation leads investors to require a risk premium for holding large-CBF stocks. Consistent with this prediction, studies show that investors demand compensation for exposure to carbon or pollution risks (Bolton and Kacperczyk 2021, 2023; Hsu, Li, and Tsou 2023).

A second possibility is that large-CBF stocks will earn higher returns due to mispricing, which may originate from unexpected cash flow shocks. A negative biodiversity impact is an externality, and some firms may, therefore, not invest in mitigating or reducing their biodiversity impacts. As a result, they may enjoy unexpectedly higher earnings and returns.

A third possibility is that large-CBF stocks will earn lower returns. Evidence shows that brown (green) stocks had lower (higher) returns, due to unexpected shifts in investors' preferences for green stocks (Pástor, Stambaugh, and Taylor 2022) and as climate attention or concerns increased (Ardia et al. 2023; Choi, Gao, and Jiang 2020; Engle et al. 2020). If growing concerns about biodiversity loss gradually shift investor preferences, then large-CBF stocks will see lower returns.

These channels compete against the null hypothesis that the CBF is unrelated to returns. This result may arise, first, because measuring and disclosing a firm's biodiversity impact is more complex and less well-developed than measuring and disclosing the corporate carbon footprint. Second, whereas the personal experience of phenomena attributable to climate change affects investors' perceptions of the problem (Choi, Gao, and Jiang 2020; Di Giuli et al. 2022), such personal experience is less likely for signals of biodiversity loss, presumably leading to lower investor awareness. Third, even if investors have a sense of biodiversity harm, they are unlikely to price the CBF metric if they ignore impact materiality.

We examine the pricing of the corporate biodiversity footprint by regressing firms' monthly stock returns on their one-year lagged CBF values (i.e., we relate 2019-2022 returns to 2018-2021 CBF values). We rely on a characteristics-based approach, which has the advantage of not requiring assumptions about the underlying asset pricing model. On average, we find no evidence that the CBF is related to returns between 2019 and 2022. However, we do find a relationship between the CBF and returns following major biodiversity-related policy changes, signifying that the biodiversity footprint had then started to be priced. In October 2021, the first part of the UN Biodiversity Conference (COP15) concluded with the Kunming Declaration (2021). Similar to the Paris Agreement, the Kunming Declaration calls for countries to act urgently to protect biodiversity by aligning financial flows to support its conservation and sustainable use. The event arguably increased both investor awareness about the loss of biodiversity and the prospect of, and uncertainty about, future biodiversity regulation or litigation. Between the Kunming Declaration and December 2022, a one-standard deviation higher log(CBF) value is associated with monthly returns that are 18.5 basis points higher (or 2.2% annualized).

We conduct an event study to examine closely whether and how investors revised their valuations of large-CBF stocks around the Kunming Declaration.[5] If the declaration raised investor awareness of biodiversity issues and the prospect of regulation aimed at preserving it, we would expect investors to revise downward their valuation of large-CBF stocks. Indeed, in the three days following the declaration, relative to the three days before, large-CBF stocks experienced a cumulative stock price decline of 1.14%, relative to small-CBF stocks.

The signing of the Kunming Declaration is a salient event, but this does not preclude the possibility that other events had similar effects. In fact, the launch of the TNFD on June 4, 2021 was another salient event that contributed to raising awareness of biodiversity issues

5. The central declaration was made on October 13, 2021. Because the outcomes of the declaration were not determined beforehand, the event qualifies as a plausible shock to investors' expectations regarding the transition risks faced by firms with large biodiversity footprints. COP15 was marked by tense talks and a deep divide between wealthy and developing countries, which made the final agreements uncertain until the day of the announcement (Eihorn 2022; Mychasuk 2022).

and the associated transition risks (though the TNFD is primarily concerned with disclosure, it increases the odds of a firm being targeted by litigation on the basis of its disclosed information). In the three days following the TNFD launch, relative to the three days before, investors reduced their valuation of large-CBF stocks by 1.5%, relative to small-CBF stocks.[6]

How do these results align with the above-mentioned channels through which biodiversity and returns may be related? Our evidence suggests that investors have started to anticipate that new regulations or litigation will target large-CBF firms. The results of our event studies indicate that around relevant events (Kunming, TNFD), the stock prices of such firms were bid down; higher returns of large-CBF firms followed. Thus, consistent with Pástor and Veronesi (2012), the increase in policy uncertainty associated with these events leads to investors demanding a biodiversity footprint premium. To corroborate this interpretation, we demonstrate that the biodiversity footprint premium is larger in countries with low biodiversity protection; firms in such countries face greater transition risks, due to the prospect of future "catch-up" regulations. In sum, the CBF appears to reflect exposure to biodiversity transition risks, and our results reflect the pricing of such risks. Consistent with this interpretation, we demonstrate that large-CBF firms had higher implied costs of capital, a proxy for expected returns, after the Kunming Declaration.

By contrast, unexpectedly higher earnings or cash flows cannot explain our result patterns. First, we document that large-CBF firms do not experience greater earnings surprises in the post-Kunming years (and neither before Kunming). Second, unexpectedly high earn-

6. Given that the TNFD launch was only four months before the Kunming Declaration, we do not claim that October 2021, the month we used to split our sample for the cross-sectional returns tests, was a unique point defining a regime shift. We find similar results if we relate returns to the CBF for the period after June 2021 (instead of October 2021). We do not detect any differential return dynamics between large- and small-CBF firms around the Montreal Agreement, which constitutes the second part of COP15. This result indicates that this summit did not provide additional information regarding firms' exposures to transition risks (possibly as the outcomes were more widely anticipated, compared to the Kunming Agreement).

ings or cash flows should be more likely in the months before Kunming; however, for this period we found non-significant return effects of the CBF. Our evidence is also hard to explain as being due to unexpected shifts in investor preferences, as this channel predicts large-CBF stocks would earn lower returns in the months after Kunming.

A potential concern is that our results are driven by the firms' carbon emissions, rather than by their broader impacts on biodiversity. Carbon emissions do negatively affect biodiversity, and do enter into the CBF computation. However, our results hold when controlling for carbon emissions and the proxy for regulatory climate change exposure from Sautner et al. (2023). They are also unchanged if we use an "emissions-free" CBF metric.

We contribute to a new literature on biodiversity finance. Closely related to our work is that of Giglio et al. (2023), who construct measures of U.S. firms' biodiversity risks from a binary firm-level indicator for disclosures in 10-Ks. They then show that returns of portfolios sorted on the industry-average of those measures covary positively with biodiversity news. This approach complements ours in terms of methodology, focus, and sample. We study the relation of firm-specific monthly returns with the biodiversity footprint, and we also document how investors revised their valuation of large- versus small-CBF firms following two global biodiversity-related events. The key feature of the CBF is that it quantifies the impact of a firm on biodiversity, and it does so for an international sample. As we show, the vast majority of our sample firms, including those with large CBF values, do not disclose biodiversity information in their 10-Ks, and so would not appear in Giglio et al. (2023)'s sample of biodiversity risk-exposed U.S. firms.

Both approaches are valuable. As explained by Cenedese, Han, and Kacperczyk (2023) for the case of climate risks, there are two principal ways of measuring biodiversity risks, one based on the actual footprint and another based on textual analysis. The first provides a quantitative link to a specific objective function, in this case, a firm's current impact on biodiversity; the benefit of the second approach is its forward-looking nature. The CBF quantifies exposure to biodiversity transition risk, but it is not forward-looking, that is, it does not take into account future efforts that may affect investor perceptions of a firm's biodiversity performance, such as whether the firm has set targets or taken strategic actions to reduce its footprint. Textual analysis of 10-Ks (or earnings calls), however, can often be used to identify a firm's willingness to take such actions. Further, while the CBF quantifies the impacts of a firm's activities on biodiversity, it does not provide information regarding physical risks from biodiversity loss; these, too, can potentially be captured from corporate text. A limitation of text-based approaches is that they rely on firms communicating or disclosing biodiversity information; currently only a minority of firms are found to do so, though this situation will likely change in the future.[7]

Several other studies on the pricing of biodiversity have been conducted recently. Hoepner et al. (2023) study 68 infrastructure firms to show that firms with better biodiversity risk management have more favorable financing conditions (lower CDS slopes). Xin et al. (2023), relate MSCI's biodiversity exposure and management scores to returns and operating performance, but find no relationships in their sample between 2013 and 2020. Coqueret, Giroux, and Zerbib (2024) find that U.S. firms in sectors heavily depending on or impacting biodiversity display higher expected returns, with the effect emerging since 2021, consistent with our findings. Finally, there is also an emerging literature on the use of private capital to finance biodiversity conservation and restoration (see, e.g., Flammer, Giroux, and Heal 2023).

7. Recent advances in textual analysis, relying on machine-learning approaches, hold some promise in terms of identifying how firms communicate biodiversity-relevant information (Schimanski et al. 2023).

2 Biodiversity footprint: Quantifying biodiversity loss

2.1 Biodiversity loss and MSA

The corporate biodiversity footprint was developed by IDL to provide investors with a science-based indicator to help them measure and manage their investments' impact on biodiversity. The CBF reflects the extent to which ecosystems affected by a firm's activities have been degraded from their pristine natural state. It aggregates the effects of multiple environmental pressures, such as land use, nitrogen deposition, emissions, or the release of toxic compounds, to quantify the biodiversity loss resulting from a firm's annual activities.

The CBF is based on the concept of Mean Species Abundance, which was proposed during the development of the GLOBIO3 model. The CBF methodology uses MSA because: i) it offers the largest and most robust toolbox (in terms of damage functions) in the scientific literature; ii) it is a holistic approach that adapts well to appraising portfolios, unlike more microscopic indicators, which are better-fitted to project analysis; and iii) it is endorsed by the scientific community and multilateral organizations (e.g., CBD, IPBES, and IPCC) and recommended by the UN (Iceberg Data Lab 2023).

MSA measures the relative abundance of native species. An area with an MSA of 0% has completely lost its native biodiversity (or is exclusively colonized by invasive species), whereas one with an MSA of 100% is considered equal in biodiversity to an ecosystem undisturbed by human activities and pressures. IA Figure A.1 in the Supplementary Appendix provides an illustration of MSA variation for forests and grasslands, and IA Section B provides a numerical example.

The CBF expresses a firm's negative impacts on biodiversity in terms of square kilometers of "artificialized" or "denatured" land (i.e., km^2.MSA). For example, a CBF of $-100km^2$

means that 10% of the original biodiversity has been lost in an area of 1,000km^2, or that a proportionally smaller amount of biodiversity, 5%, has been lost in an area of 2,000km^2. In this paper, we multiply the CBF scores by –1, so that higher values indicate a more negative impact on biodiversity.

2.2 From MSA to CBF

The CBF is calculated in three steps, which we summarize in this section. IA Section C explains each step in more detail, drawing on an example from Danone. First, IDL assesses, by sector, the products and services bought and sold by a firm throughout its value chain.[8] This step is based on IDL's internal physical input/output model ("Wunderpus"), which is an enhanced proprietary version of EXIOBASE, a detailed multi-regional environmentally extended supply-use and input-output database. Second, IDL calculates the firm's environmental pressure, based on the flow of goods and services its business depends on. Using a life-cycle analysis, four forms of environmental pressure (land use, greenhouse gas emissions, air pollution, and water pollution) are individually calculated along the firm's entire value chain, including its processes, products, and supply chains. Third, IDL translates each of these estimated pressures, using pressure-impact functions, into a biodiversity impact unit expressed in km^2.MSA. Finally, IDL aggregates the four impacts into a single overall impact. IA Figure A.2 illustrates the steps involved in the calculation of the CBF.[9]

8. IDL collects these activities on the "NACE4" level (which refers to a 4-digit level of specificity within the European Union's statistical classification of economic activities), providing a relatively detailed view of the firm. NACE is similar to the North American Industry Classification System (NAICS).

9. As shown in the figure, IDL also computes scaled versions of the CBF. For example, CBF Capital Employed is the CBF relative to the capital used by the firm. We compute such standardizations ourselves, using accounting data from Capital IQ/Compustat.

2.3 CBF applications in practice

Major institutional investors, including BNP Paribas Asset Management, AXA Investment Managers, Robeco, and Mirova, use the CBF to measure the biodiversity impact of their investments. The data are also used by three biodiversity-related funds to screen and manage stocks (HSBC World Biodiversity Screened Equity ETF, Ossiam Food for Biodiversity ETF, and AXA IM ACT Biodiversity Equity ETF); Giglio et al. (2023) used these funds to build one of their biodiversity risk measures. In addition, IDL's biodiversity measurement approach is based on impact metrics recommended in the TNFD disclosure guidelines (Milleret 2023) and is listed in the Tools Catalogue of the TNFD (2023b).

2.4 Limitations of MSA and the CBF

The CBF comes with limitations, some of which stem from how MSA measures biodiversity loss. Finance for Biodiversity (2022), NGFS and INSPIRE (2022), and OECD (2023) discuss these limitations, and also mention other approaches used to measure a loss of biodiversity. In short, MSA does not allow the loss of an individual species, or class of species, to be tracked, and it treats all species as equally valuable, independent of whether they are abundant or threatened. It does not account for an increase in a species, which is problematic, as an increase in abundance can have a stabilizing effect on an ecosystem, an idea often referred to as the insurance hypothesis (see, e.g., Yachi and Loreau 1999; Xu et al. 2021). MSA also does not allow for a comparison with the absolute number of species prevalent in an area. In addition, the ultimate quantity of interest, both for economic valuation and regulatory efforts, often is not a fall in MSA per se, but a reduction in ecosystem services. The CBF does not quantify or value the damage to these services. Furthermore, the reference points in the GLOBIO model, which constitutes a key element in the MSA calculation, are dated (going back to the 1990s), and limited information is available about the assumptions used to create the model. Some critics also argue that the GLOBIO model is biased toward the most studied species and ecosystems (Finance for Biodiversity 2022). Despite all these shortcomings, MSA provides a harmonized measure. Aggregating other, perhaps superior, specialized local indicators has proved to be too challenging so far.

Alternatives to MSA exist, with two that can be constructed for a large set of firms having received attention by investors and regulators. The first, the Potentially Disappeared Fraction of Species (PDF), is similar in spirit to MSA; it measures the fraction of species that are lost due to environmental pressures, such as land use or climate change, over a specified time frame on $1m^2$ land or $1m^3$ water. In value, PDF ranges between 0% (no species disappeared) and 100% (all species disappeared), but it does not reflect a decline in the population of a given species.[10] The second metric, Species Threat Abatement and Restoration (STAR), contains two components. The threat abatement component measures the risk of extinction in a specific area, calculated as the sum of the risks weighted by the species' threat status. The calculation excludes species for which extinction is not a concern. The second component indicates the potential for restoration.[11]

The CBF has an additional shortcoming when MSA is applied in a corporate context. Notably, because of limited data availability, a large part of the CBF calculation is based on sector averages and estimates, rather than on granular, firm-specific information. Finally,

10. Data providers have started to offer PDF-based metrics, usually in combination with MSA. ISS ESG launched one in 2022Q3, and MSCI is planning to introduce one in 2024. To our knowledge, these databases do not (yet) contain historical data, but primarily include data for the most recent year.

11. In 2023, S&P started offering a Nature and Biodiversity Risk Profile utilizing the STAR method. Other metrics with more limited scope also exist (for an overview table, see Finance for Biodiversity 2022). The Biodiversity Intactness Index (BII) reflects changes due to land use (relative to a reference state). The Biodiversity Impact Metric (BIM) builds on MSA, but focuses only on a firm's supply chain. The use of geospatial, satellite, or acoustic data to measure biodiversity loss, combined with data on a firm's locations, may lead to alternative firm-level metrics.

the CBF does not yet capture soil degradation or invasive species, and only partially captures the impact on freshwater and marine biodiversity. Despite these limitations, according to Finance for Biodiversity (2022), the CBF is the only currently available impact measure on a firm level that seeks to cover scope 3 downstream impacts.

2.5 Climate transition risks and the CBF

Biodiversity loss and climate change are interrelated (CBD Secretariat 2016), making it important to address the potentially confounding effects of carbon emissions on the CBF both conceptually and empirically. Climate change, which is generated by greenhouse gas emissions (primarily carbon), negatively affects biodiversity. There is also a reverse effect, as the loss of the biodiversity needed for natural carbon sinks in oceans, vegetation, and soils to function, for example, accentuates climate change.

While a firm's carbon footprint and its biodiversity footprint are positively correlated, there are also fundamental differences, and even conflicts, between the two environmental concepts. Efforts by firms to lower their carbon emissions (e.g., to achieve net-zero targets) may lead to more loss of biodiversity (e.g., Paulson 2023). For example, many solar farms are being built on forested land, negatively impacting natural ecosystems and habitats. Likewise, expanding renewable energy and the use of electric cars requires an increased supply of metals, such as lithium and cobalt; the mining and extraction of these metals have severe impacts on biodiversity.[12]

As we show below, empirically, the principal component of the CBF is land use, which indicates that a firm's biodiversity footprint is not identical to its carbon footprint. However,

12. Beyond these specific examples, Giglio et al. (2023) show that an aggregate biodiversity index behaves differently from an aggregate climate news index (Engle et al. 2020), suggesting that periods of high media coverage of biodiversity issues differ from periods of high media coverage of climate change issues.

in light of the conceptual links between biodiversity loss and carbon emissions, we document that our results are robust when we account for a firm's carbon footprint.

3 Data, summary statistics, and sample selection

3.1 Data sources and sample construction

Our sample construction starts with all 2,724 publicly listed firms for which CBF data are available from IDL between 2018 and 2021, and for which a match in Compustat/CRSP exists. We drop 480 firms with missing monthly returns or control variables, or with negative total assets or book equity values; 60 firms from 16 countries with fewer than ten firms (the minimum number required for our cross-country analysis); and 78 firms from two countries with missing data on biodiversity protection (Bermuda and the Cayman Islands). These data filters provide us with a final sample of 2,106 firms across 34 countries. The returns analysis relates annual CBF data for these firms to monthly returns from 2019 through 2022, resulting in a panel of 89,132 firm-month observations.[13] As the CBF is highly skewed, we use Ln(CBF) in most tests. The majority of sample firms are members of the MSCI All Country World Index (MSCI ACWI), the universe that IDL seeks to cover.

Data on firm-level carbon emissions (CO_2 Emissions) is from Trucost; we use the sum of scope 1, 2, and 3 emissions, as the CBF includes corresponding scope 1, 2, and 3 components. Data on regulatory climate change exposure (CCExposure^{Reg}) is from Sautner et al. (2023).[14] The correlation between Ln(CO_2 Emissions) and Ln(CBF) is 0.60, and that

13. For some firms in our sample, CBF data is missing in some years (especially 2021). We fill forward these missing CBF values, increasing our firm-month observations by 20%, from 66,890 to 89,132; our results do not depend on this choice.

14. Data on CO_2 Emissions (on CCExposure^{Reg}) are available for 99% (59%) of the observations entering our returns analysis.

between CCExposure^{Reg} and Ln(CBF) is 0.20. Accounting and stock price data is from Compustat, data on E scores is from Refinitiv, and country-level data on biodiversity protection is from Yale University. Appendix A defines all variables.

3.2 Descriptive statistics of the CBF

Table 1 reports summary statistics of the CBF. The mean (median) value of Ln(CBF) is 4.79 (5.28), indicating that the average (median) firm has a biodiversity impact corresponding to the complete loss of biodiversity over an area of 120.3km^2 (196.4km^2).

In Figure 1, Panel A, we decompose the CBF into its four sources: i) land use, ii) GHG emissions, iii) water pollution, and iv) air pollution. The greatest impact on biodiversity originates from land use (49% of the CBF), followed by GHG emissions (22.5%), water pollution (20%), and air pollution (8.5%). In Figure 1, Panel B, we decompose the CBF into its scope 1 to 3 dimensions. Scope 3 contributes about 79% to the CBF value, while scope 1 and scope 2 account for, on average, 15% and 6%, respectively. Scope 3 dominates, because most large firms either assemble and distribute products or provide services, and so do not directly impact the environment; for such firms (retailers, banks, or tech firms), the majority of the scope 3 footprint originates from activities upstream (e.g., provision of farmland or extraction of raw materials) or downstream (usage of products by clients, or financing activities by banks).[15]

In Table 2, Panel A, we present a ranking of industries, using the overall CBF, as well as source- and scope-based measures. The industries with the highest average CBF values are Retail & Wholesale, Paper & Forest, and Food, consistent either with their intensive land use (mostly indirectly through their supply chains in the case of, for example, food or

15. IA Table A.1 reports additional summary statistics on the CBF decomposition.

fashion retailers) or their toxic emissions into air and water. These industries are followed by Asset Management, with scope 3 biodiversity harm (indirectly through financing) being the major component of the sector's overall footprint. Firms with large scope 1 footprints, that is, with business models that have a large direct effect on local biodiversity, tend to operate in the Paper & Forest or Metals & Mining sectors.[16]

In Table 2, Panel B, we present a ranking of countries, again using the overall CBF, as well as source- and scope-based measures. The top five countries with the highest average CBF values are Brazil, Finland, Saudi Arabia, Germany, and Canada.[17]

3.3 Sample selection concerns

Our sample departs from the MSCI ACWI for two reasons. First, IDL expanded its coverage to some U.S., European, and Chinese firms outside of the index. As mentioned, the initial IDL data includes 2,724 firms with a Compustat match. While 72% or 1,954 of these firms belong to the MSCI ACWI, 28% or 770 firms are from outside of the index (conversely, about 72% of all MSCI ACWI firms are covered by IDL). Second, the data requirements described in Section 3.1 lead to further deviations from the MSCI ACWI. As a result, our final sample of 2,106 firms includes 70% or 1,477 firms from the MSCI ACWI and 30% or 629 firms from outside of the index. For comparison, the ACWI universe from 2017 to 2022 contains 2,642 firms. IA Section D analyzes the determinants of IDL's data coverage. As we detect some observable differences between covered and non-covered MSCI firms, we verify below that

16. In IA Table A.2, we replace the industry ranking with industry-average proportions of each CBF source or scope. For instance, for the Waste industry, scope 1 accounts for 78.3% of the total CBF, whereas in Asset Management, scope 3 accounts for 99.9%. Chemicals and Metal & Mining impact biodiversity mainly via the release of toxic compounds and through land use. The impact of air pollution is strongest for Transportation. In the Food, Beverages, Paper & Forest, and Tobacco sectors, land use contributes about 90% to the CBF.

17. In IA Table A.3, we do not observe a large variation across countries, in terms of the CBF decompositions.

our results hold if we restrict the sample to firms in the MSCI ACWI.

4 Biodiversity footprint: Validation and determinants

4.1 Nature Action 100 (NA100) targets and the CBF

Reliability and transparency are critical whenever a new measure is introduced to the literature. To this end, we conduct several validations of the CBF. As an outside validation, we test whether a firm's CBF relates to it being targeted by Nature Action 100 (NA100). Similar to Climate Action 100+, NA100 is an institutional investor initiative that has identified 100 firms, across eight sectors, to engage with in order to tackle biodiversity and nature loss.[18] To identify its targets, NA100 used four principles: i) the firm operates in a sector deemed to be systemically important to reversing nature loss; ii) an analysis conducted by the Finance for Biodiversity Foundation indicates the firm has a high potential impact on nature; iii) the firm has a large market capitalization (within its sector); and iv) the firm is from a developed or emerging market. NA100 was launched at COP15 and is supported by 200 institutions, representing $27 trillion in assets under management or advice as of 2023.

We calculate that the mean value of Ln(CBF) is twice as large for NA100 targets, compared to non-targeted firms (8.76 vs. 4.63, significantly different at the 1% level). If we use CBF/Total assets, then the difference is even greater, with NA100 targets having CBF intensities that are more than four times larger. Further, the majority of NA100 targets are in the top percentiles of the CBF distribution: In Figure 2, more than 50% of the NA100

18. The eight sectors are biotechnology and pharmaceuticals; chemicals; household and personal goods; consumer goods retail, including e-commerce and specialty retailers and distributors; food; food and beverage retail; forestry and packaging; and metals and mining. The target list, released on June 26, 2023, is provided here. It includes such firms as Bayer, Danone, Glencore, Home Depot, Nestlé, Procter & Gamble, and Rio Tinto.

targets locate in the top 10% of the CBF distribution (Panel A), and 69% in the top 20% (Panel B).[19] We conclude that there is a correspondence between the CBF and the set of priority targets with which institutional investors are engaging to address biodiversity loss.

4.2 Textual analysis of corporate disclosures and the CBF

4.2.1 Corporate annual reports and the CBF

While acknowledging that the CBF and the textual analysis of corporate annual reports have different objectives, we borrow the method of Giglio et al. (2023) to further validate the CBF. Giglio et al. (2023) develop a biodiversity dictionary and use it to create an indicator that equals one if a 10-K contains at least two sentences related to terms that reflect biodiversity issues (e.g., biodiversity, ecosystem(s), habitat(s), species, (rain)forest(s), deforestation, aquatic, desertification, or carbon). Their data indicate that only 3.8% of 10-K reports from 2015 through 2020 mention biodiversity issues. That number is 3.3% for our U.S.-listed sample firms, from 2018 through 2020. Using this data, we calculate that our CBF metric exhibits a modest positive correlation of 9.7% with their 10-K measure.[20] More importantly, Figure 3 shows the CBF distribution for firms which do and do not mention biodiversity terms in their 10-K filings. While, on average, firms that do mention biodiversity have higher CBF values, there is significant overlap of the two distributions. This result means that many firms without 10-K biodiversity disclosures have higher CBFs than firms with such disclosures.

In IA Section E, we provide case study excerpts to show how biodiversity issues are dis-

19. The fact that NA100 focuses on only eight sectors explains why some large-CBF firms in our sample are not on their target list. The two firms in the third CBF decile, in Panel A, are Charoen Pokphand Indonesia, a poultry processer, and the U.S. veterinary drug producer Zoetis.

20. Consistent with 10-Ks emphasizing direct biodiversity impacts, the 10-K-based measures exhibit stronger correlations with the scope 1 component of the CBF than with the scope 2 and 3 ones (IA Table A.17).

cussed in corporate annual reports. We focus on Danone, which ranks among the sample firms with the largest CBF, is a target of NA100, and is used in IA Section C to illustrate the CBF calculation. Danone is an exception in how extensively it discusses biodiversity issues. Its annual reports explain how food production and farming depend on biodiversity, and that the firm strives to protect and restore it.

4.2.2 Earnings conference calls and the CBF

Similarly, we perform a textual analysis of earnings calls to explore whether firms disclose more on biodiversity when interacting with analysts. Earnings calls are key corporate events, in which financial analysts listen to management and ask questions about a firm's current and future developments. One benefit of earnings calls is that they are available for firms outside of the U.S. We collect earnings call transcripts from Refinitiv Street Events from 2019 through 2022, and identify the relevant text using the biodiversity dictionary of Giglio et al. (2023).

We again find that biodiversity is mentioned only rarely, making a text-based validation exercise challenging: just 5.0% of the quarterly calls in our sample contain at least one biodiversity term. For 2021, in almost 94% of the earnings calls of NA100 targets, there is no mention of biodiversity. Unsurprisingly, the correlation between the CBF and the (yearly average) number of biodiversity terms in earnings calls is also just 8.8%. This low correlation provides some insights into the challenges of using textual analysis to identify biodiversity transition risks. Figure 4 shows the CBF distribution for firms with and without mentions of biodiversity terms in their earnings calls. Notably, the low correlation is the result of many large-CBF firms not discussing any biodiversity-related issues in their earnings calls. The significant overlap between the distributions in the figure further indicates that many firms that do not mention biodiversity have *higher* CBF values than those that do.

With these limitations in mind, IA Section E provides—as case studies—excerpts from earnings calls that discuss biodiversity issues. The examples come from Archer-Daniels-Midland (AMD), a food processing and commodities trading firm, and Sysco, a firm active in the marketing and distribution of food products (among others). Both firms score high in the CBF metric (top 1% of the sample) and are on the NA100 list. AMD explains how it has accelerated the deadline for a deforestation-free supply chain from 2030 to 2025, and Sysco emphasizes how it has improved sustainable grazing across 1 million acres of grassland.

4.2.3 Interpretation of text-based evidence

That simple text-based biodiversity measures overlap poorly with the biodiversity footprint is remarkable from an investor or regulatory perspective. Many firms with a large negative impact on biodiversity appear to not address the associated transition risks in their corporate reports and earnings calls, and analysts do not probe them on these risks. More advanced natural language processing techniques may be able to pick up more variation in biodiversity-related discussions among firms (Schimanski et al. 2023). Moreover, in the near future, investor demand for biodiversity disclosure will likely grow; biodiversity topics, even when measured simply, should in turn become more prominent in earnings calls and 10-Ks.[21]

4.3 Firm-level determinants

We examine firm-level drivers of the CBF by estimating the following regression for firm i in year t:

$$\text{Ln(CBF)}_{i,t} = \beta_0 + \beta_1 \mathbf{X}_{i,t} + \gamma_t + \delta_c + \mu_j + \epsilon_{i,t}, \tag{1}$$

21. According to the head of Schroders, reporting on biodiversity is where reporting on climate change was five to ten years ago (Agnew 2022). Ilhan et al. (2023) show that institutional investors currently value and demand climate risk disclosures.

where $\text{Ln(CBF)}_{i,t}$ is the natural logarithm of the CBF (in km²$.$MSA). The vector $\mathbf{X}_{i,t}$ contains various firm characteristics. We include different sets of fixed effects, capturing year (γ_t), country (δ_c), and industry (μ_j) dimensions, and fixed effects at the country-by-year ($\delta_c \times \gamma_t$) or industry-by-year ($\mu_j \times \gamma_t$) level. Standard errors are clustered at the firm level.

Table 3 presents the estimations of Equation (1). Firm size positively relates to the biodiversity footprint, which is plausible, as the CBF metric reflects the loss of biodiversity caused by a firm's activities in km^2.MSA; larger firms typically have a larger spatial impact. Firms with greater asset tangibility (PPE over assets) also have a larger footprint, which is again intuitive, given that the main CBF source is land use (firms with more tangible assets likely contribute more to the degradation of biodiversity). Consistent with Bolton and Kacperczyk (2021) for carbon emissions, the biodiversity impact is smaller for firms with higher capex. Firms with higher carbon emissions also have larger biodiversity footprints, in part because emissions are one of the pressures considered in the CBF computation. Finally, firms with better Refinitiv E scores have worse biodiversity footprints.[22] An unreported variance decomposition, assessing the relative contributions of the fixed effects in the table, shows that more than half of the CBF variation plays out at the firm level (though there is a sizeable industry component).

22. This result indicates that it may be misleading to rely on aggregate E scores, when seeking to incorporate biodiversity into investment decisions, as a negative biodiversity impact does not necessarily translate into a lower E score. One reason is that most ESG raters, including Refinitiv, focus on aspects that are financially material to shareholder value, rather than impact materiality.

5 Cross-section of returns

5.1 Estimation design: Cross-sectional regressions

In this section, we rely on cross-sectional regressions relating individual firms' returns to their CBF values. As in Bolton and Kacperczyk (2023), we employ a characteristic-based approach, rather than a factor-based model, which is well suited, given the rich cross-sectional variation in firm characteristics in our sample. With a characteristics-based approach, there is no need to make assumptions about the underlying asset pricing model.[23] We link the return of firm i in month m of year t to its corresponding biodiversity footprint in year t-1:

$$\text{Monthly return}_{i,m,t} = \beta_0 + \beta_1 \text{Ln(CBF)}_{i,t-1} + \beta_2 \mathbf{X}_{i,t-1} + \gamma_t + \delta_c + \mu_j + \epsilon_{i,m,t}, \tag{2}$$

where Monthly return$_{i,m,t}$ is the return of firm i in month m of year t, and Ln(CBF)$_{i,t-1}$ is the natural logarithm of the biodiversity footprint of firm i in year t–1. We control for various firm characteristics, following prior studies on the asset pricing implications of environmental externalities (e.g., Bolton and Kacperczyk 2023; Hsu, Li, and Tsou 2023). Specifically, $\mathbf{X}_{i,t-1}$ includes Ln(Total assets) (annual), Ln(Market cap) (monthly), Book-to-market (monthly), Leverage, Capex/Total assets, PPE/Total assets, ROA, Asset growth, Sales growth (all annual), as well as Volatility and Momentum (both monthly). Annual (monthly) variables are lagged by one year (month). We control for year-month, industry, and country fixed effects, and double cluster standard errors at the year-month and firm level.

23. As explained by Bolton and Kacperczyk (2023), a conceptual difficulty with the choice of asset pricing model, in the context of a complex pricing problem such as climate risks, is that no such model has yet been formulated. The same argument applies in our setting, especially since biodiversity risks has received less attention than climate risks.

5.2 The CBF and the cross-section of returns: Baseline results

Table 4, Column 1, reports the results of estimating Equation (2) with time, country, and industry fixed effects across the full sample period, using monthly returns between January 2019 and December 2022. While the coefficient on Ln(CBF) is positive, it is not statistically significant. Hence, on average, a larger biodiversity footprint is *not* associated with higher (or lower) returns. In Column 2, this average non-result holds when we account for time-varying unobserved heterogeneity at the industry level (with industry-by-time fixed effects).

Investors may start considering the risks associated with a firm's biodiversity footprint in response to important policy-related news that increased regulatory or legal uncertainty. Particularly relevant is the Kunming Declaration, which—together with the subsequent Montreal Agreement—has been hailed as the biodiversity equivalent of the climate-focused Paris Agreement. The Kunming Declaration was adopted at the 15$^{\text{th}}$ Conference of the Parties of the CBD (COP15) in October 2021.[24] More than 100 countries committed to developing, adopting, and implementing an effective global framework to put biodiversity on a path to recovery by 2030. Analogous to the Paris Agreement, the Declaration stresses the need to align financial flows in support of the conservation and sustainable use of biodiversity. COP15 is seen as the most important UN event of the decade related to biodiversity (CBD Secretariat 2021).

The commitments into which countries entered at COP15 have far-reaching consequences for firms, by triggering (or accelerating) biodiversity-related regulation and litigation.[25] For example, the EU Deforestation Regulation (EUDR), which came into effect in 2023, puts

24. IA Section F provides a historical overview of global and regional policy developments and initiatives.

25. While the COP15 agreements are not legally binding, the signatory countries committed to demonstrating progress toward meeting the agreed-upon targets. Similar to the Nationally Determined Contributions (NDCs) under the Paris Agreement, COP15 led to National Biodiversity Strategy and Action Plans (NBSAPs) on which countries need to provide updates.

pressure on food companies by banning food products (cattle, cocoa, coffee, oil palm, soy, wood, and rubber) linked to deforestation and forest degradation. This regulation comes with substantial compliance costs (tracing the origin of products), and potentially high fines and reputational costs in case of violation; importantly, the extent of these costs is highly uncertain. Further, the proposed EU Nature Restoration Law aims to restore nature on 20% of the EU territory (among other goals), which can only be achieved if biodiversity-negative corporate activities are restricted or taxed.

Motivated by the significance of the Kunming Declaration, in Table 4, Columns 3–6, we split stock returns into two periods: from January 2019 to September 2021 (pre-Kunming period) and from October 2021 to December 2022 (post-Kunming period). In Columns 3–4, we continue to find no significant effects of the CBF in the pre-Kunming period. By contrast, in Columns 5–6, larger CBF values are associated with significantly greater returns in the post-Kunming period. In Column 5, a one-standard-deviation increase in Ln(CBF) is associated with an additional monthly return of 18.5 basis points, or a 2.2% annualized increase. In Wald tests of coefficient equality, the coefficients on Ln(CBF) are different across the pre- and post Kunming periods (p-values of 0.019 and 0.036, respectively).

5.3 The CBF and the cross-section of returns: Country heterogeneity

To shed light on the mechanism behind these results, we examine whether the cross-sectional return effects differ across countries, depending on two measures of biodiversity protection: i) the Biodiversity & habitat index, which assesses countries' actions toward retaining natural ecosystems and protecting biodiversity within their borders; and ii) the Ecosystem vitality index, which captures how well countries are preserving, protecting, and enhancing ecosystems and the services they provide. We create two dummy variables that each equal one if biodiversity protection in a country falls below the median ("Low protection"), and zero otherwise ("High protection"); both variables are measured as of before the Kunming Declaration (end of 2020). Values of the indexes by country are reported in IA Table A.4. We then estimate an augmented version of Equation (2) for the post-Kunming period:

$$\begin{aligned}\text{Monthly return}_{i,m,t} = \beta_0 + \beta_1 \text{Ln(CBF)}_{i,t-1} \times \text{Low protection}_c \\ + \beta_2 \text{Ln(CBF)}_{i,t-1} + \beta_3 \mathbf{X}_{i,t-1} + \gamma_t + \delta_c + \mu_j + \epsilon_{i,m,t},\end{aligned} \tag{3}$$

where $\text{Monthly return}_{i,m,t}$ and $\text{Ln(CBF)}_{i,t-1}$ are defined as above, and Low protection_c in country c is constructed as just explained. We include the same control variables and fixed effects as in Equation (2). Low protection_c is absorbed by the country fixed effects.

Table 5 reports the estimations of Equation (3). In Columns 1 and 4, the effects of large-CBF stocks on returns are amplified in low-protection countries: the coefficients on $\text{Ln(CBF)}_{i,t-1} \times \text{Low protection}_c$ are positive and significant in both columns. The standalone effects for Ln(CBF) are not significantly different from zero, implying that the returns for large-CBF stocks accrue in low-protection countries. We find similar results if we use sample splits into low- and high-protection countries instead of interaction terms (Columns 2–3, 5–6).

5.4 The CBF and the cross-section of returns: Further results

Given the conceptual links and overlaps between biodiversity and climate change, as discussed in Section 2.5, one concern is that our results may reflect a carbon risk premium, rather than the broader biodiversity impacts of firms. To address this concern, we test whether our results hold when directly controlling for two measures of climate transition risk: carbon emissions and regulatory climate change exposure.[26]

IA Table A.5 reports the results of our robustness tests of Table 4. In Columns 1–4, we add Ln(CO_2 Emissions) and CCExposure^{Reg} as control variables. While the CBF continues to be unrelated to returns over the full sample period, Ln(CBF) remains related to returns in the post-Kunming period. Though significant only at the 10% level, the magnitudes of the post-Kunming estimates are similar, compared to the baseline (0.060 and 0.063 in Columns 2 and 4, which compare to 0.061 in Table 4, Column 5). As a complementary robustness check, reported in Columns 5–6, we compute the CBF considering only land use, air pollution, and water pollution (that is, we exclude the GHG component). We find that this "emissions-free" CBF is positively associated with returns in the post-Kunming period. Results are even stronger in IA Table A.6, which documents the robustness of Table 5 after we have added the two measures of climate transition risks.

A further concern is that realized returns are noisy and can lead to effects due to luck, especially in short samples (e.g., Elton 1999; Lundblad 2007). Pástor, Sinha, and Swaminathan (2008) show that the trade-off between risk and expected returns can sometimes be more easily detected using the implied cost of capital (ICC), instead of realized returns. The ICC is the discount rate (or internal rate of return) that equates a firm's market value to the present value of its expected future cash flows. Similarly, Cenedese, Han, and Kacperczyk (2023) argue, in a climate finance context, that estimates for expected returns derived from valuation models can corroborate that effects observed in realized returns indeed reflect

26. We verify that our sample firms earn a carbon premium using the method in Bolton and Kacperczyk (2023) (and using the same 2005-2018 sample period). For the 2019-2022 sample period in our paper, emissions remain positively associated with returns, but the estimate is more noisy (t-statistic of 1.24). This result is possibly due to two factors: i) the trend toward ESG investing during the past few years may have led to unexpected shifts in climate concerns and investors' preferences, pushing up realized returns for low-emission stocks, as noted by Pástor, Stambaugh, and Taylor (2022); and ii) according to Bolton and Kacperczyk (2023), the rise in the carbon premium since the Paris Agreement originates mostly from Asian firms, which constitute a comparatively smaller fraction in our sample.

required, expected returns, rather than luck. We therefore construct an ICC measure and relate it to the CBF. Following Lee, So, and Wang (2021), the ICC measure is computed as an average across four valuation models.[27] In IA Table A.7, we re-estimate Equation (2) after replacing Monthly $\text{return}_{i,m,t}$ with Monthly $\text{ICC}_{i,m,t}$.[28] We find that, after Kunming, the CBF has a positive and significant association with ICC, though a Wald test indicates that the coefficient is not statistically different from the (imprecisely estimated, but much smaller) coefficient in the pre-Kunming period. After Kunming, a one-standard-deviation increase in Ln(CBF Value) is associated with a monthly ICC increase of 0.041% (0.50% annualized).

Finally, the relation between realized returns and the CBF may originate, in part, from unexpected changes in corporate earnings. To address this concern, we follow Atilgan et al. (2023) and calculate two measures of earnings surprises. SUE1 is the one-year earnings surprise, calculated as the actual earnings per share (EPS) for the fiscal year ending in year t minus the consensus (median) analyst forecast, scaled by the end-of-year stock price. The consensus forecast is taken as of eight months prior to the end of the forecast period, i.e., four months after the prior fiscal year-end. Similarly, SUE2 is the two-year earnings surprise, calculated in an analogous manner, with the consensus forecast taken 20 months prior to the end of the forecast period.[29] We then regress in IA Table A.8 each of these two measures on

27. Our ICC measure is the mean value of those derived from the GLS (Gebhardt, Lee, and Swaminathan 2001), CAT (Claus and Thomas 2001), MPEG (Easton 2004), and AGR (Ohlson and Juettner-Nauroth 2005) models. The GLS and CAT models are based on variants of the residual-income model; they differ in terms of their forecasting horizon and terminal value estimation. The MPEG and AGR models are based on the abnormal-growth-in-earnings model; they differ in their formulation of the long-term growth in abnormal earnings. For details on the computations, see Lee, So, and Wang (2021)'s Appendix B.2. All four ICC measures are based on earnings forecasts derived from the cross-sectional mechanical forecast model of Hou, Van Dijk, and Zhang (2012), and do not rely on analyst forecasts, which facilitates the ICC computation for a large cross-section of international firms.

28. We match the ICC measure, computed at the end of month m, so that it corresponds to the realized return over the following month.

29. We remove observations where the forecast error is larger than 10% of the stock price. The median one-year (two-year) earnings surprise is about 0.00% (-0.00%) with a standard deviation of 1.64% (1.99%).

one-year-lagged values of the CBF. In these firm-year regressions, we observe no statistically significant relationship between the CBF and earnings surprises, independent of whether we consider the whole sample period or the pre- and post-Kunming years.

5.5 The CBF and the cross-section of returns: Robustness

We have conducted a wide range of robustness tests. First, we investigated whether our results might be confounded by non-linear size effects. However, in IA Table A.9, we obtain positive and significant return effects also for intensity measures (the CBF scaled by total assets or sales; this evidence is useful, as the TNFD focuses on scaled measures). Second, as shown in IA Table A.10, our baseline results hold when we implement alternative standard error clusterings. In Columns 1–2, we cluster standard errors at the firm-year level, in Columns 3–4 at the firm level, and in Columns 5–6 at the firm and year levels (as in Bolton and Kacperczyk 2021, 2023). Our choice of clustering in the baseline estimation by year-month (48 groups), instead of year (four groups), is motivated by the small number of clusters generated otherwise. Third, we verify in IA Table A.11 that our results hold if we restrict the estimation to firms inside the MSCI ACWI universe; these results are reassuring, as they suggest that IDL's coverage decision within the MSCI ACWI does not unduly bias our estimates.

6 Event study evidence

6.1 Estimation design: Event study

We conduct an event study in which we examine daily returns of firms with large versus small biodiversity footprints around the date of the Kunming Declaration. This allows us to dissect how investors revised their valuations of large-CBF stocks around the declaration, and it helps address the concern that the returns after Kunming are due to confounding factors correlated with a firm's CBF. We estimate the following regression at the firm-day level, over a window of three days before to three days after the event:

$$\text{Daily return}_{i,t} = \beta_0 + \beta_1 \text{Large CBF}_i \times \text{Post}_t + \delta_i + \gamma_t + \epsilon_{i,t}, \tag{4}$$

where Daily $\text{return}_{i,t}$ is the return of firm i in day t, Large CBF_i equals one if the firm has a large biodiversity footprint (i.e., the firm's CBF is above the median), and Post_t equals one after the event. The event date is October 13, 2021 (the day of the adoption of the Kunming Declaration), which is also the first day of the post-event window (denoted as t=0). We label the event window as [–3,+2] days, reflecting the three days before the event date and the event date plus the two following days. We control for firm (δ_i) and day (γ_t) fixed effects. The firm fixed effects control for firm characteristics or potential determinants of stock returns that are fixed around the days of the event. The standalone variables Large CBF_i and Post_t are absorbed by, respectively, the firm and time fixed effects. Standard errors are clustered at the country level. The coefficient of interest, β_1, captures the differential in daily returns for large-CBF stocks, relative to small-CBF stocks, following the Kunming Declaration.

6.2 Event study of the Kunming Declaration

Table 6 reports the results of estimating Equation (4). In Columns 1–4, we report results for raw returns, and in Columns 5–8, for abnormal returns (in excess of the domestic market index). In Column 1, Large CBF $\times$ Post is negative and statistically significant at the 1% level, indicating that large-CBF firms experienced statistically lower returns than small-CBF firms. On average, following the October 13 announcement, the daily returns of large-CBF firms were 0.38% below those of small-CBF firms. These effects reach a cumulative valuation decline of –1.14% over the three-day period. The results are similar if we control for country- or industry-wide reactions, as shown in Columns 2–3, and if we use abnormal returns, as shown in Columns 5–7. In Columns 4 and 8, we replace the Post variable with dummies capturing the individual days surrounding the Kunming Declaration. In this dynamic specification, we estimate effects relative to day t=–3. The negative price reaction for large-CBF firms mostly spans the day of the declaration and the following day (t=0 and t=+1), both in Columns 4 and 8. Before the declaration, we observe no significant differences in the returns of large- versus small-CBF firms. An exception is t=–1 in Column 4, for raw returns, where we find a weakly significant effect; this effect disappears in Column 8, with abnormal returns.

To capture possible pre-trends and reversals, we expand the time window to [–5;+5] days. Figure 5 reports the average difference in returns between large- and small-CBF stocks for a given day. While there are no significant differences before the Kunming Declaration, there is a significant relative price drop for large-CBF firms on the day of the declaration (t=0). There is no significant valuation reversal following the declaration.

In IA Table A.12, we show that the event study results hold when we control for carbon emissions and regulatory climate change exposure. In IA Table A.13, we re-estimate variants of Table 6, Column 1, documenting negative and significant return reactions for three of the four sources of pressure. We also observe a negative reaction when we categorize stocks into large- versus small-CBF groups based on intensity measures. Our results are also unchanged if we define as large-CBF firms those with a CBF value in the top quartile or top tercile, or use the continuous CBF measure instead of the Large CBF dummy. IA Table A.14 shows the event study results hold if we restrict the sample to MSCI ACWI stocks. Our results are also robust to clustering standard errors at the industry or firm levels (unreported).

6.3 Event study of the TNFD launch

The Kunming Declaration emerges as a key event, due to which the prices of large-CBF stocks were bid down. The bid-down prices, in turn, imply higher (expected) returns for large-CBF stocks, as we document by splitting the sample into a pre- and post-Kunming period in our cross-sectional tests. While these results closely align, we do not posit that the Kunming Declaration was the only relevant biodiversity-policy event or that it uniquely triggered valuation declines. Other recent events, such as the launch of the TNFD, may have contributed to changes in investors' perceptions of biodiversity transition risks. The TNFD developed a risk management and disclosure framework for organizations to report and act on evolving nature-related risks, releasing a first draft in early 2022 and its final recommendations in September 2023 (TNFD 2023a). While initially voluntary, the TNFD recommendations are widely expected to become mandatory. Because four versions of the framework had been released previously, the final version contained little surprising information. Therefore, we focus on the formal launch of the TNFD initiative, with endorsement by the G7 countries, on June 4, 2021 (just four months before the Kunming Declaration).[30]

In Table 7, we examine how investors reacted to the TNFD launch by re-estimating Equation (4) around June 4, 2021. In Column 1, we show that in the three days following the TNFD launch, relative to the three days before it, large-CBF stocks experienced a significant decline of -0.5% per day. This estimate is robust to alternative fixed effects, as shown in Columns 2–3, and we find no pre-trends, as shown in Column 4. Columns 5–8 show our conclusions are also unaffected when we use abnormal returns. Motivated by this finding, we re-estimate the cross-sectional regression from Equation (2) for the post-TNFD period,

30. A potentially confounding event was the announcement, on the same day, of a proposed regulatory revision to the Endangered Species Act (ESA) by the U.S. Fish and Wildlife Service, rescinding changes made during the Trump Administration.

instead of the post-Kunming period. Unsurprisingly, given the close proximity of the two events, Ln(CBF) positively and significantly relates to returns in the post-TNFD period. Overall, the two events appear to have shifted return dynamics.[31]

7 Interpreting the overall evidence

While we have established links between the CBF and returns, the question that emerges is what economic channel explains these patterns consistently. We evaluate three possible channels: i) shifts in investor preferences; ii) unexpected cash flow shocks; or iii) a biodiversity transition risk premium.

According to the first channel, investor preferences change over time due to a heightening of concern for biodiversity. These changes imply gradual shifts in fund flows and equity investments toward small-CBF firms and away from large-CBF firms. Though this channel may be plausible in other ESG contexts (Pástor, Stambaugh, and Taylor 2021, 2022), our overall evidence does not support it. In contrast to our results, this channel would predict that large-CBF firms have *lower* (not higher, as we found) returns in the months after the Kunming Declaration.[32] Our results are also hard to reconcile with the second channel, which predicts unexpectedly high earnings or cash flows in large-CBF firms. First, we document that the CBF does not correlate with earnings surprises in the post-Kunming years

31. In IA Table A.15, we re-estimate Equation (4) as a placebo test around the launch of the climate disclosure initiative, TCFD. Since the CBF captures a firm's impact on biodiversity, we do not expect a stock market reaction for large-CBF firms when an initiative is launched that is not specifically related to biodiversity. If, however, our results reflect a reaction to (environmental) disclosure generally, then we should also find an effect for the TCFD launch. We consider two dates: November 9, 2015, when the Financial Stability Board published its proposal to create a disclosure task force on climate risks, and December 4, 2015, when the TCFD was formally established. We do not find evidence that investors revised their valuations of large-CBF firms around either of these two dates.

32. Pástor, Stambaugh, and Taylor (2022) document that the strengthening of climate concerns is responsible for the outperformance of "green" stocks relative to "brown" stocks from 2012 to 2020.

(and before too). Second, unexpectedly high earnings or cash flows should be much more likely before Kunming; however, for this period we found non-significant return effects of the CBF. It is in turn conceptually unclear why unexpectedly higher cashflows of large-CBF stocks would materialize only in the months after Kunming.

Instead, the positive cross-sectional link between the CBF and returns is consistent with a biodiversity transition risk premium. This channel aligns with the pricing of carbon transition risks, proxied using the corporate carbon footprint (Bolton and Kacperczyk 2021, 2023). Accordingly, the CBF provides a proxy for a firm's exposure to biodiversity transition risks, and our results reflect the pricing of such risks. Our cross-country results support this interpretation: in countries with low biodiversity protection, the uncertainty about, and expected stringency of, future regulations is highest; the risk premium, thus, is larger. By the same token, firms located in countries that have already taken ambitious actions to protect biodiversity have lower exposure to transition risks, as there is much less uncertainty about future regulations. The results of our event studies also line up with the risk premium channel: they indicate that the Kunming Declaration was a key event around which the prices of large-CBF stocks were bid down, arguably in response to changes in investors' beliefs about biodiversity transition risks. The bid-down stock prices, in turn, implied higher expected returns for these large-CBF stocks. Our TNFD results can be interpreted within the risk premium channel as well. While primarily about disclosure, the TNFD launch plausibly also raised biodiversity transition risks, as more disclosure can increase the odds of a firm being targeted by litigation. Hence, like Kunming, the TNFD launch may have contributed to changing investors' awareness of biodiversity transition risks.

The risk premium that we document may arise in response to cash flow uncertainty. Specifically, investors may worry that future biodiversity-related regulations or litigation will affect corporate investments, create stranded assets, or impair the operating performance of a firms, all of which comes with heightened cash flows uncertainty. Another possible source of the risk premium relates to changes in a firm's discount rates, that is, in how investors perceive biodiversity transition risks; for example, there may be changes in the economic model investors use to price these risks. Both factors likely contribute to our findings.

A transition risk premium compensates investors for future losses related to the realization of biodiversity risks. BloombergNEF (2023) provides evidence, in a series of case studies, that such risks have indeed started to materialize. One case, for example, is that of chemicals producer 3M, who, in June 2023, entered into a $10.5 billion settlement with U.S. water authorities for having introduced substances known as PFAS into water; PFAS have been shown to be harmful to hundreds of species. The case was associated with a large share price decline in 3M's stock.

8 Comparison with MSCI and Refinitiv measures

We compare the CBF to two biodiversity measures provided by commercial data vendors: i) MSCI's biodiversity & land use exposure score, and ii) Refinitiv's biodiversity impact reduction indicator. These measures are also available for a longer time-series, but are not based on the biodiversity impact metrics discussed in Section 2. Hence, they differ conceptually from the CBF, which uses MSA to quantify a firm's biodiversity impact.[33] IA Table A.16 contrasts our CBF metric with MSCI's and Refinitiv's measures, and we explain in detail

33. As explained above, MSCI and other data providers plan on introducing impact-based measures in 2024, initially without a time-series. Hoepner et al. (2023) employ another measure of a firm's biodiversity impact, which was constructed by Eiris (now majority-owned by Moody's); however, Eiris stopped providing the measure in January 2018.

how both vendors construct their scores in IA Section G.[34]

In brief, MSCI scores a firm's biodiversity and land use exposure on a 0-10 scale (10 corresponds to the highest risk). The score aims to capture three risks for a firm: loss of license to operate; litigation by landowners and other affected parties; and increased costs of land protection and reclamation. In comparison, the CBF provides a more complete measure of the firm's biodiversity impact. Specifically, the MSCI score is not a quantitative measure of the firm's impact on biodiversity, and it is in turn not considered in the review of biodiversity metrics by Finance for Biodiversity (2022). Further, MSCI focuses on the direct operations of a firm, especially land use, rather than on the overall life cycle of its products.[35] By contrast, the life cycle assessment in the CBF calculation captures the total potential environmental impacts associated with the production of a good or service. It takes into account all or part of each production stage, from the supply of raw materials to the end of the product's life.

Refinitiv's measure is a dummy variable indicating whether or not a firm reports its impact on biodiversity, or its activities to reduce this impact. The indicator positively correlates with Ln(CBF) (correlation of 0.31), suggesting that firms with larger biodiversity footprints disclose more on the topic (IA Table A.17). IA Figure A.3 reports the distributions of CBF values for disclosing and non-disclosing firms, according to the Refinitiv measure. While firms disclosing more on biodiversity tend to have larger CBFs, many non-disclosing firms also have much larger CBFs than disclosing firms.

Beyond this simple comparison, we replicate our main results after replacing the CBF metric with MSCI's score. IA Table A.18, Panel A, reports a positive impact of the MSCI

34. MSCI also provides a biodiversity & land use *management* score, which evaluates a firm's ability to manage its exposure. This score, utilized by Xin et al. (2023), is available for a small sample.

35. Consistent with this observation, the MSCI score has a correlation of 0.56 with the Scope 1 component of the CBF, but only a –0.01 (0.33) correlation with the scope 2 (scope 3) components (IA Table A.17).

score on returns in the post-Kunming period, whereas there is no effect before.[36] When using MSCI's measure, our post-Kunming results are so strong that, even in the overall sample, the MSCI score is positive and statistically significant. In Panel B, for the event study, we find a negative and significant reaction for firms with above-median MSCI scores around the Kunming Declaration.

9 Conclusion

Biodiversity loss and climate change are two of the major crises of our era. Research on climate finance has grown rapidly over the past years, thereby improving our understanding of the potential consequences of climate change for financial markets. By stark contrast, there has been very little research on biodiversity finance. Although the two crises are related, biodiversity preservation can clash with actions taken to address climate change. For example, renewable energy and electric cars require lithium, cobalt, magnesium, and nickel, the mining of which comes with severe impacts on biodiversity (and on the human communities that rely on biodiversity). Therefore, it is important to separately analyze finance's role in the loss of biodiversity. Our paper offers a first step toward understanding the interplay between finance and biodiversity by introducing a measure of the corporate biodiversity footprint and exploring whether it is priced by investors.

Examining a large sample of international stocks, we find that, over our sample period, investors did not price the impact of firms on biodiversity, on average. However, the situation appears to be changing, as we document the emergence of a biodiversity footprint premium in the months following the Kunming Declaration (the first part of COP15) and the launch

36. The MSCI score is also available for years before 2019. We do not find a significant relation with returns even when we include additional years in the pre-Kunming period.

of the TNFD. Consistent with this effect, we document negative stock price reactions for firms with large biodiversity footprints in the days following the Kunming Declaration and the TNFD launch. Our results indicate that investors have started to ask for a risk premium in light of the uncertainty associated with future biodiversity regulation.

Supplementary material

Supplementary data are available at *Review of Finance* online.

Data availability

All of the data underlying the article's empirical analyses are publicly available from the sources listed in the article. Most of these sources require a paid subscription, but our understanding is that any researcher who wishes to purchase any of the data may freely do so.

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Appendix A. Variable definitions

Variables	Definitions	Sources
	CBF-related variables	
CBF	Biodiversity loss caused by the firm's annual activities. It results from four environmental pressures: land use transformation, emission of greenhouse gases, emission of nitrogen oxides, and release of toxic compounds into the environment. It is expressed in km^2.MSA, which is equivalent to the pristine natural area destroyed by the firm's annual activities. MSA (Mean Species Abundance) is a metric characterizing the level of biodiversity in an ecosystem. The original CBF metric is a negative number, corresponding to the degradation of biodiversity caused by the firm. We multiply this variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
Large CBF	Dummy variable that equals one if the firm has a large biodiversity footprint (CBF is above the median) as of the beginning of the year, and zero otherwise. Annual data.	Iceberg Data Lab
CBF GHG	Biodiversity loss due to the firm's greenhouse gas (GHG) emissions. In addition to direct GHG emissions due to the firm's energy consumption, GHG emissions resulting from the electricity consumption and emissions of products purchased in the firm's upstream supply chain are taken into account. We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF land use	Biodiversity loss due to the firm's transformation of pristine land into agricultural land or artificialized areas. The firm's direct pressures on land use, such as its physical assets, buildings, or plantations, are factored in. The land use impact of the firm's upstream supply chain (i.e., purchased products) is also taken into account. We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF water pollution	Biodiversity loss due to the firm's release of toxic compounds into the water. Release of substances due to the firm's direct activity (e.g., processing food or fertilizing crops) are taken into account, as well as those of the firm's upstream supply chain. We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF air pollution	Biodiversity loss due to the firm's release of nitrogen oxides (NOx) into the air. Direct pressures coming from the firm, such as NOx emissions arising from its fuel consumption, are taken into account, as are NOx emissions arising from the electricity consumption and emissions of products purchased in the firm's upstream supply chain. We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF scope 1	Biodiversity loss due to the firm's direct activities (i.e., surface artificialized or occupied). We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF scope 2	Biodiversity loss due to the firm's purchase of electricity, heat, and cooling. We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF scope 3	Biodiversity loss due to the firm's indirect activities (such as its products sold or investments made, or products purchased by the firm). We multiply the original variable by –1 so that higher values indicate a more negative impact on biodiversity. Annual data.	Iceberg Data Lab
CBF/Total assets	CBF value scaled by total assets in $. Winsorized at the 2.5% and 97.5% levels. Annual data.	Iceberg Data Lab

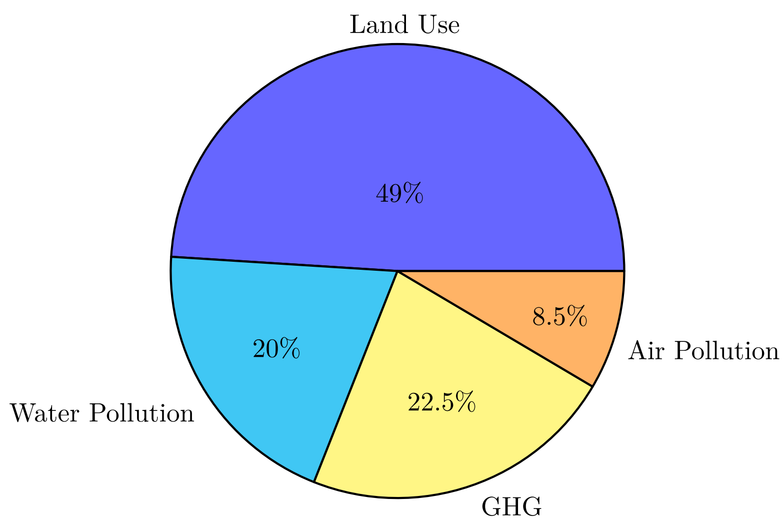
CBF/Sales	CBF value scaled by revenue in \$. Winsorized at the 2.5% and 97.5% levels. Annual data.	Iceberg Data Lab
	Stock return variables	
Monthly return (%)	Monthly stock return. We build total return using stock prices expressed in \$ (prccd), adjustment factors (ajexdi), exchange rates (exratd), and total return factors (trfd). Winsorized at the 1% and 99% levels. Monthly data.	Compustat
Volatility (%)	Standard deviation of the monthly returns over the 36 preceding months. Winsorized at the 1% and 99% levels. Monthly data.	Compustat
Momentum (%)	Average monthly return over the twelve preceding months. Winsorized at the 1% and 99% levels. Monthly data.	Compustat
Monthly ICC (%)	Monthly implied cost of capital (ICC). Following Lee, So, and Wang (2021), we construct the variable as the mean value across four ICC values of the following valuation models: GLS (Gebhardt, Lee, and Swaminathan 2001), CAT (Claus and Thomas 2001), MPEG (Easton 2004), and AGR (Ohlson and Juettner-Nauroth 2005). The GLS and CAT models are based on variants of the residual-income model; they differ in terms of their forecasting horizon and terminal value estimation. The MPEG and AGR models are based on the abnormal-growth-in-earnings model; they differ in their formulation of the long-term growth in abnormal earnings. We compute the mean across the four ICC measures, requiring ICC values to be non-missing for at least three measures. We winsorize the individual ICC measures at the 1% and 99% levels and trim the mean ICC values below 0.	Compustat
Daily return (%)	Daily stock return. We build total return using stock prices (prccd) expressed in \$, adjustment factors (ajexdi), exchange rates (exratd), and total return factors (trfd). Winsorized at the 1% and 99% levels. Monthly data.	Compustat
	Firm characteristics	
Total assets	Total assets. Winsorized at the 1% and 99% levels. Annual data.	Compustat
Book-to-market	Ratio of book equity to market capitalization. Winsorized at the 1% and 99% levels. Monthly data.	Compustat
Leverage	Total debt, divided by total assets. Winsorized at the 1% and 99% levels. Annual data.	Compustat
Capex/Total assets	Capital expenditures, divided by total assets. Winsorized at the 1% and 99% levels. Annual data.	Compustat
PPE/Total assets	Net property, plant, and equipment, divided by total assets. Winsorized at the 1% and 99% levels. Annual data.	Compustat
ROA	Income before extraordinary items, divided by total assets. Winsorized at the 1% and 99% levels. Annual data.	Compustat
Asset growth	Percentage change in total assets. Winsorized at the 1% and 99% levels. Annual data.	Compustat
Sales growth	Percentage change in sales. Winsorized at the 1% and 99% levels. Annual data.	Compustat
E score	Score that reflects how a firm uses best management practices to avoid environmental risks and to capitalize on environmental opportunities to generate long-term shareholder value. Higher numbers indicate better environmental performance. Winsorized at the 1% and 99% levels. Annual data.	Refinitiv
Market cap	Market Capitalization. Winsorized at the 1% and 99% levels. Monthly data.	Compustat
SUE1	One-year earnings surprise. Calculated as the actual earnings per share (EPS) for the fiscal year ending in year t minus the consensus (median) analyst forecast, scaled by end-of-the-year stock price. The analyst consensus forecast is taken eight months prior to the end of the forecast period, i.e. four months after the prior fiscal year-end. We remove observations where the forecast error is larger than 10% of the stock price.	IBES

SUE2	Two-year earnings surprise. Calculated as the actual earnings per share (EPS) for the fiscal year ending in year t minus the consensus (median) analyst forecast, scaled by end-of-the-year stock price. The analyst consensus forecast is taken 20 months prior to the end of the forecast period. We remove observations where the forecast error is larger than 10% of the stock price.	IBES
	Climate transition risk variables	
CO_2 Emissions	Total CO_2 and CO_2 equivalent emissions, in tonnes. It encompasses the sum of scope 1, scope 2, and scope 3 emissions. Winsorized at the 1% and 99% levels. Annual data.	Trucost
High emissions	Dummy variable that is equal to one if CO_2 Emissions is above the median value, and zero otherwise. Calculated as of the end of 2020. Annual data.	Trucost
CCExposure^{Reg}	Regulatory climate change exposure measure from Sautner et al. (2023). Reflects the relative frequency with which bigrams that capture regulatory shocks related to climate change occur in the transcripts of earnings conference calls. The measure uses the average over the last four quarters. Annual data.	Sautner et al. (2023)
High CCExposure^{Reg}	Dummy variable that is equal to one if CCExposure^{Reg} is above the median value, and zero otherwise. Calculated as of the end 2020. Annual data.	Sautner et al. (2023)
Trucost estimated emissions	Dummy variable that is equal to one if data on a firm's carbon emissions is estimated, and zero if data on a firm's carbon emissions is disclosed.	Trucost
	Other biodiversity-related variables	
10-K Biodiversity count score	Dummy variable that is equal to one if a firm's 10-K statement contains at least two sentences related to biodiversity, and zero otherwise. Annual data.	Giglio et al. (2023)
Biodiversity & habitat index	This measure assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders. It consists of seven indicators, some of which are based on separate indexes: Terrestrial biome protection, Marine protected areas, Protected Areas Representativeness Index, Species Habitat Index, Species Protection Index, and Biodiversity Habitat Index. Measured as of 2020.	Yale Center for Environmental Law & Policy
Ecosystem vitality index	This measure captures how well countries are preserving, protecting, and enhancing ecosystems and the services they provide. It comprises 42% of the total EPI score and is made up of six issue categories: Biodiversity & Habitat, Ecosystem Services, Fisheries, Acid Rain, Agriculture, and Water Resources. Measured as of 2020.	Yale Center for Environmental Law & Policy
Low protection	Dummy variable that is equal to one if a country is below the median value of the Biodiversity & habitat index (Ecosystem vitality index) as of the end 2020, and zero otherwise.	Self-constructed
Biodiversity & land use exposure score	Score from 0 to 10 indicating the extent to which a firm's business is exposed to the issue of biodiversity and land use based on its unique mix of business and geographic segments. Examples of criteria assessed include: the products and services a firm provides, location of firm operations, and the nature of those operations. Higher scores indicate greater risk. Annual data.	MSCI
Biodiversity impact reduction	Dummy variable that is equal to one if a firm reports on its impact on biodiversity or on activities to reduce its impact, and zero otherwise. Annual data.	Refinitiv

Figure 1: Decomposition of the corporate biodiversity footprint

The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by a firm's annual activities. Panel A decomposes the CBF into its constituent topical sources. Panel B decomposes the CBF into its scope 1, scope 2, and scope 3 dimensions. Scope 1 measures the environmental pressure of the firm's direct activities; scope 2 measures the pressures induced by the firm's purchase of electricity, heat, and cooling; and scope 3 measures all indirect pressures.

Panel A. Source-based CBF decomposition



Panel B. Scope-based CBF decomposition

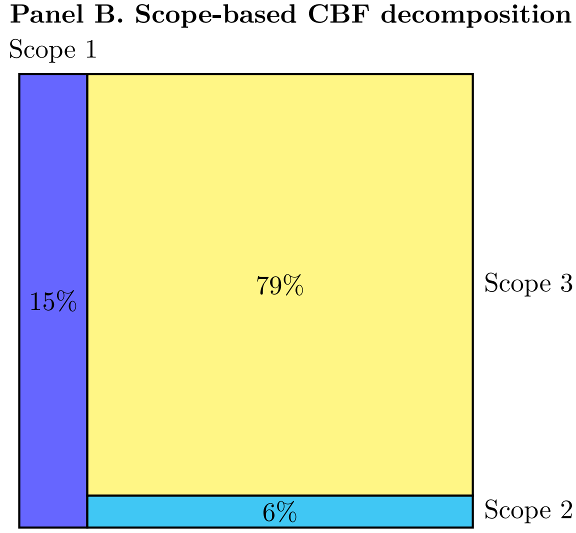
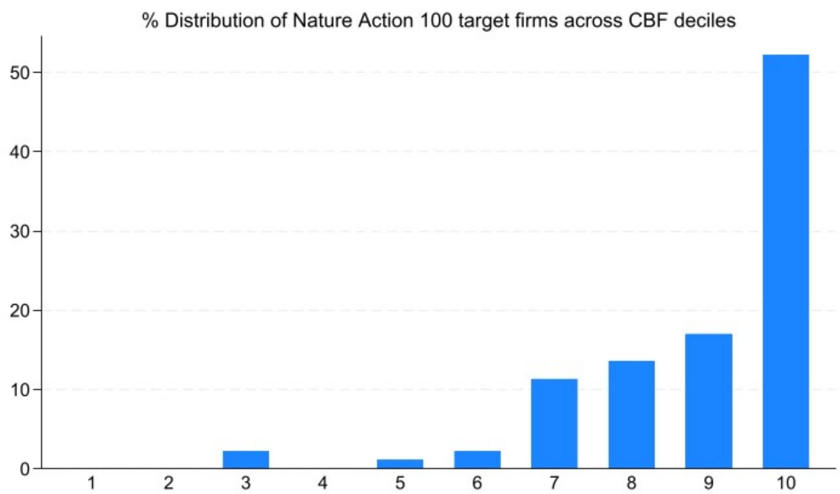


Figure 2: The corporate biodiversity footprint and Nature Action 100 targets

This figure reports the presence of Nature Action 100 target firms across deciles (Panel A) and quintiles (Panel B) of the Ln(CBF) distribution. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. For each firm, we consider the latest observation in our sample to construct the distribution. We restrict our sample in the figures to industries covered by Nature Action 100.

Panel A. Deciles of the Ln(CBF) distribution



Panel B. Quintiles of the Ln(CBF) distribution

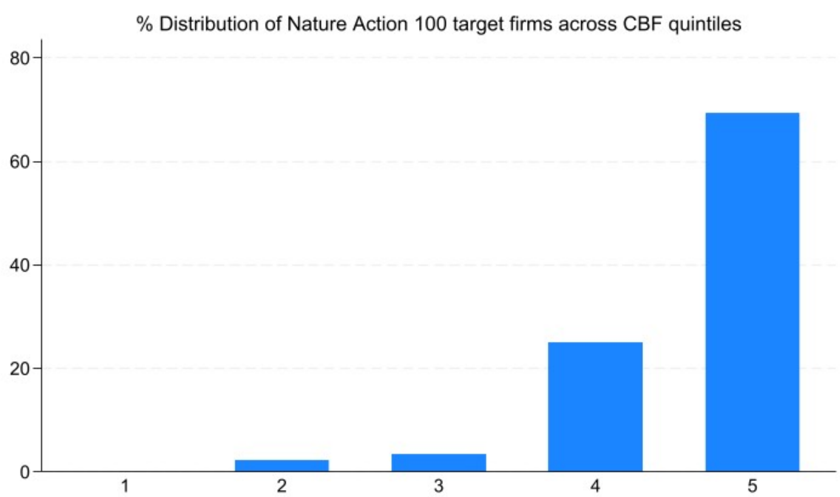


Figure 3: The corporate biodiversity footprint and biodiversity terms in 10-Ks

This figure displays the corporate biodiversity footprint (CBF) distribution for firms with and without disclosure of biodiversity terms in their 10-K reports. The measure of biodiversity disclosure is based on Giglio et al. (2023)'s variable "10-K Biodiversity Count Score."

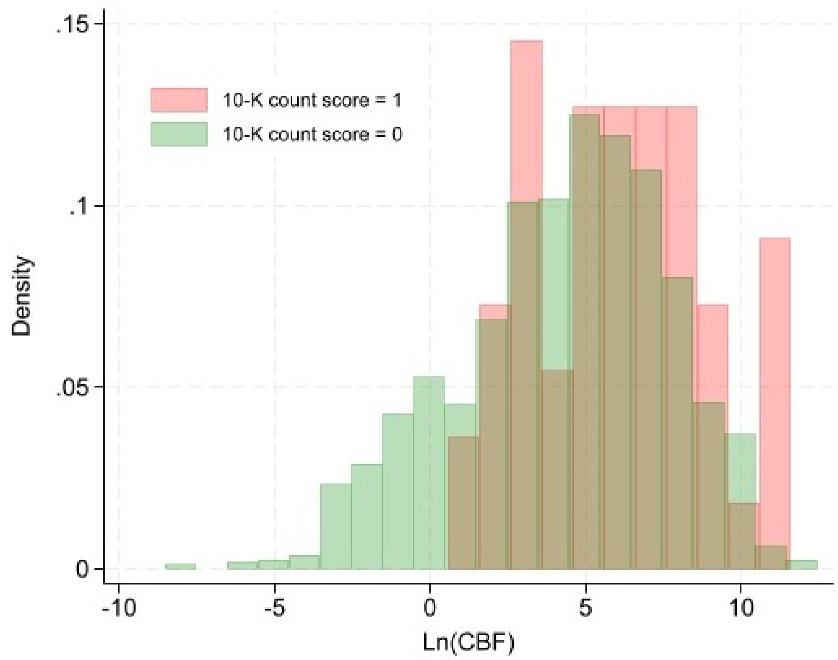


Figure 4: The corporate biodiversity footprint and biodiversity terms in earnings calls

This figure displays the corporate biodiversity footprint (CBF) distribution for firms with and without mentions of biodiversity terms in their earnings calls.

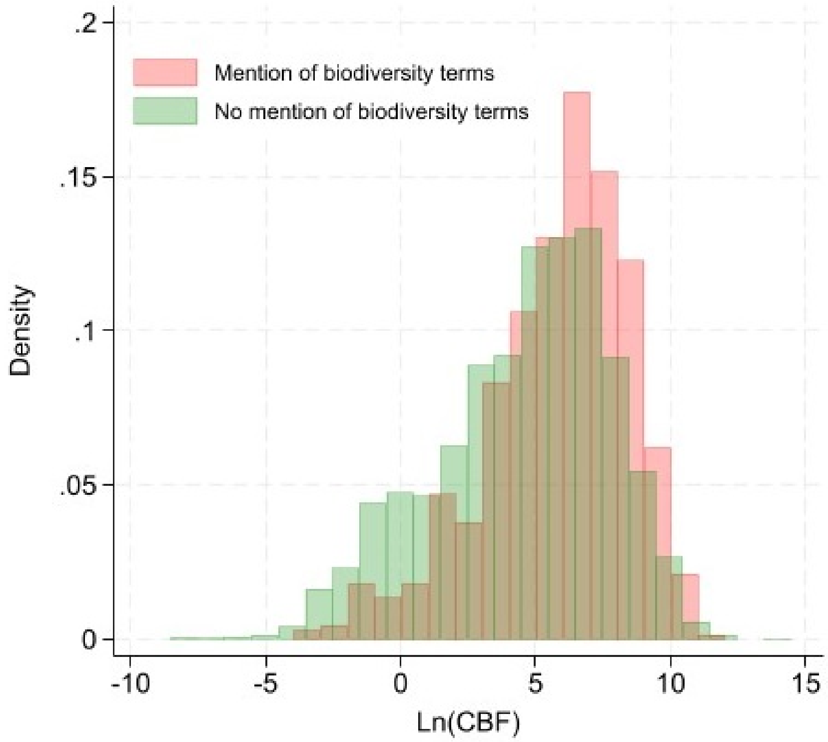


Figure 5: The Kunming Declaration: Return differences between large- and small-CBF firms

This figure reports daily mean stock abnormal return differences around the Kunming Declaration between large- and small-CBF firms. It covers the event window [–5,+5]. The day of the Kunming Declaration (event date) is t=0. Raw returns are winsorized at 1% and 99% by country. Abnormal returns are computed in excess of the mean daily return of the country and the mean daily return of the industry. Large-CBF (small-CBF) firms have a CBF value that is above (below) the median, as of the end of 2020. We also report 95% confidence intervals based on standard errors from t-tests on the equality of means for abnormal returns in both groups (small-CBF and high-CBF firms) on each day. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities.

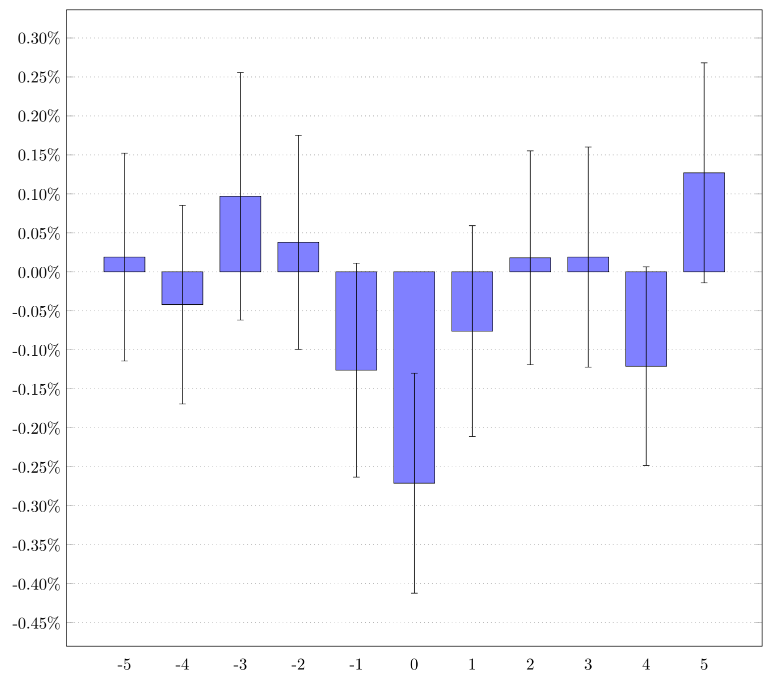


Table 1. Summary statistics

This table presents summary statistics at the firm-month level of the variables used in the returns analysis. The sample period uses returns from 2019-2022. The CBF, accounting, ESG, and CO_2 Emission variables are measured at an annual frequency and lagged by one year. Market capitalization, volatility, and momentum are measured at a monthly frequency and lagged by one month. Appendix A provides variable definitions.

Variables	#Obs.	Mean	S.D.	Min	25%	50%	75%	Max
Ln(CBF)	89,132	4.79	3.11	–9.25	3.17	5.28	7.01	13.78
Ln(CBF GHG)	89,132	2.27	2.97	–12.33	0.24	2.51	4.42	10.08
Ln(CBF land use)	88,820	3.60	3.56	–15.88	1.75	4.10	6.06	13.77
Ln(CBF water pollution)	89,132	1.37	4.27	–15.53	–1.15	2.21	4.40	11.34
Ln(CBF air pollution)	89,132	1.47	3.29	–13.47	–0.39	1.96	3.71	9.12
Ln(CBF scope 1)	89,012	0.88	3.82	–12.69	–2.03	0.98	3.81	13.77
Ln(CBF scope 2)	88,856	–4.54	5.51	–30.77	–8.70	–3.18	–0.15	6.57
Ln(CBF scope 3)	89,120	4.36	3.45	–11.26	2.78	5.01	6.78	12.11
Ln(CBF/Total assets)	89,132	–4.34	2.73	–11.28	–5.50	–3.86	–2.45	0.10
Ln(CBF/Sales)	89,108	–3.75	2.61	–10.21	–4.88	–3.17	–1.90	0.30
Monthly return (%)	89,132	1.18	10.53	–25.63	–5.28	0.81	7.02	34.40
Monthly ICC (%)	52,315	0.93	0.63	0.00	0.50	0.79	1.21	3.86
Volatility (%)	89,132	0.10	0.04	0.04	0.07	0.09	0.12	0.24
Momentum (%)	89,132	0.01	0.04	–0.05	–0.01	0.01	0.03	0.19
Ln(Total assets)	89,132	9.15	1.47	5.83	8.13	9.10	10.09	12.93
Ln(Market cap)	89,132	23.46	1.40	20.19	22.51	23.33	24.33	27.25
Book-to-market	89,132	0.42	0.57	0.01	0.12	0.24	0.49	3.87
Leverage	89,132	0.26	0.17	0.00	0.13	0.26	0.38	0.69
Capex/Total assets	89,132	0.04	0.03	0.00	0.01	0.03	0.05	0.18
ROA	89,132	0.06	0.06	–0.14	0.02	0.05	0.09	0.27
PPE/Total assets	89,132	0.28	0.22	0.00	0.10	0.23	0.43	0.86
Asset growth	89,132	0.13	0.25	–0.19	0.00	0.07	0.16	1.56
Sales growth	89,132	0.10	0.23	–0.45	–0.02	0.06	0.17	1.14
E score	84,074	53.09	26.98	0.00	33.48	57.45	75.32	99.09
Ln(CO_2 Emissions)	88,113	14.08	1.93	9.48	12.75	14.04	15.44	18.48
$CCExposure^{Reg}$	45,266	0.16	0.39	0.00	0.00	0.00	0.13	5.93

Table 2. The corporate biodiversity footprint: Rankings by industry and country

This table reports rankings of the corporate biodiversity footprint (CBF) across industries (Panel A) and countries (Panel B) (reported vertically). The different CBF measures are reported horizontally. Lower rank values indicate larger biodiversity footprints. The rankings are based on mean values across all firms in an industry or country, whereby the most recent value per firm is considered. IDL's industry classification is similar to the Revere Business Industry Classification System (RBICS). Appendix A provides variable definitions.

Panel A. Rankings by industry

	Ln(CBF)	Ln(CBF/TA)	Ln(CBF/Sales)	Ln(CBF air poll.)	Ln(CBF GHG)	Ln(CBF land use)	Ln(CBF water poll.)	Ln(CBF scope 1)	Ln(CBF scope 2)	Ln(CBF scope 3)
Asset Management	4	30	35	11	7	5	6	33	34	4
Automotive & Logistics	18	21	18	6	4	16	21	19	14	17
Beverages	15	27	29	25	27	10	25	24	22	15
Building Products	26	18	17	23	22	26	20	17	17	26
Chemicals	9	29	27	16	18	13	3	14	7	9
Construction & Real Estate	20	13	15	4	17	17	17	6	21	22
Defense	13	14	12	9	6	27	4	30	29	13
Education	35	8	7	35	35	35	35	34	35	35
Electrical Equipment	8	31	32	2	2	20	5	18	23	7
Electronics	24	12	10	20	15	23	19	23	18	24
Financial Services	7	6	9	14	11	6	7	35	24	6
Food	3	35	33	13	16	4	10	10	15	3
Healthcare	25	16	16	26	29	21	14	26	26	25
Hotel & Accommodation	21	22	28	19	20	15	18	20	6	19
Household Goods	17	19	14	10	14	1	16	4	16	18
Industrial Equipment	22	20	19	15	9	28	9	22	32	20
Insurance	14	7	6	17	13	11	8	8	27	14
Internet & Data	31	4	5	28	21	29	28	27	13	29
Leisure	27	10	11	30	31	24	29	21	31	28
Materials	16	26	26	12	8	12	30	7	4	16
Media	33	5	4	32	32	34	26	32	20	31
Metals & Mining	6	32	30	3	3	14	1	3	3	8
Oil & Gas	5	24	24	1	1	9	11	2	5	5
Paper & Forest	2	34	34	22	24	3	23	1	11	2
Pharmaceutical	10	23	22	21	23	18	2	16	33	10
Power	19	15	21	8	5	19	12	5	2	23
Retail & Wholesale	1	33	31	5	10	2	22	11	1	1
Services	34	3	3	34	33	33	32	28	25	32
Software	28	2	1	27	34	32	13	31	30	27
Telecommunications	32	1	2	33	30	31	31	29	9	30
Textiles	12	28	23	18	25	8	27	9	28	12
Tobacco	11	25	25	31	26	7	24	25	19	11
Transportation	23	17	20	7	12	22	15	15	8	21
Waste	30	9	8	29	19	30	33	13	10	34
Water	29	11	13	24	28	25	34	12	12	33

Table 2 (cont.)

Panel B. Rankings by country/region

	Ln(CBF)	Ln(CBF/TA)	Ln(CBF/Sales)	Ln(CBF air poll.)	Ln(CBF GHG)	Ln(CBF land use)	Ln(CBF water poll.)	Ln(CBF scope 1)	Ln(CBF scope 2)	Ln(CBF scope 3)
Australia	26	15	18	21	20	25	19	18	11	27
Belgium	15	16	17	33	32	11	15	26	23	15
Brazil	1	32	31	12	19	2	30	1	18	3
Canada	5	14	21	6	8	7	4	8	21	5
China	12	23	24	4	6	13	11	14	6	11
Denmark	31	28	27	14	33	1	24	32	8	30
Finland	2	29	26	22	3	3	27	3	27	1
France	13	8	7	3	9	15	14	11	3	14
Germany	4	12	11	17	4	14	1	20	7	4
Hong Kong	29	7	10	16	10	30	25	22	1	29
India	24	26	23	5	12	27	9	13	26	25
Indonesia	19	30	29	13	15	17	21	21	24	19
Ireland	28	10	5	27	18	24	26	29	31	26
Israel	34	2	2	34	34	33	34	34	34	34
Italy	27	4	6	15	5	28	29	16	30	28
Japan	20	18	13	19	14	23	6	23	9	18
Korea	22	21	19	7	11	22	16	12	13	21
Malaysia	30	25	28	10	28	26	33	15	12	31
Mexico	18	22	22	26	24	20	8	5	5	23
Netherlands	17	3	1	9	23	16	17	30	29	17
Norway	33	6	8	23	22	32	22	24	28	33
Philippines	9	31	34	24	25	5	31	27	20	7
Poland	7	24	20	2	2	12	18	4	25	10
Saudi Arabia	3	19	25	1	1	4	13	2	2	2
Singapore	14	1	4	28	30	10	32	33	17	12
South Africa	21	34	33	8	21	21	12	6	4	24
Spain	11	11	15	18	13	29	2	10	19	13
Sweden	25	20	16	31	31	18	20	19	32	22
Switzerland	16	13	12	30	27	19	5	28	16	16
Taiwan	23	5	3	32	26	34	3	31	22	20
Thailand	10	27	32	11	7	9	28	9	15	9
Turkey	32	33	30	29	29	31	23	25	33	32
United Kingdom	8	17	14	25	17	8	10	7	14	8
United States	6	9	9	20	16	6	7	17	10	6

Table 3. Determinants of the corporate biodiversity footprint

This table reports regressions relating annual values of Ln(CBF) to firm characteristics. The data frequency is yearly, and the sample period is from 2018-2021. Ln(CBF) is measured in year *t*, and firm characteristics in year *t*. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Standard errors are clustered at the firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Ln(CBF)					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Total assets)	0.851***	0.629***	-0.033	0.663***	0.661***	0.662***
	(0.045)	(0.052)	(0.066)	(0.063)	(0.063)	(0.063)
Book-to-market	–0.106	–0.046	–0.164*	–0.058	–0.064	–0.063
	(0.099)	(0.095)	(0.089)	(0.073)	(0.074)	(0.074)
Leverage	–1.045***	–1.425***	–1.652***	–1.245***	–1.264***	–1.262***
	(0.402)	(0.389)	(0.364)	(0.299)	(0.302)	(0.302)
Capex/Total assets	–9.027***	–9.692***	–10.274***	–4.162***	–4.196***	–4.077***
	(2.059)	(2.064)	(1.795)	(1.331)	(1.353)	(1.342)
PPE/Total assets	3.983***	3.807***	1.256***	–0.025	–0.023	–0.041
	(0.317)	(0.312)	(0.313)	(0.270)	(0.274)	(0.273)
ROA	1.835*	0.901	–1.335	–0.527	–0.522	-0.587
	(0.938)	(0.949)	(0.861)	(0.671)	(0.687)	(0.682)
Asset growth	–0.784***	–0.589***	–0.069	–0.324***	–0.319***	–0.326***
	(0.168)	(0.165)	(0.148)	(0.107)	(0.109)	(0.108)
Sales growth	–0.011	0.133	0.001	–0.086	–0.089	–0.077
	(0.186)	(0.172)	(0.157)	(0.116)	(0.129)	(0.122)
E score		0.027***	0.011***	0.004*	0.004*	0.004**
		(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Ln(CO_2 Emissions)			0.933***	0.352***	0.354***	0.354***
			(0.048)	(0.048)	(0.048)	(0.048)
Year fixed effects	Yes	Yes	Yes	Yes	No	No
Country fixed effects	Yes	Yes	Yes	Yes	Yes	No
Industry fixed effects	No	No	No	Yes	No	Yes
Country×year fixed effects	No	No	No	No	No	Yes
Industry×year fixed effects	No	No	No	No	Yes	No
#Obs.	7,489	7,059	6,996	6,996	6,996	6,996
R^2	0.243	0.278	0.403	0.630	0.633	0.632

Table 4. The corporate biodiversity footprint and stock returns

This table reports regressions relating monthly stock returns to Ln(CBF). The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The sample period in Columns 1–2 includes monthly returns over the full sample period, from January 2019 to December 2022; that in Columns 3–4 includes monthly returns from January 2019 to September 2021 (COP15 in Kunming started in October 2021); and that in Columns 5–6 includes monthly returns from October 2021 to December 2022. Ln(CBF) is measured as of the end of the previous year. The accounting-based right-hand variables are measured as of the last fiscal year. Market capitalization, volatility, and momentum are measured as of the end of the previous month. Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (%)					
	Whole period		Pre-Kunming period		Post-Kunming period	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(CBF)	0.003	–0.000	–0.036	–0.036	0.061**	0.057**
	(0.019)	(0.018)	(0.022)	(0.022)	(0.026)	(0.026)
Ln(Total assets)	0.211	0.158	0.143	0.112	0.336	0.290
	(0.171)	(0.164)	(0.192)	(0.187)	(0.329)	(0.313)
Ln(Market cap)	–0.468***	–0.393***	–0.426**	–0.382**	–0.372	–0.305
	(0.153)	(0.143)	(0.187)	(0.178)	(0.252)	(0.238)
Book-to-market	–0.086	–0.043	–0.072	–0.047	–0.057	–0.043
	(0.159)	(0.158)	(0.196)	(0.189)	(0.285)	(0.289)
Leverage	0.353	0.372	0.630	0.701	–0.524	–0.496
	(0.351)	(0.347)	(0.438)	(0.435)	(0.562)	(0.576)
Capex/Total assets	1.933	2.265	6.695***	6.459***	–6.763*	–5.955
	(2.200)	(2.089)	(2.100)	(2.070)	(3.518)	(3.411)
PPE/Total assets	0.327	0.353	–0.319	–0.270	1.624*	1.569*
	(0.401)	(0.414)	(0.425)	(0.427)	(0.760)	(0.747)
ROA	2.216	2.014	0.979	0.969	5.534	5.109
	(1.864)	(1.724)	(1.712)	(1.584)	(3.493)	(3.457)
Asset growth	–0.408	–0.300	0.221	0.167	–1.491**	–1.343**
	(0.336)	(0.316)	(0.334)	(0.320)	(0.566)	(0.552)
Sales growth	–0.038	–0.218	0.047	0.398	0.101	–0.403
	(0.480)	(0.374)	(0.676)	(0.509)	(0.476)	(0.340)
Volatility	5.433	5.012	14.644**	13.513*	–2.692	–2.214
	(5.096)	(5.077)	(7.126)	(7.115)	(6.226)	(6.473)
Momentum	4.407	3.134	–1.459	–0.438	–3.682	–1.515
	(5.382)	(4.770)	(6.418)	(5.913)	(8.548)	(7.804)
Wald test (p-value): Column 3 vs. 5			0.019			
Wald test (p-value): Column 4 vs. 6					0.036	
Year-month fixed effects	Yes	No	Yes	No	Yes	No
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	No	Yes	No	Yes	No
Industry×year-month fixed effects	No	Yes	No	Yes	No	Yes
#Obs.	89,132	89,132	58,218	58,218	30,914	30,914
R^2	0.251	0.320	0.245	0.309	0.255	0.324

Table 5. Heterogeneity in country biodiversity protection and stock returns

This table reports regressions of monthly stock returns on Ln(CBF) after the Kunming Declaration for firms in countries with high or low biodiversity protection. The sample period includes monthly returns from October 2021 to December 2022. Ln(CBF) is measured as of the end of the previous year. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Low protection is a dummy variable that equals one if a country is below the median value of the Biodiversity & habitat index (or below the median value of the Ecosystem vitality index) as of the end of 2020, and zero otherwise. We also report regressions using interaction terms of Ln(CBF) × Low protection. The regressions use the same control variables as Table 4 (not reported). Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (%)					
	Biodiversity & habitat index			Ecosystem viability index		
		Low	High		Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(CBF)	–0.021	0.091***	–0.046	–0.002	0.086***	–0.018
	(0.030)	(0.027)	(0.048)	(0.027)	(0.028)	(0.048)
Ln(CBF) × Low protection	0.111**			0.085**		
	(0.040)			(0.038)		
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
#Obs.	30,899	20,714	10,185	30,899	20,691	10,208
R^2	0.255	0.225	0.346	0.255	0.220	0.363

Table 6. Stock price reactions to the Kunming Declaration

This table reports regressions documenting the stock price reactions to the Kunming Declaration, with the focal date of the event being October 13, 2021. We report results for firms with large versus small CBF values. The event window consists of the [–3,+2]-day window around the focal date. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. Large CBF equals one for firms with a CBF value above the median (as of the beginning of the year), and zero otherwise. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Post equals one in the three days after the event (days t=0 to t=+2), with day t=0 being the event date. Abnormal returns are returns in excess of their domestic stock market index returns (using MSCI domestic indices). Standard errors are clustered at the country level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Daily return (%)				Abnormal daily return (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Large CBF × Post	–0.381***	–0.372***	–0.189**		–0.295***	–0.380***	–0.209**	
	(0.064)	(0.057)	(0.084)		(0.073)	(0.055)	(0.078)	
Large CBF × t = –2				0.040				–0.043
				(0.213)				(0.204)
Large CBF × t = –1				–0.504*				–0.361
				(0.278)				(0.277)
Large CBF × t = 0				–0.671***				–0.590**
				(0.218)				(0.226)
Large CBF × t = +1				–0.642***				–0.461**
				(0.193)				(0.196)
Large CBF × t = +2				–0.301*				–0.241
				(0.164)				(0.166)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day fixed effects	Yes	No	No	Yes	Yes	No	No	Yes
Country×day fixed effects	No	Yes	No	No	No	Yes	No	No
Industry×day fixed effects	No	No	Yes	No	No	No	Yes	No
#Obs.	12,301	12,301	12,301	12,301	12,301	12,301	12,301	12,301
R^2	0.240	0.332	0.298	0.243	0.192	0.256	0.245	0.194

Table 7. Stock price reactions to the TNFD launch

This table reports regressions documenting the stock price reactions to the launch of the Taskforce on Nature-related Financial Disclosure (TNFD), with the focal date of the event being June 4, 2021. We report results for firms with large versus small CBF values. The event window consists of the [–3,+2]-day window around the focal date. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. Large CBF equals one for firms with a CBF value above the median (as of the beginning of the year), and zero otherwise. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Post equals one in the three days after the event (days t=0 to t=+2), with day t=0 being the event date. Abnormal returns are returns in excess of their domestic stock market index returns (using MSCI domestic indices). Standard errors are clustered at the country level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Daily return (%)				Abnormal daily return (%)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Large CBF × Post	–0.502***	–0.479***	–0.212**		–0.423***	–0.479***	–0.195**	
	(0.108)	(0.108)	(0.098)		(0.103)	(0.107)	(0.093)	
Large CBF × t=–2				0.133				0.220
				(0.172)				(0.143)
Large CBF × t=–1				–0.143				–0.038
				(0.122)				(0.113)
Large CBF × t=0				–0.516**				–0.336*
				(0.227)				(0.172)
Large CBF × t=+1				–0.431**				–0.317**
				(0.162)				(0.130)
Large CBF × t=+2				–0.569***				–0.435***
				(0.155)				(0.144)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day fixed effects	Yes	No	No	Yes	Yes	No	No	Yes
Country×day fixed effects	No	Yes	No	No	No	Yes	No	No
Industry×day fixed effects	No	No	Yes	No	No	No	Yes	No
#Obs.	12,392	12,392	12,392	12,392	12,392	12,392	12,392	12,392
R^2	0.208	0.279	0.255	0.208	0.164	0.229	0.210	0.165

Internet Appendix

for

Do Investors Care About Biodiversity?

Alexandre Garel, Arthur Romec, Zacharias Sautner, Alexander F. Wagner

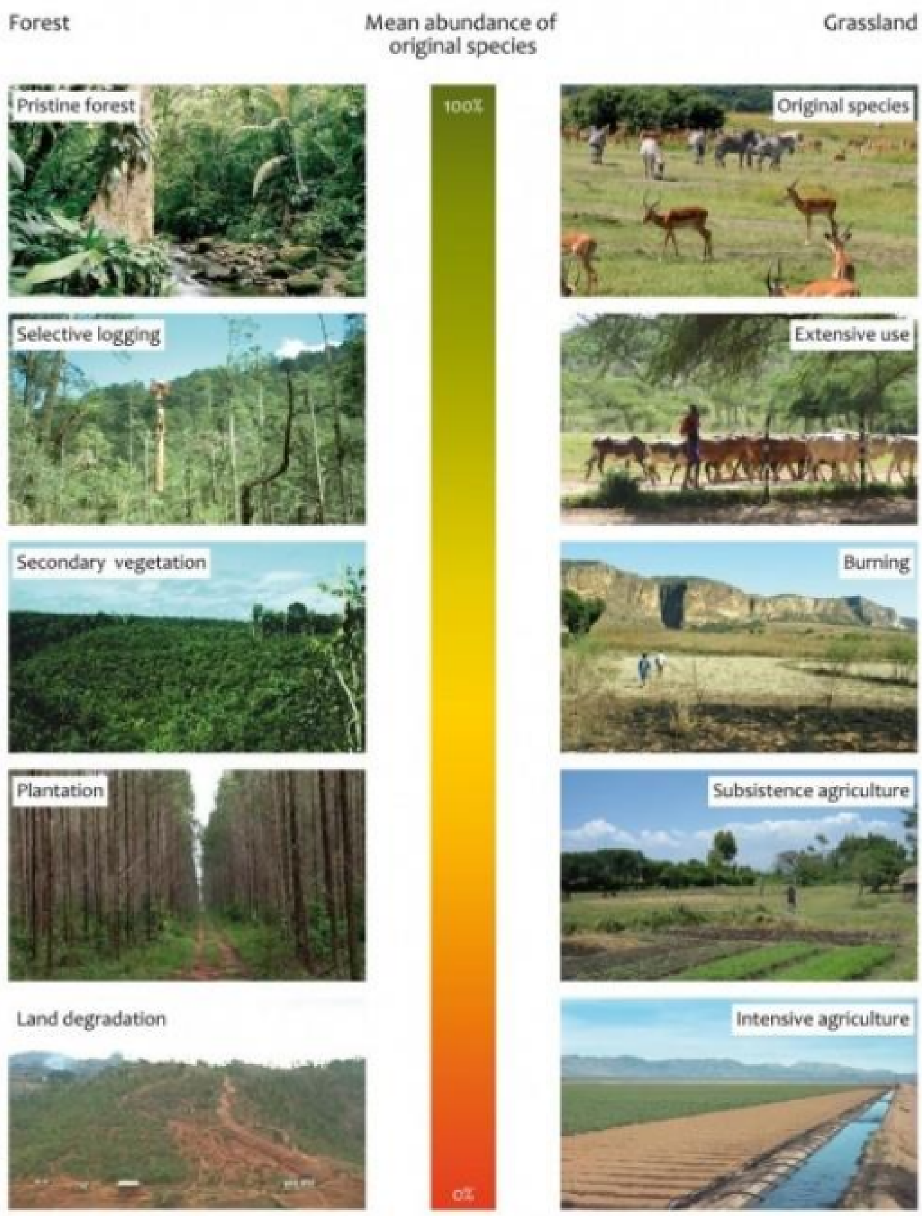
This Internet Appendix provides additional material supporting the main text. Section A provides additional tables and figures, Section B provides a numerical example of the MSA measure, Section C provides details on the construction of the CBF metric, Section D discusses determinants of data coverage by IDL, Section E provides case study examples on how firms disclose on biodiversity issues in earnings conference calls and annual reports, Section F discusses key biodiversity-related policy developments, and Section G provides details on how MSCI and Refinitiv construct their biodiversity risk measures.

A Supplemental Analysis and Robustness Checks

This section of the Internet Appendix provides supplemental analysis and robustness checks to support the main results in the paper.

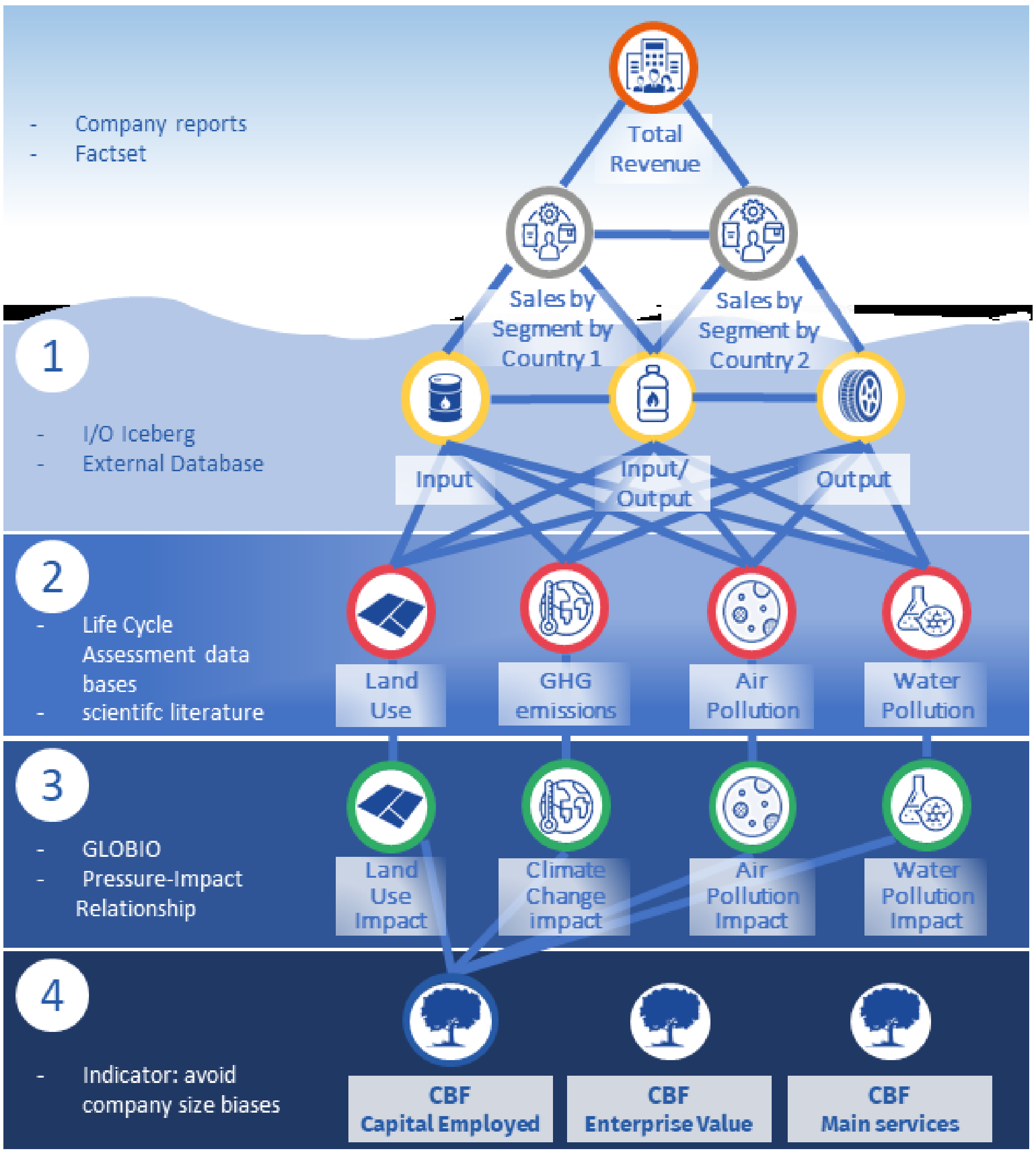
IA Figure A.1. Illustration of MSA variation

This figure illustrates the variation in Mean Species Abundance (MSA) for forest and grassland ecosystems. Source: Iceberg Data Lab (2023).



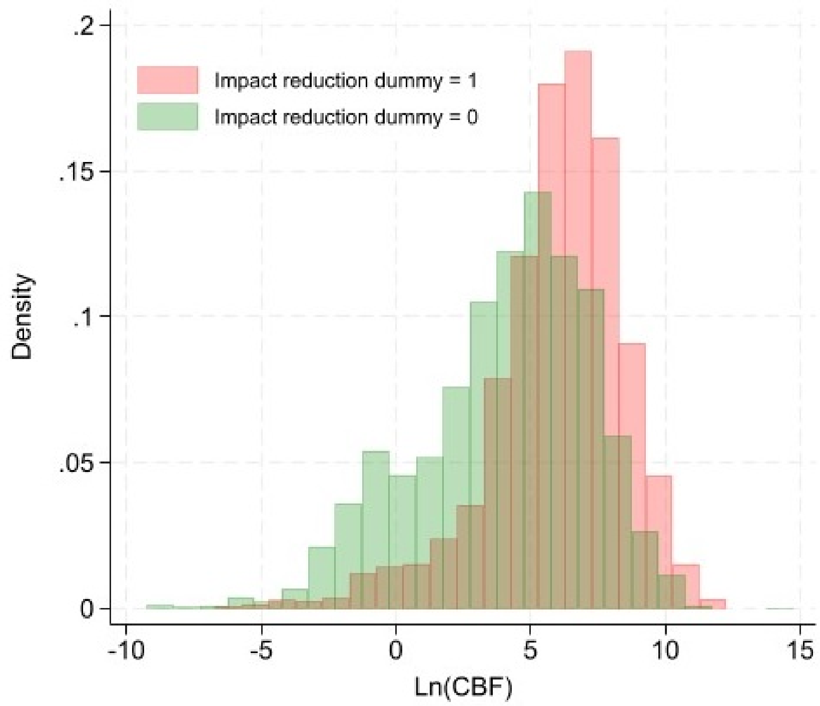
IA Figure A.2. Calculation of the biodiversity footprint

This figure illustrates the methodological steps used to calculate the CBF. CBF is the corporate biodiversity footprint and reflects the biodiversity loss caused by the firm's annual activities. Source: Iceberg Data Lab (2023).



IA Figure A.3. Biodiversity footprint and biodiversity risk measure by Refinitiv

This figure displays the CBF distribution of the biodiversity footprint for firms with and without disclosure of biodiversity risk according to Refinitiv's Biodiversity impact reduction indicator. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities.



IA Table A.1. Decomposition of the corporate biodiversity footprint: Summary statistics

This table reports the average proportion of each biodiversity footprint source (land use, air pollution, water pollution, and GHG emissions) and the average proportion of scope 1, scope 2, and scope 3 in the CBF measure. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Appendix A provides variable definitions.

Variable	#Obs.	Mean	S.D.	Min	25%	50%	75%	Max
CBF air pollution (%)	89,132	8.51	10.40	0.00	1.64	4.86	12.17	94.07
CBF GHG (%)	89,132	22.67	24.34	0.00	1.94	12.53	37.49	100.00
CBF land use (%)	89,132	48.95	33.51	–2.20	18.09	45.69	81.53	99.97
CBF water pollution (%)	89,132	20.02	27.33	0.00	0.86	6.04	28.20	99.61
CBF scope 1 (%)	89,132	14.79	23.30	–29.47	0.39	3.12	19.49	100.00
CBF scope 2 (%)	89,132	5.77	17.38	–0.03	0.00	0.02	0.48	103.10
CBF scope 3 (%)	89,132	79.55	28.74	–2.53	67.90	95.58	99.45	129.47

IA Table A.2. Decomposition of the corporate biodiversity footprint by industry

This table reports the average proportion, by industry, of each biodiversity footprint source (land use, air pollution, water pollution, and GHG emissions) and the average proportion of scope 1, scope 2, and scope 3 in the CBF measure. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Appendix A provides variable definitions.

	CBF air pol. (%)	CBF GHG (%)	CBF land use (%)	CBF water pol. (%)	CBF scope 1 (%)	CBF scope 2 (%)	CBF scope 3 (%)
Asset Management	2.34	6.96	68.76	21.95	0.01	0.01	99.98
Automotive & Logistics	14.12	31.66	44.17	10.05	5.95	0.75	93.30
Beverages	0.98	2.93	95.06	1.03	1.47	0.18	98.35
Building Products	7.12	15.09	55.87	21.92	20.28	0.78	78.93
Chemicals	6.18	9.63	51.57	33.28	8.19	1.06	91.43
Construction & Real Estate	15.47	15.73	62.74	6.07	23.88	1.77	74.35
Defense	8.38	15.21	28.20	48.21	0.67	0.34	98.99
Education	3.12	5.06	80.00	11.82	3.15	0.27	96.58
Electrical Equipment	11.21	29.33	11.34	48.13	1.38	0.03	98.59
Electronics	5.46	45.29	28.91	21.22	10.99	15.88	73.19
Financial Services	10.71	32.70	46.09	10.67	3.45	32.91	63.64
Food	2.09	3.28	93.59	1.64	3.50	0.26	96.24
Healthcare	1.28	1.63	68.61	28.49	0.98	0.37	98.65
Hotel & Accommodation	3.26	3.30	85.24	8.20	3.07	0.72	96.21
Household Goods	9.10	16.78	51.49	25.57	14.56	1.05	84.39
Industrial Equipment	7.94	25.05	25.28	41.73	2.04	0.09	97.87
Insurance	8.64	25.05	51.50	14.81	7.54	19.88	72.59
Internet & Data	10.45	42.21	41.71	5.64	3.55	8.65	87.79
Leisure	6.47	17.94	61.92	13.67	17.19	6.22	76.60
Materials	9.58	22.14	66.27	2.01	27.13	0.99	71.87
Media	8.65	24.15	35.01	32.19	2.70	14.30	83.00
Metals & Mining	7.63	15.50	27.54	49.33	42.26	0.41	57.33
Oil & Gas	10.40	39.93	44.32	5.35	26.56	0.22	73.22
Paper & Forest	1.59	4.56	88.63	5.22	21.91	0.34	77.75
Pharmaceutical	0.82	1.67	22.55	74.96	2.61	0.04	97.35
Power	16.01	44.56	22.05	17.39	47.08	3.03	49.89
Retail & Wholesale	2.46	5.33	91.03	1.18	4.43	0.26	95.30
Services	14.18	37.11	41.72	6.99	12.38	32.06	55.56
Software	9.16	31.55	53.34	5.94	8.24	9.78	81.98
Telecommunications	9.59	48.24	37.12	5.05	10.56	34.69	54.75
Textiles	3.50	4.65	90.36	1.49	12.81	4.42	82.77
Tobacco	0.27	0.76	96.44	2.54	1.08	0.10	98.84
Transportation	24.20	37.34	25.63	12.83	38.47	4.16	57.46
Waste	6.63	62.92	22.21	8.24	78.28	1.53	20.19
Water	12.47	9.60	76.47	1.46	87.41	3.15	9.43

IA Table A.3. Decomposition of the corporate biodiversity footprint by country/region

This table reports the average proportion, by country/region, of each CBF source (land use, air pollution, water pollution, and GHG emissions) and the average proportion of scope 1, scope 2, and scope 3 in the CBF measure. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Appendix A provides variable definitions.

	CBF air pol. (%)	CBF GHG (%)	CBF land use (%)	CBF water pol. (%)	CBF scope 1 (%)	CBF scope 2 (%)	CBF scope 3 (%)
Australia	13.34	26.92	41.04	18.70	24.01	6.88	69.11
Belgium	6.30	15.86	53.37	24.47	9.79	2.50	87.72
Brazil	9.49	22.94	63.29	4.28	35.19	0.81	64.00
Canada	8.08	26.17	46.29	19.47	26.37	3.68	69.95
China	9.12	19.96	46.18	24.74	16.41	3.67	79.93
Denmark	3.17	16.56	65.19	21.73	10.84	1.46	87.70
Finland	5.45	19.01	61.35	14.19	7.32	2.98	89.70
France	11.58	26.55	46.84	15.03	14.39	6.44	79.18
Germany	7.59	26.10	44.32	21.99	12.54	6.15	81.31
Hong Kong	11.99	36.62	39.70	11.71	15.52	20.34	64.14
India	10.13	23.64	45.14	21.09	14.90	2.36	82.74
Indonesia	5.30	15.65	67.07	11.97	10.85	0.49	88.70
Ireland	6.49	24.11	56.45	12.94	11.17	3.43	85.40
Israel	15.95	16.99	54.22	12.84	7.45	3.13	89.42
Italy	11.63	35.50	41.41	11.46	13.58	8.73	77.69
Japan	7.93	22.38	47.37	22.57	10.72	4.29	85.26
Korea	11.16	24.77	43.63	20.72	20.82	5.00	74.18
Malaysia	14.49	23.14	57.46	4.91	27.15	5.49	67.36
Mexico	7.36	31.69	46.59	17.33	32.98	6.31	63.76
Netherlands	10.80	24.57	48.51	16.22	11.34	14.48	74.18
Norway	13.32	31.57	34.20	20.91	19.39	0.85	79.76
Philippines	12.84	13.49	70.75	2.92	3.80	11.16	85.03
Poland	10.07	25.28	53.96	10.70	25.07	11.83	63.10
Saudi Arabia	8.92	24.01	35.10	31.98	21.46	6.20	72.34
Singapore	11.48	37.11	35.81	15.62	22.64	13.53	63.83
South Africa	6.60	13.74	46.75	32.91	30.21	1.78	68.01
Spain	11.18	27.73	33.02	28.07	33.14	7.00	59.87
Sweden	7.13	17.71	52.00	23.16	7.80	3.13	89.07
Switzerland	6.50	20.90	43.73	28.87	7.53	7.80	84.67
Taiwan	7.74	42.80	32.32	19.26	18.89	12.66	68.60
Thailand	7.13	26.89	59.98	6.70	17.24	2.45	80.30
Turkey	9.62	19.00	48.24	23.14	19.86	6.68	73.46
United Kingdom	5.44	19.02	57.07	18.47	19.47	2.39	78.15
United States	7.63	21.36	52.52	18.65	11.96	8.02	80.05

IA Table A.4. Biodiversity protection indexes by country/region

This table reports values per country/region of the Biodiversity & habitat index and the Ecosystems viability index. Values are as of 2020. We list countries/regions alphabetically.

Country/region	Biodiversity & habitat index	Ecosystem viability index
Australia	83.7	63.8
Belgium	87.4	64.8
Brazil	78.1	52.2
Canada	60.5	57.3
China	19.0	34.4
Denmark	81.7	76.4
Finland	75.5	65.3
France	88.3	72.3
Germany	88.8	68.9
Hong Kong	19.0	34.4
India	33.7	35.2
Indonesia	56.3	43.7
Ireland	65.8	58.6
Israel	47.6	54.0
Italy	75.6	61.3
Japan	76.6	65.1
Korea	62.6	56.6
Malaysia	55.1	42.9
Mexico	72.9	55.9
Netherlands	83.7	64.8
Norway	71.5	63.8
Philippines	56.6	41.4
Poland	89.0	62.3
Saudi Arabia	38.8	41.8
Singapore	20.9	40.2
South Africa	63.2	51.0
Spain	87.6	66.0
Sweden	72.5	65.6
Switzerland	63.0	72.5
Taiwan	65.0	55.8
Thailand	53.0	43.5
Turkey	15.1	36.9
United Kingdom	88.0	74.3
United States	67.5	60.3

IA Table A.5. Cross-section of returns: Controlling for climate transition risk

This table reports regressions relating monthly stock returns to Ln(CBF) after controlling for measures of climate transition risk. Ln(CO_2 Emissions) is the natural logarithm of Scope 1, 2, and 3 carbon emissions from Trucost. $CCExposure^{Reg}$ is the regulatory climate change exposure measure from Sautner et al. (2023). The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The regressions use the same control variables as Table 4 (not reported). Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (%)					
	Whole period	Post-Kunming	Whole period	Post-Kunming	Whole period	Post-Kunming
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(CBF)	0.003	0.060*	0.030	0.063*		
	(0.019)	(0.028)	(0.022)	(0.030)		
Ln(CO_2 Emissions)	–0.007	–0.047				
	(0.067)	(0.124)				
$CCExposure^{Reg}$			0.404*	0.304		
			(0.230)	(0.231)		
Ln(CBF without GHG)					0.005	0.037*
					(0.017)	(0.020)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
#Obs.	88,113	30,663	45,266	15,660	89,132	30,914
R^2	0.252	0.256	0.316	0.329	0.251	0.255

IA Table A.6. Heterogeneity in country biodiversity protection: Controlling for climate transition risk

This table reports regressions relating monthly stock returns to Ln(CBF) after the Kunming Declaration for firms in countries with high and low biodiversity protection after controlling for measures of climate transition risk. Ln(CO_2 Emissions) is the natural logarithm of Scope 1, 2, and 3 carbon emissions from Trucost. $CCExposure^{Reg}$ is the regulatory climate change exposure measure from Sautner et al. (2023). The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The regressions use the same control variables as Table 5 (not reported). Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (\%)					
	Biodiversity & habitat index			Ecosystem viability index		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(CBF) × Low protection	0.109**	0.151**		0.083**	0.123**	
	(0.040)	(0.052)		(0.038)	(0.056)	
Ln(CBF without GHG) × Low protection			0.092**			0.069**
			(0.031)			(0.030)
Ln(CBF)	–0.020	–0.056		–0.001	–0.035	
	(0.034)	(0.047)		(0.031)	(0.046)	
Ln(CBF without GHG)			–0.032			–0.015
			(0.028)			(0.026)
Ln(CO_2 Emissions)	–0.042			–0.044		
	(0.124)			(0.124)		
$CCExposure^{Reg}$		0.309			0.294	
		(0.231)			(0.232)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
#Obs.	30,648	15,645	30,899	30,648	15,645	30,899
R^2	0.256	0.329	0.255	0.256	0.329	0.255

IA Table A.7. Cross-section of returns: Implied cost of capital

This table reports regressions relating monthly implied cost of capital (ICC) estimates to Ln(CBF). The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The regressions use the same control variables as Table 4 (not reported). Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly ICC (in %)		
	Whole period	Pre-Kunming	Post-Kunming
	(1)	(2)	(3)
Ln(CBF)	0.008*	0.004	0.014**
	(0.004)	(0.004)	(0.005)
Controls	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
#Obs.	52,315	34,545	17,770
R^2	0.405	0.399	0.493

IA Table A.8. The corporate biodiversity footprint and earnings surprises

This table reports regressions relating yearly one-year and two-year earnings surprises to Ln(CBF). SUE1 (SUE2) is the one-year (two-year) earnings surprise measured as the actual EPS minus the I/B/E/S median analyst forecast 8 (20) months prior to the end of the forecast period, scaled by the stock price. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The sample period in Columns 1–2 includes earnings surprises over the full sample period (2019-2022), that in Columns 3–4 includes earnings surprises of 2019 and 2020; and that in Columns 5–6 includes earnings surprises of 2021 and 2022. Ln(CBF) is measured as of the end of the previous year. The regressions use the same control variables as Table 4 (not reported). Standard errors are clustered at the firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Whole period		Pre-Kunming		Post-Kunming	
	(1)	(2)	(3)	(4)	(5)	(6)
	SUE1	SUE2	SUE1	SUE2	SUE1	SUE2
Ln(CBF)	-0.000	-0.003	-0.003	-0.015	0.006	0.021
	(0.010)	(0.012)	(0.013)	(0.015)	(0.015)	(0.018)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
#Obs.	7,454	7,113	3,375	3,258	4,079	3,855
R^2	0.097	0.147	0.109	0.200	0.148	0.188

IA Table A.9. Cross-section of returns: CBF intensity measures

This table reports regressions relating monthly stock returns to Ln(CBF) after replacing Ln(CBF) by Ln(CBF/Total assets) and Ln(CBF/sales). The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The regressions use the same control variables as Table 4 (not reported). Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (%)			
	Whole period	Post-Kunming	Whole period	Post-Kunming
	(1)	(2)	(3)	(4)
Ln(CBF/Total assets)	0.005	0.058*		
	(0.021)	(0.028)		
Ln(CBF/Sales)			0.012	0.071**
			(0.022)	(0.030)
Controls	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
#Obs.	89,132	30,914	89,108	30,899
R^2	0.251	0.255	0.252	0.255

IA Table A.10. Cross-section of returns: Alternative clustering of standard errors

This table reports regressions relating monthly stock returns to Ln(CBF) after clustering standard errors differently (indicated below). The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The regressions use the same control variables as Table 4 (not reported). Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (%)					
	Whole period	Post-Kunming	Whole period	Post-Kunming	Whole period	Post-Kunming
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(CBF)	0.003	0.061**	0.003	0.061**	0.003	0.061**
	(0.015)	(0.025)	(0.014)	(0.024)	(0.037)	(0.004)
SE clustering	Firm-year		Firm		Firm and year	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
#Obs.	89,132	30,914	89,132	30,914	89,132	30,914
R^2	0.251	0.255	0.251	0.255	0.251	0.255

IA Table A.11. Cross-section of returns: Sample selection

This table reports regressions relating monthly stock returns to Ln(CBF) after restricting the sample to firms inside the MSCI ACWI universe. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. The regressions use the same control variables as Table 4 (not reported). Standard errors are clustered at the year-month and firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Monthly return (%)	
	Whole period	Post-Kunming
	(1)	(2)
Ln(CBF)	0.008	0.054*
	(0.020)	(0.026)
Controls	Yes	Yes
Year-month fixed effect	Yes	Yes
Country fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
#Obs.	62,947	22,016
R^2	0.283	0.287

IA Table A.12. Market reaction to Kunming Declaration: Controlling for climate transition risk

This table reports regressions documenting the stock price reactions to the Kunming Declaration after controlling for climate transition risk, with the focal date of the event being October 13, 2021. We report results for firms with large versus small CBF values. The event window consists of the [–3,+2]-day window around the focal date. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. Large CBF equals one for firms with a CBF value above the median (as of the beginning of the year), and zero otherwise. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Post equals one in the three days after the event (days t=0 to t=+2), with day t=0 being the event date. High Emissions is a dummy variable that equals one if firm has an above-median level of carbon emissions (Scope 1, 2, and 3) as of the end 2020. High CCExposure^{Reg} is a dummy variable that equals one if a firms has an above-median value of CCExposure^{Reg} as of end 2020, and zero otherwise. Standard errors are clustered at the country level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Daily returns (%)			
	(1)	(2)	(3)	(4)
Large CBF × Post		–0.349***		–0.395***
		(0.097)		(0.073)
High Emissions × Post	–0.234**	–0.064		
	(0.100)	(0.137)		
High CCExposure^{Reg} × Post			–0.158**	–0.057
			(0.066)	(0.071)
Firm fixed effects	Yes	Yes	Yes	Yes
Day fixed effects	Yes	Yes	Yes	Yes
#Obs.	12,182	12,182	5,490	5,490
R^2	0.240	0.242	0.259	0.262

IA Table A.13. Market reaction to Kunming Declaration: Additional results

This table reports regressions documenting the stock price reactions to the Kunming Declaration, with the focal date of the event being October 13, 2021. We report results for firms with large versus small CBF values, using either the sources of CBF (Columns 1–4), intensity measures (Columns 5–6), or alternative percentiles to identify large and small CBF firms (Columns 7–8). We also report continuous values of Ln(CBF) instead of indicators (Column 9). The event window consists of the [–3,+2]-day window around the focal date. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. In Columns 1–4, Large CBF for a source equals one for firms with a CBF value above the median (as of the beginning of the year), and zero otherwise. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Post equals one in the three days after the event (days t=0 to t=+2), with day t=0 being the event date. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Daily returns (%)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Large CBF air pollution x Post	–0.268**								
	(0.107)								
Large CBF land use × Post		–0.368***							
		(0.072)							
Large CBF GHG × Post			–0.316***						
			(0.110)						
Large CBF water pollution × Post				–0.205					
				(0.184)					
Ln(CBF/Total assets) × Post					–0.377***				
					(0.094)				
Ln(CBF/Sales) × Post						–0.384***			
						(0.137)			
Top quartile CBF × Post							–0.394***		
							(0.083)		
Top tercile CBF × Post								–0.379***	
								(0.093)	
Ln(CBF) × Post									–0.073***
									(0.010)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
#Obs.	12,301	12,223	12,301	12,301	12,301	12,295	12,301	12,301	12,301
R^2	0.238	0.240	0.239	0.238	0.240	0.240	0.239	0.239	0.241

IA Table A.14. Market reaction to Kunming Declaration: Sample selection

This table reports regressions documenting the stock price reactions to the Kunming Declaration after restricting the sample to firms inside the MSCI universe, with the focal date of the event being October 13, 2021. We report results for firms with large versus small CBF values. The event window consists of the [–3,+2]-day window around the focal date. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. Large CBF equals one for firms with a CBF value above the median (as of the beginning of the year), and zero otherwise. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Post equals one in the three days after the event (days t=0 to t=+2), with day t=0 being the event date. Standard errors are clustered at the country level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	Daily return (%)		
	(1)	(2)	(3)
Large CBF x Post	–0.555***	–0.547***	–0.315***
	(0.063)	(0.060)	(0.103)
Firm fixed effects	Yes	Yes	Yes
Day fixed effects	Yes	No	No
Country×day fixed effects	No	Yes	No
Industry×day fixed effects	No	No	Yes
#Obs.	8,761	8,761	8,755
R^2	0.253	0.358	0.325

Table A.15. Stock price reactions to the TCFD launch

This table reports regressions documenting the stock price reactions to the launch of the Taskforce on Climate-related Financial Disclosure (TCFD), with the focal dates of the event being November 9, 2015 (when the Financial Stability Board published its proposal to create a disclosure task force on climate risks) and December 4, 2015 (when the TCFD was formally established). We report results for firms with large versus small CBF values. The event window consists of the [–3,+2]-day window around the focal dates. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. Large CBF equals one for firms with a CBF value above the median (as of 2020), and zero otherwise. The corporate biodiversity footprint (CBF) reflects the biodiversity loss caused by the firm's annual activities. Post equals one in the three days after the event (days t=0 to t=+2), with day t=0 being the event date. Standard errors are clustered at the country level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	November 9, 2015			December 4, 2015		
	Daily return (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
Large CBF × Post	0.071	0.100	–0.070	–0.327	–0.183	–0.087
	(0.168)	(0.122)	(0.141)	(0.199)	(0.182)	(0.231)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Day fixed effects	Yes	No	No	Yes	No	No
Country×day fixed effects	No	Yes	No	No	Yes	No
Industry×day fixed effects	No	No	Yes	No	No	Yes
#Obs.	11,488	11,488	11,488	11,530	11,530	11,530
R^2	0.249	0.392	0.295	0.257	0.452	0.303

IA Table A.16. Comparison of firm-level biodiversity measures

Measure	**Source**	**Type**	**Definition**	**Coverage**
Corporate biodiversity footprint (CBF)	Iceberg Data Lab	Impact	Measure of the absolute biodiversity loss caused by the firm's annual activities. It is expressed in km^2.MSA, which is equivalent to the pristine natural area destroyed by the firm's annual activities. For details, see Section 2.	International
Biodiversity & land use exposure score	MSCI	Impact	Score from 0 to 10 indicating the extent to which a firm's business is exposed to the issue of biodiversity and land use based on its unique mix of business and geographic segments. Examples of criteria assessed include: the products and services a firm provides; location of firm operations; and the nature of those operations. Higher scores indicate greater risk. For details, see Section 8.	International
Biodiversity impact reduction	Refinitiv	Disclosure	Dummy variable that is equal to one if a firm reports on its impact on biodiversity on on activities to reduce its impact. For details, see Section 8.	International

IA Table A.17. Correlation matrix for biodiversity risk measures

This table presents correlations for the different firm-level biodiversity measures. Appendix A provides variable definitions.

	1	2	3	4	5	6	7
1. Ln(CBF)	1.00						
2. Ln(CBF scope 1)	0.68	1.00					
3. Ln(CBF scope 2)	0.20	0.19	1.00				
4. Ln(CBF scope 3)	0.96	0.57	0.14	1.00			
5. 10-K Biodiversity count score	0.10	0.21	0.04	0.08	1.00		
6. Refinitiv biodiversity impact reduction	0.31	0.41	0.18	0.26	0.21	1.00	
7. MSCI Biodiversity & land use exposure	0.39	0.56	–0.01	0.33	0.30	0.38	1.00

IA Table A.18. MSCI biodiversity & land use exposure and stock returns

Panel A of this table reports regressions relating monthly stock returns to the MSCI biodiversity & land use exposure. The sample period in Columns 1–2 includes monthly returns over the full sample period from January 2019 to December 2022. The sample period in Columns 3–4 includes monthly returns from January 2019 to September 2021 (the COP15 in Kunming started in October 2021), and in Columns 5–6 monthly stock returns from October 2021 to December 2022. Panel B reports the Kunming stock price reactions analysis. Standard errors are double clustered at the year-month and firm level in Panel A, and at the country level in Panel B. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

Panel A. Cross-section of stock returns

	Monthly return (%)					
	Whole Period		Pre-Kunming period		Post-Kunming period	
	(1)	(2)	(3)	(4)	(5)	(6)
MSCI biodiversity & land use exposure	0.127**	0.113**	0.057	0.042	0.205**	0.200**
	(0.052)	(0.047)	(0.066)	(0.053)	(0.073)	(0.072)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	No	Yes	No	Yes	No
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	No	Yes	No	Yes	No
Industry×year-month fixed effects	No	Yes	No	Yes	No	Yes
#Obs.	82,085	82,085	52,943	52,943	29,142	29,142
R^2	0.261	0.332	0.254	0.321	0.265	0.337

Panel B. Market reaction to COP15 - Kunming

	Daily return (%)		
	(1)	(2)	(3)
Large MSCI score × Post	–0.415***	–0.387***	–0.230**
	(0.099)	(0.105)	(0.092)
Firm fixed effects	Yes	Yes	Yes
Day fixed effects	Yes	No	No
Country×day fixed effects	No	Yes	No
Industry×day fixed effects	No	No	Yes
#Obs.	11,296	11,296	11,296
R^2	0.241	0.344	0.301

B Construction of the MSA metric: Example

This section of the Internet Appendix provides a numerical example for the calculation of the MSA metric. The MSA metric is an indicator of local biodiversity intactness. MSA ranges from 0% to 100%, where 100% means that the species assemblage is fully intact, and 0% means that all original species are extirpated (locally extinct). MSA is calculated based on the abundance of individual species under influence of a given pressure, compared to their abundance in an undisturbed situation (natural situation/reference).

Notice that only species present in the undisturbed situation are included, and increases in individual species abundance from the reference to the impacted situation are ignored. This is done to avoid the indicator being inflated by opportunistic or generalist species that benefit from habitat disturbance.

For example, in IA Figure B.1, three species decrease in abundance (tree, deer, and owl) and two show an increase (frog, rodent). As new species and abundance increases do not count, the MSA is calculated as the mean of the abundance ratios of the four species in the reference situation, whereby the increase in frog abundance is ignored.

IA Figure B.1. Computation of MSA

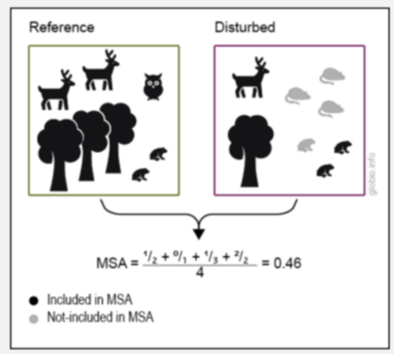
This figure illustrates the computation of the MSA metric. In the example, three species decrease in abundance (tree, deer and owl) and two show an increase (frog, rodent). As new species and abundance increases do not count, the MSA is calculated as the mean of the abundance ratios of the four species in the reference situation, whereby the increase in frog abundance is ignored. Source: https://www.globio.info/what-is-globio.

Species abundance ratio: $\frac{A_{i,disturbed}}{A_{i,reference}} = \frac{Nb \text{ individuals species } i \text{ in } \textbf{disturbed} \text{ state}}{Nb \text{ individualsspecies } i \text{ in } \textbf{reference} \text{ state}}$

Mean: $MSA = \sum_{i\ species} \frac{1}{N_{species}} \times \frac{A_{i,disturbed}}{A_{i,reference}}$

Example:

Species	Taxa	Indigenous / Invasive	Nb of individuals in reference state	Nb of individuals in disturbed state	Abundance Ratio A_i
Deer	Mammal	Indigenous	2	1	$\frac{1}{2}$
Tree	Plants	Indigenous	3	1	$\frac{1}{3}$
Owl	Bird	Indigenous	1	0	$\frac{0}{1}$
Frog	Amphibian	Indigenous	2	3	$\frac{2}{2}$
Rat	Mammal	Invasive	0	3	0
Total					**0.46**



C Step-by-step construction of the CBF

This section of the Internet Appendix provides additional information on how the measure we use to assess a firm's impact on biodiversity, the corporate biodiversity footprint (CBF), is constructed. The data provider IDL developed this science-based indicator to help financial institutions measure and manage their investments' impact on biodiversity. The CBF is calculated in three steps. The following subsections comment on each step, using as an example the dairy manufacturer Danone (which in the U.S. is called Dannon). IA Figure C.1 summarizes the calculation of the 2021 biodiversity footprint for Danone (its CBF is −10,486 km^2.MSA), and IA Figure C.2 provides more details on each step in the calculation. A general, publicly available introduction to IDL's methodology is provided in Iceberg Data Lab (2023).

C.1 Step 1: From business activities to commodities used

For each firm, IDL first collects data on the activities (business segments) per country at the NACE4 (and sometimes NACE5) level. Based on these Revenue x Segment x Country data, IDL's input/output model, Wunderpus, translates these data into quantities consumed (or produced) of a set of commodities. In this analysis, IDL depends on the granularity of disclosure by each firm. For example, in the U.S., Danone has substantial activities in fresh dairy products (NACE4 Code: 1051 - Manufacture of fresh dairy products), beverages (NACE4 Code: 1107 - Manufacture of soft drinks; production of mineral waters and other bottled waters), and biscuits (NACE4 Code: 1072 - Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes), among others. Based on its research, IDL concludes that roughly €2 billion of Danone's 2021 revenue (out of a total of €18.76 billion) stem from its dairy and cheese making operations in the U.S.

IDL's version of the EXIOBASE input/output model turns each of these segment-country-revenue combinations into a quantity of commodities used. The model covers 216 countries, 2,130 products and services, and 1,219 NACE sectors. In our example, the revenue from Danone's dairy and cheese making operations in the U.S. are turned into an estimated tons of milk consumed. If a firm directly reports the quantities of the commodities it uses, the IDL analyst that covers the firm can adjust the model's estimates. In the case of Danone, their 2021 sustainability report states that they collected 5.6 million tons of fresh milk that year. The report also states that 29% of this milk was collected in North America. Combining the model and the disclosed information, IDL concludes that 1.6 million tons of the milk used in Danone's production process came from the U.S.

C.2 Step 2: From commodities to environmental pressures

Once IDL has computed, for a given firm, a list of all the commodities it uses, and the quantities of each commodity, this information is converted into environmental pressures. To do so, IDL draws upon various databases on life cycle analysis (LCA). These include, for example, data from EcoInvent, but also from the Food and Agriculture Organization (FAO) and the academic literature. The general idea behind LCA is to link one unit of a given commodity to an increase of x units in the respective environmental pressure, that is, pressure from land use, air pollution, water pollution, or CO_2 emissions.

First, in terms of land use pressure, IDL associates 1,000 tons of cows' milk with an environmental impact on 13km^2. This type of impact is labeled as occupational land use, meaning that the firm's ongoing operations maintain the area at a different level of biodiversity than the land originally had and prevent its return to that pristine state. If a firm expands its operations, there may be an additional impact labeled as transformational land use.[1]

Second, to estimate air pollution pressure, IDL's LCA model focuses on the impacts of nitrogen and sulfur, aggregating both terrestrial acidification and terrestrial eutrophication. Third, to estimate water pollution pressure, IDL's model calculates the increase in toxic substances in fresh water. Plastic entanglement is also considered to be part of water pollution. For both air and water pollution, there is no distinction between maintained and additional impact. Finally, IDL collects or estimates data on greenhouse gas emissions (GHGs), measured in tons of CO_2 equivalent.

1. Transformational and occupational land use pressures may overlap, for example, if additional land is farmed to grow soy as food for the cows. IDL distinguishes three sub-pressures resulting in transformational land use: Incremental land use corresponds to the additional surface that a firm occupies, compared to the previous year. Fragmentation emphasizes the impact of human activities through the dividing of a natural landscape into smaller fragments. Encroachment corresponds to the perturbations caused by lights and noises that can lead to biodiversity loss.

C.3 Step 3: From environmental pressures to impact on MSA

To turn the four environmental pressures from land use, air pollution, water pollution, and GHG emissions into an impact on km^2.MSA, IDL requires an estimate of the damage. In general, the framework is to compute:

$$\text{Impact} = \text{Pressure} \times (\text{Final MSA} - \text{Initial MSA}),$$

where Impact is a negative number whenever MSA is reduced through a firm's activities. For estimates of the damage, IDL mostly relies on the GLOBIO model (Schipper et al. 2020). GLOBIO has compiled numerous scientific research articles to create damage functions (or pressure-impact functions, some being simple linear functions) that convert an environmental pressure into a biodiversity impact.

C.3.1 Land use

In the case of Danone, large parts of its corporate biodiversity footprint originate from the land use needed to breed and feed dairy cattle. The estimates take into account the fact that some types of land use have a lower impact on biodiversity than others. As seen in Figure 2C of Schipper et al. (2020), intensive land use, for example, has a far greater negative impact on MSA than minimal use. The damage is thus computed relative to a reference point. In general, IDL posits an initial MSA of 65%, which is the average MSA for land use worldwide in the baseline year 2015 (for wood commodities, the initial MSA is 85%). IDL argues that this baseline is more appropriate than assuming an initial MSA of 100%, as such a baseline may overestimate the impact of a firm's activities on biodiversity. The final MSA depends on the actual land use. Specifically, according to an example provided by IDL, for cows' milk the final MSA is posited to be 60%. Therefore, the land use impact of 1,000 tons of cows' milk is computed as

$$13\text{km}^2 \times (60\%–65\%) = –0.65 \text{ km}^2.\text{MSA}.$$

It is interesting to see how a different activity by Danone plays out in this computation. Danone also sells soy milk products. Significantly less land is required to produce 1,000 tons of soy beverage: IDL estimates the corresponding pressure to be 0.5km², compared to 13km² for cows' milk. However, the damage is far greater: Soy agriculture is estimated to almost completely wipe out biodiversity in the areas where it is conducted, resulting in a final MSA of only 20%. Therefore, the impact of 1,000 tons of soy beverage is

$$0.5\text{km}^2 \times (20\%\text{–}65\%) = \text{–}0.23 \text{ km}^2.\text{MSA}.$$

Hence, the impact of soy beverages per ton is still smaller than that of cows' milk, but the difference is far less pronounced than it would appear, based solely on the amount of land needed.

Returning to the MSA impact of cows' milk, a firm that sources 1 million tons of cows' milk would have a CBF component of 1,000 × –0.65 km².MSA = –650 km².MSA. Using such computations, IDL estimates the overall land use CBF of Danone in 2021 to be equal to –10,314.17 km².MSA.

Country by country, and activity by activity, IDL aggregates all these land use calculations into a total land use CBF for Danone. We do not have the exact data that IDL uses for these computations, so we cannot completely derive the full land use CBF for Danone here.

C.3.2 Air and water pollution

For air pollution and water pollution, IDL proceeds similarly. Based on the estimate of tons of NOx emissions, and given the damage functions in the GLOBIO model for different biomes, IDL aggregates the total impact of a firm's nitrogen deposition worldwide as the sum of the impacts on each biome. IDL also converts SOx into NOx equivalents, using acidification potentials, and thus can allocate the impact of sulfur emissions. Finally, IDL's model quantifies the biodiversity loss in freshwater ecosystems by drawing on data from UNEP and SETAC to characterize the ecotoxicological impacts of chemical emissions.

C.3.3 GHG emissions

GHG emissions affect biodiversity because climate change causes changes in species distribution, which is often associated with population declines in local species (Alkemade, Bakkenes, and Eickhout 2011). The damage function for GHG emissions first estimates the impact of a certain number of tons of CO_2 on temperature, then estimates the impact of an increase in temperature by x units on MSA per km² (worldwide).

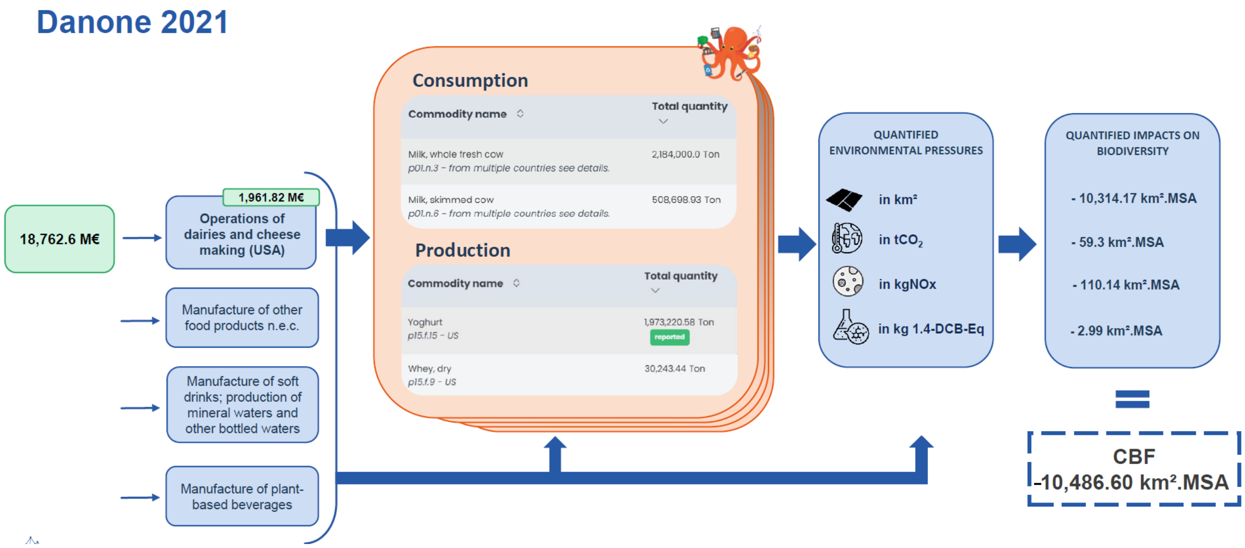
To perform this computation, IDL first draws on Joos et al. (2013), who estimate that the integrated absolute global mean temperature potential of one kg of CO_2 for the 100-year time horizon is 4.76.10-14°$C.yr.kgCO_2^{-1}$. Then IDL draws on literature that estimates impacts on biodiversity expressed in MSA, for example, the meta-analysis of Arets, Verwer, and Alkemade (2014). For 14 different biomes, they propose a damage function linking the impact of each degree of Global Mean Temperature Increase (GMTI) to a relative loss of biodiversity, expressed in MSA. Knowing the respective surface area of each of these 14 biomes, it is then possible to calculate their respective absolute MSA loss, expressed in km².MSA (Wilting et al. 2017). Danone discloses that it emitted 978kt CO_2 (scope 1 and 2) in 2021. IDL states that they always use modeled scope 3 data. Combining these data, IDL computes a contribution to temperature increase. Then, applying estimates from the GLOBIO model, which simulates the impact of this temperature increase on each of the 14 terrestrial biomes on Earth, to their respective surface areas, IDL arrives at an MSA reduction (and thus a CBF) of –59.3km² due to Danone's GHG emissions.

C.4 Changes in the CBF over time

Once the process by which the CBF is calculated is understood, it becomes apparent that a firm's CBF will change over time. First, there may be changes in revenues per segment-country, either newly modeled or because reported inputs are replacing modeled ones. For instance, Danone has produced more granular information in its more recent documents, regarding its activities and its use of commodities. Second, there may be changes in a firm's actual activities. For instance, if Danone requires more milk, then more cows will be needed to produce it, and extra soy will be needed to feed the cows, all of which adds to the firm's land use pressure (e.g., if forests are cut down to grow the soy), thus potentially increasing the firm's CBF. By contrast, some firms may reduce their CBF by engaging in restorative actions such as maintaining forest.

IA Figure C.1. CBF calculation for Danone: Overview

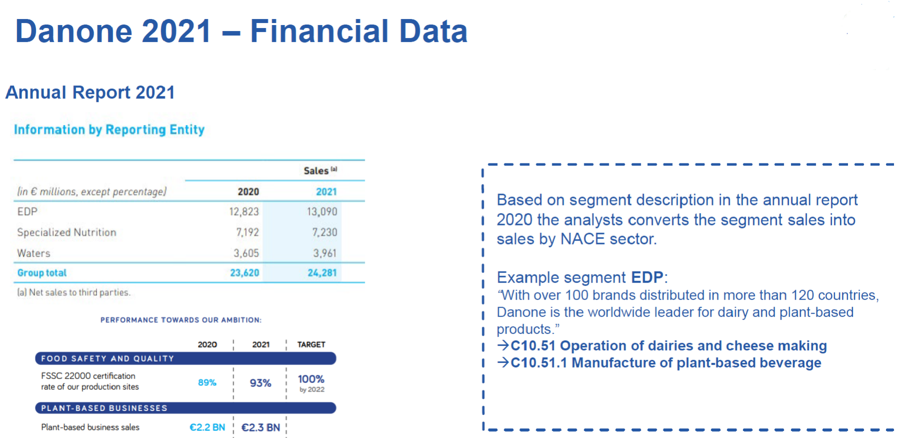
This figure illustrates the calculation of the corporate biodiversity footprint (CBF) for food producer Danone for the year 2021. The CBF reflects the biodiversity loss caused by the firm's annual activities.



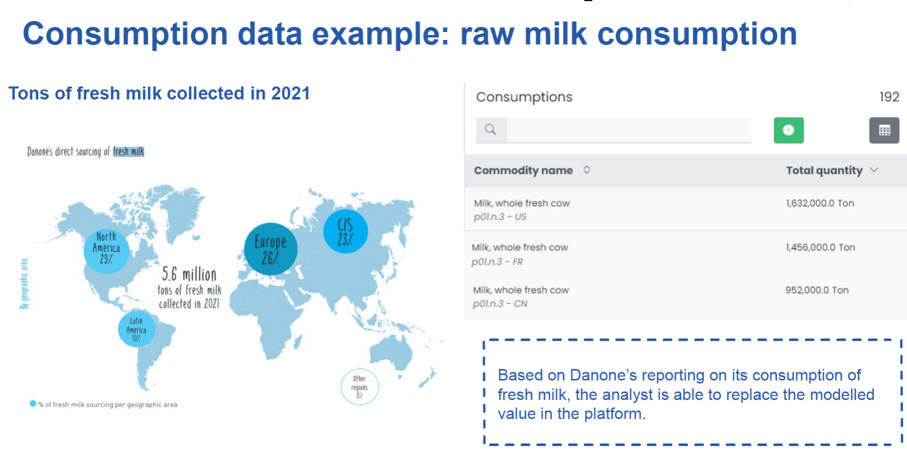
IA Figure C.2. CBF calculation for Danone: Details

Panel A illustrates how data from Danone's annual report are used to determine its sales by NACE sector, which constitutes one step in calculating its corporate biodiversity footprint (CBF) for the year 2021. Panel B illustrates how Danone's raw milk consumption, per geographical area, is used to calculate the firm's 2021 CBF. Panel C illustrates how the data on carbon emissions are used to calculate Danone's 2021 CBF. Panel D illustrates the contribution to the CBF by products and by sources of environmental pressures for Danone for the year 2021. Source: Iceberg Data Lab.

Panel A. Annual report data



Panel B. Raw milk consumption data



Panel C. Reported emissions data

Reported emissions used

GHG Data Scope 1 & 2

	Year ended December 31	
Scope 1 and 2 emissions, market-based *(in $ktCO_2$)* [a]	**2020**	**2021**
Scope 1	668	683
Scope 2	479	295
Total Scopes 1 & 2	**1,147**	**978**
Absolute emissions reduction, scopes 1 and 2, market-based since 2015	**38.1%**	**48.3%**

[a] Greenhouse Gas scope, see Methodology Note.

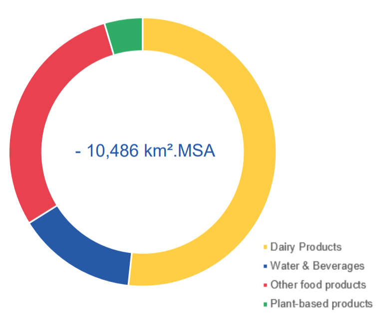
When the company reports on its CO2eq emissions, we integrate those values in the platform and replace the modelled data.

We use reported scope 1 & 2 emissions but we always model the scope 3.

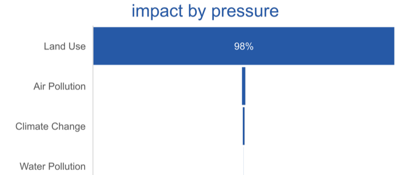
Panel D. Biodiversity impact by product

Corporate Biodiversity Footprint

Absolute contribution to CBF impact by products



Distribution of absolute contribution to CBF impact by pressure



Danone specializes in the worldwide manufacture and sale of fresh dairy products, nutrition food, and beverages. Like most Agri-food companies, its biodiversity footprint is driven by its supply chain through the land needed for the raw materials used to manufacture its products. The commodities which have the most material impact on biodiversity are the dairy products (land needed to breed and feed the dairy cattle) which require a higher land use occupation than other non-animal-related products. This results in a higher biodiversity ratio compared to industry peers.

D Determinants of sample coverage

This section of the Internet Appendix discusses determinants of data coverage by IDL.

A concern is that firms covered by IDL may be systematically different from non-covered firms, and these differences may bias any estimated biodiversity risk premium. For example, IDL may cover firms where investors worry about biodiversity issues, and our sample may in turn be biased towards firms with a biodiversity risk premium. A related concern is that the covered MSCI ACWI may be systematically different from the non-covered one. This is important to explore given that the MSCI ACWI is global market index followed by many investors ($4.3 trillion in assets are benchmarked to the index as of June 30, 2023). Sample selection effects may in turn suggest that biodiversity is priced in global equity markets, while in fact it is only priced among the select index subset covered by IDL.

We perform two tests in IA Table D.1 to understand potential biases. First, in Column 1, we condition on the MSCI ACWI universe and compare characteristics of covered and non-covered firms. To this end, we create a first dummy variable, IDL coverage, which equals one if an MSCI ACWI firm is covered by IDL, and zero if an MSCI ACWI firm is not covered. We then relate this variable to firm characteristics and proxies for a firm's transparency of environmental information (E score, Trucost estimated emissions, Biodiversity impact reduction). The latter variables help us understand whether some MSCI ACWI members are covered as they are more transparent. We find that MSCI ACWI firms covered by IDL are larger and invest more, but none of the information environment proxies emerges as a predictor of IDL coverage. Second, in Column 2, we condition on the universe covered by IDL and contrast firms inside and outside of the MSCI ACWI. We now create a second dummy, MSCI ACWI member, which is one if a firm covered by IDL is in the MSCI ACWI, and zero if it is not. We find that non-MSCI ACWI firms covered by IDL are relatively smaller and less environmentally transparent (as indicated by Trucost estimated emissions). In light of these observable differences, we verify below that our results hold if we restrict the sample to firms inside the MSCI ACWI universe.

IA Table D.1. Firm-level determinants of data coverage

This table reports reports regressions relating whether an MSCI ACWI firm is covered by IDL (whether a firm covered by IDL is a member of the MSCI ACWI) to firm characteristics. IDL coverage equals one if an MSCI ACWI firm is covered by IDL, and zero if an MSCI ACWI firm is not covered by IDL. MSCI ACWI member equals one if firm covered by IDL is included in the MSCI ACWI, and zero if firm covered by IDL is not included in the MSCI ACWI. Standard errors are clustered at the firm level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions..

	IDL coverage	MSCI ACWI member
	MSCI ACWI firms	IDL firms
	(1)	(2)
Ln(Total assets)	-0.012	0.072***
	(0.014)	(0.012)
Ln(Market cap)	0.087***	0.111***
	(0.011)	(0.009)
Leverage	0.005	0.063
	(0.065)	(0.058)
Capex/Total assets	0.638*	-0.118
	(0.380)	(0.344)
PPE/Total assets	-0.069	0.018
	(0.080)	(0.069)
ROA	0.216	0.092
	(0.140)	(0.119)
Asset growth	0.056**	0.007
	(0.022)	(0.018)
Sales growth	0.037	0.035
	(0.027)	(0.023)
Ln(CO_2 Emissions)	-0.003	-0.008
	(0.009)	(0.007)
E score	-0.000	-0.001
	(0.001)	(0.000)
Trucost estimated emissions	-0.015	-0.088***
	(0.028)	(0.025)
Biodiversity impact reduction	0.018	-0.015
	(0.025)	(0.021)
Institutional ownership (Lagged)	0.000	0.001
	(0.001)	(0.001)
Year-month fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
# Obs.	5,338	5,490
R^2	0.224	0.438

E CBF and corporate disclosures: Case studies

This section of the Internet Appendix provides examples of how firms disclose biodiversity issues.

E.1 Examples from annual reports

Danone, Integrated Annual Report, 2019

"Together with partners, we launched two business-led coalitions 'One Planet Business for Biodiversity' (OP2B) and 'Business for Inclusive Growth' (B4IG), to transform farming and promote inclusive growth. These pioneering initiatives will help accelerate the food revolution and impact at scale."

"...for food, just nine account for 66% of total crop production (*), while 60% of biodiversity has been lost. Business must promote a more diverse, resilient agriculture system. In line with our Goals to protect natural resources and serve the food revolution with partners, we co-built with the World Business Council for Sustainable Development the 'One Planet Business for Biodiversity' (OP2B) business coalition. Launched by Emmanuel Faber at the UN General Assembly in September 2019, OP2B unites 19 leading companies in a collective effort to promote biodiversity - by scaling up regenerative farming practices, diversifying crop production, eliminating deforestation and conserving ecosystems - and will report transparently on progress and impact. (*) UN Food & Agriculture Organization, 2019."

"Producing food for future generations and farming responsibly depends on biodiversity - from soil regeneration to water filtration, pest control and pollination. Together with partners, we are striving to both protect and restore biodiversity and transform people's relationship with nature, helping to create a healthy, resilient food system."

"To promote biodiversity in the U.S., we have expanded our portfolio of yogurts to include non-GMO Project Verified options since 2016, in line with people's preferences. In particular, we have supported farmers in cultivating non-genetically modified feed for their cows. We have also launched a multi-year, $6 million research program to help improve soil health and productivity. Importantly, we display the non-GMO Project Verified logo on packs and highlight any GM ingredients in our portfolio to help people make informed purchasing decisions."

E.2 Examples from earnings conference calls

Archer-Daniels-Midland, Earnings Conference Call, April 26, 2022

"We are advancing sustainability commitments in other parts of our business as well. Last year, we unveiled new goals to reduce Scope 3 emissions and eliminate deforestation from our supply chain. This is critical work. We do not make these kinds of commitments without an achievable plan to meet them, and once we move forward, we constantly challenge ourselves to do it faster. That is why last week, we announced that we've accelerated our deadline for a completely deforestation-free supply chain by 5 years from 2030 to 2025."

Sysco Corp, Earnings Conference Call, May 4, 2021

"Lastly, our corporate social responsibility initiatives in 2025 goals are progressing well. Our industry-leading CSR efforts are setting the standard for care and progress across 3 pillars of people, product and planet. We are making great strides on this very important work, as evidenced by our recent announcement with Cargill, which is a critical partnership, along with the National Fish and Wildlife Foundation to improve sustainable grazing practices across 1 million acres of grassland. This effort helps to improve soil health, promote biodiversity and increase carbon storage and safeguard the livelihoods of ranchers and the communities in which we serve."

F Biodiversity policy developments

This section of the Internet Appendix provides a summary of key biodiversity policy developments.

F.1 Pre-COP15 developments

The international biodiversity conservation agenda dates back to the 1980 "World Conservation Strategy" commissioned by the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN). The United Nation (UN) Convention on Biological Diversity (CBD) was opened for signature at the Earth Summit in Rio de Janeiro on June 5, 1992 and entered into force on December 29, 1993. Since then, 15 Conferences of the Parties to the CBD (COPs) have been held, though success has been limited. None of the 20 targets set at COP 10, for the period 2011-2020 (Aichi targets), have been fully reached (CBD Secretariat 2020).

While the UN CBD entered into force in 1993 and several Conferences of the Parties (COPs) to the CBD have adopted various plans to protect biodiversity, most goals have not been achieved (CBD Secretariat 2020); notably, the U.S. has signed but not ratified the CBD. Recent globally coordinated steps toward protecting biodiversity include the Kunming Declaration of 2021 and the Montreal Agreement of 2022, which we discuss in the next subsection.

Various initiatives at the intersection of corporations and the public sector have also emerged recently. In particular, the Taskforce on Nature-related Financial Disclosures (TNFD) is a market-led and science-based initiative supported by national governments, businesses and financial institutions worldwide. Modeled after the Taskforce on Climate-related Financial Disclosures (TCFD), it consists of 40 individual Taskforce Members representing financial institutions, corporates and market service providers with over US$20 trillion in assets. It was launched in June 2021.

While we focus on global developments, important region- and country-specific policy developments have also taken place, motivated in part by the local economic and financial consequences of biodiversity loss. For example, in the European Union (EU), the 2018 Action Plan on Financing Sustainable Growth has led to the establishment of a taxonomy of sustainable activities (which mostly concerns non-financial firms) and the consequent obligations of financial firms to disclose the "sustainable" part of their activities. The EU has also recently adopted regulatory technical standards for disclosures under the Sustainable Finance Disclosure Regulation (SFDR). The SFDR contains Principle Adverse Impact (PAI) indicators, and one of these (PAI 7) requires information on activities negatively affecting biodiversity sensitive areas. Further, the EU Taxonomy's Environmental Objective 6 includes the protection and restoration of biodiversity and ecosystems. Last but not least, the Taxonomy's Do No Significant Harm (DNSH) principle requires that corporate activities are not detrimental to the ecosystem and status of protected habitats and species. In France, a decree implementing the Article 29 of the Law on Energy and Climate requires financial institutions to disclose biodiversity-related risk (next to climate-related risks). In the U.S., following his executive order on protecting public health and the environment issued in January 2021, president Biden asked Fish and Wildlife Services (FWS) and National Marine Fisheries Service (NMFS) to review the changes made to the Endangered Species Act (ESA) during Trump mandate. On June 4, 2021, the two agencies released a plan to improve and strengthen the implementation of the ESA. In particular, they announced that the Trump administration's ESA rules which were making it easier to remove species from the endangered list or to exclude areas from critical habitat designation will be rescinded.

F.2 COP15: Kunming and Montreal summits

Major progress on biodiversity protection was made at the two parts of the UN Biodiversity Conference (COP15), which took place in October 2021 (Kunming) and December 2022 (Montreal). COP15 had been meant to take place in Kunming in October 2020, but it was delayed four times due to the COVID-19 pandemic. Reflecting a major breakthrough to protect biodiversity, the Kunming Declaration (2021) calls for countries to act urgently to protect biodiversity through their decision-making and to recognize the importance of conservation in protecting human health. In particular, it emphasizes the need to eliminate, phase out or reform subsidies and other incentives that are harmful to biodiversity. Analogous to the Paris Agreement for climate change, the landmark Kunming Declaration stresses the need to align financial flows to support the conservation and sustainable use of biodiversity (Article 13). The second part of the COP15, in Montreal, ended with an agreement including 23 targets for achievement by 2030. The most prominent one, known as 30×30, places at least 30% of the world's land and ocean areas under protection. The Montreal Agreement (2022) also reaffirms that all relevant public and private activities as well as fiscal and financial flows should progressively be aligned with biodiversity protection (Target 14). Another target adopted in the Montreal Agreement includes requirements for large and transnational firms and financial institutions to monitor, assess, and transparently disclose their risks, dependencies, and impacts on biodiversity through their operations, supply and value chains, and portfolios (Target 15).

F.3 Post-COP 15 developments

Since the COP15, central banks and financial market supervisors are increasingly paying attention to the topic (see, e.g., NGFS and INSPIRE 2022). Specifically, in March 2022, the Network for Greening the Financial System (NGFS), which regroups over 125 central banks and financial supervisors, published a statement acknowledging that nature-related risks could have important implications for financial stability and should therefore be considered as part of central banks' mandate. In September 2023, NGFS (2023) released a conceptual framework which aims to define nature-related financial risks and related concepts, to offer a framework to help central banks and supervisors identify and assess sources of physical and transition risks, assess economic risks, and assess risk to, from and within the financial system, and to outline the next steps to be taken by the NGFS Taskforce, including bridging the modelling and data gaps.

Also in September 2023, TNFD (2023) published its final recommendations. These are designed to be consistent with Target 15 of the Montreal Agreement, include 14 recommendations covering nature-related dependencies, impacts, risks and opportunities. These recommendations are regrouped in four pillars: i) *governance* (i.e., disclosure of the organisation's governance of nature-related dependencies, impacts, risks and opportunities), ii) *strategy* (i.e., disclosure of the effects of nature-related dependencies, impacts, risks and opportunities on the organisation's business model, strategy, and financial planning), iii) *risk and impact management* (i.e., description of the processes used by the organisation to identify, assess, prioritise and monitor nature-related dependencies, impacts, risks and opportunities), and iv) *metrics and targets* (i.e., disclosure of the metrics and targets used to assess and manage material nature-related dependencies, impacts, risks and opportunities).

The International Sustainability Standards Board (ISSB)—a standard-setting body established in 2021-2022 under the International Financial Reporting Standards Foundation (IFRS)-—has highlighted in early May 2023 that as it seeks to outline the roadmap for the next two years, it has identified four potential projects, one of which is on biodiversity, ecosystems and ecosystem services.

There are also important recent initiatives by institutional investor coalitions and NGOs, such as Nature Action 100, a global investor engagement initiative to tackle nature loss and biodiversity degradation. In September 2023, Nature Action 100 unveiled a list of 100 firms that the 190 institutional investor participants (representing $23.6 trillion assets under management) will engage with. Moreover, "Business for Nature" has called for nature assessment and disclosure to be mandatory. French SIF and Iceberg Data Lab (2022) provide an overview of these more recent policy developments and initiatives.

Finally, policy and regulation continue to evolve. For example, the High Seas Treaty (also referred to as the Biodiversity Beyond National Jurisdiction Treaty), adopted at the UN in June 2023, represents a landmark agreement for the safeguard of oceans and for the protection of marine biological diversity beyond national jurisdictions. The treaty was adopted in response to a blaring gap in ocean protection as only about 1% of the high seas areas was protected. It contains provisions based on the polluter-pays principle as well as mechanisms for disputes. As part of its 2030 biodiversity strategy, the EU has taken several actions to protect biodiversity including the adoption of a proposal for a nature restoration law (June 2022), the publication of sets of guidelines on forests (March 2023), the adoption of a proposal for a soil health law (July 2023), and the adoption of a proposal for a regulation establishing an EU forest monitoring framework (November 2023). Also, as mandated by the EU Corporate Sustainability Reporting Directive (CSRD), in July 2023, the European Commission adopted, in form of a Delegated Act, the European Sustainability Reporting Standards (ESRS), one of which requires extensive biodiversity disclosure (for companies which deem biodiversity material).

G Biodiversity measures by MSCI and Refinitiv: Score construction

This section of the Internet Appendix provides details on how MSCI and Refinitiv construct their biodiversity risk measures.

To compute the MSCI biodiversity & land use exposure measure, MSCI aims to capture three risks for firms: i) loss of license to operate; ii) litigation by landowners and other affected parties; and iii) increased costs of land protection and reclamation. It assesses firms based on their business segment and geographic exposures, for which it generates separate subscores that are then combined into an overall score. For the segment exposure, MSCI considers the percentage of each segment's operations with high/moderate/low impact on biodiversity, drawing on information from the World Resources Institute, Refinitiv, and firm disclosures. The overall Business Segment Exposure Score is a weighted average of the biodiversity and land use risk exposure scores of a firm's business segments (weighted by segment assets). Similarly, the Geographic Exposure Score is a weighted average of the biodiversity and land use risk scores of the countries and regions in which a firm operates (weighted by the assets in each geographic segment). MSCI states that it incorporates information from Global Forest Watch, the World Resources Institute, the UNDP Human Development Report, Refinitiv, and firm disclosures. The two subscores are then combined into an overall score, but the score can be further altered by other firm-specific factors, if applicable (e.g., size of workforce, percentage outsourced, etc.). MSCI scores a firm's biodiversity and land use exposure on a 0-10 scale, with 10 corresponding to the highest and 0 to the lowest risk.

In comparison, Refinitiv biodiversity impact reduction measure is not a score ranging from 0 to 10, but instead a dummy variable indicating whether a firm reports its impact on biodiversity or on activities to reduce this impact. Refinitiv constructs the indicator for a global sample.

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Swiss Finance Institute

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