

Guardians of the Biodiversity:
Do Banks Care about Firm's Biodiversity Risk?*

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Abstract

This study examines whether and when banks incorporate borrowing firms' biodiversity risk into their loan decisions. We find a positive correlation between biodiversity risk disclosed in 10-K reports and loan spreads. To explore the mechanisms, we show that both regulatory and physical biodiversity risks are associated with higher loan spreads, but banks' responses to these two types of risks differ. Specifically, top biodiversity-financing banks penalize Perpetrator firms with regulatory risk but support Victim firms with physical risk. Relationship lending can mitigate the negative impact of physical risk on loan costs but not regulatory risk. Together, these findings highlight banks' nuanced roles in biodiversity finance. For causal inference, we use biodiversity litigations as exogenous shocks to firms' biodiversity risk and obtain consistent results. We also show that the influence of biodiversity risk on loan spreads is distinct from that of climate change and other environmental risk.

JEL Classification: C45, G32, Q54

Keywords: Biodiversity risks, biodiversity litigation, sustainable finance, green innovation, bank lending, syndicated loan

Protesters in front of Citibank's Manhattan headquarters wearing robes and holding signs reading "biodiversity loss," "bleached corals," and "heat waves."

——WNCT Greenville, July 9, 2024

1. Introduction

Biodiversity risk is a complex issue that involves a range of ecological, economic, and social factors. It encompasses the potential for species extinction, habitat destruction, and the degradation of ecosystem services. The loss of biodiversity may pose severe economic and social repercussions, such as diminished productivity, heightened susceptibility to pests and diseases, and the erosion of ecosystem services vital to human well-being and economic progress (Heal, 2004; Dasgupta, 2021; Raynor et al., 2021; WEF, 2023; Frank and Sudarshan, 2024). In the 19th Global Risks Report from the World Economic Forum (WEF), biodiversity loss and ecosystem collapse are recognized as the top and long-term global risks our society faces. The Millennium Ecosystem Assessment also estimates an alarming extinction rate of up to 24 species per day.

Previously underestimated by the financial sector, biodiversity loss is now being acknowledged as a risk that can potentially destabilize the financial system, with far-reaching consequences for the wider economy. How financial institutions integrate biodiversity risk into their decision-making processes and risk management frameworks is essential for addressing the unique challenges posed by biodiversity loss and promoting sustainable economic development (OECD, 2020). Along with the bond market and equity market contributing to sustainable investing (Hartzmark and Sussman, 2019; Flammer, 2020; Barber et al., 2021; Flammer, 2021), there is a growing trend of directing private capital toward initiatives for conserving and restoring biodiversity (Flammer et al., 2025).

Nowadays, banks have become increasingly aware of the risk associated with biodiversity loss as the degradation of ecosystems can significantly affect their clients'

financial health and default probabilities. Despite this increasing public attention, the academic literature lacks rigorous studies that explore the influence of biodiversity risk on banks' lending decisions. Our study aims to fill this research gap by addressing the question: Do banks consider borrowing firms' biodiversity risk in their lending decisions, and if so, what factors may aggravate or mitigate banks' concerns about the risk?

To fix the idea, we classify firms/borrowers into two distinct categories, Perpetrators and Victims, based on their involvement in biodiversity losses. Perpetrators face regulatory (transition) risks arising from regulations and policies aimed at preventing biodiversity loss (Battiston et al., 2021). Victims encompass firms that experience adverse effects on their business operations and profitability due to the physical risks associated with biodiversity decline (Huang et al., 2022). These risks and costs might deteriorate firms' financial health and ability to repay the loans. Prior studies on the regulatory and physical risks of climate change have documented that both risks would affect bank lending decisions (Battiston et al., 2021; Ivanov et al., 2024). Accordingly, banks may impose higher loan prices on firms with significant biodiversity risks, beyond just climate risks.

However, it remains uncertain how banks will anticipate and respond to the biodiversity risks associated with borrowers. Contrary to expectations, banks might potentially offer lower interest rate spreads to firms that pose a biodiversity risk. As suggested by prior studies, investors' and consumers' taste premium for greenness could dominate the risk premium (Dai et al., 2021; Pástor et al., 2021, 2022). Companies that emphasize biodiversity risk are likely to be more proactive in addressing biodiversity concerns. Thus, banks may also use lower loan rates to signal their commitment to sustainability and to attract borrowers who prioritize biodiversity concerns. Another possibility is that banks may not pay attention to the biodiversity risk of their borrowers if the economic repercussions on the borrowers' financial

health are not significant. In such cases, the biodiversity risk may not be a salient factor in banks' lending decisions.

To test the competing hypotheses, we use syndicated loan data from the DealScan database and firm-level biodiversity risk metrics as outlined in Giglio et al. (2023). Our analysis encompasses a period spanning from 2004 to 2019. The results show a positive correlation between biodiversity risk levels and loan spreads. Specifically, we observed an economic impact ranging from a 35.9 to a 54.7 basis-point increase in loan spreads for borrowers who disclose biodiversity risks in their 10-K reports, as opposed to those who do not. Our findings are robust to controlling for various other climate risks as identified in Sautner et al. (2023) and environmental risks derived from the RepRisk database. Additionally, the results hold using alternative spread measures that account for net upfront fees, and alternative firm-year level sample structure.

To elucidate the mechanisms and examine the distinct role of biodiversity financing by banks, we follow our hypothesis development and categorize borrowers into two groups: Perpetrators, defined as those facing regulatory biodiversity risks, and Victims, defined as those confronted with physical biodiversity risks. Our results indicate that both types of risks are associated with higher loan spreads. However, when conducting mechanism tests based on banks' characteristics, we find that banks' attitudes towards these two risks differ.

Our first mechanism test reveals that biodiversity financiers tend to penalize Perpetrators but are more lenient towards Victims. Empirically, the results show that when lead banks are top biodiversity financiers, the positive relationship between regulatory risk and loan spread is intensified, while the positive relationship between physical risk and loan spread is mitigated.

Our second mechanism test suggests that relationship lending with banks can only reduce the loan premium for Victims, not for Perpetrators. We find that relationship lending weakens the positive relationship between biodiversity risk and loan spread only when the risk is

physical, not regulatory. Together, these mechanisms highlight the nuanced differences in banks' approaches to biodiversity financing.

Next, we leverage state-level biodiversity lawsuits as an exogenous shock to identify the causal relationship. Such events are expected to heighten awareness among companies headquartered in the affected states, prompting them to mitigate their biodiversity risks. The previous research has demonstrated that community-level shocks can influence corporate decision-making, particularly when managers perceive litigation risks or threats stemming from such events (Levy et al., 2018; Huang et al., 2020; Chen et al., 2021).¹ Consequently, the initiation of state-level lawsuits can be considered relatively exogenous to firm-specific decisions regarding biodiversity risk management and subsequent bank loan outcomes. We find that these biodiversity lawsuits are associated with reduced bank loan spreads. These findings offer confirming evidence for a causal link between biodiversity risk and the pricing of bank loans.

In our subsequent cross-sectional analysis, we concentrate on the characteristics of the borrowers. We find that borrowers' green governance may alleviate banks' concerns regarding biodiversity risk. Governance by institutional investors, particularly those with an ESG focus, can potentially serve as an alternative channel for banks to monitor borrowers' biodiversity risks. We also find that firms with higher R&D expenditures exhibit a weaker positive correlation between biodiversity risk and loan spread, suggesting that banks may be more inclined to accommodate borrowers who are proactive in addressing biodiversity risks through innovative investments.

¹ For instance, terrorist attacks affect managers' moods and adjust their managerial forecasts accordingly (Chen et al., 2021). The Supreme Court ruling in *Gantler v. Stephens* (2009), which affects CFO personal litigation risk, further affects firms' disclosure and accounting choices (Levy et al., 2018). The ruling from the Ninth Circuit on *Silicon Graphics Inc. Securities Litigation* affects the firms' assessment of litigation risk and their earnings management decisions when they are located in the Ninth Circuit regime (Huang et al., 2020).

Our study contributes to several lines of literature. First, it addresses the call for biodiversity finance made by Karolyi and Tobin-de la Puente (2023), which emphasizes the need for further research on how biodiversity risks can be accurately priced and how private capital can be effectively intermediated in this context. Historically, the financial sector paid much less attention to biodiversity risk than other environmental or climate risks. Nevertheless, with a growing recognition that biodiversity loss poses significant threats that could destabilize the financial system and have broader economic consequences, biodiversity conservation is emerging as a major focus for sustainable finance, potentially surpassing climate change risk mitigation and adaptation. Given the burgeoning but inconclusive evidence on whether and how financial institutions price biodiversity risk (Cherief et al., 2022; Coqueret and Giroux, 2023; Garel et al., 2024), our findings provide important implications for private debt markets.

Second, our study adds to the literature on the impact of bank initiatives on ESG issues. By leveraging their influential positions, banks can encourage or enforce superior risk management practices, thereby proactively fostering borrowers' sustainability. For instance, ethical banks that finance only socially responsible projects have been shown to operate effectively and contribute to social efficiency (Barigozzi and Tedeschi, 2015). Recent banking studies show that lenders not only select borrowers based on their ESG alignment but also influence and discipline the borrowers to enhance their ESG performance (Houston and Shan, 2022). Furthermore, when bank managers harbor green preferences, they tend to provide more favorable recommendations for green loan applications (Bu et al., 2024). By concentrating on banks' consideration of biodiversity issues, our study provides a novel perspective by documenting banks' nuanced roles for firms' regulatory and physical biodiversity risks.

Moreover, our study expands the literature on risk management in the banking industry by examining the integration of biodiversity risk into banks' lending decisions. This new dimension of risk is distinct from other types of risks, such as credit risk, political uncertainty,

tax incidences, CEO turnover, operational risk, and climate risk (e.g., Altman, 1968; Altman and Kishore, 1996; Pan et al., 2018; Akins et al., 2020; Kang et al., 2021; Gad et al., 2024; Ginglinger and Moreau, 2023). By demonstrating the tangible financial implications of biodiversity risk and its heterogeneous effects, our study provides policy implications by highlighting the importance of recognizing and addressing biodiversity risks within broader risk management practices of financial institutions.

Finally, our research design provides the methodology for establishing a causal relationship between biodiversity risk and bank loan pricing. To address the identification challenge, we utilize biodiversity litigation as staggered exogenous shocks. This approach allows us to examine how biodiversity risk causally affects bank loan decisions. While several recent studies explore the relationship between acute biodiversity events or country-level biodiversity incidences (Cherief et al., 2022; Becker et al., 2023), none attempts to address the endogeneity concerns as far as we know.

2. Literature Review and Hypothesis Development

2.1 Sustainable Investing

Financial institutions are pivotal in the realm of sustainable investing, a domain that transcends niche strategies to permeate mainstream investment practices (Liang et al., 2022; Hartzmark and Sussman, 2021). This trend indicates a growing recognition of the dual benefits of sustainable investing: aligning with environmental and social values while also seeking profitable returns.

Impact investors, including venture capital and growth equity funds, are particularly focused on generating not only financial gains but also measurable positive impacts on society or the environment (Barber et al. 2021). Investors have to trade off the benefits and costs of financial gains and ESG outcomes. For example, some hedge funds that endorse responsible

investment have to sacrifice the return and cater to investors' preferences (Liang et al., 2022). Nevertheless, the continuous attention from investors generates a large impact on firms' decisions. For example, Ilhan et al. (2023) have shown that institutional investors value and demand firm climate risk disclosure, which further imposes a positive impact on firms' disclosure of climate issues. Investors' continued attention to climate change drives companies to embrace green strategies and mitigate negative publicity to enhance their financial performance (Flammer, 2015; Krüger, 2015).

Apart from the equity market, bond markets embrace sustainable investing, with an increasing issuance of green bonds aimed at funding eco-friendly initiatives. Flammer (2021) shows that the debut of green bonds is met with a favorable stock market reaction, particularly for issuers who are first-timers or have secured third-party validation. Such bonds are seen as a reliable indicator of a company's dedication to environmental responsibility and are instrumental in achieving tangible environmental improvements (Flammer, 2020). The escalating interest in green bonds mirrors the wider movement to incorporate ESG factors into fixed-income investment strategies.

Banks, also re-evaluate their lending criteria by considering sustainability (Martini et al., 2024; Sautner et al., 2024; Roncoroni et al., 2021; Bu et al., 2024). Huang et al. (2022) demonstrate that firms with significant climate risk exposure are more likely to face stringent loan terms unless they adopt robust climate risk management strategies. Reghezza et al. (2022) provide evidence that European banks have redirected their credit away from polluting entities post the Paris Agreement, underscoring the profound influence of regulatory policies and green initiatives on banking practices. Recent banking studies show that lenders not only select borrowers based on their ESG alignment but also influence and discipline the borrowers to enhance their ESG performance (Houston and Shan, 2022).

In essence, the convergence of equity and bond market dynamics, coupled with the proactive stance of banks, is fostering a financial ecosystem that not only acknowledges but also actively promotes sustainable investing, thereby encouraging corporate sustainability and environmental responsibility.

2.2 Biodiversity Risk

The issue of biodiversity risk is complex and multifaceted, with implications for several different areas, including the ecological, economic, and social. It refers to the possibility of species extinction, habitat destruction, and the deterioration of ecosystem services. The loss of biodiversity can have notable economic and social implications, including reduced productivity, increased vulnerability to pests and diseases, and the decline of ecosystem services that are vital for human well-being and economic development (e.g., Heal, 2004; Dasgupta, 2021; WEF, 2023). For example, Frank and Sudarshan (2024) have shown that the collapse of keynote species in India has increased the human mortality rate due to the negative shock to sanitation. Raynor et al. (2021) document that restoring the wolf populations reduces the deer-vehicle collisions in Wisconsin, yielding an economic benefit that is 63 times greater than the cost of verified wolf predation on livestock. Similarly, Dasgupta (2021) pointed out that in areas where fishing is not regulated or is poorly managed, fish stocks can be rapidly depleted, leading to the collapse of entire marine ecosystems due to overfishing and negatively affect fishing industry. To summarize, biodiversity issue is closely related to the social and economic welfare of the human beings as our economies are embedded within nature and not external to it.

Biodiversity risk is closely interconnected with global warming and climate change, but it also has distinct characteristics. First, biodiversity risk centers on the variety and variability of life on Earth, including the interdependence of species and their habitats. In contrast, climate risk primarily focuses on changes in climate systems, such as temperature rise, sea-level

changes, and altered precipitation patterns, resulting from greenhouse gas emissions and other human activities that affect the climate. Second, the policies and regulations surrounding biodiversity risk often involve conservation efforts, habitat restoration, and the sustainable use of natural resources. For example, the UK's 2021 Environmental Bill introduces mandatory goals for nature conservation, water and air quality, and waste management to be achieved by 2030. On the other hand, climate risk mitigation strategies typically revolve around reducing carbon emissions, investing in renewable energy, and promoting low-carbon technologies (Hong et al., 2020; Dasgupta, 2021).

Given the distinct and fundamental differences between biodiversity risk and climate risk, studying biodiversity finance is both timely and crucial. Understanding how financial institutions can effectively integrate biodiversity risk into their decision-making processes and risk management frameworks is essential for addressing the unique challenges posed by biodiversity loss and promoting sustainable economic development. Global biodiversity finance is estimated at USD 78-91 billion per year. Governments allocate an estimated USD 500 billion annually towards support that may have detrimental impacts on biodiversity (OECD, 2020). This highlights the need to redirect financial flows towards biodiversity conservation and restoration efforts.

Similar to climate change, the financial risks associated with biodiversity loss can be broadly categorized into two types: physical risk and regulatory (transition) risk. Physical risk arises when biodiversity loss causes damage to ecosystems that negatively impact business operations and productivity. For example, the decline in insect populations can have adverse consequences on crop yields, which can affect production processes along the supply chain. These realized losses can be reflected in the financial balance sheets and linked to market or credit risks (OECD, 2021). Regulatory risk arises from stricter public policies and government regulations aimed at forcing companies to adopt sustainable business practices or limiting the

exploitation of land and sea resources. Non-compliance with such regulations can trigger liability risks, including litigation by environmentalists, regulatory penalties, and increased insurance costs.

2.3 Biodiversity Risk and Bank Lending Decision

For the hypothesis development, we claim that firms' biodiversity risk is associated with higher bank loan spread. To better illustrate, we categorize borrowing firms into two distinct categories based on their involvement in biodiversity losses.

The first category, referred to as *Perpetrators*, comprises firms engaged in economic activities that potentially harm biodiversity. These Perpetrators mainly face regulatory or transition risks arising from regulations and policies that aim to prevent biodiversity loss (Battiston et al., 2021). Oil and mining companies are prime examples as their drilling and mining activities significantly impact wildlife habitats. Consequently, these firms face potential future litigations and the imposition of new conservation regulations and policies, which could curtail their business opportunities, operation profitability, and loan repayment capability.

The second category, known as *Victims*, encompasses firms that experience adverse effects on their business operations and profitability due to physical risks associated with biodiversity decline (Huang et al., 2022). For example, the loss of marine biodiversity and degradation of ecosystem services can significantly impact the long-term profitability of sustainable fishing enterprises or water supply companies.

The cumulative impact of these risks and their associated costs can exacerbate the financial stability of such firms and diminish their capacity to service their debt obligations (Battiston et al. 2021; Ivanov et al., 2024). Hence, we hypothesize that banks also consider borrowers' biodiversity risk, potentially leading to increased ex-ante pricing in their lending strategies.

However, it remains an empirical question whether banks care about the biodiversity risks of their borrowers to the extent that can be discerned in the loan spreads. As previous research has shown, there is a growing preference among investors and consumers for environmentally friendly options, which could outweigh the risk premium (Dai et al., 2021; Pástor et al., 2021, 2022). Firms that disclose biodiversity risks in their financial reports could be the ones that are more conscious of biodiversity issues. Accordingly, banks might use lower prices for such firms to demonstrate their dedication to sustainable practice if banks have green taste. Another possibility is that, if the financial impact of biodiversity risk on a borrower's health is not substantial, banks may choose to overlook this risk. In these instances, biodiversity risk may not be a key consideration in the banks' lending strategies.

Besides, emerging studies exploring the impact of biodiversity risk on equity markets yield inconclusive findings with significant heterogeneity. For example, Coqueret and Giroux (2023) utilize data from Iceberg DataLab and find that the risk premium for biodiversity has been close to zero over the past decade, while the expected return on biodiversity premium has been negative in recent years. Conversely, Garel et al. (2024) find a notable emergence of a biodiversity footprint premium following the Kunming Declaration in October 2021 based on the same biodiversity footprint data from Iceberg. However, the Iceberg DataLab has practical limitations, as it relies heavily on an estimation footprint based on input and output models. Besides, neither study examines bank lending decisions. Our paper fills the gap in the understanding of the relationship between biodiversity risk on bank lending decisions.

3. Data and Research Design

3.1 Data Source and Sample Selection

We obtain the data on firm-level biodiversity risk from Giglio et al. (2023), which is based on textual analysis of the firms' 10-K report from 2004 to 2019. Giglio et al. (2023) use

the biodiversity dictionary to identify the biodiversity-related sentences that contain 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. The examples are illustrated in Appendix B. Their biodiversity count score is a dummy variable that equals one if a company's 10-K statement includes a minimum of two sentences that pertain to biodiversity, and zero otherwise. The measurement obtained from the 10-K report is at the firm-year level, which allows for better capture of firms' self-assessment of biodiversity risks across firms and years.

We obtain loan pricing data from the syndicated bank loans in the DealScan Database. Consistent with established methodologies in the prior research, we determine the loan tranche spread by calculating the difference between the coupon spread over LIBOR and the annual fee on the drawn loan amount, commonly referred to as the "all-in-drawn-spread" within the DealScan Database. We then divide this figure by 100 to normalize the spread (Drucker and Puri, 2005; Bharath et al., 2011; Kang et al., 2021). In addition to the loan spread, we also consider other loan characteristics such as maturity, loan amount, utilization of collateral, financial covenants, and the intended purpose of the loan, all of which are sourced from the DealScan Database.

The biodiversity lawsuit data is from the Climate Change Litigation Databases provided by Columbia Law School and the Columbia Climate School.² This comprehensive dataset encompasses U.S. litigations for a wide range of legal claims, including those based on federal statutes, constitutional provisions, and state laws. Our analysis focuses on cases related to biodiversity issues such as water conservation, wildlife habitats, and endangered species, with an emphasis on those at the state level or those with significant state-wide impact. By

² <https://climatecasechart.com/us-climate-change-litigation/>

examining State Impact Assessment Laws and Federal Statutory Claims, we have identified 10 cases and four affected states that meet our criteria in our sample period. We employ the petition of these cases as exogenous shocks to the firms' attention on biodiversity risk management. A detailed summary of these cases is presented in Appendix C. To ensure the accuracy of these cases, we cross-reference them with additional litigation databases, including the CEQA portal and Casetext, to verify the litigation details and ascertain the event year for the initial petition of each case.³

Firms' fundamental financial variables are obtained from COMPUSTAT. The ownership ratio of ESG-oriented investors is derived from the 13F filings and the MSCI KLD database. Our firm-level climate change risk measures are sourced from Sautner et al. (2023), while the firms' environmental risks are taken from the RepRisk Database.

We extract 321,325 observations from the DealScan Database from 2004 to 2019, which encompass 153,289 unique loan tranches.⁴ We employ the DealScan-Compustat link file provided by Chava and Roberts (2008) to match these observations based on borrowers' IDs. We then use the firms' GVKEY to merge this dataset with quarterly financial fundamentals from COMPUSTAT and the biodiversity risk measures. To ensure a robust analysis, we limited our sample to observations with complete information on both loan characteristics and firm fundamentals. This restriction reduces the size of our final sample to 22,991 observations across 572 unique borrowers.

3.2 Research Design

3.2.1 Baseline Regression

³ <https://casetext.com/case/ctr-for-biological-diversity-v-cal-fish-game-commn>;
https://ceqaportal.org/ceqacase.cfm?cq_id=1612

⁴ The data source of biodiversity risk covers till the year 2020. However, we exclude the year 2020 as the mean spread is 2.42, increasing 20% compared to the sample mean before COVID-19. The results are robust including the year 2020.

To examine whether banks incorporate borrowers' biodiversity risk into their lending decisions, we estimate the following regression model, presented as Equation (1):

$$\begin{aligned} Spread_{i,j,l,t} = & \beta_0 + \beta_1 BIO_RISK_{i,t} + \theta LoanControl_{i,j,l,t} \\ & + \gamma BorrowerControl_{i,t} + FixedEffects + \varepsilon_{i,j,l,t} \end{aligned} \quad (1)$$

Spread is defined as coupon spread over LIBOR on the drawn amount plus annual fee ("all-in-spread down" or AISD in Dealscan) at the time of loan origination, divided by 100. The indices i,j,l,t denote borrower i , lender j , loan l , and year t , respectively. The indices i,j,l,t denote borrower i , lender j , loan l , and year t , respectively. We follow Kang et al. (2021) to regress the spread in year t on the firm's biodiversity risk in year t . *BIO_RISK* is a binary variable representing the explicit mention of biodiversity risk within a firm's 10-K reports. This variable is coded as one if the company's 10-K filing contains at least two sentences related to biodiversity, and zero otherwise.

Following Gad et al. (2023), we perform our regression analysis at the tranche-bank level, recognizing that a single borrower may engage in multiple loan contracts with different banks within the same year. Given that all the participating banks' characteristics, not only the ones from lead arrangers, could influence loan pricing (Gad et al., 2023), we utilize the tranche-bank structure and control for lender-fixed effects and year-fixed effects. We incorporate borrower and year-fixed effects to control for unobserved, time-invariant characteristics of borrowers and broader macroeconomic trends. We add loan-type fixed effects to compare the variations within each type of loan. Furthermore, in the expanded models, we introduce joint fixed effects for lender \times year and lender \times borrower relationships to account for the time-variant attributes of individual banks and the specific dynamics of each lender-borrower pair. Standard errors are clustered at the firm level.

We also follow the prior literature (e.g., Kang et al., 2021) to include both loan control variables and borrowers' control variables that could potentially affect the loan price. Loan

characteristics include maturity (*LOG_MATURITY*), loan amount (*LOG_LOAN_AMOUNT*), the usage of collaterals (*COLLATERAL*), financial covenants (*FIN_COV*), and loan purposes (*LOAN_PURPOSE*). The control variables for borrowers' characteristics include firm size, the natural logarithm of market value (*Ln_MV*), leverage ratio (*LEV*), Property, plant, and equipment scaled by assets (*PPE*), profitability (*ROA*), market-to-book ratio (*MTB*) and R&D scaled by assets (*R&D*). The details of variable construction can be found in Appendix A Variable definition. To establish the robustness, we include different sample constructions. As the biodiversity risk measure is at the firm-year level, in the robustness tests, we also aggregate the loans' data at the firm-year level, taking the average of loan spread for borrower *i* in year *t*. We also add additional control variables such as climate risk or environmental risk to show the distinct effect of biodiversity risk on loan pricing beyond these related risks.

3.2.2 Staggered DID for Biodiversity Litigation

To strengthen the causal inference in our study, we utilize state-level biodiversity lawsuits as an exogenous shock. This approach is designed to account for the attention garnered by companies headquartered in the affected states and the subsequent reduction in their biodiversity risk. It is crucial to acknowledge the potential impact of omitted variables—such as macroeconomic conditions—that could concurrently influence both a firm's biodiversity risk and bank financing decisions. Moreover, there is a possibility of reverse causality, where financial constraints could affect a firm's management of biodiversity risk. Firms may deprioritize biodiversity risk management in favor of securing financing, particularly when facing challenges in accessing capital, which could lead to increased biodiversity risks (Kim and Xu, 2019). In turn, higher bank financing costs may exacerbate a firm's biodiversity risk.

In the United States, the involvement in biodiversity lawsuits, despite the uncertainty of outcomes until a final ruling, attracts significant public attention and intensifies scrutiny

(Rodríguez-Garavito and Boyd, 2023; Zhou and Ding, 2023). The prior research has demonstrated that community shocks, including litigation risks, can influence firm decision-making, particularly when managers are aware of such risks (Levy et al., 2018; Huang et al., 2020; Chen et al., 2021). Consequently, the initiation of state-level lawsuits can be considered relatively exogenous to the firm-specific decisions regarding biodiversity risk management and bank loan outcomes, providing a plausible setting to identify the causal effects of biodiversity risk on financing costs.

Empirically, we adopt a staggered difference-in-differences (DID) design based on state-level biodiversity litigation. We conduct the regression analysis as Equation (2) below:

$$\begin{aligned} Spread_{i,j,l,t} = & \beta_0 + \beta_1 BIO_LAWSUIT_{i,t} + \theta LoanControl_{i,j,l,t} \\ & + \gamma BorrowerControl_{i,t} + FixedEffects + \varepsilon_{i,j,l,t} \end{aligned} \quad (2)$$

BIO_LAWSUIT equals one if the borrower's headquarters is located in the state affected by the biodiversity lawsuit after the initiation of the litigation; zero otherwise. For instance, for firms headquartered in California, *BIO_LAWSUIT* equals one following the initiation year of 2007 for the case *Center for Biological Diversity v. California Department of Fish and Game Commission*. Thus, *BIO_LAWSUIT* captures both the treatment and post-effects as we add firm and year fixed effects. The control variables included in our analysis are consistent with those utilized in Equation (1). Given that biodiversity lawsuits are expected to prompt a reduction in firms' biodiversity risk, which in turn could lead to a decrease in loan spreads, we expect β_1 in Equation (2) to be negative.

Our analysis is centered on the headquarters as the pivotal location affected by biodiversity lawsuits, given that senior management, who are responsible for a firm's risk management and sustainability strategies, are typically based there. We use the lawsuit initiation year as the event year because it marks the initial public disclosure of the litigation, which is when it becomes a salient consideration for the affected borrowers. To substantiate

our assumption regarding the impact of biodiversity litigation on corporate behavior, we conduct an analysis that evaluates how the initiation of these lawsuits influences the firm's biodiversity risk management, using a firm-year sample reported in Appendix D.

3.2.3 Descriptive Statistics

Figure 1 illustrates the year-on-year trend in the percentage of U.S. public firms mentioning biodiversity risk within their annual 10-K reports. This metric, calculated at the firm-year level before merging the dataset with the DealScan Database, demonstrates a notable upward trajectory over the sample period. Initially, in 2004, only about 1% of firms referenced biodiversity risk in their reports, which has risen to approximately 4% by 2019. This upward trend indicates a growing emphasis on biodiversity risk management among U.S. public corporations, reflecting an increased awareness and response to environmental concerns within the business community.

Table 1 presents the summary statistics for the variables utilized in our baseline regression analysis. The mean loan spread (*Spread*), measured in basis points (100bp), is 2.008. The natural logarithm of loan maturity, expressed in months, is 3.879, which corresponds to an average loan term of approximately 48 months. The natural logarithm of the loan amount stands at 6.674, translating to a mean loan size of \$792 million. The usage of collateral in loan agreements is prevalent, with 41.1% of loans featuring collateral. Similarly, financial covenants are included in 36.3% of the loan contracts. Loans designated for Mergers and Acquisitions (M&A), management buyouts, and recapitalization purposes constitute 15.2% of the sample.

In Table 2, we examine the relationship between our measure of biodiversity risk and other indicators of climate change and environmental risk by calculating pairwise correlations. *BIO_REG_RISK* is regulation (i.e., transition) risks related to biodiversity risk. *CC_REG_RISK* and *CC_PH_RISK* are regulation and physical risks related to climate change. The analysis

reveals that while there is a positive correlation between the biodiversity risk measure and other climate change/environmental risk measures, the extent of overlap is modest, with all correlation coefficients falling below 0.1. Specifically, the correlation coefficient between the biodiversity risk indicator (*BIO_RISK*) and the measure of climate change risk (*CC_RISK*) is 0.09. Additionally, the correlation between *BIO_RISK* and the environmental risk metric from the RepRisk database (*ENV_RISK*) is only 0.045. These findings suggest that biodiversity risk is a distinct construct from other forms of climate change and environmental risks, justifying its separate consideration in our study.

4. Results

4.1 Main Results: Biodiversity Risk and Loan Spread

The baseline regression results are presented in Table 3. In Column (1), we add borrower and year fixed effects. In Column (2), we add borrower, loan type, year, and lender fixed effects. In all the other analyses, we also follow this model specification. In Column (3), we add borrower, loan type, and lender \times year fixed effects to consider the banks' time-variant characteristics across years. In Column (4), we further add lender \times borrower fixed effects to consider the endogenous match between the borrower and the bank.

The coefficient on *BIO_RISK* for the first three Columns are all positive and significant at the 1% level. The coefficient in Column (4) remains positive at the 5% level even after controlling for the lender and borrower match. In terms of economic magnitude, taking Column (2) as a benchmark, firms with biodiversity risk are subject to an average loan spread that is 51.9 basis points higher compared to firms without such risk. From Columns (1) to (4), the estimated economic impact ranges from 35.9 to 54.7 basis points, which is a non-trivial effect.

This magnitude is comparable to that found in prior studies examining the relationship between climate risk and the cost of loans (Huang et al., 2022).⁵

For control variables, larger loan amounts and the inclusion of financial covenants within loan agreements are associated with a reduced loan spread. This finding may reflect a lower perceived risk by lenders when loans are collateralized with larger amounts or when financial covenants are in place to protect their interests. Conversely, the use of collateral in loan agreements and loans intended for takeovers or similar purposes is positively associated with higher loan spreads. This positive association could be attributed to the increased risk perceived by lenders in transactions involving mergers and acquisitions, which often involve greater uncertainty and financial leverage. The magnitudes and directions of these effects are consistent with those reported in previous literature (Kang et al., 2021; Huang et al., 2022). Additionally, we find that firm-level characteristics exhibit a weaker association with bank loan decisions after incorporating firm and year fixed effects. This suggests that much of the variability in loan spreads could be attributed to firm-specific factors captured by these fixed effects.

4.2 Mechanism Tests: Nuanced Role of Bank

To better understand the role of banks in biodiversity financing, we conduct mechanism tests to examine whether and when banks differentiate between firms' regulatory risk and physical risk.

4.2.1. Perpetrators vs. Victims

We first categorize biodiversity risk into regulatory risk and physical risk based on our hypothesis development regarding Perpetrators and Victims. To test whether banks consider

⁵ In Huang et al. (2022), firms subject to climate risk are charged 42.32 basis points greater in loan spread compared to the firms without climate risk.

these two types of borrowers differently in terms of loan cost, we regress loan spreads on regulatory biodiversity risk (*BIO_REG_RISK*) and physical biodiversity risk (*BIO_PHY_RISK*). The regression results are presented in Table 4, Column (1). The coefficients on *BIO_REG_RISK* and *BIO_PHY_RISK* are both positive and significant, indicating that banks account for both types of risks in their lending decisions.

Specifically, the coefficient on *BIO_REG_RISK* is 0.401, while the coefficient on *BIO_PHY_RISK* is 0.884. Although the economic magnitude of *BIO_PHY_RISK* is twice that of *BIO_REG_RISK*, the p-value for the equality test on the two coefficients is not statistically significant at conventional levels. This suggests that banks consider both regulatory and physical risks in their lending decisions.

4.2.2. Top Biodiversity Financing Banks

While both physical and regulatory risks are associated with higher loan spreads, banks may exhibit nuanced differences in their treatment of these risks. Specifically, we examine how top biodiversity financiers differentiate between Perpetrators and Victims in terms of loan pricing. In 2019, 50 global banks provided loans and underwriting exceeding USD 2.6 trillion to economic sectors identified by scientists and governments as primary drivers of biodiversity loss.⁶ As top biodiversity financiers, these banks have a significant role and reputation in biodiversity financing. We hypothesize that top biodiversity financiers would be more supportive of Victims facing physical biodiversity risks while being more vigilant in assessing and addressing transitional biodiversity risks for Perpetrators. To identify top biodiversity financiers, we use data from the Bankrolling Extinction, which ranks the top 10 banks based on their investments in biodiversity. Specifically, we define *TOPBIO_FINANCER* as the number of lead arrangers or co-lead arrangers within a syndicated loan that are among the top 10 banks.

⁶ https://www.banktrack.org/article/bankrolling_extinction_the_top_10_banks_financing_biodiversity_loss

The results are presented in Column (2) of Table 5. The interaction term between *BIO_REG_RISK* and *TOPBIO_FINANCER* yields a positive and statistically significant coefficient at the 1% level, indicating that top biodiversity financiers increase loan spreads for Perpetrators. Conversely, the interaction term between *BIO_PHY_RISK* and *TOPBIO_FINANCER* yields a negative and statistically significant coefficient, suggesting that these banks reduce loan spreads for Victims. Additionally, the equality test confirms that the coefficients for these interaction terms are statistically different at the 1% level.

These findings indicate that top biodiversity financiers treat Perpetrators and Victims differently. Although both regulatory and physical risks are associated with higher loan costs, top biodiversity financiers penalize Perpetrators while supporting Victims facing biodiversity risks. This aligns with their mission to promote biodiversity financing.

4.2.3. Relationship Lending

In this section, we examine whether relationship lending can mitigate the positive association between biodiversity risk and loan spreads. The existing literature suggests that relationship lending enhances banks' access to borrower-specific information through private channels, thereby enabling more effective monitoring of borrowers' financial health (Chernenko and Sunderam, 2014; Lin et al., 2012). This enhanced understanding allows banks to better manage risks, potentially including those related to biodiversity. Consequently, relationship lending may serve as a substitute for traditional risk management practices by providing banks with the necessary information to assess and mitigate biodiversity-related risks. However, it remains unclear whether relationship lending differentiates between physical and regulatory risks. To quantify the extent of relationship lending, we adopt the methodology proposed by Lin et al. (2012), which is based on the history of lending relationships between banks and borrowers. Specifically, we use a dummy variable termed *RELA_LENDING*, which

is assigned a value of one if the bank has served as the lead bank for a particular borrower at any time within the preceding five years and zero otherwise.

The results presented in Column (3) of Table 5 show that the coefficient on the interaction term between *BIO_PHY_RISK* and *RELA_LENDING* is negative and statistically significant at the 1% level. In contrast, the interaction term between *BIO_REG_RISK* and *RELA_LENDING* is insignificant. The equality test confirms that these two coefficients are statistically different at the 1% level. These findings suggest that relationship lending mitigates the impact of physical risks but not regulatory risks.

A plausible explanation is that physical risk is relatively fixed and difficult for firms to manage, whereas regulatory risk can be more dynamic and subject to policy changes. Therefore, during repeated lending, the initial premium associated with physical risk diminishes, but this is not the case for regulatory risk. In conclusion, banks exhibit nuanced differences in their treatment of Perpetrators and Victims, considering the boundary conditions of the two types of borrowers.

4.3 Identification: Biodiversity Litigation

Table 5 delineates the impact of biodiversity litigation on bank loan spreads, employing the regression framework outlined in Equation (2) and incorporating the same set of fixed effects as specified in Column (2) of Table 3. The coefficient attributed to the variable *BIO_LAWSUIT* is negative and statistically significant at the 5% level. Firms headquartered in states embroiled in biodiversity litigation exhibit a loan spread that is 53.4 basis points lower than firms in non-affected states. The finding implies a response by management within affected firms to proactively mitigate their biodiversity risk exposure following the initiation of litigation. This risk mitigation behavior is posited to result in reduced perceived credit risk

by banks (irrespective of whether banks pay more attention to biodiversity risk), thereby translating into a lower loan spread and a consequent decrease in the cost of bank loan financing.

In Panel B of Table 4, we conduct a pre-trend analysis to identify the existence of any differences in loan spreads between the treated and control groups before the initiation of the biodiversity lawsuits. *BIO_LAWSUIT* ($t-1$) is a binary indicator that equals one if the firm's state is anticipated to be involved in a biodiversity lawsuit within the subsequent year. Similarly, *BIO_LAWSUIT* ($\leq t-3$) indicates a lawsuit within three years or later. The coefficient on *BIO_LAWSUIT* ($\geq t+3$) is normalized and serves as a benchmark. We find that the pre-treatment coefficients do not exhibit statistical significance.

To validate the shock of biodiversity lawsuits to firms' biodiversity risk, we perform a panel regression analysis at the firm-year level by regressing the *BIO_RISK* measure against the *BIO_LAWSUIT* indicator. The sample encompasses public firms with available 10-K reports, spanning from 2004 to 2019. The result of this analysis is shown in Appendix D. Consistent with our hypothesis, the commencement of biodiversity lawsuits is associated with a reduction in the affected firms' biodiversity risk. This finding reinforces the notion that biodiversity litigation can serve as an exogenous shock that diminishes borrowers' biodiversity risk, thereby influencing bank lending decisions.

4.5 Other Cross-sectional Tests

In the next two sections, we shift our focus to how the characteristics of the borrowers affect the relationship between biodiversity risk and bank loan spreads.

4.5.1. Green Governance

We conjecture that borrowers' green governance practices could alleviate banks' concerns regarding biodiversity risk. The "green governance" refers to the ESG considerations that are prioritized by institutional investors. Such governance practices act as a proxy for the

risk management efforts undertaken by borrowers (Azar et al., 2021), potentially reducing the need for banks to engage in extensive monitoring of borrowers' biodiversity risks. Consequently, firms with a higher presence of ESG-oriented investors are more likely to reduce their biodiversity risk, leading to lower loan spreads.

In our assessment of borrowers' green governance, we adhere to the methodology employed by Cao et al. (2023), who use the institutional ownership ratio combined with the value-weighted ESG scores from the MSCI KLD database of their portfolio holdings. Column (1) of Table 6 presents the results. The interaction term between *BIO_RISK* and *ESG_IOR* exhibits a negative and statistically significant coefficient at the 1% level. This result suggests that the presence of green governance practices among borrowers can act as a mitigating factor for banks when assessing biodiversity risk, effectively serving as a substitute for traditional risk management strategies in the context of bank loans.

4.5.2 Innovation

This section explores how borrowers' innovation affects our main finding, in particular, whether banks would be more lenient and supportive of borrowers' innovative activities, even if they face high biodiversity risks. To combat the long-term effects of ecosystem destruction, firms need to invest in green and clean technologies, which potentially entail higher expenses for research and development. We do not have a clear prediction for this test, as banks may find it either more costly or risky to provide financing for firms with more intensive green innovation. However, this exercise helps us better understand the extent to which banks are willing to support innovative, environmentally sustainable practices of their borrowers with biodiversity risks.

We adopt a borrower's research and development (R&D) expenses as a proxy for their innovative efforts and use the decile ranking of R&D expenses (*R&D_RANK*) to mitigate the influence of outliers and account for the skewness inherent in raw R&D expenditure data. A

higher decile ranking indicates a greater commitment to innovation. In our analysis, we create an interaction term between *BIO_RISK* and *R&D_RANK* and include it in a regression model. Column (2) of Table 6 shows that the coefficient on the *BIO_RISK* \times *R&D_RANK* interaction term is negative and statistically significant. This result implies that while banks may impose a higher loan spread on firms with greater biodiversity risk, they also demonstrate support for the innovative endeavors of these firms.

4.6 Additional Analysis

4.6.1 Additional Controls of Climate Change Risk and Environmental Risk

In our extended analysis, we introduce further controls to account for climate change risk and environmental risk. These controls are designed to provide a more comprehensive assessment of various types of conceptually related risks that may influence bank lending decisions. Specifically, we incorporate the climate change risk measure (*CC_RISK*) developed by Sautner et al. (2023), which is derived from a textual analysis of conference call manuscripts. The *CC_RISK* measure captures the relative frequency with which bigrams associated with climate change are mentioned in conjunction with terms indicative of risk or uncertainty within the same sentence during earnings conference calls.⁹ Additionally, we utilize environmental risk data (*ENV_RISK*) from the RepRisk Database. This metric is calculated by multiplying the risk score provided by RepRisk with the relevant environmental percentage. The inclusion of these control variables leads to a reduction in our sample size due to data availability, which is the key reason why we do not have these control variables in our main analysis.

Table 7 shows that, after incorporating controls for both climate change and environmental risks into our regression model, the coefficient on our biodiversity risk (*BIO_RISK*) remains positive and statistically significant. This result highlights that

⁹ Controlling for regulation and physical climate change risks yields similar results.

biodiversity risk is a distinct and relevant factor in bank loan pricing, independent of other environmental and climate-related risks.

4.6.2 Robustness Tests

We perform two robustness checks to ensure the reliability of our results. These checks involve the use of alternative specifications for the dependent variables, as well as different firm-year sample structures. The findings from these tests are compiled in Table 8. In Panel A, we utilize an alternative calculation for the net spread in Ivashina (2009), which is determined by subtracting the up-front fee from the spread. The qualitative results from this approach are consistent with those initially presented in Table 3. Lastly, we modify our sample structure to examine the relationship between a borrower's biodiversity risk and the average cost of the loan at the firm-year level. This entails aggregating the spread data at the firm level to serve as our dependent variable, resulting in a sample of 1,207 unique firm-year observations. Concurrently, we also aggregate the other loan control variables at the firm level. The results, as shown in Panel B, indicate that the coefficient on *BIO_RISK* remains positive and significant at the 5% level.

4.6.3 Consequence Tests on Green Patents

Furthermore, we investigate the consequences of increased loan spreads on firms' green innovation outcomes, particularly in relation to their biodiversity risk. We regress firms' green innovation output measured by green patents on the interaction between biodiversity risk (*BIO_RISK*) and the average loan spread (*Spread_AVG*). To ensure comparability, our analysis is confined to firms that have filed for at least one patent in year t . To address the right-skewed distribution of the green patent data, we employ the natural logarithm transformation of the number of green patents filed by the firm (*Ln_GreenPatent*). The green patents are identified

using the patent data source developed by Kogan et al. (2017) and the patent classification system from the OECD.¹⁰

As detailed in Appendix E, the coefficient on the interaction term *BIO_RISK* × *Spread_AVG* is found to be negative and statistically significant at the 1% level. This result implies that for firms with higher biodiversity risk, banks that impose a higher loan spread as a risk premium may inadvertently impede the firm's green innovation efforts, as evidenced by a diminished output of green patents. Conversely, the findings suggest that if banks were to offer more favorable loan terms to firms with biodiversity risk, this could potentially stimulate an increase in the firms' green innovative output. Such banking credit would foster greater productivity in the development of green patents to address the biodiversity issue.

5. Conclusion

The study underscores the critical role of biodiversity risk in the financial sector, particularly in bank lending decisions. The findings indicate that biodiversity loss is not only an environmental concern but also a significant financial risk that can affect the stability of the financial system and the economy at large. Our research contributes to the literature by providing novel evidence that banks price biodiversity risk into their lending decisions. More importantly, we show the nuanced roles of banks for firms identified as Perpetrators or Victims.

Our empirical analysis, utilizing syndicated loan data and firm-level biodiversity risk measures, reveals that the acknowledgment of biodiversity risk in financial reporting is associated with a 35.9 to 54.7 basis-points increase in loan spread. This relationship holds even after controlling for other climate and environmental risks. The use of state-level biodiversity

¹⁰ The source of the patent dataset and green patent. <https://github.com/KPSS2017/Technological-Innovation-Resource-Allocation-and-Growth-Extended-Data>; https://www.oecd-ilibrary.org/environment/measuring-environmental-innovation-using-patent-data_5js009kf48xw-en

lawsuits as an exogenous shock further strengthens the causal inference between biodiversity risk and bank loan pricing.

Moreover, the mechanism tests reveal that top biodiversity-financing banks penalize firms facing regulatory risk but support those confronting physical risk. Besides, relationship lending can mitigate the negative impact of physical risk on loan costs, but it does not have a significant effect on regulatory risk. Additional cross-sectional tests indicate that borrowers with stronger green governance and higher R&D investments tend to face lower loan spreads. This suggests that banks are more willing to support borrowers who actively manage their biodiversity risks and innovate towards sustainability.

Our study responds to the call for further research in the emerging field of biodiversity finance, thereby addressing a significant gap in the current academic discourse. Our results also enhance the broader understanding of risk management practices within the banking industry. The integration of biodiversity considerations into banking regulations and risk management frameworks is highlighted as a policy implication. Furthermore, the research methodology employed in this study, which leverages biodiversity litigation as an exogenous shock, introduces an innovative approach to establishing causality in the relationship between biodiversity risk and bank loan pricing.

In conclusion, the recognition and management of biodiversity risk are essential for both financial institutions and borrowing firms. Considering the increasing trend for biodiversity finance, banks must incorporate biodiversity risk into their lending strategies to mitigate potential financial instability. Meanwhile, firms need to actively manage their biodiversity risk to reduce their cost of capital. Our findings emphasize the need for a collaborative approach between the financial sector and borrowing firms to address the challenges posed by biodiversity loss, ensuring a sustainable and financially stable future.

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Figure 1. The percentage of biodiversity risk across years

The figure shows the percentage of firms mentioning biodiversity risk in 10-K reports across years. The X-axis is the years from 2004 to 2019. The Y-axis is the percentage of biodiversity risk (pct_biocount), which is the number of firms with biodiversity risk divided by the number of firms in year t. The red line is the fitted value of the data points.

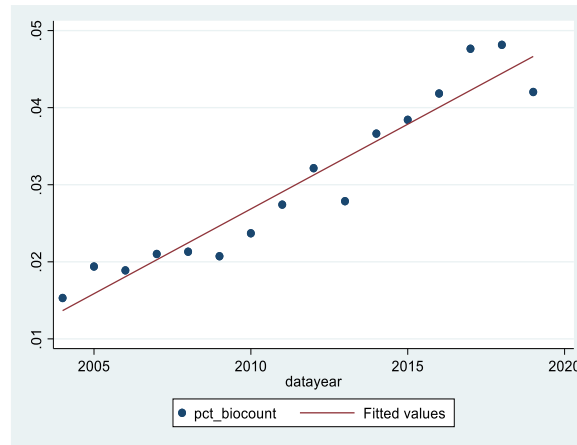


Table 1. Summary statistics

This table shows the summary statistics of the key variables. The sample structure is at the tranche-bank level with 22,991 observations. The table presents both loan-level and firm-level characteristics. *Spread* is calculated as a coupon spread over LIBOR on the drawn amount plus the annual fee (“all-in-spread drawn” in DealScan Database divided by 100). *BIO_RISK* is a dummy variable, which equals one if the firm disclosed biodiversity-related words in the 10-K reports; zero otherwise. All the other variables are defined in Appendix A. All the continuous variables are winsorized at the 1% and 99%.

	Mean	St.Dev	p25	Median	p75
<i>Loan</i>					
<i>Spread (in 100bps)</i>	2.008	1.461	1.000	1.570	2.500
<i>LOG_MATURITY</i>	3.879	0.610	3.611	4.111	4.111
<i>LOG_LOAN_AMOUNT</i>	6.674	1.489	5.565	6.621	7.608
<i>COLLATERAL</i>	0.411	0.492	0.000	0.000	1.000
<i>FIN_COV</i>	0.363	0.481	0.000	0.000	1.000
<i>LOAN_PURPOSE</i>	0.152	0.359	0.000	0.000	0.000
<i>Firm</i>					
<i>BIO_RISK</i>	0.056	0.230	0.000	0.000	0.000
<i>BIO_REG_RISK</i>	0.037	0.188	0.000	0.000	0.000
<i>BIO_PHY_RISK</i>	0.019	0.138	0.000	0.000	0.000
<i>Ln_MV</i>	8.067	1.745	6.605	8.106	9.393
<i>LEV</i>	0.224	0.158	0.116	0.215	0.307
<i>PPE</i>	0.268	0.240	0.089	0.180	0.412
<i>ROA</i>	0.013	0.019	0.004	0.011	0.021
<i>MTB</i>	3.149	4.283	1.389	2.110	3.299
<i>R&D</i>	0.019	0.050	0.000	0.000	0.000

Table 2. Correlation between biodiversity risk and climate change/environmental risk

The table shows the Pearson correlation between biodiversity risk and other climate change and environmental risk measures at the firm-year level. Climate change-related risk measures are from Sautner et al. (2019). Environmental risk is from the RepRisk database. All the other variables are defined in Appendix A. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) <i>BIO_RISK</i>	1.000						
(2) <i>BIO_REG_RISK</i>	0.810***	1.000					
(3) <i>BIO_PHY_RISK</i>	0.577***	-0.012**	1.000				
(4) <i>CC_RISK</i>	0.082***	0.057***	0.060***	1.000			
(5) <i>CC_REG_RISK</i>	0.024***	0.023***	0.008	0.327***	1.000		
(6) <i>CC_PHY_RISK</i>	0.027***	0.005	0.040***	0.055***	0.003	1.000	
(7) <i>ENV_RISK</i>	0.045***	0.053***	0.002	0.050***	0.045***	0.004	1.000

Table 3. Biodiversity risk and loan spread

This table shows the OLS regression of loan spread on firm-level biodiversity disclosure. The dependent variable is the loan tranche spread calculated as coupon spread over LIBOR on the drawn amount plus the annual fee (“all-in-spread drawn” in DealScan Database divided by 100). The variable of interest is the dummy variable *BIO_RISK*, which equals one if the firm disclosed biodiversity-related words in the 10-K reports; zero otherwise. Control variables include loan characteristics and borrower characteristics. Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

<i>Dependent Variable =</i>	<i>Spread</i>			
	(1)	(2)	(3)	(4)
<i>BIO_RISK</i>	0.542*** (3.296)	0.519*** (3.374)	0.547*** (3.737)	0.359** (2.054)
<i>LOG_MATURITY</i>	0.050 (0.840)	0.055 (1.033)	0.080 (1.595)	0.061 (1.076)
<i>LOG_LOAN_AMOUNT</i>	−0.244*** (−4.646)	−0.208*** (−4.621)	−0.215*** (−5.240)	−0.187*** (−3.986)
<i>COLLATERAL</i>	0.385*** (3.692)	0.382*** (3.623)	0.346*** (3.446)	0.248** (2.169)
<i>FIN_COV</i>	−0.519*** (−6.155)	−0.430*** (−5.206)	−0.343*** (−4.290)	−0.368*** (−4.200)
<i>LOAN_PURPOSE</i>	0.357** (2.284)	0.292** (2.166)	0.286** (2.046)	0.171 (1.012)
<i>Ln_MV</i>	0.085 (0.941)	0.066 (0.778)	0.043 (0.594)	0.086 (0.997)
<i>LEV</i>	0.430 (1.238)	0.482 (1.427)	0.401 (1.435)	0.280 (0.786)
<i>PPE</i>	−1.364* (−1.652)	−1.135 (−1.436)	−1.359* (−1.757)	−0.606 (−0.729)
<i>ROA</i>	−0.595 (−0.347)	−1.148 (−0.699)	−0.326 (−0.221)	−0.391 (−0.236)
<i>MTB</i>	0.002 (0.249)	0.001 (0.116)	0.001 (0.151)	0.001 (0.124)
<i>R&D</i>	0.303 (0.741)	0.188 (0.510)	0.070 (0.250)	0.057 (0.140)
Borrower FE	Yes	Yes	Yes	No
Loan Type FE	No	Yes	Yes	Yes
Year FE	Yes	Yes	No	Yes
Lender FE	No	Yes	No	No
Lender × Year FE	No	No	Yes	No
Lender × Borrower FE	No	No	No	Yes
Obs.	22,098	21,816	21,233	19,976
Adj. R ²	0.730	0.764	0.783	0.792

Table 4. Mechanism tests: Nuanced role of bank

This table shows the mechanism tests on regulatory risk v.s. physical risk and banks' heterogeneous influence on the two risks. In Column (1), *BIO_REG_RISK* equals 1 if the firm's biodiversity risk is regulatory risk, 0 otherwise. *BIO_PHY_RISK* equals 1 if the firm's biodiversity risk is physical risk, 0 otherwise. In Column (2), *TOPBIO_FINANCER* is the number of lead/co-lead arrangers that belong to the top 10 banks for biodiversity financing. In Column (3), *RELA_LENDING* is a dummy variable that equals one if the bank was ever the lead arranger for the borrower within the last 5 years; zero otherwise. Control variables include loan characteristics and borrower characteristics. Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

<i>Dependent Variable =</i>	<i>Spread</i>		
	(1)	(2)	(3)
<i>BIO_REG_RISK</i>	0.401*** (2.652)	0.250 (1.556)	0.432*** (2.680)
<i>BIO_PHY_RISK</i>	0.844*** (3.503)	1.822*** (3.814)	0.889*** (3.901)
<i>Equality Test</i>	P=0.118		
<i>BIO_REG_RISK</i> × <i>TOPBIO_FINANCER</i>		0.190*** (3.620)	
<i>BIO_PHY_RISK</i> × <i>TOPBIO_FINANCER</i>		-0.960*** (-3.374)	
<i>Equality Test</i>		P=0.0001	
<i>BIO_REG_RISK</i> × <i>RELA_LENDING</i>			-0.110 (-1.328)
<i>BIO_PHY_RISK</i> × <i>RELA_LENDING</i>			-0.515*** (-4.590)
<i>Equality Test</i>			P=0.0007
<i>TOPBIO_FINANCER</i>		-0.071** (-1.968)	
<i>RELA_LENDING</i>			0.017 (0.361)
Borrower FE	Yes	Yes	Yes
Loan Type FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Lender FE	Yes	Yes	Yes
Obs.	21,816	21,816	21,816
Adj. R ²	0.776	0.768	0.765

Table 5. Identification: Biodiversity lawsuit

The table shows the effect of state-level biodiversity lawsuits on the bank loan spread. In Panel A, *BIO_LAWSUIT* equals one if the borrower's headquarters is located in the state that is affected by the biodiversity lawsuits after the initiation of the litigation; zero otherwise. In Panel B, we conduct dynamic analysis to examine the pre-trend of the staggered DID design. We use the dummy variable of biodiversity lawsuit before and after the event. For example, *BIO_LAWSUIT* ($t-1$) is the indicator that equals one if the firm state is involved in a biodiversity lawsuit in one year. Control variables include loan characteristics and borrower characteristics. Standard errors are clustered at the firm level, and the corresponding t -statistics are included in parentheses. Levels of significance are presented as follows: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Panel A. Biodiversity lawsuit and loan spread

<i>Dependent Variable =</i>	<i>Spread</i>
	(1)
<i>BIO_LAWSUIT</i>	-0.534** (-2.444)
<i>LOG_MATURITY</i>	0.065 (1.231)
<i>LOG_LOAN_AMOUNT</i>	-0.212*** (-4.680)
<i>COLLETERAL</i>	0.379*** (3.699)
<i>FIN_COV</i>	-0.402*** (-4.813)
<i>LOAN_PURPOSE</i>	0.294** (2.175)
<i>Ln_MV</i>	0.044 (0.500)
<i>LEV</i>	0.403 (1.261)
<i>PPE</i>	-1.167 (-1.399)
<i>ROA</i>	-1.067 (-0.653)
<i>MTB</i>	0.001 (0.107)
<i>R&D</i>	0.266 (0.717)
Borrower FE	Yes
Loan Type FE	Yes
Year FE	Yes
Lender FE	Yes
Obs.	21,816
Adj. R ²	0.764

Panel B. Dynamic analysis

<i>Dependent Variable =</i>	<i>Spread</i>
	(1)
<i>BIO_LAWSUIT</i> ($\leq t-3$)	-0.059 (-0.153)
<i>BIO_LAWSUIT</i> ($t-2$)	0.451 (0.935)
<i>BIO_LAWSUIT</i> ($t-1$)	0.604 (1.540)
<i>BIO_LAWSUIT</i> (t)	-0.703** (-2.192)
<i>BIO_LAWSUIT</i> ($t+1$)	-0.382 (-1.020)
<i>BIO_LAWSUIT</i> ($t+2$)	-0.528** (-2.346)
Controls	Yes
Borrower FE	Yes
Loan Type FE	Yes
Year FE	Yes
Lender FE	Yes
Obs.	21,816
Adj. R ²	0.766

Table 6. Borrower characteristics: Green governance and innovation

This table shows the cross-sectional tests based on borrower characteristics. Column (1) shows the effect of green governance proxied by ESG-oriented Investors. *ESG_IOR* is the institutional ownership ratio of borrowers based on the value-weighted ESG scores of their portfolio holdings. Column (2) shows the effect of R&D decile rankings. Control variables include loan characteristics and borrower characteristics. Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

<i>Dependent Variable =</i>	<i>Spread</i>	
	(1)	(2)
<i>BIO_RISK</i>	0.794*** (3.951)	0.666*** (3.790)
<i>ESG_IOR</i>	−0.031 (−0.039)	
<i>BIO_RISK</i> × <i>ESG_IOR</i>	−9.432*** (−4.397)	
<i>R&D_RANK</i>		−0.003 (−0.172)
<i>BIO_RISK</i> × <i>R&D_RANK</i>		−0.140*** (−2.841)
Borrower FE	Yes	Yes
Loan Type FE	Yes	Yes
Year FE	Yes	Yes
Lender FE	Yes	Yes
Obs.	18,739	21,816
Adj. R ²	0.774	0.764

Table 7. Additional controls of climate change risk and environmental risk

This table shows the robustness test after controlling for climate change risk and other environmental risk measures. *CC_RISK* is the climate change risk measure used by Sautner et al. (2019) based on climate change contents disclosed in a conference call. *ENV_RISK* is the risk measure offered by the RepRisk database multiplied by the percentage of environmental-related issues. Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

<i>Dependent Variable =</i>	<i>Spread</i>	
	(1)	(2)
<i>BIO_RISK</i>	0.451*** (3.174)	0.722** (2.084)
<i>CC_RISK</i>	0.290 (0.977)	0.401 (1.208)
<i>ENV_RISK</i>		0.025* (1.826)
Controls	Yes	Yes
Borrower FE	Yes	Yes
Loan Type FE	Yes	Yes
Year FE	Yes	Yes
Lender FE	Yes	Yes
Obs.	19,419	11,021
Adj. R ²	0.776	0.807

Table 8. Robustness tests

This table shows two robustness tests for the OLS regression in Table 3. For Panel A, we replace the *Spread* with the *Net Spread* calculated as the spread minus the up-front fee, following Ivashina (2009). In Panel B, we aggregate the sample into the borrower firm-year sample structure. Loan characteristics are averaged for each firm-year observation, indicated by the suffix (*_AVG*). Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

Panel A. Spread net upfront fee

<i>Dependent Variable =</i>	<i>Net Spread</i>			
	(1)	(2)	(3)	(4)
<i>BIO_RISK</i>	0.456*** (2.723)	0.422*** (2.728)	0.418*** (2.916)	0.303* (1.912)
Controls	Yes	Yes	Yes	Yes
Borrower FE	Yes	Yes	Yes	No
Loan Type FE	No	Yes	Yes	Yes
Year FE	Yes	Yes	No	Yes
Lender FE	No	Yes	No	No
Lender × Year FE	No	No	Yes	No
Lender × Borrower FE	No	No	No	Yes
Obs.	22,098	21,816	21,233	19,976
Adj. R ²	0.714	0.747	0.770	0.773

Panel B. Firm-year sample

<i>Dependent Variable =</i>	<i>Spread_AVG</i>	
	(1)	(2)
<i>BIO_DISCLOSE</i>	0.344** (2.158)	0.430** (2.442)
<i>LOG_MATURITY_AVG</i>		0.032 (0.303)
<i>LOG_LOAN_AMOUNT_AVG</i>		−0.268*** (−5.624)
<i>COLLETERAL_AVG</i>		0.409*** (3.459)
<i>FIN_COV_AVG</i>		−0.592*** (−5.540)
<i>LOAN_PURPOSE_AVG</i>		0.356** (2.414)
<i>Ln_MV</i>		−0.010 (−0.098)
<i>LEV</i>		0.307 (0.629)
<i>PPE</i>		−0.681 (−0.829)
<i>ROA</i>		−1.182* (−1.715)
<i>MTB</i>		0.011 (0.753)
<i>R&D</i>		−4.334 (−0.996)
Borrower FE	Yes	Yes
Year FE	Yes	Yes
Obs.	1,207	1,154
Adj. R ²	0.602	0.652

Appendix A: Variable definition

Variable	Definition
<i>BIO_RISK</i>	A dummy variable equals one if the firm disclosed biodiversity-related words in the 10-K reports; zero otherwise. The data follows Giglio et al. (2023) from the author's website http://www.biodiversityrisk.org/download/
<i>BIO_REG_RISK</i>	A dummy variable equals one if the disclosed biodiversity risk is regarding regulatory risk; zero otherwise. The data follows Giglio et al. (2023) from the author's website http://www.biodiversityrisk.org/download/
<i>BIO_PHY_RISK</i>	A dummy variable equals one if the disclosed biodiversity risk is regarding physical risk but not regulatory risk; zero otherwise. Specifically, <i>BIO_PHY_RISK</i> equals one if <i>BIO_RISK</i> equals one but <i>BIO_REG_RISK</i> equals zero.
<i>BIO_LAWSUIT</i>	A dummy variable equals one if the borrower's headquarters is located in the state that is affected by the biodiversity lawsuit after the initiation of the litigation; zero otherwise.
<i>CC_RISK</i>	Climate change risk measure from Sautner et al. (2023). It is the relative frequency with which bigrams related to climate change are mentioned together with the word "risk" or "uncertainty" (or synonyms thereof) in one sentence in the transcripts of earnings conference calls. It is the number of such bigrams divided by the total number of bigrams in the transcripts.
<i>CC_REG_RISK</i>	Climate change risk measure related to regulation from Sautner et al. (2023). The relative frequency with which bigrams that capture regulatory shocks related to climate change risk occur in the transcripts of earnings conference calls. It is the number of such bigrams divided by the total number of bigrams in the transcripts.
<i>CC_PHY_RISK</i>	Climate change risk measure related to physical risk from Sautner et al. (2023). The relative frequency with which bigrams that capture physical shocks related to climate change risk occur in the transcripts of earnings conference calls. It is the number of such bigrams divided by the total number of bigrams in the transcripts.
<i>ENV_RISK</i>	Environmental risk measured by RepRisk. Using the risk score multiply the environmental percentage.
<i>Spread</i>	The loan tranche spread is calculated as coupon spread over LIBOR on the drawn amount plus the annual fee ("all-in-spread drawn" in DealScan Database divided by 100).
<i>LOG_MATURITY</i>	Loan maturity is calculated as a logarithm of maturity (months) of each loan tranche.
<i>LOG_LOAN_AMOUNT</i>	Loan size is calculated as the logarithm of the loan amount (in \$million) of each loan tranche.
<i>COLLETERAL</i>	An indicator variable that takes the value of one if a given loan tranche is collateralized, and zero otherwise.
<i>FIN_COV</i>	An indicator variable that takes the value of one if a given loan tranche is attached to any financial covenant, and zero otherwise.

<i>LOAN_PURPOSE</i>	An indicator variable that takes the value of one if the main purpose of a loan tranche belongs to one of the following: acquisition, MBO, takeover or recapitalization, and zero otherwise.
<i>Ln_MV</i>	Borrower's market value, calculated as the logarithm of stock price multiply the number of shares outstanding.
<i>LEV</i>	Borrower's leverage ratio, calculated as the long-term debt scaled by total assets.
<i>PPE</i>	Borrower's tangible assets are calculated as the net PPE scaled by total assets.
<i>ROA</i>	The borrower's ROA is calculated as the income before extraordinary items scaled by total assets.
<i>MTB</i>	Borrower's market-to-book ratio. Market value is calculated as the number of outstanding shares multiplied by the stock price at the end of the year (year-quarter). Book value is the book value of equity at the end of the year (year-quarter).
<i>R&D</i>	Borrower's R&D expenditure is calculated as R&D scaled by total revenue.
<i>R&D_RANK</i>	Decline ranking or R&D expenditure within the sample.
<i>TOPBIO_FINANCER</i>	A number of arrangers/co-arrangers for each loan tranche that belongs to the top 10 banks with biodiversity exposure. Biodiversity top bank list is from https://www.banktrack.org/article/bankrolling_extinction_the_top_10_banks_financing_biodiversity_loss
<i>RELA_LENDING</i>	The dummy variable equals one if the bank was ever the lead bank for the borrower within the last 5 years; zero otherwise.
<i>ESG_IOR</i>	ESG-oriented investors' ownership ratio according to the value-weighted ESG scores (from the MSCI KLD database) of their portfolio holdings, following Cao et al. (2023).
<i>Net Spread</i>	Spread minus the up-front fee.
<i>Spread_AVG</i>	Loan spread aggregated at firm-year level. If other loan characteristics are also averaged for each firm-year, it is also indicated by the suffix (<i>_AGV</i>)
<i>Ln_GreenPatent</i>	The natural log transformation of the number of green patents (<i>Ln_GreenPatent</i>). Green patents are derived from the patent data source developed by Kogan et al. (2017) and then matched with the patent classification from the OECD. The source of the patent dataset and green patent. https://github.com/KPSS2017/Technological-Innovation-Resource-Allocation-and-Growth-Extended-Data ; https://www.oecd-ilibrary.org/environment/measuring-environmental-innovation-using-patent-data_5js009kf48xw-en

Appendix B. Examples of biodiversity risk in 10-K reports

Example 1. Perpetrators: Transition risk of biodiversity loss (AES Corporation, 2019)

Our businesses are subject to stringent environmental laws and regulations by many federal, regional, state and local authorities, international treaties and foreign governmental authorities. These laws and regulations generally concern emissions into the air, effluents into the water, use of water, wetlands preservation, remediation of contamination, waste disposal, **endangered species** and noise regulation. Failure to comply with such laws and regulations or to obtain or comply with any associated environmental permits could result in fines or other sanctions. For example, in recent years, the EPA has issued notices of violation (NOVs) to a number of coal-fired

Example 2. Victims: Physical risk of biodiversity loss (American Water Works Company, 2018)

Our ability to meet the existing and future water demands of our customers depends on an adequate water supply. Drought, governmental restrictions, overuse of sources of water, **the protection of threatened species or habitats**, contamination, or other factors may limit the availability of ground and surface water. We employ a variety of measures in an effort to obtain adequate sources of water supply, both in the short-term and over the long-term. The geographic diversity of our service areas may mitigate some of the economic effect on the water supply associated with weather extremes we might encounter in any particular service territory. For example, in any given summer, some areas may experience drier than average weather, which may reduce the amount of source water available, while other areas we serve may experience wetter than average weather.

Appendix C: Case summary of biodiversity lawsuits

State	Petition Year	Lawsuit (s)
California	2007	<i>Center for Biological Diversity v. California Department of Fish and Game Commission</i>
	2009	<i>Center for Biological Diversity v. California Public Utilities Commission</i>
	2009	<i>Center for Biological Diversity v. California Department of Forestry</i>
	2009	<i>Center for Biological Diversity v. Town of Yucca Valley</i>
	2008	<i>Center for Biological Diversity v. City of Desert Hot Springs</i>
	2010	<i>Center for Biological Diversity v. California Department of Forestry and Fire Protection</i>
North Carolina	2010	<i>Center for Biological Diversity v. Department of Fish and Wildlife</i>
Massachusetts	2010	<i>Defenders of Wildlife v. North Carolina Department of Transportation</i>
Massachusetts	2017	<i>Conservation Law Foundation v. Department of Environmental Protection</i>
	2017	<i>Center for Biological Diversity v. U.S. Fish & Wildlife Service (for Arizona endangered species)</i>

Appendix D: Validation test of biodiversity lawsuits and biodiversity risk

This table shows the results of the validation test of the impact of biodiversity lawsuits on firm-level biodiversity risk. The regression analysis is conducted at the firm-year level and adds firm and year-fixed effects. Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

<i>Dependent Variable =</i>	<i>BIO_RISK</i>
	(1)
<i>BIO_LAWSUIT</i>	−0.013** (−2.459)
<i>Ln_MV</i>	−0.000 (−0.230)
<i>LEV</i>	−0.007 (−0.682)
<i>PPE</i>	0.005 (0.208)
<i>ROA</i>	−0.030*** (−2.810)
<i>MTB</i>	−0.000 (−0.528)
<i>R&D</i>	−0.035** (−2.408)
Firm & Year FE	Yes
Obs.	39,376
Adj. R ²	0.555

Appendix E: Consequence on green innovation output

This table represents the consequence test on firms' green innovation output. The dependent variable is the natural logarithm of the number of green patents filed by the firm (*Ln_GreenPatent*). For comparability, we restrict the test to the firms that have at least one patent filed. Standard errors are clustered at the firm level, and the corresponding *t*-statistics are included in parentheses. Levels of significance are presented as follows: **p*<0.1; ***p*<0.05; ****p*<0.01.

<i>Dependent Variable =</i>	<i>Ln_GreenPatent</i>
	(1)
<i>BIO_RISK</i> × <i>Spread_AVG</i>	−0.325*** (−3.565)
<i>BIO_RISK</i>	0.470 (0.843)
<i>Spread_AVG</i>	0.006 (0.114)
<i>Ln_MV</i>	−0.037 (−0.272)
<i>LEV</i>	−0.999* (−1.835)
<i>PPE</i>	−0.457 (−0.304)
<i>ROA</i>	−1.982* (−1.698)
<i>MTB</i>	0.019** (2.124)
<i>R&D</i>	−7.024* (−1.778)
Firm & Year FE	Yes
Obs.	362
Adj. R ²	0.812