Do Investors Care About Biodiversity?

Finance Working Paper N° 905/2023
June 2023

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Abstract

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Keywords: Biodiversity, Corporate Biodiversity Footprint, Stock returns

JEL Classifications: G12, G30, Q5

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1 Introduction

Biodiversity, the variety of living organisms in all habitats, is deteriorating at an unprecedented and alarming speed. Between 1970 and 2018, the world has seen a 69% loss of monitored wildlife (WWF 2022), and biosphere integrity is one of the planetary boundaries that has been overstepped (Rockström et al. 2009; Steffen et al. 2015). Global biodiversity collapse jeopardizes the goods and services humans obtain from ecosystems to ensure their well-being, including food, air and water quality, and landscape, 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 United Nations (UN) Convention on Biological Diversity (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). Recent globally coordinated steps toward protecting biodiversity include the Kunming Declaration of 2021 and the Montreal Agreement of 2022.

Given the potentially dramatic financial consequences of the loss of biodiversity, central banks and financial market supervisors are increasingly paying attention to the topic (e.g., NGFS and INSPIRE 2022). However, the link between biodiversity and finance has received little attention by academic researchers. As noted by Karolyi and Tobin-de la Puente (2023), no studies in the top ten finance journals reference biodiversity.[2] In this paper, we take a step toward filling this gap by introducing to the finance literature a new science-based measure, the Corporate Biodiversity Footprint (CBF) and exploring whether investors price the biodiversity footprint caused by firms.

1. The World Economic Forum (2022) 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).
2. By contrast, the economics of biodiversity have received early and substantial attention (e.g., Weitzman 1992, 1993; Metrick and Weitzman 1998; Heal 2003, 2004; Dasgupta 2021).

Our measure was developed by Iceberg Data Lab (IDL) and reflects the extent to which the business operations of a firm have degraded ecosystems from their pristine natural state. To this end, the CBF metric aggregates the biodiversity loss caused by a firm's annual activities and expresses this loss in terms of km^2MSA (Mean Species Abundance).[3] The measure quantifies a firm's direct and indirect impacts on biodiversity from four sources: land use, greenhouse gas emissions, water pollution, and air pollution. Importantly, the CBF metric captures biodiversity along the value chain, not just the direct impact of a firm. Thus, using the nomenclature of the climate literature, IDL decomposes the CBF metric into scope 1, 2, and 3 components.[4]

Our international sample represents the universe of publicly listed firms for which data on biodiversity footprints are available from IDL over the years 2018-2021. The sample consists of 2,025 firms from 32 countries. 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 industries with the largest average biodiversity footprints, which reflects these sectors' pressures from intensive land use or air pollution.[5] These industries are followed by Asset Management, consistent with scope 3 biodiversity harm (indirectly through financing) being a major component of that sector's overall footprint. A variance decomposition shows that, while there is a sizeable industry component of the biodiversity footprint (around 40%), there is substantial heterogeneity within industries.

3. For example, a CBF score of 100km^2MSA corresponds to a reduction of original biodiversity of 10% over an area of 1,000km^2 or of 1% over an area of 10,000 km^2.

4. 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 firm's purchase of electricity, heat, and cooling; and scope 3 measures all indirect pressures induced by the firm's activity, such as the products sold or investments made, as well as the products purchased by the firm.

5. 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.

This is a strength of the CBF measure as it allows the exploration of granular within-industry variation in biodiversity footprints. Capturing such variation is important because several institutional investors recently started to conduct negative screening policies in which they exclude the laggards within certain industry sectors (e.g., La Banque Postale Asset Management 2022). When analyzing the firm-level determinants of a firm's biodiversity footprint, we find that larger firms have a significantly more negative impact on biodiversity. The biodiversity footprint also relates positively to a firm's carbon emissions, which represent one channel through which firms harm biodiversity.[6]

Prior literature makes ambiguous predictions for how a firm's biodiversity footprint may affect its stock returns. The first possibility is that stocks with a larger footprint will earn higher returns as they potentially face transition or reputational risks. Transition risks may result from compliance with an increasingly demanding regulatory environment regarding biodiversity preservation. The theoretical framework of Pástor and Veronesi (2012) implies that the policy uncertainty associated with such future regulation may lead to investors requiring a risk premium for holding large-CBF stocks. Recent studies show that investors already demand compensation for the exposure to carbon risks (e.g., Bolton and Kacperczyk 2021; Bolton and Kacperczyk 2023) or risks related to pollution (Hsu, Li, and Tsou 2023). Beyond risk considerations, investors' preferences for green firms may lead to divestment of large-CBF stocks, depressing their stock prices and leading to higher expected returns (e.g., Pástor, Stambaugh, and Taylor 2021; Pedersen, Fitzgibbons, and Pomorski 2021).[7]

The second possibility is that large-CBF stocks will earn lower returns. Recent evidence

6. On top of capturing the central role played by land use, the biodiversity footprint of a firm differs from its carbon footprint (or industrial pollution) in that it explicitly identifies the impact on biodiversity of these environmental pressures.

7. For example, NBIM, Norway's sovereign wealth fund, divested from 60 investments due to deforestation risk (Norges Bank 2018).

shows that, despite having lower expected returns than brown stocks, green stocks can have higher realized returns due to unexpected shifts in investors' preferences for green stocks or customers' tastes for green products (e.g., Pástor, Stambaugh, and Taylor 2021, 2022). Other studies find that, when attention to climate change or other climate concerns increases, green stocks outperform brown stocks (Ardia et al. 2023; Choi, Gao, and Jiang 2020; Engle et al. 2020). To the extent that concerns about biodiversity deterioration are recent and still developing, as investors' or customers' tastes shift, small-CBF stocks may see higher returns.

The third possibility is that a firm's CBF does not affect returns. First, ways to measure and disclose a firm's impact on biodiversity are more complex and less well-developed than those for climate change.[8] Investors may be unable to discriminate between high versus low harm to biodiversity, even if they have preferences or anticipate risk. Second, whereas the personal experience of phenomena attributable to climate change, such as abnormally hot temperatures, affects investors' perceptions of the problem (e.g., 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 awareness of it among investors. Third, even if investors have a sense of biodiversity harm, to the extent that they focus on the financial materiality of corporate environmental policies and ignore the impact materiality (i.e., the impact on the environment), they are unlikely to price stocks based on a firm's biodiversity footprint.

We examine the pricing of the biodiversity footprint by regressing monthly stock returns of firms on their one-year lagged biodiversity footprints (i.e., we relate firms' returns from 2019 through 2022 to their 2018-2021 CBF values). We follow Bolton and Kacperczyk (2023) in relying on a characteristics-based approach, which has the advantage that there is no need

8. Ilhan et al. (2023) provide evidence that institutional investors value and demand climate risk disclosures. Though evolving fast, demand for biodiversity footprint disclosure is much less prevalent, and the quality of information is poor. According to the head of Schroders, reporting on biodiversity is where reporting on climate change was five to ten years ago (Agnew 2022).

to make assumptions about the underlying asset pricing model. The baseline result is that, on average, no robust evidence exists that the biodiversity footprint is priced between 2019 and 2022 (whether measured absolutely, or scaled by assets, for example).

However, we find strong evidence that a firm's biodiversity footprint started to be priced following a major biodiversity-related policy event. In October 2021, the UN Biodiversity Conference (COP15) took place in Kunming and concluded with the Kunming Declaration (2021). Similar to the Paris Agreement for climate change, the Kunming Declaration calls for countries to act urgently to protect biodiversity by aligning financial flows to support the conservation and sustainable use of biodiversity. The momentum was sustained through the second part of the COP15, taking place in December 2022, which ended with the Montreal Agreement (2022). This agreement includes 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. These events arguably increased both investor awareness about the loss of biodiversity and the prospect of future biodiversity regulations. The model by Pástor and Veronesi (2012) implies that the associated increase in biodiversity-policy uncertainty should lead to investors requiring a risk premium for large-CBF stocks. Consistent with this prediction, our monthly regression model estimates that, between the Kunming Declaration and December 2022, a one-standard deviation increase in the log of the CBF value is associated with an additional monthly return of 23 basis points, or a 2.8% annualized increase.

To corroborate that the emergence of a biodiversity footprint premium is indeed due to the Kunming Declaration, we conduct an event study which examines closely whether and how investors revised their valuations of large-CBF stocks around the conference. We conduct a similar event study around the Montreal Agreement.[9] If the Kunming Declara-

9. The central declarations were made on October 13, 2021 and December 19, 2022, respectively. Because the outcomes of the two parts of COP15 were not determined beforehand, they qualify as plausible shocks to

tion raised investor awareness of biodiversity issues and the prospect of regulations aimed at preserving it, we would expect investors to revise downward their valuation of large-CBF stocks. Indeed, in the three days following the Kunming Declaration, relative to the three days before, large-CBF stocks experienced a cumulative stock price decline of -1.18%, significant at the 1% level, relative to small-CBF stocks.[10] For the Montreal Declaration, we find a negative stock price reaction for firms located in countries with low current levels of biodiversity protection, and this effect is particularly strong for firms with a large land use biodiversity footprint. This result is plausible given that the Montreal Agreement's key 30×30 target is most relevant for firms with large land-use related biodiversity impacts and for countries that require relatively more regulation to contribute to the 30x30 target.

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

To understand whether the results are driven by the specifics of the CBF metric, we re-estimate our tests using MSCI's biodiversity and land use exposure score. Similar overall results emerge. However, as we emphasize in the main text, the MSCI score does not provide a quantification of the footprint of a firm and does not consider the full value chain of a firm. Despite these limitations, one reason why the MSCI score is priced is that it remains useful to identify firms with some biodiversity impact (even if it does not quantify this impact).[11]

Our results relate to two strands of the literature. First, we contribute to a new literature on biodiversity finance. To the best of our knowledge, three other research teams examine

investors' expectations regarding the transition risks faced by firms with large biodiversity footprints. Both conferences were marked by tense talks and a deep divide between wealthy and developing countries, which made the final agreements uncertain until the day of their announcement (Eihorn 2022; Mychasuk 2022).

10. We observe a similar negative reaction when we categorize stocks based on intensity measures.

11. This explanation is consistent with the idea that investors are willing to pay for sustainable investments but not for more impact (Heeb et al. 2023).

the interplay between biodiversity and finance, namely Giglio et al. (2023), Flammer, Giroux, and Heal (2023), and Hoepner et al. (2023). Closely related is the work by Giglio et al. (2023). Their approach differs from ours in terms of methodology, focus, and sample. Specifically, Giglio et al. (2023) construct measures of US firms' biodiversity risk to assess the covariation of returns of portfolios sorted on the industry-average of that measure with biodiversity news. The industry-level measures are compiled from a binary firm-level indicator of the existence of disclosures on biodiversity risks in 10-Ks (3.8% of firms discuss biodiversity risks). Our measure quantifies the impact of firms' activities on biodiversity, and does so for a global sample. Finally, we document how investors revised their valuation of large versus small CBF firms following global biodiversity agreements. Flammer, Giroux, and Heal (2023) examine the use of private capital to finance biodiversity conservation and restoration. 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).

Second, we contribute to the study of the pricing of ESG risks. Our results are in line with recent evidence documenting the existence of a carbon premium (Bolton and Kacperczyk 2021; Bolton and Kacperczyk 2023) and a pollution premium (Hsu, Li, and Tsou 2023). We confirm and extend these papers' conclusion that ESG risks are (increasingly) getting priced, and demonstrate this for what is now, next to climate change, the focal ESG topic among institutional investors. Our analysis of the COP15 complements work showing how climate policy shocks are priced by investors (see, e.g., Ramelli et al. (2021) on the effects of the 2016 and 2020 US elections and findings in Bolton and Kacperczyk (2021) on the effects of the Paris agreement). Notably, by combining cross-sectional asset pricing tests with event study evidence around the Kunming Declaration, we shed light on how important policy events act as catalysts that lead to revised investor expectations and the emerge of a risk premium.

2 Data and Variables

2.1 Data Sources and Sample Construction

Our sample construction starts with all publicly listed firms for which data on biodiversity footprints are available from IDL between 2018 and 2021. The pricing analysis relates these annual data to monthly returns between 2019 and 2022. The sample largely spans the MSCI All Country World Index, which is the universe that IDL tries to cover. We restrict the sample to firm-years for which we can compute monthly returns and our control variables. We drop observations with negative book or market values of equity, with returns exceeding 100%, and from countries with fewer than ten firms.[12] For some sample firms, we fill forward missing CBF values because CBF data may be missing in some years (especially for 2021). This procedure increases the number of firm-month observations by 20% (from 68,088 to 85,122), but our results do not depend on this choice. The sample for the pricing analysis consists of 85,122 firm-month observations from 2,025 unique firms located in 32 countries.

We obtain accounting and stock price data (in USD) from Compustat, data on ESG scores and carbon emissions from Refinitiv, and data on country-level biodiversity protection and preservation from the OECD. The Biodiversity and Habitat score, calculated by the Commonwealth Scientific and Industrial Research Organization, is from Yale's Environmental Performance Index web platform. Appendix A defines all variables.

12. We also exclude the following island countries: "Netherlands Antilles", "Faroe Islands", "Guernsey", "Isle of Man", "Jersey", "Marshall Islands", "Bermuda", and "Cayman Islands".

2.2 Corporate Biodiversity Footprint (CBF)

2.2.1 Overall Corporate Biodiversity Footprint

Our measure of a firm's impact on biodiversity is the Corporate Biodiversity Footprint (CBF) constructed by IDL. The data provider developed the measure to provide a science-based indicator that helps financial institutions measure and manage their investments' impact on biodiversity. IDL biodiversity data are used by major institutional investors, including BNP Paribas Asset Management, AXA Investment Managers, Robeco, and Mirova. The CBF metric reflects the extent to which ecosystems affected by a firm's activities have been degraded from their pristine natural state. The metric aggregates the biodiversity loss caused by annual firm activities resulting from environmental pressures (e.g., land use, nitrogen deposition, emissions, and release of toxic compounds). The CBF metric is based on the concept of Mean Species Abundance (MSA), one of the key reference metrics used by the Convention on Biological Diversity (CBD) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).[13] MSA measures the relative abundance of native species in an ecosystem, compared to their abundance in undisturbed ecosystems. It therefore captures the conservation status of an ecosystem in relation to its original state, that is, undisturbed by human activities and pressures. An area with an MSA of 0% has completely lost its original biodiversity (or is exclusively colonized by invasive species), whereas an MSA of 100% reflects a biodiversity level equal to an original,

13. MSA was proposed during the development of the GLOBIO3 model, the objective of which is to simulate the impact of different human pressure scenarios on biodiversity. GLOBIO3 calculates the local terrestrial biodiversity intactness, as expressed by the MSA indicator. The CBF methodology uses MSA to express its biodiversity score 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 (e.g., endangered species) which are better-fitted to project analysis; and iii) it is endorsed by the scientific community and multilateral organizations (e.g., IPBES and IPCC), and recommended by the UN.

undisturbed ecosystem. Figure 1 provides a photographic illustration of MSA variation for forest and grassland ecosystems.

– Figure 1 –

To capture the area over which MSA is affected by a firm's activities, the biodiversity footprint is expressed in terms of km^2MSA. The CBF metric measures the potential negative change in MSA due to a firm's activities, by translating its combined degradation of nature into square kilometers. In other words, if one combines all of the firm's negative impacts on biodiversity, the CBF metric expresses this impact in terms of square kilometers of "artificialized" or "denatured" land. For example, a CBF value of 100km^2 means that 10% of the original biodiversity is lost over an area of 1,000km^2, or that a proportionally lower amount of biodiversity, 1%, is lost over the larger area of 10,000km^2.

The CBF metric is calculated in four steps. First, based on its internal physical input/output model, IDL assesses the products purchased and sold by a firm throughout its value chain and allocates the firm's product flows by NACE4 sector. Second, it calculates the firm's environmental pressures based on its product flows, considering four pressures: land use, greenhouse gas emissions, air pollution, and water pollution. These four pressures are calculated along the whole value chain of the firm, appraising its processes, products, and supply chains. Third, IDL translates these four pressures, using pressure-impact functions, into one biodiversity impact unit, expressed in km^2MSA. Finally, it aggregates the different impacts into an overall absolute impact. Figure 2 illustrates the steps involved in the calculation of the CBF metric and how each pressure is translated into a quantified impact on biodiversity, expressed in km^2MSA.

– Figure 2 –

Figures 3 and 4 illustrate the calculations of the 2021 biodiversity footprints for food producer Danone (-10,486 km^2MSA) and automotive manufacturer Stellantis (-2,539 km^2MSA), respectively. Large parts of Danone's footprint originate from the supply chain, in particular in relation to the land needed for the raw materials used to manufacture its products. The firm's largest biodiversity impact originates from its dairy products, especially from land use needed to breed and feed dairy cattle. Figure IA.1 provides for Danone more details on the steps in the calculation of its biodiversity footprint.

– Figures 3 and 4 –

As 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. We label the resultant variable CBF VALUE.

2.2.2 Source- and Scope-Based Corporate Biodiversity Footprint

In some tests, we decompose CBF VALUE into its constituent sources and consider a firm's impact on biodiversity from: i) land use, ii) greenhouse gas emissions, iii) water pollution, and iv) air pollution. We also decompose the biodiversity footprint into its scope 1, scope 2, and scope 3 dimensions. Similar to the measurements used for carbon emissions, the scope 1 footprint reflects the direct pressures generated by a firm, that is, the loss of biodiversity directly caused by the establishments owned or controlled by the firm. The scope 2 footprint, by contrast, captures an indirect effect, namely the loss of biodiversity caused by the generation of purchased heat, steam, and electricity consumed by the firm. Finally, the scope 3 footprint measures the loss of biodiversity caused by the operations and products of the firm, but coming from sources that the firm does not own or control.

3 Anatomy of the Corporate Biodiversity Footprint

3.1 Descriptive Evidence of the Biodiversity Footprint

Table 1 reports summary statistics for the corporate biodiversity footprint of our sample firms. As the variable is highly skewed, we use the natural logarithm of CBF VALUE for most of our tests. The mean and median values of Ln(CBF VALUE) are 4.81 and 5.28, respectively, indicating that the average (median) sample firm has an impact on biodiversity corresponding to the complete loss of biodiversity over an area of 122.7 km^2 (196.4 km^2). The biodiversity footprint of firms varies substantially in the cross-section. Specifically, Ln(CBF VALUE) has a standard deviation of 3.08.

– Table 1 –

In Figure 5, Panel A, we decompose the CBF metric into its four source-based subcomponents. The greatest impact on biodiversity originates from land use, which accounts for 49% of the overall CBF VALUE, followed by greenhouse gas emissions (22%), water pollution (20%), and air pollution (9%). Figure 5, Panel B, shows that firms' scope 3 footprints contribute about 80% to the overall CBF VALUE, while the scope 1 and scope 2 components account for, on average, 14.5% and 5.5%, respectively. Scope 3 is dominant in the overall footprint metric because most large international firms either assemble and distribute products or provide services, implying that they usually do not have direct impacts on their environments (examples include retailers, banks, or tech firms); for such firms, the largest parts of the scope 3 footprints originate from upstream (e.g., providers of farming land or extracting raw materials) or downstream (e.g., usage of products and services by clients, financing activities by banks) activities. To the contrary, firms with large scope 1 footprints tend to operate in the paper and forest business or in metals and mining, that is, with business models that have a much larger direct effect on the local biodiversity.[14]

– Figure 5 –

In Table 2, we present a ranking of industries and countries, using the overall as well as source- and scope-based measures.[15] The industry- and country-level rankings are created after averaging the measures across all firms in an industry or country. In Panel A, the industries with the highest average CBF VALUE are Retail & Wholesale, Paper & Forest, and Food, consistent either with their intensive land use (mostly indirectly through the supply chain in the case of, for example, food or 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 biodiversity footprint. In Panel B, countries with firms that have the highest average biodiversity footprints include Finland, Saudi Arabia, Canada, Brazil, and Germany.

– Table 2 –

In Table IA.2, we do not observe significant variation across countries in terms of the two footprint decompositions; for example, in all countries, the environmental pressure contributing the most to biodiversity impact is land use. Likewise, on average, the scope 3 footprint is dominant in all countries. Comparatively, in Table IA.3, there is much more variation across industries in terms of the decomposition of the CBF metric. For instance, for the Waste industry, scope 1 accounts for 75.3% of the total footprint, whereas in Asset

14. Table IA.1 reports additional summary statistics at the firm-year level on the source- and scope-based decompositions of the CBF metric.

15. IDL's industry classification is similar to the Revere Business Industry Classification System (RBICS).

Management, scope 3 accounts for 99.9% of CBF VALUE. The Chemicals and Metal & Mining industries impact biodiversity mainly through the release of toxic compounds and land use. The main biodiversity impact from the Power, Internet & Data, and Waste industries is through greenhouse gas emissions. The Transportation industry is the sector for which the impact of air pollution is the strongest. In Food, Beverages, Paper & Forest, and Tobacco, land use contributes about 90% or more to the overall footprint.

3.2 Variance Decomposition of the Biodiversity Footprint

We next assess the relative contributions of industry-, year-, country-, and firm-level variation in explaining the biodiversity footprint. To this end, we conduct a variance decomposition for both the raw CBF metric and for an intensity measure (CBF VALUE/TOTAL ASSETS). In Table IA.4, we find that the firm-level biodiversity footprint has a sizeable industry component (41.1% and 52.6%, respectively), confirming the presence of important industry differences in the CBF metric (as shown above). Time fixed effects explain little of the variation, yielding an incremental R^2 of only 0.1% for the raw and intensity measures. Likewise, country fixed effects only account for about 3 to 5% of the variation. Interactions between industry and time fixed effects or between country and time fixed effects provide little additional explanatory power. Importantly, large parts of the variation, 55.3% for the raw measure and 41.8% for the intensity measure, are unexplained by these sets of fixed effects. This indicates that variation in the biodiversity footprint mainly plays out at the firm level. Thus, even within an industry, the negative impact on biodiversity is heterogeneous across firms.

3.3 Firm-Level Determinants of the Biodiversity Footprint

In this section, we build on the variance decomposition and examine firm-level determinants of the CBF metric by estimating the following regression for firm i in year t from 2018 to 2021:

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

where $\text{CBF}_{i,t}$ is Ln(CBF VALUE), the natural logarithm of CBF VALUE in km^{2}MSA (we also report results for the biodiversity footprint intensity). The vector $\boldsymbol{X}_{i,t}$ contains various firm characteristics. We include different sets of fixed effects, capturing year (γ_t), country (δ_c), and industry (μ_j) dimensions. Some estimations also use fixed effects at the level of the country-year ($\gamma_t \times \delta_c$), industry-year ($\gamma_t \times \mu_j$), or country-industry-year ($\gamma_t \times \delta_c \times \mu_j$). Standard errors are clustered by firm.

– Table 3 –

Table 3 presents the results of estimating Equation (1) with different sets of fixed effects. The results indicate that firm size is positively associated with the biodiversity footprint. As the CBF metric reflects the loss of biodiversity caused by a firm's activities expressed in km^{2}MSA, it is not surprising that larger firms have a greater negative impact on biodiversity (we use both raw and scaled CBF measures in the returns analysis). Our estimates also indicate that firms with greater asset tangibility (PPE over assets) have larger biodiversity footprints. To the extent that the main source of the biodiversity footprint is land use, firms with more tangible assets are likely to 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 capital expenditures. Our results further indicate that firms with higher carbon emissions have larger biodiversity footprints. This result is explained by the fact that carbon emissions are one of the sources of environmental pressure considered when computing the CBF metric. Finally, firms with better Refinitiv E scores tend to have a worse biodiversity footprint. For investors selecting investments based on firms' biodiversity footprints, this implies that it may be misleading to rely on aggregate E scores.[16]

In Table IA.5, we examine the determinants of the footprint intensity measure (Ln(CBF VALUE/TOTAL ASSETS)). The determinants of this measure are similar to those for the unscaled measure, although their statistical significance is lower. Unsurprisingly, one notable exception is firm size, which is negatively related to CBF intensity.

4 Corporate Biodiversity Footprint and Stock Returns

4.1 Estimation Design: Cross-Sectional Regressions

In this section, we present our findings on the pricing of the biodiversity footprint. We first consider unconditional pricing effects across the entire sample period, and then dissect these average effects conditional on recent biodiversity policy events that increased regulatory uncertainty. We rely on cross-sectional regressions relating individual firms' returns to their biodiversity footprints. Following Bolton and Kacperczyk (2023), we employ a firm characteristic-based approach, rather than a factor-based model; this approach is well suited, given the rich cross-sectional variation in firm characteristics in our sample. Moreover, with a characteristics-based approach, there is no need to make assumptions about the underlying

16. A negative biodiversity impact does not need to translate into a lower E score. First, most ESG raters, including Refinitiv, focus on aspects that are financially material to shareholder value, rather than the impact materiality of ESG policies. Second, there is a distinction between the current biodiversity footprint and a firm's environmental responsibility, which typically captures future-oriented strategies and voluntary initiatives. Finally, Refinitiv's ratings measure relative performance within an industry; a firm in a "dirty" industry with greater environmental externalities may, therefore, earn a high E score if it performs better than its peers.

asset pricing model.[17] Specifically, we link the return of firm i in month m of year t to its corresponding biodiversity footprint in year *t-1*:

$$\text{MONTHLY RET}_{i,m,t} = \beta_0 + \beta_1 \text{CBF}_{i,t-1} + \beta_2 \mathbf{X}_{i,t-1} + \gamma_t + \delta_c + \mu_j + \epsilon_{i,m,t} \,, \tag{2}$$

where $\text{MONTHLY RET}_{i,m,t}$ is the return of firm i in month m of year t and $\text{CBF}_{i,t-1}$ is the biodiversity footprint (Ln(CBF VALUE)) of firm i in year *t-1*. As before, we also report results for intensity measures. Through $\boldsymbol{X}_{i,t-1}$, 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, $\boldsymbol{X}_{i,t-1}$ includes the natural logarithm of total assets (annual), the natural logarithm of the market capitalization (monthly), leverage (annual), the book-to-market ratio (monthly), PPE over assets (annual), capital expenditures over assets (annual), return on equity (annual), asset growth (annual), sales growth (annual), momentum (monthly), and volatility (monthly). Annual (monthly) variables are lagged by one year (month). We control for time (year-month), industry, and country fixed effects. We double cluster standard errors at the time and firm level.

4.2 Biodiversity Footprint Premium for the Full Sample Period

Table 4 reports in Column 1 the results of estimating Equation (2) with industry, time, and country fixed effects across the full sample period using monthly returns between January 2019 and December 2022. The coefficient on Ln(CBF VALUE) is positive but not statistically significant. This indicates that, on average, a larger biodiversity footprint is *not* associated

17. As explained by Bolton and Kacperczyk (2023), a basic conceptual difficulty with the choice of asset pricing model, in the context of a complex pricing problem such as climate change risk, is that no such model has yet been formulated. The same argument applies to the biodiversity footprint and its associated risks, especially since biodiversity issues are more recent and have received less attention than carbon emissions.

with greater (or lower) returns. In Column 2, this result does not change when we account for time-varying unobserved heterogeneity at the industry level by including industry $\times$ time fixed effects. Similarly, in Table IA.6, we also cannot detect that various intensity-based measures of a firm's biodiversity footprint are priced across the full sample period (using CBF VALUE over total assets, sales, or PPE). A similar picture emerges when using the source-based CBF components land use, greenhouse gas emissions, water pollution, and air pollution separately. Overall, the estimates suggest that the biodiversity footprint is not statistically significant associated with returns over the full sample period between January 2019 and December 2022.

– Table 4 –

4.3 Biodiversity Footprint Premium since the Kunming Declaration

Investors may start considering the risks associated with a firm's biodiversity footprint in response to important policy-related news. Two major international biodiversity policy changes, the Kunming Declaration and the Montreal Agreement, which together have been hailed as being the biodiversity equivalent of the climate-focused Paris Agreement, are arguably particularly relevant. The Kunming Declaration was adopted at the 15$^{\text{th}}$ Conference of the Parties of the CBD (COP15) in October 2021.[18] More than 100 countries committed to developing, adopting, and implementing an effective post-2020 global framework to put biodiversity on a path to recovery by 2030 at the latest. Analogous to the Paris Agreement,

18. The 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 until recently. Appendix B provides a historical overview of global and regional policy developments and initiatives.

the Kunming Declaration stresses the need to align all financial flows in support of the conservation and sustainable use of biodiversity (Article 13). The second part of COP15, held in December 2022, resulted in the landmark Montreal Agreement to protect 30% of the planet's lands, coastal areas, and inland waters by the end of the decade.

In Table 4, Columns 3 through 6, we split the full sample period into monthly return observations from January 2019 to September 2021 (pre-Kunming period) and from October 2021 to December 2022 (post-Kunming period). In Columns 3 and 4, we continue to find no significant biodiversity footprint premium in the period before the Kunming Declaration.

By contrast, in Columns 5 and 6, a larger biodiversity footprint is associated with significantly greater returns in the post-Kunming period from October 2021 to December 2022. The estimated effect is economically sizeable. According to Column 5, a one-standard-deviation increase in Ln(CBF VALUE) is associated with an additional monthly return of 23 basis points, or a 2.8% annualized increase. Table IA.6 reveals a positive and significant relation with stock returns also when we employ biodiversity intensity measures.[19] It also shows that the pricing of the subcomponents greenhouse gases and water pollution has also become significant in the post-Kunming period (for air pollution, the significance is narrowly below conventional significance levels). Overall, the results indicate that following the Kunming agreement, a biodiversity footprint premium started to emerge.

19. This is consistent with the framework of Taskforce for Nature-Related Financial Disclosures, which focuses on scaled measures.

5 Stock Price Reactions to Biodiversity Policy Events

5.1 Estimation Design: Event Study

A concern with the analysis in the prior section is that the emergence of a biodiversity footprint premium after the Kunming Declaration is not the result of increased regulatory uncertainty, but instead due to other factors correlated with a firm's biodiversity footprint and, therefore, spurious. To address this concern, we conduct an event study in which we examine the daily stock returns of firms with large versus small biodiversity footprints around the date of the Kunming Declaration. We estimate the following panel regression at the firm-day level over a window of three days before to three days after the event:

$$\text{DAILY RET}_{i,t} = \beta_0 + \beta_1 \text{LARGE CBF}_i \times \text{POST}_t + \delta_i + \gamma_t + \epsilon_{i,t}, \tag{3}$$

where $\text{DAILY RET}_{i,t}$ is the stock return of firm i in day t; we employ both raw returns and abnormal returns (in excess of each firm's domestic market index). LARGE CBF_i equals one if the firm has a large biodiversity footprint (CBF VALUE is above the median) and POST_t equals one after the event. We consider the event date to be the last day of the conference (October 13, 2021). We define the event day as the first day of the post-event window and denote it as t = 0 (the event window is in turn labeled as [-3,2], covering three days before the event date and three days following the event date (the event date plus two further days). We control for firm (δ_i) and day (γ_t) fixed effects.[20] Standard errors are clustered at the country level.[21] The coefficient of interest (β_1) captures the differential in stock returns for firms with large biodiversity footprints in the days following the Kunming conference, relative to firms

20. The firm fixed effects control for firm characteristics or potential determinants of stock returns that are fixed around the days of the events. The standalone variables LARGE CBF_i and POST_t are absorbed by, respectively, the firm and time fixed effects.

21. Results are robust to clustering of the standard errors at the industry or firm levels.

with small biodiversity footprints. To the extent that the Kunming Declaration contributed to increasing awareness about biodiversity issues and the prospect of future regulations aimed at preserving it, we expect investors to have revised downward their valuation of firms with large biodiversity footprints.

5.2 Stock Price Reactions to the Kunming Declaration

Table 5 reports the results of estimating Equation (3) around the Kunming Declaration. In Columns 1 through 4, we report results for raw returns and in Columns 5 through 8 for abnormal returns. In Column 1, the coefficient on LARGE CBF $\times$ POST is negative and statistically significant at the 1% level, indicating that firms with large biodiversity footprints experienced statistically lower returns than firms with small footprints. On average, in the three days following the October 13 announcement, the daily returns of large-CBF firms were 0.39% below those of small-CBF firms. These effects accumulate to a cumulative stock price decline of -1.18% over the three-day period. Columns 2 and 3 address the concern that results are driven by unobserved effects at the country or industry level. When we control for any country-wide or industry-wide reactions to the Kunming Declaration, the coefficient on the interaction term continues to be negative and statistically significant at the 1% level. In Columns 5 through 7, we reestimate the same regressions using abnormal daily stock returns as the dependent variable. We continue to find that large-CBF firms experienced negative returns in the days following the Kunming Declaration.

In Columns 4 and 8, we replace the POST variable with dummies capturing the individual days surrounding the Kunming Declaration. The negative stock price reaction for large-CBF firms mostly spans the day of the declaration and the following day. Before the declaration, we observe no significant differences in the returns of large- versus small-CBF stocks. An exception is t = -1 for raw returns, for which we find a weakly significant effect; however, this effect disappears once we consider abnormal returns. Overall, the return patterns around the event are consistent with the outcome of the conference being uncertain and unanticipated by investors. This supports our interpretation that the return differential following the event was due to the announcement.

– Table 5 –

In Table IA.7, we reestimate variants of Table 5, Column 1. We find negative and statistically significant stock price reactions for three of the four sources of pressures, with water pollution being the exception. We also observe a negative reaction when we categorize stocks as large- versus small-CBF based on the intensity measures. This table further shows that results are also unchanged if we remove observations for which the absolute value of daily returns is higher than 5%, define large-CBF firms as those with a CBF value in the top quartile, use the continuous measure of CBF, or consider a larger time window around the event ([-5,4]).

5.3 Stock Price Reactions to the Montreal Agreement

Having documented how investors reacted to the Kunming Declaration, we apply the same event-study methodology to the Montreal Agreement, in order to understand whether stock prices adjusted further around the second part of the COP15. Table 6, Panel A, reports the results of estimating Equation (3) around the Montreal Agreement, which was reached on December 19, 2022. As before, LARGE CBF$_i$ equals one if the firm has a large biodiversity footprint (CBF VALUE is above the median) and POST$_t$ equals one after the event date. We find that the coefficient on the interaction between LARGE CBF$_i$ and POST$_t$ is generally not statistically significant and small in magnitude, independent of whether we consider raw or abnormal stock returns. This average zero-return effect may, however, mask heterogeneity in the price reactions depending on a country's level of biodiversity protection. The reason is that, with the prominent 30×30 target, the Montreal Agreement places emphasis on the protection of land and marine areas. This agreement may, therefore, trigger different stock price reactions across countries depending on their pre-existing level of biodiversity protection. As a matter of fact, country-level biodiversity protection varies greatly across the globe, as illustrated in Table IA.8. The table lists three country-level measures of the protection of biodiversity around the world (higher values indicate better biodiversity protection in a country): i) the Biodiversity and Habitat Score developed by Yale University, which assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders; ii) an indicator of the extent to which a country's territorial areas are protected; and iii) a similar indicator for protection of maritime areas. To decompose the average effect around the Montreal Agreement, we create three dummy variables that each equal one if the level of biodiversity protection in a firm's country falls in the bottom quartile of the distribution (low protection).

– Table 6 –

In Columns 1 through 3 of Table 6, Panel B, we show that firms from low-protection countries experienced lower stock returns in the days following the Montreal Agreement. On average, in the three days following the December 19 announcement, the daily returns of firms from low-protection countries were about 1.5% below those of firms located in high-protection countries. These results suggest that investors revised downward their valuations for firms located in laggard countries. In Columns 4 through 6, we examine whether large-CBF firms from low-protection countries experienced more negative stock price reactions to the Montreal announcement. The variable of interest is the triple interaction LOW BIODIVERSITY PROTECTION x POST x LARGE CBF LAND USE. In this panel, we focus on the land use component because the most prominent target of the Montreal Agreement was to place 30% of land and sea under protection. For two out of the three proxies for biodiversity protection, the triple interaction is negative and statistically significant. Among firms located in low-protection countries, those with a large land-use related biodiversity footprint experience an additional decrease in daily returns of about 0.3% in the three days following the Montreal announcement.

6 Comparison With Other Biodiversity Risk Measures

As the biodiversity finance literature is nascent, we conclude our analysis by discussing the main features of our biodiversity footprint measure and comparing them to other measures that were either recently employed in the finance literature or are available in databases of commercial data vendors. We compare our CBF metric with i) MSCI's biodiversity & land use exposure score, ii) Giglio et al. (2023)'s biodiversity risk exposure measures, and iii) Refinitiv's biodiversity impact reduction indicator. Table IA.9 summarizes the comparison. As we explain next, the comparison shows that the CBF measure identifies quantitative information on firms' impact on biodiversity and as such is most relevant for the research question of this paper. We use the MSCI score, which is closest in spirit, for a robustness check in the next subsection.[22]

22. 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.

6.1 MSCI Biodiversity & Land Use Exposure Measure

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. The score 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. As such, as the name suggests, MSCI primarily focuses on the issue of land use when assessing biodiversity risks.

To compute the score, MSCI 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.).

The CBF value and MSCI score both seek to measure firms' impact on biodiversity (though MSCI mostly considers land use). However, because of important differences in the way they are computed, the CBF metric provides a more complete measure of the biodiversity impact. First, unlike the CBF measure, the MSCI score of 0 to 10 is not a quantitative measure of the actual (estimated) impact on biodiversity. Indeed, the MSCI exposure score is not considered in the review of biodiversity metrics by Finance for Biodiversity (2022). Second, the description provided by MSCI suggests that the assessment focuses on the direct operations of a firm, rather than the overall life cycle of its products. Consistent with this observation, the MSCI exposure score has a correlation of 0.55 with the Scope 1 component of our CBF score, but only a 0.01 and 0.31 correlation, respectively, with the scope 2 and 3 components (see Table IA.10). By contrast, the life cycle assessment, used in the calculation of the CBF, allows to capture the potential environmental impacts associated with the production of a good or service, taking into account all or part of the production stages, from the supply chains of raw materials to the end of the product's life.

6.2 Giglio et al. (2023) Biodiversity Risk Measure

Building on textual analysis of US firms' 10-K statements, the main firm-level measure developed by Giglio et al. (2023) is a dummy variable equal to one if a 10-K statement contains at least two sentences related to biodiversity risk. This measure is helpful in identifying firm disclosures about biodiversity risks, whereas our CBF measure focuses on the negative impact that firms have on biodiversity, independent of whether they disclose on it. The latter seems important, as Giglio et al. (2023)'s data indicate that only a small subset of firms disclose exposure to biodiversity risk (only 3.8% of 10-K reports mention the topic between 2015-2020); numbers are even smaller when the topic is about biodiversity regulatory risk, one of the specific risk sources they consider. In Table IA.10, the CBF measure exhibits a modest positive correlation of 0.08 with this 10-K-based biodiversity measure (the correlation is based on US firms). To further understand how the measures relate, Figure 6, Panel A, shows the distribution of the CBF metric for firms with or without 10-k-based exposure to biodiversity risk. While, on average, firms mentioning biodiversity risk in their 10-K reports tend to have higher CBF values, there is significant overlap of the two distributions. This indicates that many firms without disclosures of biodiversity risks have higher biodiversity footprints than firms with such disclosures. Consistent with 10-K reports emphasizing firms' direct impacts on biodiversity, the 10-k-based measures exhibit stronger correlations with the scope 1 CBF component than with the scope 2 and 3 components (Table IA.10).

– Figure 6 –

6.3 Refinitiv Biodiversity Impact Reduction Measure

The measure of biodiversity impact reduction by Refinitiv is constructed for a global sample as a dummy variable indicating whether a firm reports its impact on biodiversity or on activities to reduce this impact. In Table IA.10, this indicator positively correlates with ln(CBF VALUE) (correlation of 0.32), suggesting that firms with larger biodiversity footprints disclose more on the topic. Figure 6, Panel B, 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 higher CBF values, there are also many cases where non-disclosing firms have much larger biodiversity footprints than disclosing firms.

6.4 Results with MSCI Biodiversity & Land Use Exposure Score

In this section, we present our returns results replacing the CBF metric with MSCI's biodiversity score. This alternative construct also intends to capture firms' impact on biodiversity, though, as discussed above, it has some limitations (for example, its score does not readily translate into a quantitative statement about the actual footprint of a firm, and it does not consider the whole value chain). Table IA.11, Panel A, reports regressions of monthly stock returns using this alternative impact metric. Similar to the results for CBF VALUE, a positive impact of the MSCI's score on stock returns emerges in the post-Kunming period, whereas there is no effect before.[23] For MSCI's measure, the post-Kunming results are so strong that even in the overall sample, the MSCI score is positive and statistically significant. In Panel B, we examine stock price reactions to the Kunming Declaration. Again, there is a negative and significant stock price reaction for firms with above-median impact scores if we use raw returns (results are less pronounced and below conventional significance for abnormal returns). However, when including industry-day fixed effects in Column 4, the estimates turn insignificant, indicating that the MSCI score has a strong industry component.

7 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.

23. 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.

Examining a large sample of international stocks, we find that over our sample period, investors did not care about the impact of firms on biodiversity, on average. However, things appear to be changing, as we document the emergence of a biodiversity footprint premium following the Kunming Declaration (the first part of the COP15). Consistent with this effect, we document negative stock price reactions for firms with large biodiversity footprints in the days following the Kunming Declaration. Stock prices of firms with large biodiversity footprints further dropped after the Montreal Agreement (the second part of the COP15). Our results indicate that investors start to ask for a return premium in light of the uncertainty associated with future biodiversity regulation.

Appendix A. Variable Definitions

Variables	Definitions	Sources
CBF VALUE	This variable measures the absolute biodiversity loss caused by the firm's annual activities. It results from the addition of 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^2MSA, 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
CBF GHG	This variable measures a firm's responsibility for greenhouse gas (GHG) emissions, an important driver of biodiversity loss. 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	This variable measures the firm's responsibility for the 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	This variable measures the firm's responsibility for the 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	This variable measures the firm's responsibility for the release of nitrogen oxides (NOx) into the air, a major factor in biodiversity loss. 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	This variable measures the impact on biodiversity 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	This variable measures the environmental pressures of a firm due to its 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	This variable measures all indirect pressures due to the firm's 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 VALUE/TOTAL ASSETS	CBF VALUE scaled by total assets in USD. Winsorized at the 2.5% and 97.5% levels. Annual data.	Iceberg Data Lab
CBF VALUE/SALES	CBF VALUE scaled by revenue in USD. Winsorized at the 2.5% and 97.5% levels. Annual data.	Iceberg Data Lab
CBF VALUE/PPE	CBF VALUE scaled by net property, plant, and equiment in USD. Winsorized at the 2.5% and 97.5% levels. Annual data.	Iceberg Data Lab
MONTHLY RETURN (%)	Monthly stock return. We build total return using stock prices expressed in USD(prccd), adjustment factors (ajexdi), exchange rates (exratd), and total return factors (trfd). Winsorized at the 1% and 99% levels. Monthly data.	COMPUSTAT
DAILY RETURN (%)	Daily stock return. We build total return using stock prices (prccd) expressed in USD, 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. Monhtly data.	COMPUSTAT
TOTAL ASSETS	Total assets. Winsorized at the 1% and 99% levels. Annual data.	COMPUSTAT
MARKET CAP	Market Capitalisation. Winsorized at the 1% and 99% levels. Monhtly 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
ROE	Income before extraordinary items divided by common equity. 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
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
CO2 EMISSIONS	Natural total CO2 and CO2 equivalent emissions, in tonnes. It encompasses direct (scope 1) and indirect (scope 2) emissions. Winsorized at the 1% and 99% levels. Annual data.	Refinitiv
BIODIVERSITY & HABITAT SCORE	The Biodiversity and Habitat Score assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders. It consists of seven indicators: terrestrial biome protection (weighted for the national and global rarity of biomes), 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
PROTECTED TERRESTRIAL AREA (%)	Country-level terrestrial protected area coverage, calculated from the World Database on Protected Areas (WDPA). Measured as of 2020.	OECD
PROTECTED MARINE AREA (%)	Country-level marine protected area coverage, calculated from the World Database on Protected Areas (WDPA). Measured as of 2020.	OECD
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
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	Giglio et al. (2023)
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	Refinitiv

Appendix B. Biodiversity Policy 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 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 we focus on global developments in this paper, important region- and country-specific developments are motivated in part by the economic and financial consequences of biodiversity loss. For example, in the European Union, 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). Moreover, central banks and financial market supervisors are increasingly paying attention to the topic (see, e.g., NGFS and INSPIRE (2022)). Finally, various initiatives at the intersection of corporations and the public sector have emerged. For example, "Business for Nature" has called for nature assessment and disclosure to be mandatory. The Taskforce on Nature-related Financial Disclosures (TNFD) proposes a framework for financial institutions and firms, analogous to the Task Force on Climate-related Financial Disclosures (TCFD). French SIF and Iceberg Data Lab (2022) provide an overview of these policy developments and initiatives.

References

Agnew, H. 2022. "Biodiversity quickly rises up the ESG investing agenda." *Financial Times.*

Ardia, D., K. Bluteau, K. Boudt, and K. Inghelbrecht. 2023. "Climate change concerns and the performance of green vs. brown stocks." *Management Science,* forthcoming.

Bolton, P., and M. Kacperczyk. 2021. "Do investors care about carbon risk?" *Journal of Financial Economics* 142 (2): 517–549.

Bolton, P., and M. T. Kacperczyk. 2023. "Global pricing of carbon-transition risk." *Journal of Finance,* forthcoming.

CBD Secretariat. 2020. *Global Biodiversity Outlook Report 5.* Convention on Biological Diversity.

Choi, D., Z. Gao, and W. Jiang. 2020. "Attention to global warming." *Review of Financial Studies* 33 (3): 1112–1145.

Dasgupta, P. 2021. *The economics of biodiversity: The Dasgupta Review.* U.K. Her Majesty's Treasury.

Di Giuli, A., A. Garel, R. Michaely, and A. Petit-Romec. 2022. "Climate change and mutual fund voting on environmental proposals." *Available at SSRN 3997730.*

Eihorn, C. 2022. "Nearly every country signs on a sweeping deal to protect nature." *New York Times.*

Engle, R. F., S. Giglio, B. Kelly, H. Lee, and J. Stroebel. 2020. "Hedging climate change news." *Review of Financial Studies* 33 (3): 1184–1216.

Finance for Biodiversity. 2022. *Guide on biodiversity measurement approaches.*

Flammer, C., T. Giroux, and G. M. Heal. 2023. "Biodiversity Finance." *Available at SSRN 4379451.*

French SIF and Iceberg Data Lab. 2022. *Finance & Biodiversity: Understanding and Acting.*

Giglio, S., T. Kuchler, J. Stroebel, and X. Zeng. 2023. "Biodiversity Risk."

Heal, G. M. 2003. "Bundling biodiversity." *Journal of the European Economic Association* 1 (2): 137–175.

———. 2004. "Economics of biodiversity: An introduction." *Resource and Energy Economics* 26 (2): 105–114.

Heeb, F., J. Kölbel, F. Paetzold, and S. Zeisberger. 2023. "Do investors care about impact?" *Review of Financial Studies,* forthcoming.

Hoepner, A. G., J. Klausmann, M. Leippold, and J. Rillaerts. 2023. "Beyond Climate: 'EU taxonomy' criteria, materiality, and CDS term structure." *Swiss Finance Institute Research Paper,* nos. 23-10.

Hsu, P.-H., K. Li, and C.-Y. Tsou. 2023. "The pollution premium." *Journal of Finance,* forthcoming.

Ilhan, E., P. Krueger, Z. Sautner, and L. Starks. 2023. "Climate risk disclosure and institutional investors." *Review of Financial Studies,* forthcoming.

IPBES. 2020. *Workshop on biodiversity and pandemics: Workshop report.* Intergovernmental Science-Policy Platform on Biodiversity / Ecosystem Services.

Karolyi, G. A., and J. Tobin-de la Puente. 2023. "Biodiversity finance a call for research into financing nature." *Financial Management,* forthcoming.

Kunming Declaration. 2021. *Declaration from the High-Level Segment of the UN Biodiversity Conference 2020 (Part 1) under the Theme: Ecological Civilization: Building a Shared Future for All Life on Earth.*

La Banque Postale Asset Management. 2022. *Biodiversity Policy.*

Metrick, A., and M. L. Weitzman. 1998. "Conflicts and choices in biodiversity preservation." *Journal of Economic Perspectives* 12 (3): 21–34.

Montreal Agreement. 2022. *COP 15: Nations Adopt Four Goals, 23 Targets for 2030 In Landmark UN Biodiversity Agreement.*

Mychasuk, E. 2022. "UN summit reaches landmark biodiversity agreement." *Financial Times.*

NGFS and INSPIRE. 2022. *Central banking and supervision in the biosphere.* Network for Greening the Financial System (NGFS) - International Network for Sustainable Financial Policy Insights, Research, / Exchange (INSPIRE) Study Group on Biodiversity / Financial Stability.

Norges Bank. 2018. *Responsible Investment. Government Pension Fund Global.*

Pástor, L., R. F. Stambaugh, and L. A. Taylor. 2021. "Sustainable investing in equilibrium." *Journal of Financial Economics* 142 (2): 550–571.

———. 2022. "Dissecting green returns." *Journal of Financial Economics* 146 (2): 403–424.

Pástor, L., and P. Veronesi. 2012. "Uncertainty about Government Policy and Stock Prices." *Journal of Finance* 67 (4): 1219–1264.

Pedersen, L. H., S. Fitzgibbons, and L. Pomorski. 2021. "Responsible investing: The ESG-efficient frontier." *Journal of Financial Economics* 142 (2): 572–597.

Ramelli, S., A. F. Wagner, R. J. Zeckhauser, and A. Ziegler. 2021. "Investor rewards to climate responsibility: Stock-price responses to the opposite shocks of the 2016 and 2020 US elections." *Review of Corporate Finance Studies* 10 (4): 748–787.

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, et al. 2009. "A safe operating space for humanity." *Nature* 461 (7263): 472–475.

Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, et al. 2015. "Planetary boundaries: Guiding human development on a changing planet." *Science* 347 (6223): 1259855.

Weitzman, M. L. 1992. "On diversity." *Quarterly Journal of Economics* 107 (2): 363–405.

———. 1993. "What to preserve? An application of diversity theory to crane conservation." *Quarterly Journal of Economics* 108 (1): 157–183.

World Bank. 2020. *Mobilizing Private Finance for Nature.*

World Economic Forum. 2022. *The State of Finance for Nature in the G20.*

WWF. 2022. *Living Planet Report.*

Figure 1: Illustration of MSA Variation

This figure illustrates the variation in Mean Species Abundance (MSA) for forest and grassland ecosystems. Source: GLOBIO, 2019.

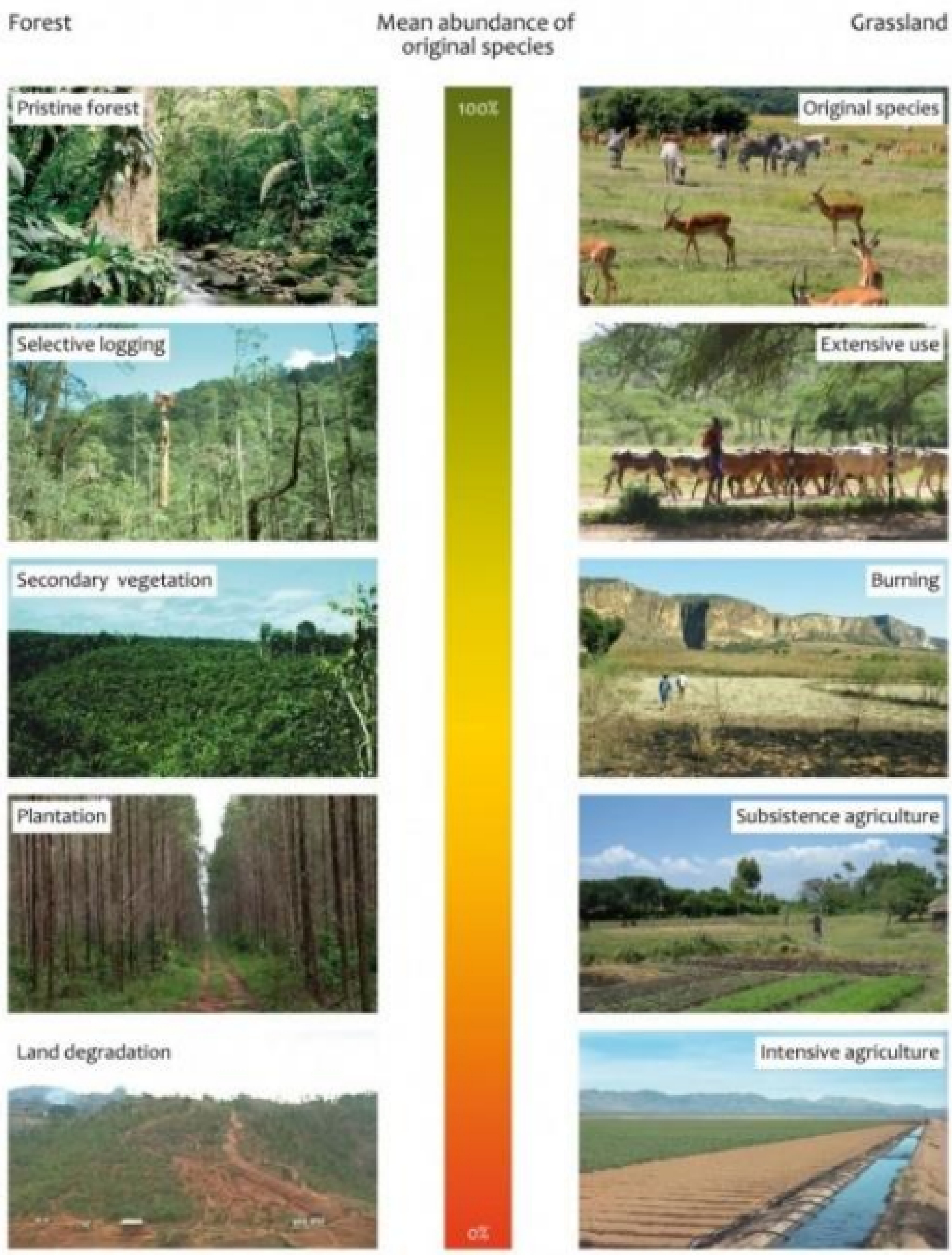


Figure 2: Calculation of the Biodiversity Footprint

This figure illustrates the methodological steps used to calculate the corporate biodiversity footprint (CBF). Source: Iceberg Data Lab.

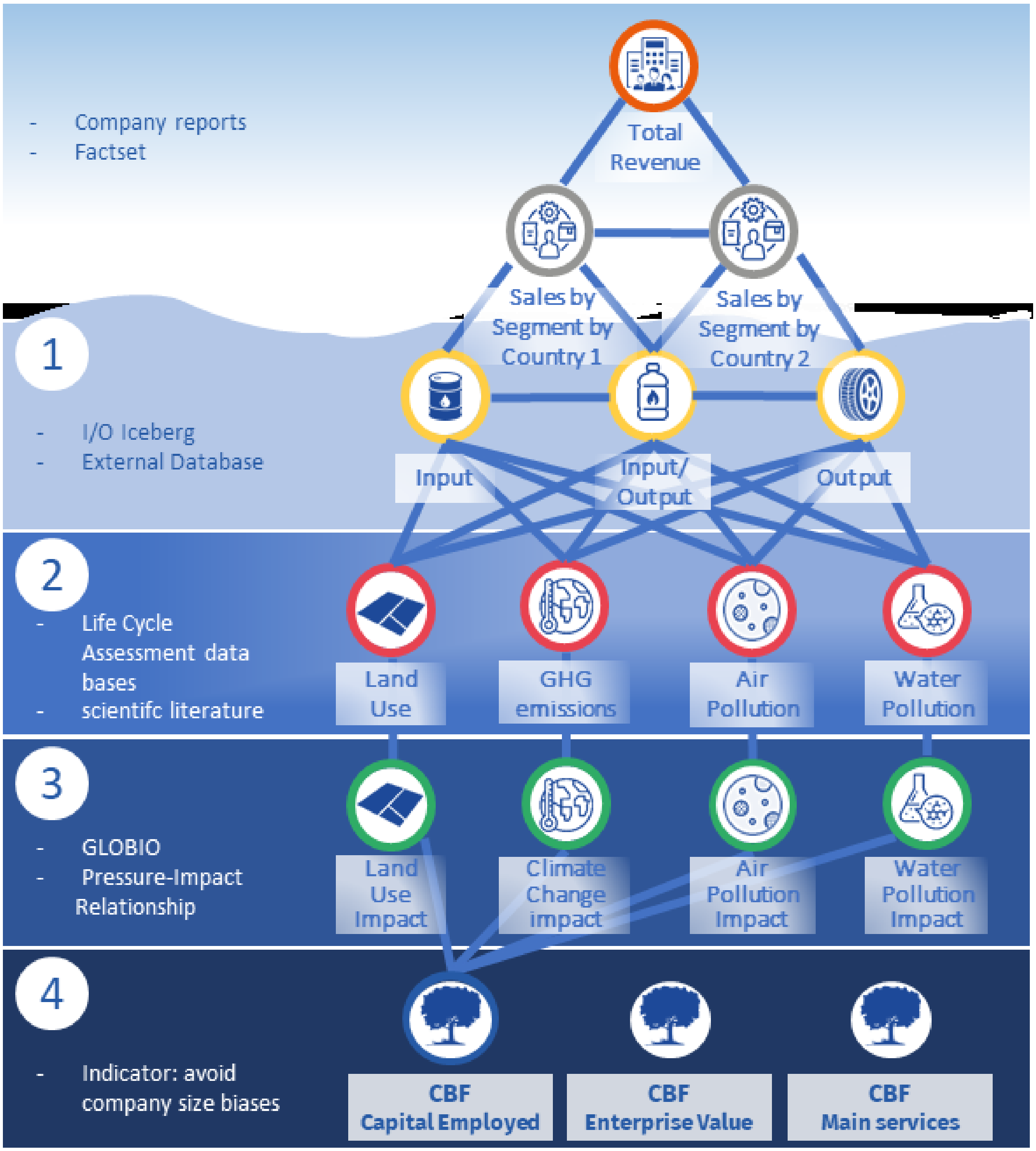


Figure 3: Biodiversity Footprint Calculation for Danone

This figure illustrates the calculation of the corporate biodiversity footprint (CBF) for food producer Danone for the year 2021. Source: Iceberg Data Lab.

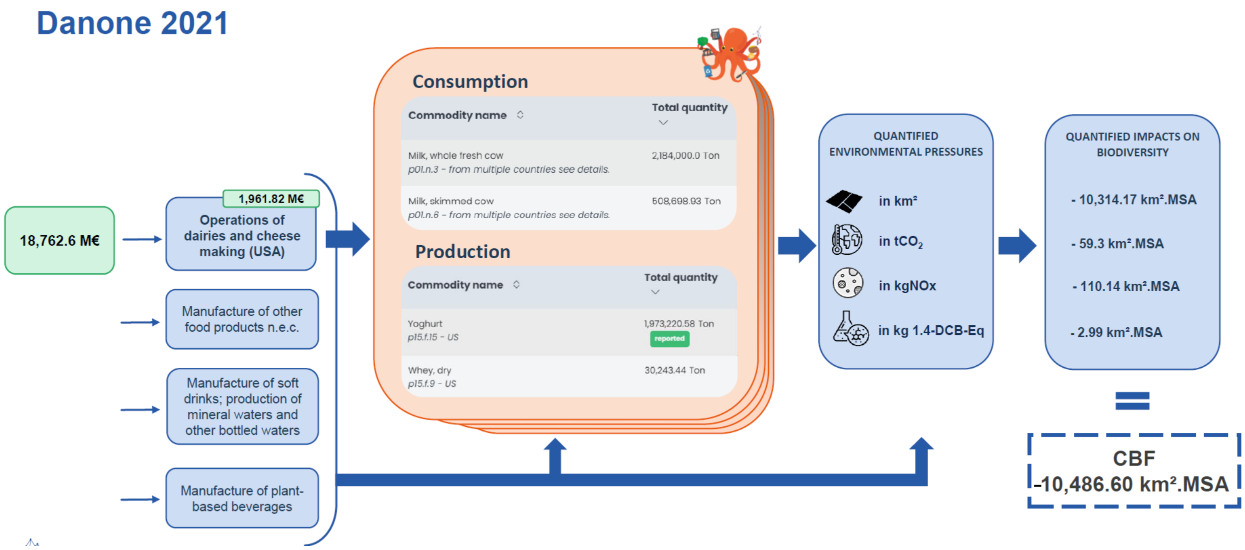


Figure 4: Biodiversity Footprint Calculation for Stellantis

This figure illustrates the calculation of the corporate biodiversity footprint (CBF) for automotive manufacturer Stellantis for the year 2021. Source: Iceberg Data Lab.

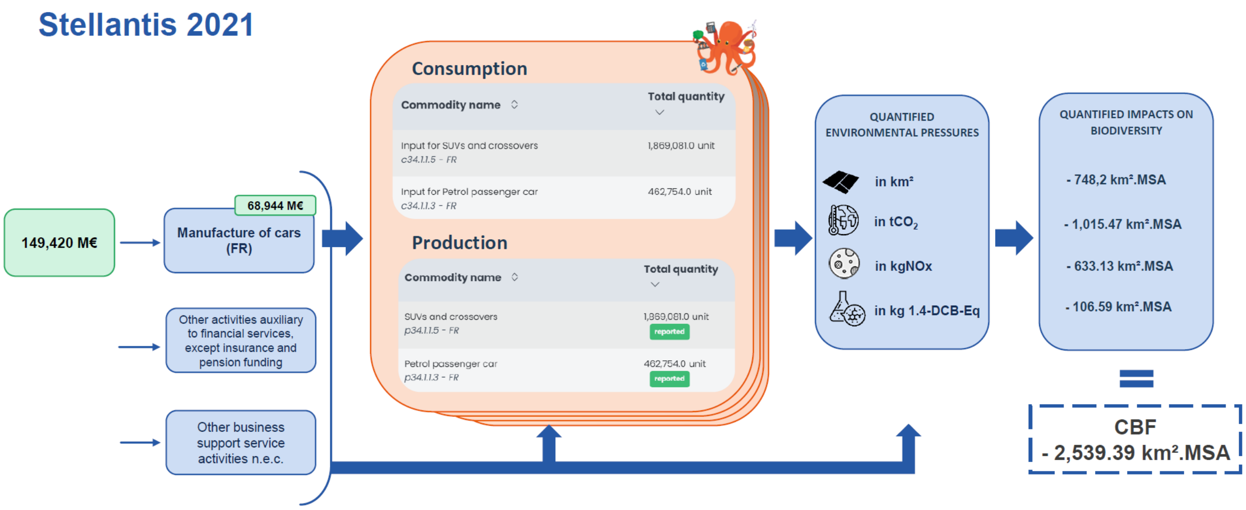
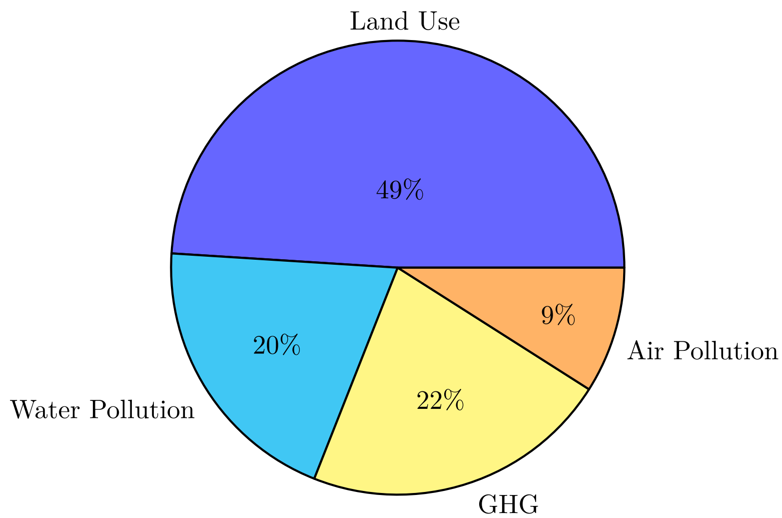


Figure 5: Decomposition of the Corporate Biodiversity Footprint

Panel A decomposes the corporate biodiversity footprint (CBF) into its constituent topical subcomponents or sources. Panel B decomposes the biodiversity footprint 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

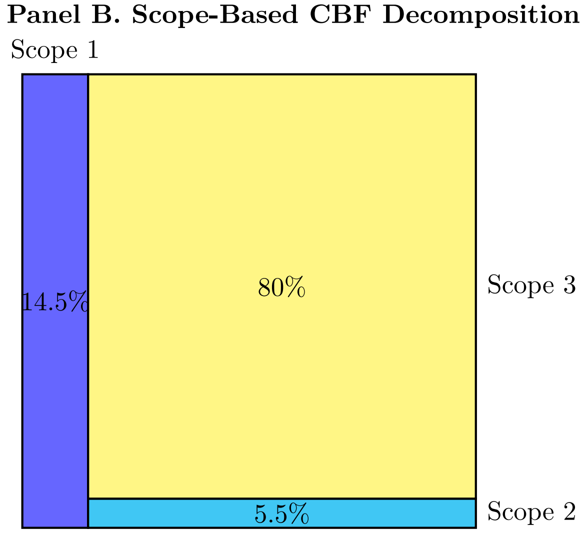
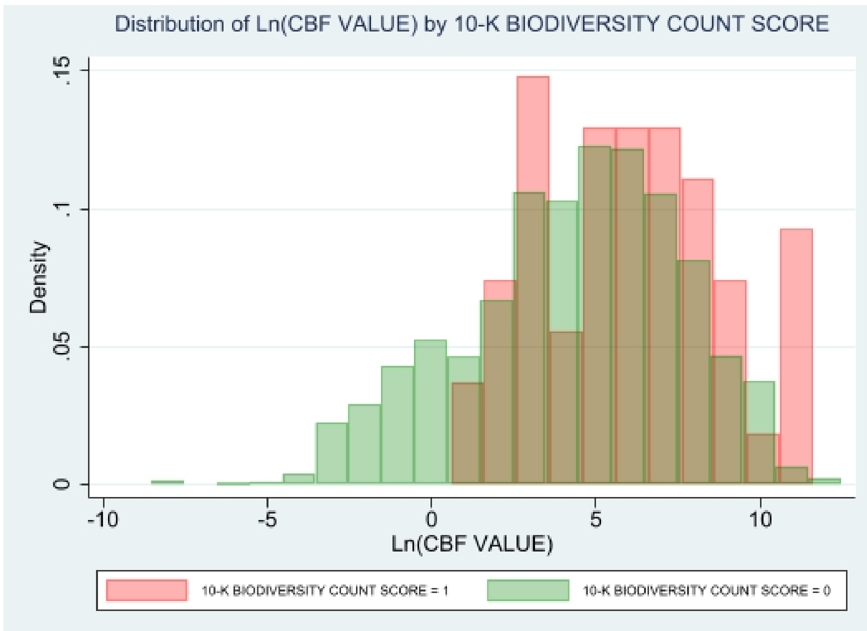


Figure 6: CBF Distribution for Firms With and Without Disclosure of Biodiversity Risk

Panel A displays the distribution of the corporate biodiversity footprint (BBF) for firms with and without disclosure of biodiversity risk based on Giglio et al. (2023)'s variable "10-K Biodiversity Count Score." Panel B displays the distribution of the biodiversity footprint for firms with and without disclosure of biodiversity risk according to Refinitiv's biodiversity impact reduction indicator.

Panel A. Disclosure of Biodiversity Risk (Giglio et al. 2023)



Panel B. Disclosure of Biodiversity Risk based on Refinitiv

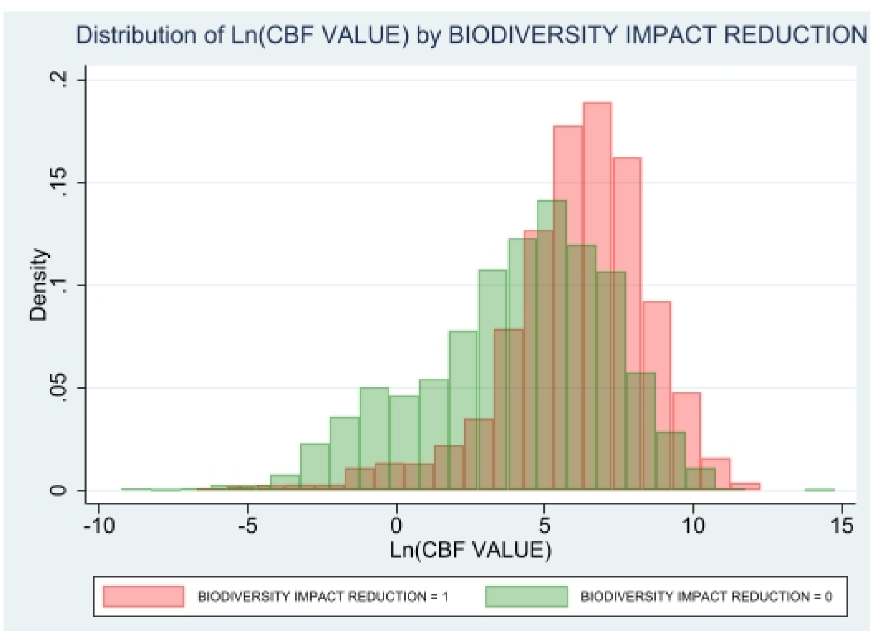


Table 1. Summary Statistics

This table presents summary statistics at the firm-month level of the variables used in the returns analysis. The sample period uses returns between 2019-2022. The CBF, accounting, ESG, and CO2 emission variables are measured at the annual frequency and lagged by one year. Market capitalization, volatility, and momentum are measured at the monthly frequency and lagged by one month. Appendix A provides variable definitions.

Variables	#Obs.	Mean	S.D.	Min	0.25	Mdn	0.75	Max
Ln(CBF VALUE)	85,122	4.81	3.08	-9.25	3.20	5.28	7.00	13.78
Ln(CBF GHG)	85,122	2.28	2.96	-9.87	0.25	2.51	4.42	10.08
Ln(CBF LAND USE)	85,122	3.60	3.54	-15.88	1.77	4.08	6.02	13.77
Ln(CBF WATER POLLUTION)	85,122	1.46	4.18	-15.53	-1.07	2.26	4.43	11.34
Ln(CBF AIR POLLUTION)	85,122	1.52	3.22	-13.47	-0.36	1.95	3.72	9.12
Ln(CBF SCOPE 1)	85,122	0.90	3.81	-12.69	-1.98	0.99	3.80	13.77
Ln(CBF SCOPE 2)	85,122	-4.55	5.51	-30.77	-8.72	-3.23	-0.13	6.57
Ln(CBF SCOPE 3)	85,122	4.40	3.38	-11.26	2.82	5.00	6.76	12.11
Ln(CBF VALUE/TOTAL ASSETS)	85,122	-4.29	2.69	-11.09	-5.46	-3.83	-2.43	0.11
Ln(CBF VALUE/SALES)	85,098	-3.72	2.57	-10.14	-4.85	-3.16	-1.90	0.32
Ln(CBF VALUE/PPE)	85,074	-2.58	2.55	-8.67	-4.00	-2.19	-0.77	1.74
MONTHLY RET (%)	85,122	1.17	10.52	-25.46	-5.28	0.80	7.01	34.23
VOLATILITY (%)	85,122	9.88	3.87	4.02	7.16	9.16	11.67	24.40
MOMENTUM (%)	85,122	1.30	3.97	-4.92	-1.21	0.53	2.77	18.83
Ln(TOTAL ASSETS)	85,122	9.12	1.47	5.83	8.10	9.08	10.06	12.88
Ln(MARKET CAP)	85,122	23.44	1.41	20.21	22.49	23.30	24.32	27.25
BOOK-TO-MARKET	85,122	0.42	0.56	0.01	0.12	0.24	0.49	3.75
LEVERAGE	85,122	0.26	0.17	0.00	0.13	0.26	0.38	0.68
CAPEX/TOTAL ASSETS	85,122	0.04	0.03	0.00	0.02	0.03	0.05	0.18
ROE	85,122	0.06	0.06	-0.14	0.02	0.05	0.09	0.27
PPE/TOTAL ASSETS	85,122	0.28	0.22	0.00	0.10	0.23	0.43	0.85
ASSET GROWTH	85,122	0.14	0.25	-0.17	0.02	0.07	0.17	1.56
SALES GROWTH	85,122	0.11	0.24	-0.47	-0.01	0.07	0.18	1.15
E SCORE	62,292	52.12	27.43	0.00	31.29	56.72	74.89	99.15
Ln(CO2 EMISSIONS)	45,518	12.99	2.48	-2.25	11.37	12.89	14.66	19.75
BIODIVERSITY & HABITAT SCORE	85,122	61.92	21.85	15.10	60.50	67.50	76.60	89.00
TERRESTRIAL PROTECTED AREA (%)	85,122	15.24	10.39	0.20	12.05	12.96	21.65	39.54
MARINE PROTECTED AREA (%)	83,791	15.35	12.71	0.00	1.85	15.80	19.15	45.30

Table 2. Corporate Biodiversity Footprint Rankings by Industry and Country

This table reports different rankings of the corporate biodiversity footprint (CBF) across industries in Panel A and countries in Panel B (reported vertically). The different footprint measures are reported horizontally. Lower ranks indicate larger biodiversity footprints. The rankings are based on mean values, whereby the most recent value per firm is considered. Appendix A provides variable definitions.

Panel A. Rankings by Industry

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

Table 2 (cont.)

Panel B. Rankings by Country

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

Table 3. Determinants of the Corporate Biodiversity Footprint

This table reports panel regressions of the corporate biodiversity footprint in year t on firm characteristics in year t. The data frequency is yearly. In all columns, the dependent variable is Ln(CBF VALUE). 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 VALUE)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln(TOTAL ASSETS)	0.860***	0.630***	0.314***	0.869***	0.864***	0.869***	0.863***
	(0.045)	(0.054)	(0.072)	(0.062)	(0.063)	(0.063)	(0.076)
BOOK-TO-MARKET	0.001	0.085	-0.022	0.012	0.007	0.003	0.077
	(0.100)	(0.108)	(0.113)	(0.083)	(0.085)	(0.083)	(0.094)
LEVERAGE	-1.310***	-1.587***	-2.180***	-1.685***	-1.695***	-1.699***	-1.598***
	(0.411)	(0.408)	(0.441)	(0.332)	(0.337)	(0.334)	(0.467)
CAPEX/TOTAL ASSETS	-8.511***	-8.615***	-13.238***	-5.091***	-5.109***	-4.974***	-4.083*
	(2.060)	(2.161)	(2.603)	(1.879)	(1.923)	(1.898)	(2.320)
PPE/TOTAL ASSETS	3.993***	3.931***	1.813***	-0.052	-0.078	-0.075	-0.243
	(0.315)	(0.322)	(0.424)	(0.339)	(0.346)	(0.343)	(0.447)
ROE	1.755*	0.870	-0.787	-0.227	-0.168	-0.310	-0.318
	(0.947)	(1.040)	(1.253)	(0.899)	(0.929)	(0.918)	(1.237)
ASSET GROWTH	-0.791***	-0.512***	0.035	-0.231	-0.249	-0.231	-0.358*
	(0.169)	(0.191)	(0.244)	(0.164)	(0.169)	(0.164)	(0.201)
SALES GROWTH	0.143	-0.179	-0.154	-0.133	-0.172	-0.148	-0.318
	(0.177)	(0.247)	(0.289)	(0.234)	(0.257)	(0.245)	(0.344)
E SCORE		0.026***	0.026***	0.010***	0.010***	0.010***	0.008**
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Ln(CO2 EMISSIONS)			0.410***	0.122***	0.122***	0.121***	0.091**
			(0.045)	(0.037)	(0.037)	(0.037)	(0.045)
#Obs.	7,161	5,238	3,816	3,816	3,809	3,812	3,185
Year Fixed Effects	Yes	Yes	Yes	Yes	No	No	No
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	No	No
Industry Fixed Effects	No	No	No	Yes	No	Yes	No
Country-Year Fixed Effects	No	No	No	No	No	Yes	No
Industry-Year Fixed Effects	No	No	No	No	Yes	No	No
Country-Industry-Year Fixed Effects	No	No	No	No	No	No	Yes
R^2	0.251	0.290	0.317	0.615	0.620	0.619	0.684

Table 4. Corporate Biodiversity Footprint and Stock Returns

This table reports regressions of monthly stock returns on the corporate biodiversity footprint (Ln(CBF VALUE)). Ln(CBF VALUE) is measured as of the end of the previous year. The sample period in Columns 1 and 2 includes monthly returns over the full sample period from January 2019 to December 2022. The sample period in Columns 3 and 4 includes monthly returns from January 2019 to September 2021 (the COP15 in Kunming started in October 2021) and in Columns 5 and 6 monthly stock returns from October 2021 to December 2022. 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.

	Whole Period		Pre-Kunming Period		Post-Kunming Period	
MONTHLY RET (%)	(1)	(2)	(3)	(4)	(5)	(6)
Ln(CBF VALUE)	0.009	0.007	-0.034	-0.033	0.077**	0.074**
	(0.020)	(0.020)	(0.023)	(0.023)	(0.030)	(0.030)
Ln(TOTAL ASSETS)	0.220	0.167	0.141	0.110	0.341	0.300
	(0.168)	(0.159)	(0.186)	(0.180)	(0.321)	(0.305)
Ln(MARKET CAP)	-0.476***	-0.404***	-0.423**	-0.380**	-0.386	-0.326
	(0.152)	(0.141)	(0.182)	(0.172)	(0.249)	(0.234)
BOOK-TO-MARKET	-0.106	-0.071	-0.085	-0.068	-0.068	-0.063
	(0.162)	(0.162)	(0.195)	(0.188)	(0.314)	(0.318)
LEVERAGE	0.315	0.368	0.701	0.787*	-0.707	-0.680
	(0.350)	(0.347)	(0.434)	(0.433)	(0.504)	(0.518)
CAPEX/TOTAL ASSETS	1.869	2.093	7.031***	6.607***	-7.087*	-6.201*
	(2.276)	(2.209)	(2.181)	(2.202)	(3.572)	(3.422)
PPE/TOTAL ASSETS	0.369	0.404	-0.314	-0.243	1.624*	1.560*
	(0.413)	(0.428)	(0.428)	(0.431)	(0.796)	(0.788)
ROE	2.106	1.916	1.025	0.987	5.239	4.804
	(1.798)	(1.672)	(1.710)	(1.603)	(3.299)	(3.265)
ASSET GROWTH	-0.201	-0.115	0.308	0.270	-1.347**	-1.241*
	(0.345)	(0.327)	(0.348)	(0.333)	(0.599)	(0.583)
SALES GROWTH	0.055	-0.080	-0.107	0.230	0.262	-0.151
	(0.470)	(0.361)	(0.678)	(0.509)	(0.492)	(0.335)
VOLATILITY	0.047	0.042	0.140*	0.129*	-0.032	-0.028
	(0.050)	(0.050)	(0.069)	(0.069)	(0.062)	(0.064)
MOMENTUM	0.040	0.027	-0.016	-0.006	-0.042	-0.019
	(0.054)	(0.048)	(0.063)	(0.058)	(0.087)	(0.080)
#Obs.	85,122	85,110	55,582	55,570	29,540	29,540
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
R^2	0.247	0.315	0.240	0.304	0.251	0.320

Table 5. Stock Price Reactions to COP15 - Kunming Declaration

This table reports the stock price reactions to the first part of the COP15 (Kunming Declaration), with the focal date of the event being October 13, 2021. We report results for firms with large versus small corporate biodiversity footprints (CBFs). 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). 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. Daily returns are winsorized at the 1% and 99% 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	-0.395***	-0.391***	-0.216**		-0.314***	-0.399***	-0.237**	
	(0.067)	(0.061)	(0.091)		(0.082)	(0.058)	(0.089)	
LARGE CBF × t = -2				0.063				-0.034
				(0.225)				(0.216)
LARGE CBF × t = -1				-0.536*				-0.394
				(0.277)				(0.271)
LARGE CBF × t = 0				-0.682***				-0.620***
				(0.206)				(0.214)
LARGE CBF × t = +1				-0.680***				-0.496**
				(0.191)				(0.199)
LARGE CBF × t = +2				-0.302*				-0.253
				(0.174)				(0.177)
#Obs.	11,535	11,535	11,535	11,535	11,535	11,535	11,535	11,535
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
R^2	0.239	0.243	0.330	0.297	0.196	0.199	0.259	0.248

Table 6. Stock Price Reactions to COP15 - Montreal Agreement

This table reports stock price reactions to the second part of the COP15 (Montreal), with the focal date of the event being the December 19, 2022. Panel A reports results for firms with large versus small corporate biodiversity footprints (CBFs). The event window consists of the [-3,2]-day window around the focal date. The stock price reaction is computed as the within-firm difference in daily returns between the three trading days before and after the event. LARGE CBF equals one for firms with a CBF VALUE above the median (as of the beginning of the year). 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). Panel B reports results for large versus small CBF Land Use firms and conditional on low biodiversity protection. LOW BIODIVERSITY PROTECTION equals one when a firm is located in a country that ranks in the bottom quartile for different proxies of domestic biodiversity protection: Biodiversity & Habitat Score (Columns 1 and 4), Terrestrial Protected Areas (Columns 2 and 5), and Maritime Protected Areas (Columns 3 and 6). Standard errors are clustered at the country level. Daily returns are winsorized at the 1% and 99% level. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

Panel A. Average Stock Price Reactions

	DAILY RETURN (%)			ABNORMAL DAILY RETURN (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
LARGE CBF × POST	-0.129	-0.052	-0.064	-0.061	-0.064	-0.096
	(0.111)	(0.072)	(0.097)	(0.076)	(0.075)	(0.066)
#Obs.	11,950	11,950	11,950	11,950	11,950	11,950
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
R^2	0.296	0.529	0.338	0.154	0.248	0.200

Panel B. Stock Price Reactions Conditional on Country-Level Biodiversity Protection

	(1)	(2)	(3)	(4)	(5)	(6)
Biodiversity Protection Proxy:	Biodiversity & Habitat Score	Terrestrial Protected Areas	Marine Protected Areas	Biodiversity & Habitat Score	Terrestrial Protected Areas	Marine Protected Areas
LOW BIODIV. PROT. × POST	-1.688***	-1.487***	-1.584***	-1.513***	-1.403***	-1.415***
	(0.422)	(0.495)	(0.444)	(0.423)	(0.467)	(0.452)
LOW BIODIV. PROT. × POST × LARGE CBF LAND USE				-0.320**	-0.160	-0.323**
				(0.141)	(0.145)	(0.139)
LARGE CBF LAND USE × POST				-0.050	-0.144*	-0.076
				(0.083)	(0.082)	(0.081)
#Obs.	11,950	11,950	11,758	11,950	11,950	11,758
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Day Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.331	0.323	0.323	0.331	0.324	0.324

Internet Appendix

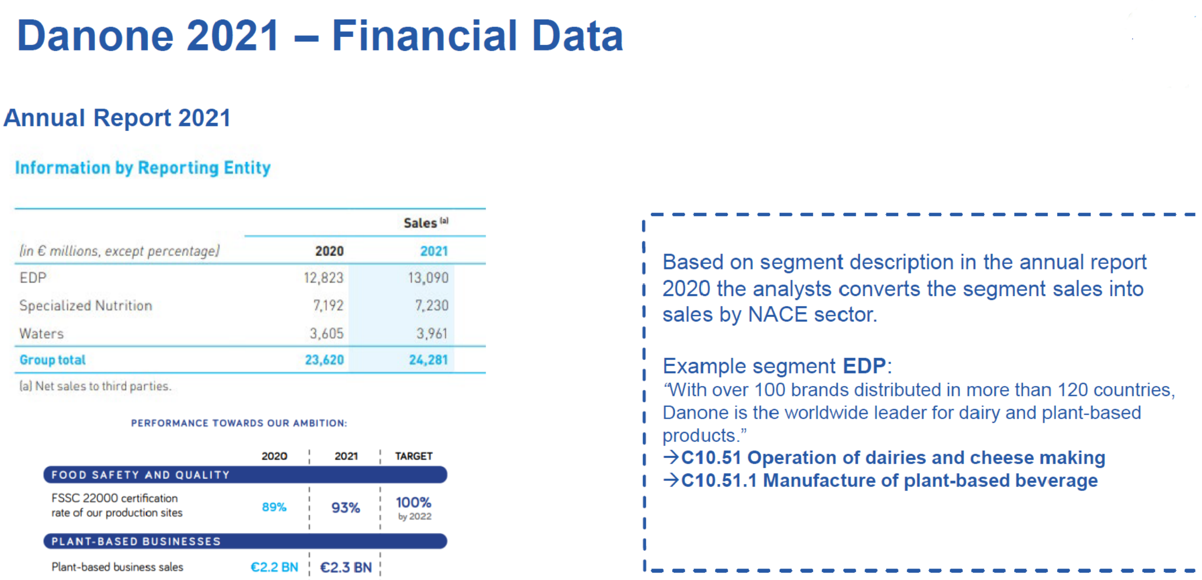
for

Do Investors Care About Biodiversity?

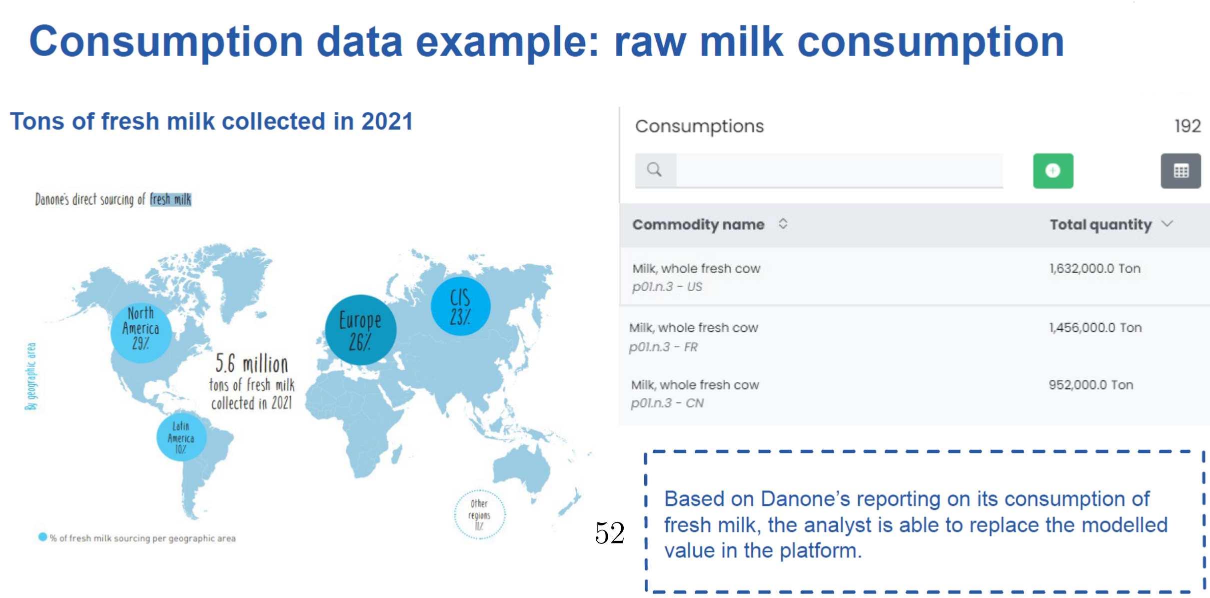
Figure IA.1. Biodiversity Footprint Calculation for Danone

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 the firm's biodiversity footprint for the year 2021. Panel B illustrates how Danone's raw milk consumption, per geographical area, is used to calculate the firm's biodiversity footprint for the year 2021. Panel C illustrates how the data on carbon emissions are used to calculate Danone's biodiversity footprint for the year 2021. Panel D illustrates the contribution to biodiversity footprint 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

Scope 1 and 2 emissions, market-based *(in $ktCO_2$)*[a]	2020	2021
		Year ended December 31
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%**

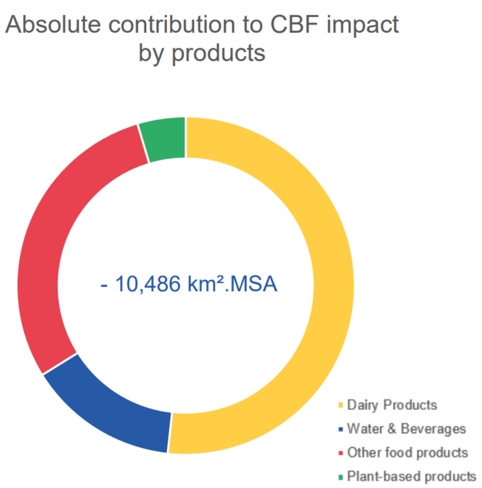
(a) Greenhouse Gas scope, see Methodology Note.

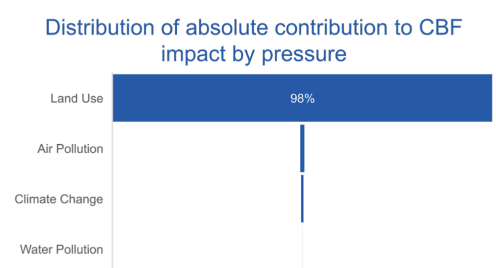
When the company reports on its CO2eq emissions, we integrate those values in the platform and replace the modelled data.

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

Panel D. Biodiversity Impact by Product

Corporate Biodiversity Footprint





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.

Table IA.1. Decomposition of the Corporate Biodiversity Footprint: Summary Statistics

This table reports the average proportion of each biodiversity footprint subcomponent (land use, air pollution, water pollution, and GHG emissions) and the average proportion of scope 1, scope 2, and scope 3 in our measure of the corporate biodiversity footprint (CBF VALUE). Appendix A provides variable definitions.

Variable	#Obs.	Mean	S.D.	Min	25%	Mdn	75%	Max
CBF AIR POLLUTION (%)	85,122	8.60	10.43	0.00	1.67	4.87	12.62	94.07
CBF GHG (%)	85,122	22.30	23.89	0.00	1.94	12.21	37.01	100.00
CBF LAND USE (%)	85,122	48.83	33.41	0.00	18.17	45.45	81.52	99.97
CBF WATER POLLUTION (%)	85,122	20.43	27.49	0.00	0.94	6.38	29.42	99.61
CBF SCOPE 1 (%)	85,122	14.63	23.24	0.00	0.39	3.08	18.41	100.00
CBF SCOPE 2 (%)	85,122	5.59	17.15	0.00	0.00	0.02	0.48	100.00
CBF SCOPE 3 (%)	85,122	79.87	28.43	0.00	68.33	95.69	99.45	100.00

Table IA.2. Decomposition of the Corporate Biodiversity Footprint by Country

This table reports the average proportion, by country, of each biodiversity footprint subcomponent (land use, air pollution, water pollution, and GHG emissions) and the average proportion of scope 1, scope 2, and scope 3 in our measure of the corporate biodiversity footprint (CBF VALUE). 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	13.10%	26.43%	42.10%	18.37%	23.58%	6.76%	69.66%
Belgium	6.85%	17.29%	57.80%	18.05%	10.47%	2.72%	86.80%
Brazil	10.84%	27.48%	56.73%	4.95%	35.43%	0.92%	63.65%
Canada	9.77%	23.62%	38.58%	28.03%	30.02%	2.27%	67.71%
China	9.16%	19.47%	46.63%	24.74%	16.03%	3.39%	80.59%
Denmark	3.14%	16.54%	59.06%	27.91%	10.88%	1.46%	87.66%
Finland	5.45%	19.01%	61.35%	14.19%	7.32%	2.98%	89.70%
France	11.64%	26.85%	45.97%	15.53%	15.45%	6.25%	78.31%
Germany	7.50%	25.76%	44.89%	21.86%	12.32%	6.05%	81.63%
Hong Kong	12.37%	37.38%	38.18%	12.08%	18.23%	21.88%	59.89%
India	10.21%	23.79%	45.66%	20.34%	14.74%	2.34%	82.93%
Indonesia	5.22%	15.50%	66.48%	12.80%	10.16%	0.53%	89.35%
Italy	11.63%	35.50%	41.41%	11.46%	13.58%	8.73%	77.69%
Japan	7.97%	22.05%	47.57%	22.66%	10.58%	4.08%	85.61%
Korea	11.16%	24.78%	43.63%	20.72%	20.74%	5.09%	74.18%
Malaysia	14.49%	23.14%	57.46%	4.91%	27.15%	5.49%	67.36%
Mexico	7.03%	29.84%	49.59%	16.33%	31.40%	5.92%	65.54%
Netherlands	8.74%	21.32%	55.16%	14.78%	7.55%	11.60%	80.84%
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	12.34%	32.28%	38.57%	16.82%	20.82%	10.47%	68.70%
South Africa	6.54%	14.04%	43.34%	36.08%	32.99%	1.69%	65.32%
Spain	14.39%	23.55%	33.94%	28.13%	36.63%	2.33%	61.04%
Sweden	7.15%	18.01%	52.21%	22.62%	8.17%	3.11%	88.72%
Switzerland	6.16%	18.18%	45.88%	29.78%	7.77%	7.01%	85.22%
Taiwan	8.07%	39.22%	34.34%	20.45%	17.13%	10.17%	72.86%
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	5.64%	19.68%	56.90%	17.78%	18.84%	3.41%	77.75%
United States	7.68%	21.04%	52.27%	19.15%	11.86%	7.91%	80.26%

Table IA.3. Decomposition of the Corporate Biodiversity Footprint by Industry

This table reports the average proportion, by industry, of each biodiversity footprint subcomponent (land use, air pollution, water pollution, and GHG emissions) and the average proportion of scope 1, scope 2, and scope 3 in our measure of the corporate biodiversity footprint (CBF VALUE). 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%	21.94%	0.02%	0.01%	99.98%
Automotive & Logistics	13.72%	31.10%	45.06%	10.12%	6.10%	0.73%	93.17%
Beverages	1.01%	2.94%	94.99%	1.06%	1.63%	0.17%	98.20%
Building Products	7.10%	15.51%	55.21%	22.18%	20.82%	0.83%	78.34%
Chemicals	5.58%	9.27%	52.54%	33.26%	8.16%	1.05%	91.47%
Construction & Real Estate	16.26%	15.88%	61.82%	6.05%	24.53%	1.80%	73.67%
Defense	8.93%	17.12%	26.96%	47.00%	0.63%	0.34%	99.03%
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	5.18%	41.92%	31.10%	22.61%	8.24%	14.01%	77.82%
Financial Services	10.96%	33.21%	45.33%	10.69%	3.38%	33.95%	62.67%
Food	2.14%	3.45%	93.29%	1.76%	3.66%	0.28%	96.06%
Healthcare	1.30%	1.65%	67.48%	29.56%	1.01%	0.37%	98.62%
Hotel and Accommodation	3.26%	3.30%	85.24%	8.20%	3.07%	0.72%	96.21%
Household Goods	9.47%	16.92%	49.65%	27.08%	14.79%	1.11%	84.10%
Industrial Equipment	7.91%	24.61%	25.13%	42.35%	2.10%	0.10%	97.81%
Insurance	8.90%	25.10%	50.57%	15.43%	6.57%	21.72%	71.71%
Internet & Data	11.09%	42.98%	40.52%	5.42%	3.51%	8.37%	88.12%
Leisure	6.63%	18.51%	60.63%	14.23%	17.89%	6.36%	75.75%
Materials	9.52%	22.71%	65.92%	1.84%	28.51%	1.04%	70.45%
Media	8.94%	22.82%	34.60%	33.64%	2.74%	15.89%	81.37%
Metals & Mining	7.56%	15.36%	27.17%	49.91%	42.23%	0.42%	57.35%
Oil & Gas	10.62%	38.96%	44.86%	5.56%	26.54%	0.21%	73.26%
Paper and Forest	1.67%	4.88%	87.89%	5.55%	20.84%	0.37%	78.79%
Pharmaceutical	0.82%	1.64%	22.13%	75.42%	2.57%	0.03%	97.40%
Power	15.97%	44.25%	22.12%	17.66%	47.14%	3.10%	49.76%
Retail and Wholesale	2.64%	5.41%	90.77%	1.18%	3.74%	0.31%	95.95%
Services	14.59%	37.20%	41.19%	7.03%	12.52%	32.78%	54.70%
Software	9.37%	32.07%	52.59%	5.96%	8.40%	9.98%	81.62%
Telecommunications	9.95%	47.52%	37.34%	5.19%	10.69%	33.63%	55.68%
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	24.08%	37.19%	25.64%	13.09%	37.81%	4.16%	58.12%
Waste	7.65%	57.41%	25.34%	9.60%	75.31%	1.64%	23.05%
Water	12.47%	9.60%	76.47%	1.46%	87.41%	3.15%	9.43%

Table IA.4. Variance Decomposition

This table provides a variance decomposition of the CBF measures. Regressions are estimated at the firm-year level. Intercepts are not reported. Appendix A provides variable definitions.

Incremental R^2	Ln(CBF VALUE)	Ln(CBF VALUE/TOTAL ASSETS)
Year Fixed Effects	0.10%	0.10%
Country Fixed Effects	3.00%	5.10%
Industry Fixed Effects	41.10%	52.60%
Industry × Year Fixed Effects	0.20%	0.10%
Country × Year Fixed Effects	0.30%	0.30%
"Firm Level"	55.30%	41.80%
Sum	100.00%	100.00%

Table IA.5. Determinants of the Corporate Biodiversity Footprint: Intensity Measure

This table reports panel regressions of the corporate biodiversity footprint in year *t* on firm characteristics in year *t*. The data frequency is yearly. The dependent variable is Ln(CBF VALUE/TOTAL ASSETS). 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 VALUE/TOTAL ASSETS)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln(TOTAL ASSETS)	-0.139***	-0.354***	-0.675***	-0.138**	-0.143**	-0.138**	-0.139**
	(0.042)	(0.049)	(0.066)	(0.057)	(0.057)	(0.057)	(0.069)
BOOK-TO-MARKET	-0.004	0.070	-0.027	0.003	-0.006	-0.007	0.056
	(0.097)	(0.103)	(0.107)	(0.076)	(0.078)	(0.076)	(0.085)
LEVERAGE	-1.458***	-1.732***	-2.287***	-1.730***	-1.732***	-1.743***	-1.693***
	(0.384)	(0.383)	(0.416)	(0.307)	(0.312)	(0.310)	(0.423)
CAPEX/TOTAL ASSETS	-8.162***	-8.130***	-12.252***	-4.562***	-4.683***	-4.415***	-3.531*
	(1.929)	(1.992)	(2.339)	(1.631)	(1.674)	(1.647)	(1.926)
PPE/TOTAL ASSETS	3.921***	3.870***	1.805***	0.005	-0.015	-0.021	-0.201
	(0.305)	(0.312)	(0.406)	(0.319)	(0.325)	(0.323)	(0.413)
ROE	1.521*	0.682	-0.800	-0.189	-0.122	-0.261	-0.212
	(0.898)	(0.998)	(1.186)	(0.822)	(0.849)	(0.839)	(1.109)
ASSET GROWTH	-0.751***	-0.486***	0.034	-0.214	-0.226	-0.211	-0.346*
	(0.159)	(0.179)	(0.228)	(0.145)	(0.150)	(0.145)	(0.180)
SALES GROWTH	0.196	-0.101	-0.049	-0.037	-0.058	-0.051	-0.199
	(0.162)	(0.220)	(0.253)	(0.184)	(0.202)	(0.191)	(0.258)
E SCORE		0.024***	0.025***	0.008***	0.008***	0.009***	0.006**
		(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Ln(CO2 EMISSIONS)			0.401***	0.121***	0.122***	0.120***	0.093**
			(0.042)	(0.033)	(0.033)	(0.034)	(0.039)
#Obs.	7,161	5,238	3,816	3,816	3,809	3,812	3,185
Year Fixed Effects	Yes	Yes	Yes	Yes	No	No	No
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	No	No
Industry Fixed Effects	No	No	No	Yes	No	Yes	No
Country-Year Fixed Effects	No	No	No	No	No	Yes	No
Industry-Year Fixed Effects	No	No	No	No	Yes	No	No
Country-Industry-Year Fixed Effects	No	No	No	No	No	No	Yes
R^2	0.123	0.164	0.216	0.589	0.595	0.594	0.663

Table IA.6. Biodiversity Footprint Intensity Measures and the Cross-Section of Returns

This table reports the results of Table 4, Panel A, Columns 1, 3, and 5, after replacing Ln(CBF VALUE) by Ln(CBF VALUE/TOTAL ASSETS), Ln(CBF VALUE/SALES), Ln(CBF VALUE/PPE), or by its sub-components. Appendix A provides variable definitions.

	Whole Period			Pre-Kunming Period			Post-Kunming Period		
	Coef.	#Obs.	R2	Coef.	#Obs.	R2	Coef.	#Obs.	R2
Ln(CBF VALUE/TOTAL ASSETS)	0.009	85,122	0.247	-0.037	55,582	0.240	0.075**	29,540	0.251
Ln(CBF VALUE/SALES)	0.017	85,098	0.247	-0.032	55,573	0.240	0.092**	29,525	0.251
Ln(CBF VALUE/PPE)	0.012	85,074	0.247	-0.038	55,549	0.240	0.086***	29,525	0.251
Ln(CBF GHG)	0.027	85,122	0.247	-0.001	55,582	0.240	0.079*	29,540	0.251
Ln(CBF LAND USE)	0.011	85,122	0.247	-0.007	55,582	0.240	0.031	29,540	0.251
Ln(CBF WATER POLLUTION)	0.001	85,122	0.247	-0.020	55,582	0.240	0.029*	29,540	0.251
Ln(CBF AIR POLLUTION)	0.015	85,122	0.248	-0.014	55,582	0.242	0.049	29,540	0.252

Table IA.7. Market Reaction to COP15 - Kunming: Additional Results

This table presents additional analyses, building on the specification in Column 1 of Table 5, to report on the market reaction to the first part of the COP15 (Kunming). We report results for firms with large versus small CBFs. The event window consists of the [-3,2]-day window around the focal date of October 13, 2021. The market reaction is computed as the within-firm difference in daily returns between the three trading days before versus after the event. We only report estimates on the main coefficient of interest (LARGE CBF × POST). LARGE CBF equals one for firms with a CBF value above the median value (as of the beginning of the year). Abnormal returns are returns in excess of their domestic stock market index returns (using MSCI indices). 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 by country except for region-level regressions. Intercepts are not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix A provides variable definitions.

	LARGE CBF × POST	#Obs.	R^2	Fixed Effects
LARGE CBF AIR POLLUTION	-0.274**	11,535	0.238	Firm, Day
LARGE CBF LAND USE	-0.411***	11,535	0.240	Firm, Day
LARGE CBF GHG	-0.312**	11,535	0.238	Firm, Day
LARGE CBF WATER POLLUTION	-0.214	11,535	0.237	Firm, Day
Ln(CBF VALUE/TOTAL ASSETS)	-0.386***	11,535	0.239	Firm, Day
Ln(CBF VALUE/SALES)	-0.397**	11,529	0.239	Firm, Day
Ln(CBF VALUE/PPE)	-0.272**	11,529	0.238	Firm, Day
Dropping absolute returns \textgreater 5%	-0.375***	11,191	0.255	Firm, Day
Top Quartile CBF Value	-0.405***	11,535	0.239	Firm, Day
Continuous CBF Value	-0.077***	11,535	0.240	Firm, Day
Event Window [-5,4]	-0.240***	19,398	0.172	Firm, Day

Table IA.8. Biodiversity Protection Proxies by Country

This table reports each country's Biodiversity and Habitat Score, its terrestrial protected areas (in %), and its marine protected areas (in %). Appendix A provides variable definitions. Values are reported as of end 2020.

	BIODIVERSITY & HABITAT SCORE	% TERRESTRIAL PROTECTED AREA	% MARINE PROTECTED AREA
Australia	83.70	20.34	41.18
Belgium	87.40	15.39	37.63
Brazil	78.10	30.27	26.50
Canada	60.50	12.62	9.06
China	19.00	1.68	0.53
Denmark	81.70	15.53	18.24
Finland	75.50	13.25	10.94
France	88.30	27.91	38.73
Germany	88.80	37.45	45.30
Hong Kong	19.00	1.68	0.53
India	33.70	0.64	0.03
Indonesia	56.30	12.14	2.98
Italy	75.60	21.65	7.43
Japan	76.60	30.44	13.27
Korea	62.60	16.81	1.85
Malaysia	55.10	13.24	4.67
Mexico	72.90	14.52	22.13
Netherlands	83.70	26.57	26.81
Norway	71.50	17.59	0.87
Philippines	56.60	15.76	1.60
Poland	89.00	39.54	24.81
Saudi Arabia	38.80	4.75	2.44
Singapore	20.90	5.82	0.00
South Africa	63.20	9.22	14.69
Spain	87.60	28.09	12.73
Sweden	72.50	15.14	15.80
Switzerland	63.00	12.05	-
Taiwan	65.00	1.68	0.53
Thailand	53.00	18.42	4.52
Turkey	15.10	0.20	0.15
United Kingdom	88.00	27.74	41.30
United States	67.50	12.96	19.15

Table IA.9. 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^2MSA, which is equivalent to the pristine natural area destroyed by the firm's annual activities. For details, see Section 2.2.	International
Biodiversity and 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 6.1.	International
10-K Biodiversity-Count Score	Giglio et al. (2023)	Disclosure	Dummy variable that is equal to one if a firm's 10-K statement contains at least two sentences related to biodiversity. Biodiversity-related sentences are identified using a Biodiversity Dictionary that contains the following biodiversity-related terms: biodiversity, ecosystem(s), ecology (ecological), habitat(s), species, (rain)forest(s), deforestation, fauna, flora, marine, tropical, freshwater, wetland, wildlife, coral, aquatic, desertification, carbon sink(s), ecosphere, and biosphere. For details, see Section 6.2.	US
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 6.3.	International

Table IA.10. 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 VALUE)	1.00						
2. Ln(CBF SCOPE 1)	0.68	1.00					
3. Ln(CBF SCOPE 2)	0.21	0.20	1.00				
4. Ln(CBF SCOPE 3)	0.96	0.58	0.14	1.00			
5. 10-K BIODIVERSITY COUNT SCORE	0.08	0.18	0.02	0.07	1.00		
6. REFINITIV BIODIVERSITY IMPACT	0.32	0.40	0.17	0.27	0.21	1.00	
7. MSCI BIODIVERSITY AND LAND USE SCORE	0.37	0.55	0.01	0.31	0.27	0.39	1.00

Table IA. 11. MSCI Biodiversity and Land Use Exposure and Stock Returns

Panel A of this table reports regressions of monthly stock returns on MSCI Biodiversity and Land Use Exposure Score. The sample period in Columns 1 and 2 includes monthly returns over the full sample period from January 2019 to December 2022. The sample period in Columns 3 and 4 includes monthly returns from January 2019 to September 2021 (the COP15 in Kunming started in October 2021) and in Columns 5 and 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

	Whole Period		Pre-Kunming Period		Post-Kunming Period	
MONTHLY RET (%)	(1)	(2)	(3)	(4)	(5)	(6)
MSCI BIODIVIVERSITY & LAND USE EXPOSURE SCORE	0.121**	0.109**	0.045	0.041	0.199**	0.185**
	(0.051)	(0.048)	(0.052)	(0.050)	(0.079)	(0.077)
#Obs.	77,687	77,675	50,100	50,088	27,587	27,587
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-YearMonth Fixed Effects	No	Yes	No	Yes	No	Yes
R^2	0.256	0.327	0.249	0.316	0.262	0.333

Panel B. Market Reaction to COP15 - Kunming

DAILY RETURN (%)	(1)	(2)	(3)	(4)
LARGE MSCI SCORE × POST	-0.316***	-0.276***	-0.031	
	(0.095)	(0.101)	(0.090)	
LARGE MSCI SCORE × t = -2				0.426***
				(0.129)
LARGE MSCI SCORE × t = -1				-0.319
				(0.218)
LARGE MSCI SCORE × t = 0				-0.307**
				(0.127)
LARGE MSCI SCORE × t = +1				-0.333**
				(0.124)
LARGE MSCI SCORE × t = +2				-0.234
				(0.227)
#Obs.	10,336	10,336	10,336	10,336
Firm Fixed Effects	Yes	Yes	Yes	Yes
Day Fixed Effects	Yes	Yes	No	No
Country-Day Fixed Effects	No	No	Yes	No
Industry-Day Fixed Effects	No	No	No	Yes
R^2	0.237	0.241	0.337	0.299

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