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Nature at Risk, Finance at Stake: A Systematic Literature Review of Biodiversity Risk in Finance Research

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ABSTRACT

Biodiversity-related financial risk is increasingly recognized not only as a market concern but as an ethical and systemic imperative for businesses and financial institutions. This systematic literature review synthesizes 103 peer-reviewed studies to examine how biodiversity risk is conceptualized, measured, and integrated within financial research. While awareness of biodiversity as a systemic financial risk is expanding, the field remains theoretically fragmented and methodologically uneven. Four dominant themes emerge: financial materiality, visibility and recognition, governance and accountability, and levels of analysis. Building on these findings, the review introduces an eco-financial transmission framework that connects biodiversity loss to financial exposure through valuation, governance, and disclosure channels. It further underscores the moral responsibility of financial actors to embed biodiversity into investment practices, ESG strategies, and regulatory design. By integrating ecological economics with ethical finance, this review advances a conceptual foundation for a financial system that not only mitigates biodiversity risk but also supports long-term ecological resilience.

1 | Introduction

How is biodiversity-related risk understood, measured, and integrated within financial research, and what are the key pathways for advancing this emerging field? This question guides the present systematic literature review (SLR). The research seeks to consolidate and critically examine the existing academic knowledge of biodiversity risk in finance and draw future research avenues in the same.

Biodiversity finance refers to the mobilization of public and private financial resources to support the conservation, restoration, and sustainable use of biodiversity.[1] More than a niche concern, biodiversity risk or more broadly, nature-related risk, is now widely recognized as a systemic financial risk (Gardes-Landolfini et al. 2024), capable of disrupting global markets, impairing asset values, and threatening macroeconomic stability. As ecosystems deteriorate, the services they provide, for example, pollination, water purification, soil health, and climate regulation, are diminished, creating cascading effects across sectors, portfolios, and economies (Karolyi and Tobin-de la Puente 2023; Nedopil 2023).

However, addressing biodiversity risk is not merely a financial imperative; it is also an ethical obligation (Boiral and Heras-Saizarbitoria 2017). Business ethics underscores the duty of financial actors to account for environmental impact in their decision-making, recognizing that their investments can either contribute to ecological degradation or foster sustainability (Eccles et al. 2014). The principles of corporate social

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responsibility and ethical finance advocate for integrating biodiversity considerations into managerial decision-making (Kopnina et al. 2024), ensuring that economic activities do not exacerbate ecological harm. Financial institutions, investors, and policymakers must therefore adopt ethical frameworks that balance profitability with environmental stewardship, fostering long-term resilience and sustainability.

Despite its material relevance, biodiversity risk remains underrepresented in financial research compared to climate-related risks. Recent bibliometric evidence reveals that biodiversity finance is highly fragmented across disciplines, with limited theoretical coherence and few finance-led solutions (Hutchinson and Lucey 2024). This fragmentation has left investors and regulators without standardized valuation tools, consistent risk frameworks, or robust empirical data to price biodiversity-related exposures. As a result, biodiversity loss, although an existential threat to economic stability and responsible for risks to over half of global GDP (Flammer et al. 2025), is weakly integrated into financial decision-making and disclosure practices. The field also lacks standardized metrics, integrated valuation tools, and consistent theoretical framing (Garel et al. 2024). In most ESG frameworks and disclosure practices, biodiversity is often treated as subordinate to climate concerns (Kopnina et al. 2024). The research gap has tangible consequences: investors struggle to assess exposure to biodiversity-related risks (Giglio et al. 2025; Taskforce on Nature-Related Financial Disclosures 2025), regulators face challenges in designing effective accountability mechanisms (Financial Stability Board 2024; Network for Greening the Financial System 2024), and society bears the long-term cost of ecosystem degradation (Dasgupta 2021). Addressing these gaps is therefore critical not only for market stability but also for sustaining ecological and social resilience. Recent initiatives such as the Taskforce on Nature-Related Financial Disclosures (TNFD) and the Kunming–Montreal Global Biodiversity Framework have brought new urgency and visibility to this topic, spurring a wave of empirical and conceptual inquiry.[2] These initiatives align with ethical business principles, advocating for transparency, accountability, and proactive risk management in financial decision-making.

This SLR analyses 103 peer-reviewed journal articles to evaluate how biodiversity-related financial risk is conceptualized, assessed, and governed. Moving beyond descriptive classification, the review develops an eco-financial transmission framework that connects biodiversity loss to financial risk through reinforcing channels: valuation, governance, and disclosure. It integrates insights from ecological economics, systemic-risk theory, and corporate governance. In parallel, it also grounds biodiversity accountability in explicit ethical traditions to show that biodiversity risk is not only an exposure but also a question of moral duty and institutional virtue.

The research identifies four interrelated themes shaping the literature: (1) financial materiality of biodiversity risk; (2) biodiversity risk recognition and visibility; (3) governance and accountability mechanisms; and (4) level of biodiversity risk analysis (including firm, sector, portfolio, macroeconomics, and conceptual level analyses). Each theme is assessed for its methodological robustness, geographic scope, sectoral focus, and contribution to theory and practice. Through these themes, it evaluates methodological robustness and theoretical depth, situating biodiversity risk in finance research as an emerging interdisciplinary field linking environmental limits with financial stability.

Recent reviews have advanced the biodiversity risk–finance agenda but with different emphases. Hutchinson and Lucey (2024) offer a bibliometric overview of biodiversity finance by mapping conservation finance, green bonds, and ecosystem services without systematically interrogating financial risk typologies or governance mechanisms. Karolyi and Tobin-de la Puente (2023) outline a conceptual research agenda but do not synthesize empirical evidence on biodiversity-related financial risk. Coqueret et al. (2025) focus narrowly on biodiversity's pricing effects in equity markets. In contrast, this review systematically consolidates the biodiversity risk in financial literature and advances from classification to conceptual synthesis, integrating ecological and ethical dimensions with financial analysis. By doing so, it contributes a theory-led, risk-focused synthesis that positions biodiversity loss as both an ecological boundary and a financial transmission mechanism.

2 | Research Framework and Methodology

In this study, we employ the SLR methodology to examine existing research on the biodiversity risk in finance research (Tranfield et al. 2003). We adopt the SLR framework and approach proposed by researchers in sustainability, especially in biodiversity to ensure transparency, replicability, and methodological rigor (Borghei 2021; Fatima and Elbanna 2023; Keckel et al. 2025; Mahran and Elamer 2023; Roberts, Hassan, et al. 2021).

The publication sample is collected from two leading academic databases: Scopus and Web of Science (Borghei 2021; Donthu et al. 2021). The detailed review process is illustrated in Figure 1. While gray literature and practitioner reports (e.g., TNFD, WWF, WEF) offer valuable policy insights, these were excluded to maintain research quality (Donthu et al. 2021; Snyder 2019; Tranfield et al. 2003). This approach aligns with prior systematic reviews in sustainability accounting and finance (Mahran and Elamer 2023), which similarly limited inclusion to peer-reviewed journal articles to maintain quality standards. Our keyword search strategy is based on a combination of the terms “biodiversity risk” and “finance”[3] (Borghei 2021; Mahran and Elamer 2023) to ensure comprehensive coverage and minimize the risk of omitting relevant articles. We also utilized the Biodiversity Dictionary developed by Giglio et al. (2025) in related research on biodiversity risk and finance, to refine the biodiversity risk keyword group in our search strategy.

Each stage of the PRISMA protocol is systematically applied to ensure transparency and replicability. During the identification phase, relevant studies are retrieved from Scopus and Web of Science using predefined keyword combinations. The identification and screening phases involve removing duplicates,

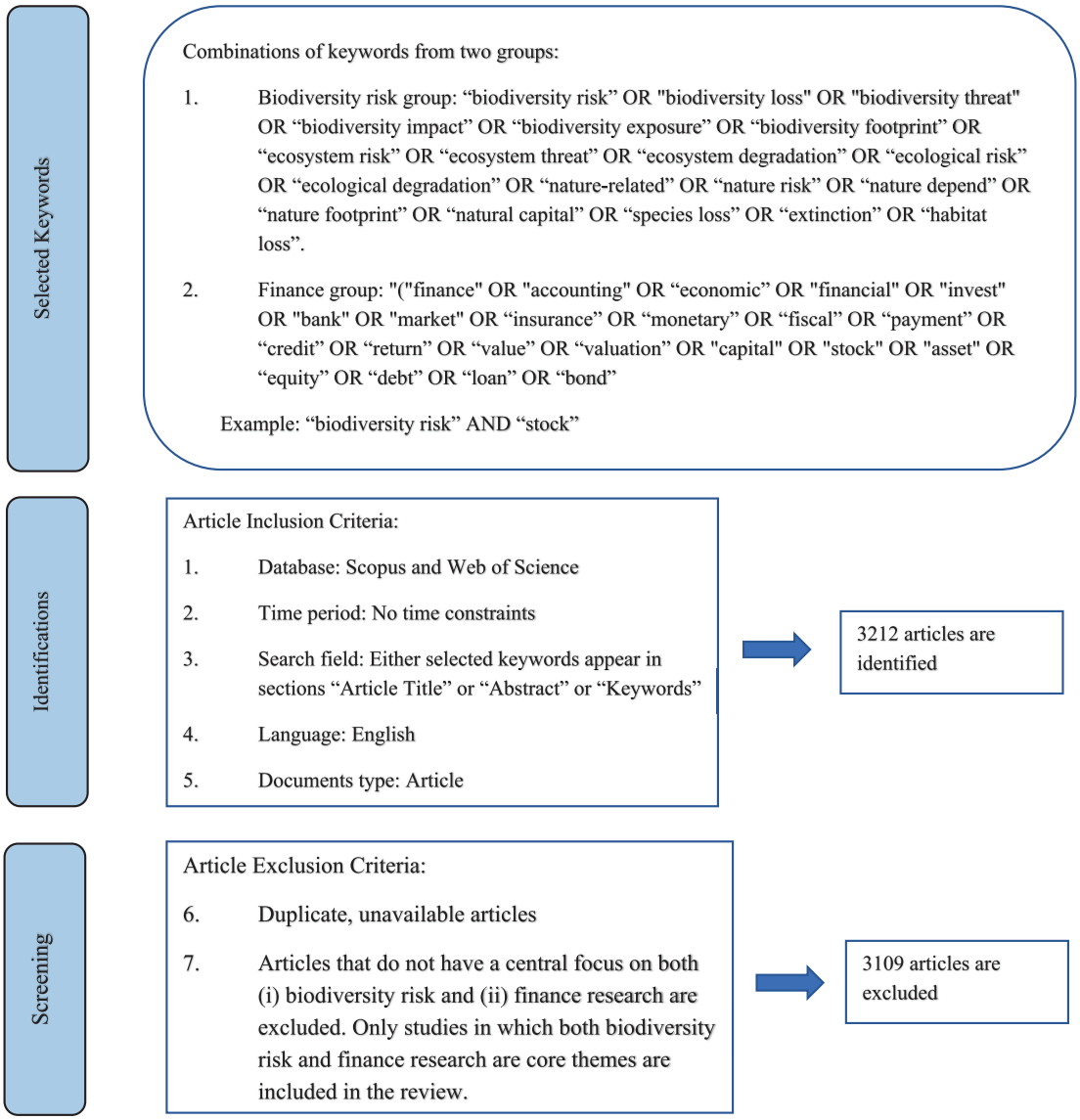

FIGURE 1 | PRISMA research framework for finance research on biodiversity risk.

non-English, and nonacademic sources, with no time restrictions applied[4] (Fatima and Elbanna 2023; Ibrahim et al. 2022; Roberts, Hassan, et al. 2021). In the eligible phase, abstracts and full texts are manually reviewed to confirm that studies explicitly addressed biodiversity risk within a financial context. The final sample consists of 103 research articles.

In the final stage, we apply a coding framework to classify the articles through the deductive approach. It is based on key attributes such as publication year, authorship, title, research objective, geographical context, theoretical framework, journal, methodology, and main findings (Borghei 2021; Gaur and Kumar 2018; Gillan et al. 2021; Hutchinson and Lucey 2024; Karolyi and Tobin-de la Puente 2023; Mahran and Elamer 2023). The analysis showed that most studies addressed one or multiple of the following core dimensions: financial materiality of biodiversity risk, biodiversity risk recognition and visibility, governance and accountability for biodiversity risk, and level of biodiversity risk analysis.

3 | Results

3.1 | Descriptive Analysis of Articles Published Across Academic Journals

To understand the academic attention towards biodiversity risk in finance research, we first conducted a quantitative review of publication outlets and temporal distribution (Pisani et al. 2017; Roberts, Hassan, et al. 2021).

3.1.1 | Distribution by Journal

Figure 2 illustrates the spread of 103 articles across 51 academic journals. The most prominent journal is *Business Strategy and the Environment*, which accounts for 18 articles, demonstrating its leading role in bridging biodiversity and corporate sustainability within financial discourse. This is followed by *Finance Research Letters* (eight articles), *Ecological Economics* (seven

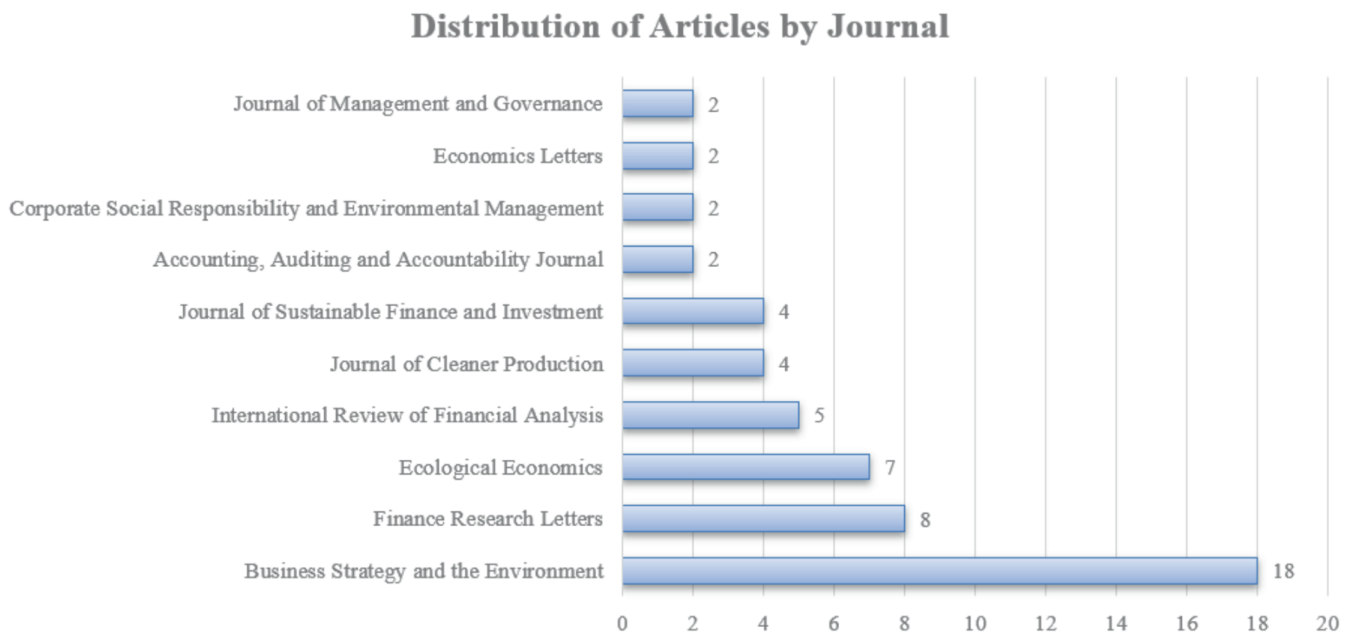

FIGURE 2 | Distribution of articles by academic journal. *Source:* Scopus and Web of Science (WoS).

articles), and *International Review of Financial Analysis* (five articles). Notably, over 33 journals have published only a single article on this topic. This fragmentation signals an early stage of academic consolidation, suggesting the topic is still dispersed across various subfields and lacks a dedicated scholarly home. Given the growing urgency of biodiversity loss, there is a clear opportunity for the field to coalesce through special issues or themed collections in key journals.

In terms of journal-level influence, *Business Strategy and the Environment* stands out as the most influential outlet in biodiversity risk and finance research, recording the highest citation count (393) as demonstrated in Table 1. It is followed by *Ecological Economics* (304) and *Accounting, Auditing and Accountability Journal* (262), which together shape much of the field's current thinking on sustainability, biodiversity valuation, and corporate accountability. The most cited studies, including problematizing accounting for biodiversity and crop biodiversity, risk management, and the implications of agricultural assistance, reflect the field's continuing orientation toward governance and ecological economics rather than financial modeling. Although biodiversity risk has increasingly entered the finance literature, journals in core finance areas remain limited among the most cited, suggesting that biodiversity risk research is still consolidating its presence within mainstream financial scholarship.

3.1.2 | Temporal Distribution

As shown in Figure 3, publication activity remained minimal until the mid-2010s, with less than five articles per year up to 2012. Early contributions, such as those in 1997, 2005, and 2007, were sporadic and largely conceptual or exploratory. A notable inflexion occurs from 2023 onward, with 19 publications in 2023, followed by a surge to 28 articles in 2024. By April 2025, 21 papers have been published. This sharp acceleration may be attributed to the mainstreaming of biodiversity risk within global financial regulation, particularly in response to TNFD and the adoption of the Kunming–Montreal Global Biodiversity Framework.

3.1.3 | Distribution by Methodology and Theory Applied

Biodiversity risk in finance research remains methodologically and theoretically unbalanced. Table 2 shows that quantitative approaches, especially panel econometrics (38 studies), event studies, and asset pricing models, dominate the field, reinforcing its financial and econometric orientation. Mixed-method and qualitative designs, such as content analysis and interviews, appear less frequently but contribute important insights into disclosure, accountability, and stakeholder engagement. Conceptual and theoretical papers (21 studies) form a growing yet secondary stream, often proposing integrative frameworks rather than empirical validation. Theoretical foundations are led by stakeholder, legitimacy, and institutional theories, while ecological and ethical perspectives remain peripheral. This concentration on financial materiality underscores the field's analytical maturity but limits interdisciplinary depth.

3.2 | Geographic Distribution of Publications

In our sample, 54 studies employ cross-border samples, which supports a strong preference for generalized, globally relevant insights (Ibrahim et al. 2022). However, there is evidence of country-specific studies, e.g., the United States 13 publications, followed by the United Kingdom (9), China (7), South Africa (7), and the broader European region (7), Australia (4). The dominance of publications from the United States, the United Kingdom, Australia, and Europe, as illustrated in Figure 4, aligns with previous studies (Hutchinson and Lucey 2024),

TABLE 1 | Distribution of top cited journals and publications in biodiversity risk and finance research.

Top cited journal		Top cited publications		
Journal	**Total citations**	**Publication**	**Journal**	**Total citations**
Business Strategy and the Environment	393	Problematising Accounting for Biodiversity	*Accounting, Auditing and Accountability Journal*	176
Ecological Economics	304	Crop Biodiversity, Risk Management and the Implications of Agricultural Assistance	*Ecological Economics*	170
Accounting, Auditing and Accountability Journal	262	European Firms' Corporate Biodiversity Disclosures and Board Gender Diversity From 2002 to 2016	*British Accounting Review*	139
British Accounting Review	139	Biodiversity and Threatened Species Reporting by the Top Fortune Global Companies	*Accounting, Auditing and Accountability Journal*	86
Journal of Management and Governance	84	Exploring Factors Relating to Extinction Disclosures: What Motivates Companies to Report on Biodiversity and Species Protection?	*Business Strategy and the Environment*	84
Oxford Review of Economic Policy	72	Biodiversity Pressure and the Driving Forces Behind	*Ecological Economics*	73
Journal of Cleaner Production	63	The Evolution of Corporate No Net Loss and Net Positive Impact Biodiversity Commitments: Understanding Appetite and Addressing Challenges	*Business Strategy and the Environment*	60
Journal of Sustainable Finance and Investment	61	Inorganic Fertiliser Use and Biodiversity Risk: An Empirical Investigation	*Ecological Economics*	56
Technological Forecasting and Social Change	51	Organisational Structure, Innovation Performance and Customer Relationship Value in the Greek Advertising and Media Industry	*Journal of Business and Industrial Marketing*	50
Journal of Business and Industrial Marketing	50	The Interaction of Climate Risk and Bank Liquidity: An Emerging Market Perspective for Transitions to Low Carbon Energy	*Technological Forecasting and Social Change*	50

while contributions from emerging countries remain limited. This geographic distribution of publications reveals a strong bias towards Global North contexts, with the majority of studies conducted in the United States, the United Kingdom, and Europe. Of the 103 reviewed papers, approximately two-thirds are based in or use data from developed economies, reflecting the dominance of advanced financial systems and greater data availability. In contrast, Global South regions, including biodiversity-rich countries such as Brazil, South Africa, and China, account for a much smaller share of research, typically focusing on disclosure and governance rather than financial modeling or risk quantification. The findings further indicate a clear divergence between contexts: studies in developed economies treat biodiversity risk as financially material and quantifiable, while those in emerging economies emphasize governance, legitimacy, and ethical accountability, reflecting institutional and data constraints. This imbalance underscores the need for more context-specific, empirical research in emerging markets where biodiversity loss and financial exposure are often most acute.

3.3 | Methodological Landscape of Biodiversity Finance Research

This section critically reviews the landscape of empirical and conceptual approaches in the literature, drawing attention to their scope, depth, and limitations.

3.3.1 | Methodological Approaches in Biodiversity Risk–Finance Research

Quantitative, finance-oriented methods dominate biodiversity risk research, particularly where risk is conceptualized as affecting firm valuation, investor behavior, asset pricing, or financial stability (Coqueret et al. 2025; Garel et al. 2024). This dominance reflects the broader integration of sustainability concerns into financial economics frameworks, where the quantification of market reactions, pricing anomalies, and firm-level outcomes remains central.

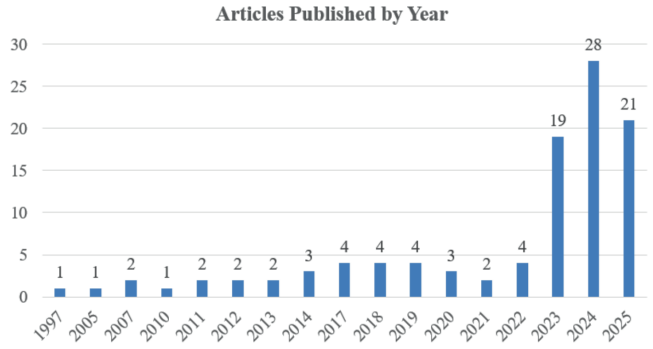

FIGURE 3 | Articles published by year *Source:* Scopus and Web of Science (WoS).

The most widely used methodologies are summarized in Table 3 alongside the main purposes they serve in biodiversity finance research. The key papers selected represent seminal, methodologically rigorous contributions that either introduced, validated, or substantially expanded specific empirical approaches to measuring biodiversity risk in financial contexts.

3.3.2 | Metrics for Measuring Biodiversity Risk: Impact-Based vs. Disclosure-Based Approaches

Quantifying biodiversity risk in finance research hinges not only on modeling techniques but also on the metrics used to represent exposure (Karolyi and Tobin-de la Puente 2023). These are typically drawn from disclosure systems, text analytics, and ecological footprint tools, reflecting varying conceptions of biodiversity as either a measurable externality or a disclosure-driven reputational risk. Biodiversity risk metrics fall into two broad categories:

- Impact-based metrics (e.g., PDF, MSA, nSTAR), which focus on biodiversity degradation linked to firm activities or supply chains.
- Disclosure-based metrics (e.g., RepRisk, natural language processing [NLP] from 10-Ks, TNFD alignment), which assess how biodiversity risks are perceived, disclosed, or governed.

Impact-based approaches rely on ecological indicators such as MSA, PDF, and STAR/nSTAR, integrated into tools like BFFI and GBS. These are used to measure biodiversity loss linked to corporate activities and portfolios. Ma et al. (2024) apply MSA-based input–output modeling to estimate sectoral biodiversity footprints, while Layman et al. (2024) and Garel et al. (2024) incorporate STAR and factor-based models to evaluate species risk and transition exposure. Coqueret et al. (2025) extend this to asset pricing by constructing a biodiversity risk factor link.

Disclosure-based metrics assess how biodiversity risk is communicated, governed, or priced in financial markets. A foundational study by Giglio et al. (2025) introduces a BERT-based NLP approach to quantify biodiversity and regulatory risk salience in corporate 10-K filings, demonstrating its predictive power for asset pricing, option volatility, and stock returns. This methodology has shaped subsequent work. Liang et al. (2024) apply it to model biodiversity-related crash risk. Bach et al. (2025) use sentiment-adjusted biodiversity disclosure scores to examine the performance and cost structures of US firms. Ma et al. (2024) build biodiversity risk indices from Chinese media, refining Giglio's lexicon to capture localized perceptions of physical and transition risk to negative return premia in exposed sectors. Complementary methods include RepRisk incident scores and frameworks like TNFD and ENCORE, which standardize risk disclosure and ecosystem dependency mapping. Azizi et al. (2025), Anthony and Morrison-Saunders (2023), and He et al. (2024) use structured content analysis to evaluate biodiversity reporting across firms, revealing gaps in materiality, sector alignment, and regulatory influence. While disclosure metrics offer scalability and timeliness, they face challenges in ecological accuracy and cross-firm comparability.

3.4 | Theoretical Framing of Biodiversity Risk

Biodiversity risk in finance research spans diverse theoretical traditions, with financial economics at the forefront. Asset pricing and portfolio theory underpin efforts to quantify biodiversity risk premia, particularly in biodiversity-intensive sectors. Coqueret et al. (2025) embed biodiversity exposure, measured via the Corporate Biodiversity Footprint (CBF), into multifactor pricing models, identifying a persistent negative return premium. Drawing on market efficiency theory, event studies such as Jérôme and Poretti (2025) and Garel et al. (2024) show that announcements of TNFD-aligned disclosures elicit statistically significant negative cumulative abnormal returns (CARs), particularly in high-impact sectors, reflecting investor uncertainty and regulatory risk pricing.

Institutional and legitimacy theories have become dominant frameworks in financial research addressing biodiversity risk. Azizi et al. (2025) and Sun and Lange (2023) find that biodiversity disclosures are shaped predominantly by coercive and mimetic institutional pressures—such as regulatory expectations and peer imitation. This indicates that firms often engage in symbolic reporting to manage legitimacy and reputational risks, rather than to advance substantive ecological accountability. Previous studies have also applied legitimacy theory to explain corporate biodiversity and extinction disclosures. They show that companies use these disclosures to maintain or restore societal acceptance, often in response to external pressures, through symbolic communication, external assurance, and alignment with sustainability frameworks (Hassan et al. 2022; Hassan et al. 2020; Roberts, Nandy, et al. 2022).

Both Sun and Lange (2023) and Roberts, Nandy, et al. (2022) apply stakeholder theory to frame corporate biodiversity disclosures as responses to stakeholder pressures and expectations. Sun and Lange (2023) use stakeholder theory to show that biodiversity disclosures are driven more by external pressure than true accountability. Meanwhile, Roberts, Nandy, et al. (2022) extend the theory by treating species as stakeholders, adding an ethical duty to corporate reporting. Bassen et al. (2024) link biodiversity governance quality to reduced stock price crash risk, drawing from stakeholder and signaling theories.

However, contributions rooted in ecological economics remain fewer but significant. Giglio et al. (2025) emphasize biodiversity's nonlinear, irreversible dynamics—challenging the assumptions of linear risk models. Their BERT-based biodiversity salience model

TABLE 2 | Top methodological and theoretical clusters in biodiversity risk–finance research.

Methodological cluster	General methodological category	Number of publications	Main interpretive note	Theoretical framework	Number of publications	Main disciplinary use
Panel econometrics and regression analysis	Quantitative	38	Focused on financial materiality and firm-level biodiversity risk effects	Stakeholder theory	24	Sustainability/ESG/ corporate governance
Event study and asset pricing models	Quantitative	8	Captures market sensitivity to biodiversity-related events and risks	Legitimacy theory	22	Corporate reporting/ biodiversity disclosure
Text mining and NLP risk measurement	Quantitative	9	Innovative data use; still limited to disclosure and sentiment metrics	Institutional theory (coercive, normative, mimetic)	18	Governance/sustainable finance/regulation
Content analysis and disclosure indexing	Mixed/Qualitative	25	Examines biodiversity disclosure practices and accountability narratives	Signaling theory	7	Finance/disclosure/ ESG transparency
Interviews and case studies	Qualitative	12	Explores corporate–stakeholder engagement and ethical accountability	Resource-based view (RBV)	9	Corporate finance/innovation/ competitive advantage
Conceptual and theoretical framework papers	Conceptual	21	Establishes normative and theoretical bases for biodiversity–finance integration	Financial materiality and double materiality framework	19	Biodiversity finance/ risk disclosure

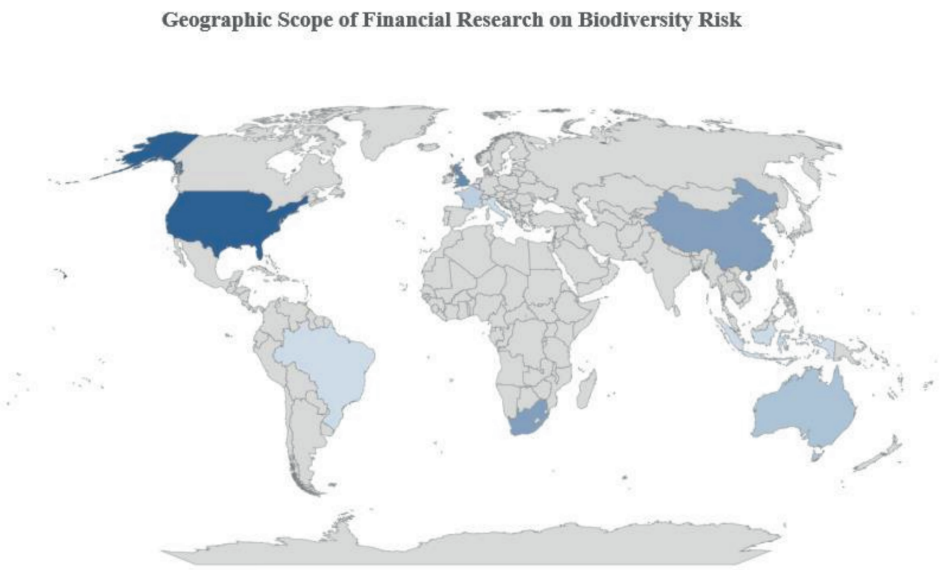

FIGURE 4 | Geographic distribution of scientific research on biodiversity risk in finance. *Source:* Scopus and Web of Science (WoS).

TABLE 3 | Methodologies applied in biodiversity finance research.

Methodology	Primary purpose	Representative studies
Panel regressions	Quantify the relationship between biodiversity risk and firm-level outcomes	Bach et al. (2025); Li et al. (2025); Ahmad and Karpuz (2024)
Event studies	Identify short-term abnormal market reactions to biodiversity-related disclosures or policies	Cherief et al. (2025); Garel et al. (2024)
Crash risk modeling	Assess the impact of biodiversity risk on extreme downside firm-specific events	Liang et al. (2024); Bassen et al. (2024)
Asset pricing models	Evaluate biodiversity risk premia in capital markets	Coqueret et al. (2025); Garel et al. (2024)
Content analysis	Assess biodiversity-related disclosures in corporate reports	Azizi et al. (2025); Anthony and Morrison-Saunders (2023)
NLP/text mining	Identify and score biodiversity-related sentiment in ESG disclosures	Giglio et al. (2025); He et al. (2024); Kalhoro and Kyaw (2024)
Qualitative-theoretical methods	Capture stakeholder perceptions on biodiversity finance and disclosure	Ackers and Adebayo (2024); Nedopil (2023); Karolyi and Tobin-de la Puente (2023)

has been adapted by Liang et al. (2024) and He et al. (2024) to measure biodiversity-related financial risk through corporate texts. Atkins et al. (2023) further advance this ecological framing, advocating for extinction accounting to move disclosures beyond symbolic gestures toward planetary accountability. Collectively, these approaches reflect a growing tension between treating biodiversity as a priced externality and recognizing it as a systemic planetary boundary. Table 4 outlines the main theories commonly applied, along with representative studies.

3.5 | Thematic Analysis: A Research Framework of Biodiversity Risk in Finance Research

This section offers a critical and comprehensive thematic synthesis of biodiversity risk research in finance in five interlinked themes: (1) financial materiality of biodiversity risk, (2) biodiversity risk recognition and visibility, (3) governance and accountability for biodiversity risk, and (4) level of biodiversity risk analysis. We follow the approach of previous relevant studies on sustainability finance systematic reviews (Borghei 2021; Gillan et al. 2021; Mahran and Elamer 2023) to cluster the major themes in 103 academic articles on biodiversity risk in finance research. Quantitative studies, which dominate the field of financial materiality of biodiversity risk, generally frame biodiversity loss as a measurable source of financial exposure, affecting firm value, cost of capital, and portfolio risk through econometric evidence and market-based indicators. In contrast, qualitative and conceptual research tends to interpret biodiversity risk as a matter of accountability, ethics, and legitimacy, emphasizing how firms narrate or obscure their dependence on nature.

TABLE 4 | Most commonly applied theories in financial research on biodiversity risk.

Theory	Description	Key studies
Financial economics	Biodiversity risk priced in asset returns; event study abnormal returns	Coqueret et al. (2025); Jérôme and Poretti (2025); Garel et al. (2024); Bassen et al. (2024)
Institutional/legitimacy theory	Disclosures as legitimacy-seeking under coercive/mimetic pressures	Azizi et al. (2025); Sun and Lange (2023), Haque and Jones (2020), Ali et al. (2024), Hassan et al. (2020)
Stakeholder theory	Disclosures shaped by stakeholder expectations and reputational logic	Roberts, Nandy, et al. (2022), Sun and Lange (2023)
Ecological economics	Biodiversity risk as nonlinear systemic risk; critique of traditional finance	Giglio et al. (2025); Liang et al. (2024); He et al. (2024)

3.5.1 | Financial Materiality of Biodiversity Risk

A fundamental question driving recent finance research on biodiversity risk is whether biodiversity loss represents a financially material risk and if that impacts corporate valuation, firm behavior, and financial market dynamics in measurable ways (Garel et al. 2024; Karolyi and Tobin-de la Puente 2023). Drawing on a systematic analysis of 103 studies, this section identifies five recurring sub-themes that structure how financial materiality is established: mainly, impacts on equity valuation, firm performance, investor sentiment, capital structure, and credit markets.

3.5.1.1 | Equity Valuation and Biodiversity Risk. The relationship between biodiversity risk and equity valuation occupies a central place in biodiversity–finance research, emphasizing how equity markets price biodiversity exposure. Garel et al. (2024) introduce the CBF, showing that firms with high CBF scores experience significant negative abnormal returns after biodiversity policy events like the Kunming Declaration and the launch of the TNFD, which highlights investors' sensitivity to transition risks. Kalhoro and Kyaw (2024) demonstrate that firms proactively managing biodiversity risks observe positive CARs ahead of major policy milestones, whereas firms with unmanaged risks show no noteworthy market response. Liang et al. (2024) and Bassen et al. (2024) present evidence that biodiversity risk positively correlates with stock price crash risk, while robust governance mechanisms reduce these effects. Ma et al. (2024) propose a Biodiversity Risk Index (BRI), illustrating biodiversity risks' predictive strength for market returns, particularly in nature-dependent industries, with physical risks showing immediate impacts.

3.5.1.2 | Firm Fundamentals and Performance Effects. Biodiversity risk directly impacts firm-level fundamentals such as profitability, cost structures, and operational efficiency, with Bach et al. (2025) linking biodiversity exposure to declining profits, rising costs, and weakened growth prospects in ecosystem-dependent sectors like agriculture and chemicals. Li et al. (2025) highlight how biodiversity risk undermines total asset productivity, pushing firms to bear higher operational and financing costs to address ecological uncertainty. Additionally, Elsayed (2023) demonstrates that transparent biodiversity disclosure positively correlates with return on assets, enhancing stakeholder trust and signaling effective risk management, thereby boosting firm value.

3.5.1.3 | Investor Sentiment and Market Response. Investor sentiment amplifies biodiversity's financial effects, as El Ouadghiri et al. (2025) observe that public biodiversity attention—tracked through Google Trends and news metrics—drives positive returns on biodiversity-aligned assets during major environmental events. Ma et al. (2025) analyze global spillover dynamics, revealing that biodiversity awareness increasingly shapes stock market behavior across G7 and BRICS economies, with high-profile events like COP15 intensifying its impact and the US market acting as a receiver of volatility. These findings underscore biodiversity's dual role as both a financial risk and a sentiment-sensitive factor influencing asset flows.

3.5.1.4 | Capital Structure and Financing Behavior. Firms increasingly adjust their financing strategies to address biodiversity-related disruptions. Ahmad and Karpuz (2024) find that firms with high biodiversity risk maintain larger cash reserves to cushion potential operational shocks, while Liu et al. (2025) associate biodiversity exposure with a higher likelihood of seasoned equity offerings as a means of managing ecological risks. Similarly, Zhou et al. (2025) document reduced dividend payouts among biodiversity-sensitive firms, reflecting a reallocation of capital toward compliance and risk mitigation efforts. Meanwhile, Yang and Li (2025) analyze how biodiversity disclosure regulation affects firm behavior and report an uptick in the use of short-term debt for long-term financing needs, thereby increasing financial fragility among less-prepared firms.

3.5.1.5 | Debt Markets and Loan Pricing. Recent research highlights how biodiversity-related risks are increasingly priced into debt markets. Becker et al. (2025) show that EU banks price biodiversity risk in syndicated loans, charging higher spreads to firms with greater exposure, especially when risk indicators are available ex ante. Similarly, Hadji-Lazaro et al. (2024) reveal that French financial institutions carry substantial exposure to biodiversity-related risks through their corporate debt and equity portfolios. Yang and Li (2025) observe that ecological uncertainty has led firms to favor short-term borrowing, as the cost of long-term debt rises. On the institutional side, Lang et al. (2023) show that ecological risks significantly impair bank liquidity in emerging markets. From a regulatory perspective,

Ackers and Adebayo (2024) note the lack of biodiversity-specific risk models in banking, echoing concerns from the ECB and NGFS about systemic financial risks, while Hill Clarvis et al. (2014) highlight the slow integration of biodiversity metrics into sovereign credit ratings despite frameworks like E-RISC.

3.5.2 | Biodiversity Risk Recognition & Visibility

This section provides a critical examination of how biodiversity risk is currently recognized across the literature, structured around four dominant approaches: narrative disclosure, data-driven textual analysis, physical science-based footprinting, and market signal interpretation. Table 5 illustrates the analytical approaches used to recognize and assess biodiversity risk in financial studies.

3.5.2.1 | Symbolic Narrative Disclosure: Legitimacy Over Accountability. The most common form of biodiversity risk recognition continues to be narrative disclosure within CSR, sustainability, or integrated reporting. However, these are often symbolic rather than strategic, shaped more by reputational incentives (Fafaliou et al. 2022) than operational risks. Studies by Anthony and Morrison-Saunders (2023) and Roberts, Nandy, et al. (2022) show that biodiversity is frequently embedded in philanthropic narratives, vague conservation commitments, or SDG references that lack material specificity. A comparative analysis by Ackers and Adebayo (2024) finds that in jurisdictions like South Africa, symbolic disclosures dominate among financial and service firms, relying heavily on images and general statements rather than measurable outcomes.

3.5.2.2 | Data-Driven Textual Approaches: Algorithmic Detection, Semantic Gaps. With the rise of machine learning, textual analysis methods such as NLP have been applied to biodiversity risk detection. He et al. (2024) analyze 4000 Chinese corporate annual reports and develop a biodiversity exposure index, revealing extensive underreporting and semantic obfuscation. Ma et al. (2024) construct a BRI from Chinese news media using sentiment analysis to quantify biodiversity-related risks and evaluate its predictive power on stock returns. Both studies, inspired by Giglio et al. (2025), show that despite high potential, these tools struggle with terminological inconsistency, limiting their effectiveness without better disclosure standards. These concerns are echoed by Bhattacharyya and Yang (2019), who highlight that sustainability narratives often fail to articulate quantitative biodiversity dependencies, remaining focused on compliance language. This approach holds promise for scaling biodiversity risk assessment across large datasets, yet it also highlights a deeper challenge: the limited semantic clarity and terminological standardization in biodiversity discourse. Without more consistent language and definitional frameworks, even sophisticated algorithms struggle to differentiate genuine recognition from surface-level mentions.

3.5.2.3 | Footprinting and Scientific Modeling: From Impact to Dependency. Another emerging approach links biodiversity recognition to physical science-based footprint models or ecological impact assessments. de Carvalho et al. (2023) propose a global assessment of corporate biodiversity risk that incorporates direct and indirect dependencies across value chains. Similarly, de Silva et al. (2019) critically evaluate corporate biodiversity pledges such as "no net loss" and "net positive impact," finding that many lack credible scientific baselines or enforcement mechanisms.

Glaring methodological limitations persist in this domain. Coqueret et al. (2025) introduce biodiversity factors into asset pricing models, but note difficulties in isolating biodiversity risks from correlated environmental variables such as greenhouse gas emissions. The complexity and nonlinearity of biodiversity-related dependencies are also highlighted by Giglio et al. (2025), who argue that biodiversity loss operates across ecological thresholds and cannot be captured by linear risk metrics. Ackers and Adebayo (2024) emphasize that footprinting approaches rarely incorporate socioecological context or indigenous knowledge systems, which are essential for holistic biodiversity governance. In a related study, Garel

TABLE 5 | Analytical approaches for recognizing and assessing biodiversity risk in financial studies.

Recognition mode	Approach	Representative studies	Critical observations
Narrative disclosure	CSR/sustainability reporting with symbolic biodiversity mentions	Anthony and Morrison-Saunders (2023); Roberts, Nandy, et al. (2022); Hassan et al. (2020)	Superficial, reputation-driven; lacks metrics or material risk framing
Textual/NLP approaches	Algorithmic analysis of report content to build exposure indices	He et al. (2024); Giglio et al. (2025); Ma et al. (2024); Kalhoro and Ahmed (2025)	Reveals underreporting, semantic vagueness, and compliance bias in disclosures
Scientific footprinting and modeling	Quantitative assessment of biodiversity impact/dependencies	de Carvalho et al. (2023); Coqueret et al. (2025); Garel et al. (2024)	Faces data and modeling limitations; weak inclusion of socioecological and systemic factors
Market-based signals	Financial markets reaction to biodiversity-linked event	Capelli et al. (2025); Garel et al. (2024); Jérôme and Poretti (2025), Cherief et al. (2025)	Emerging market sensitivity to biodiversity risks, but pricing remains inconsistent due to low investor literacy, vague disclosures, and immature market tools

et al. (2024) investigate whether investors respond to biodiversity risk at the portfolio level. Using biodiversity footprint data and firm-level exposures, the study finds limited evidence of market reaction, suggesting that even when scientifically grounded data are available, they may not translate into meaningful financial visibility unless better integrated into ESG frameworks.

3.5.2.4 | Market-Based Recognition: Signals, Reactions, and Pricing Gaps. A growing literature attempts to infer biodiversity visibility through market reactions to biodiversity-related events. Jérôme and Poretti (2025) indicate that firms experience notable declines in CARs upon announcing their intention to adopt the TNFD Recommendations. Similarly, a recent event study on the EU Nature Restoration Law finds that firms exposed to biodiversity-intensive operations experienced elevated volatility and negative market reactions around key legislative milestones Capelli et al. (2025). This suggests that investors may increasingly interpret biodiversity transparency not as neutral information, but as a signal of latent regulatory, reputational, or litigation risk (Dempsey 2013; Treepongkaruna 2024). Karolyi and Tobin-de la Puente (2023) attribute these reactions to limited biodiversity literacy among analysts and institutional investors, who struggle to interpret biodiversity risk in financial frameworks.

3.5.3 | Governance and Accountability for Biodiversity Risk

This section provides an overview of the financial research concerning governance and accountability in relation to biodiversity risk.

3.5.3.1 | Internal Governance and Strategic Control. Robust internal governance can translate biodiversity risk from symbolic concern into strategic action. Bassen et al. (2024) empirically show that firms with strong biodiversity governance experience lower stock price crash risk, suggesting that biodiversity oversight may be a proxy for broader governance quality. Treepongkaruna (2024) finds that proactive biodiversity reporting frameworks are associated with more resilient firm responses and reduced reputational exposure, supporting the argument that biodiversity governance is not merely cosmetic.

White et al. (2023) provide a scientific foundation for internal biodiversity governance, outlining principles to embed ecological knowledge into board-level decisions. These include evidence-based risk assessments, long-term performance metrics, and ecosystem service valuation. However, as Karolyi and Tobin-de la Puente (2023) and Ali et al. (2024) observe, biodiversity literacy among financial executives remains limited, constraining the operationalization of such principles.

Despite these advances, biodiversity governance is still often relegated to CSR silos rather than integrated into enterprise risk management. Roberts, Nandy, et al. (2022) and Anthony and Morrison-Saunders (2023) find that biodiversity issues are typically framed as reputational risks, not operational concerns, limiting board accountability. Ackers and Adebayo (2024) critique such symbolic disclosure practices, calling for biodiversity KPIs to be hardwired into strategic oversight.

3.5.3.2 | External Governance, Regulation, and Stakeholder Pressure. External governance plays a vital role in biodiversity accountability, especially where internal mechanisms are weak. Ackers and Adebayo (2024) highlight how NGO coalitions, investor alliances, and public agencies are reshaping biodiversity norms through soft law and multistakeholder governance platforms. For example, SEEA Ecosystem Accounting and TNFD frameworks promote standardized disclosure and national-level environmental accounting, although firm-level uptake is still in early stages (Edens et al. 2022; Karolyi and Tobin-de la Puente 2023).

In the South African context, Raar et al. (2020) document how biodiversity governance in national parks has introduced transparency practices, yet enforcement remains inconsistent across sectors. Similarly, European efforts such as the CSRD and EU Taxonomy reflect an advanced governance regime (Azizi et al. 2025), but biodiversity-specific indicators lag behind those for climate. Reputational dynamics also function as informal external governance. Roberts, Nandy, et al. (2022) and Hassan et al. (2020) show that firms often respond to public or NGO scrutiny with reactive disclosures, suggesting stakeholder pressure can partially substitute for regulation. However, without institutional backing, such responses tend to be episodic and symbolic.

3.5.3.3 | Ethical and Philosophical Foundations of Accountability. Beyond institutional structures, scholars have advanced ethical critiques of biodiversity governance. Maroun and Atkins (2018) and Cuckston (2018) advocate for "extinction accounting," calling on corporations to engage with the irreversible nature of biodiversity loss and to assume moral responsibility. Their work integrates intergenerational equity, rights of nature, and nonanthropocentric logics, challenging the dominance of financial materiality. Raar et al. (2020) apply structuration theory to demonstrate how biodiversity risk discourse is co-constructed through governance practices, underscoring the need for participatory mechanisms. Complementary insights from Schaltegger et al. (2023) and Kennedy et al. (2023) advocate for adaptive governance models that integrate resilience thinking into biodiversity accountability.

Classical ethical theories further strengthen these debates by providing a structured basis for critique. From a deontological perspective, biodiversity disclosure represents a duty to human and nonhuman stakeholders, reinforcing arguments around rights of nature and double materiality (Barker and Mayer 2025; Roberts, Georgiou, et al. 2023). A consequentialist approach shifts attention to outcomes, yet evidence indicates that mitigation frameworks remain weak on avoidance and fail to capture systemic spillovers across global value chains (White et al. 2023; Wilting and van Oorschot 2017). A virtue ethics orientation highlights stewardship and prudence, but studies show biodiversity is often overshadowed by climate concerns, reducing reporting to symbolic gestures rather than substantive commitments (Herbert et al. 2023; Roberts, Nandy, et al. 2022). These perspectives move beyond gestural

ethics by embedding biodiversity risk in explicit philosophical traditions.

3.5.4 | Level of Biodiversity Risk Analysis

This section contributes by synthesizing how different analytical levels shape the identification, measurement, and transmission of biodiversity-related financial risks.

3.5.4.1 | Firm-Level Analysis: Operational Visibility but Limited Systemic Insight. The majority of existing literature is concentrated at the firm level, often focusing on disclosure practices, financial performance, or risk exposure. For instance, Bassen et al. (2024) and Treepongkaruna (2024) analyze how firm-level biodiversity management correlates with crash risk and litigation exposure. He et al. (2024) apply NLP to firm-level sustainability reports to assess biodiversity exposure across over 4000 Chinese companies, revealing semantic vagueness and significant underreporting in biodiversity-intensive sectors.

Studies such as Roberts, Nandy, et al. (2022) and Anthony and Morrison-Saunders (2023) evaluate narrative disclosures and CSR framing at the firm level, often concluding that biodiversity is symbolically acknowledged but not materially integrated. Ackers and Adebayo (2024) critique these superficial disclosures, calling for a strategic integration of biodiversity into governance structures. While firm-level studies are crucial for understanding operational practices, they frequently suffer from low generalizability and tend to overlook systemic feedback between firms and ecological systems.

3.5.4.2 | Sector-Level Analysis: Identifying High-Risk Industries. Sectoral analysis plays a key role in identifying which industries are most exposed to biodiversity loss or dependency. For example, de Carvalho et al. (2023) offer a global biodiversity risk mapping across industries, revealing high vulnerability in mining, agriculture, and pharmaceuticals. Bhattacharyya and Yang (2019) examine sector-specific disclosures and find consistent patterns of underreporting in biodiversity-reliant sectors, especially where regulatory pressure is weak. Work by Garel et al. (2024) uses sectoral footprint data to show that even when risks are measurable, they are not necessarily priced by investors, especially in biodiversity-intensive sectors. The sectoral level provides greater insight into material risk concentrations than firm-level studies alone, but still lacks visibility into cross-sectoral spillovers and macrofinancial implications. Across the 103 studies, biodiversity risk research is dominated by samples from financial institutions and diversified corporate datasets, while high-exposure sectors such as agriculture and extractives receive comparatively limited empirical attention. Emerging coverage of tourism, manufacturing, and state-owned enterprises suggests growing diversification, yet systematic investigation of biodiversity dependencies in supply chains remains largely absent.

3.5.4.3 | Portfolio and Market-Level Analysis: Investor Exposure and Pricing Dynamics. Several studies have shifted the analytical lens to investor portfolios and market-level responses. Karolyi and Tobin-de la Puente (2023) attribute this to biodiversity illiteracy among financial analysts, while Garel et al. (2024) similarly, report limited investor sensitivity to biodiversity exposure, even when quantified through ecological footprint data. Loan pricing studies (e.g., Loan Pricing and Biodiversity Exposure: Nature-Related Spillovers to the Financial Sector) reveal how biodiversity risk may affect credit spreads in specific industries, offering a nascent but important financial-market-level view. Empirical results show that biodiversity exposure is priced into syndicated loan spreads, particularly for firms in nature-dependent sectors (Becker et al. 2025).

3.5.4.4 | Macroeconomic and Systemic-Level Analysis: The Missing Frontier. A growing body of research is beginning to conceptualize biodiversity risk as a systemic issue with macrofinancial consequences. For example, "Biodiversity Loss and Financial Stability as a New Frontier for Central Banks" (France case) illustrates how ecosystem degradation can propagate through the financial system, affecting inflation, growth, and credit cycles Hadji-Lazaro et al. (2024). Complementing this, Ma et al. (2025) find that while biodiversity attention—measured via global search trends—has so far produced mild spillover effects on most national stock markets, US markets show clear responsiveness, particularly during major events like COP15. This suggests that biodiversity signals are starting to register within financial systems. Despite these insights, macrolevel analyses of biodiversity risk remain scarce. This underrepresentation may reflect the challenges of modeling biodiversity risk transmission across ecological and financial systems. Yet, it signals a significant research gap.

3.6 | Bibliometric Analysis

To deepen the findings, a bibliometric analysis is conducted using the VOSviewer software (Hutchinson and Lucey 2024; Mustafa et al. 2022). To ensure the rigor and credibility of the analysis, the dataset was limited to 68 publications drawn from journals ranked AJG 2 or higher in the Academic Journal Guide (ABS 2+) (Goodell et al. 2023). Three complementary visualizations are generated, including co-authorship, co-citation, and keyword co-occurrence networks, to reveal the intellectual and collaborative structure of biodiversity finance research.

The co-authorship network (Figure 5) reveals fragmented collaboration, with a few key authors such as Lee Roberts, Warren Maroun, Salvatore Di Falco, Feng Ma, and Anna Min Du forming small regional clusters. Limited cross-institutional links indicate an emerging field with developing international collaboration across finance, accounting, and environmental research.

The co-citation map reveals two principal intellectual clusters: biodiversity accounting and governance (Atkins and Maroun; Boiral and Heras-Saizarbitoria) and financial risk and valuation (Karolyi and Tobin-de la Puente; Sautner), as illustrated in Figure 6. These clusters reflect the theoretical fragmentation identified in the literature review, highlighting a disciplinary divide between ecological, financial, and governance-oriented perspectives.

In Figure 7, the keyword co-occurrence map reveals a more balanced thematic landscape. The term "biodiversity" is excluded to improve the visibility of other thematic linkages, as it is the

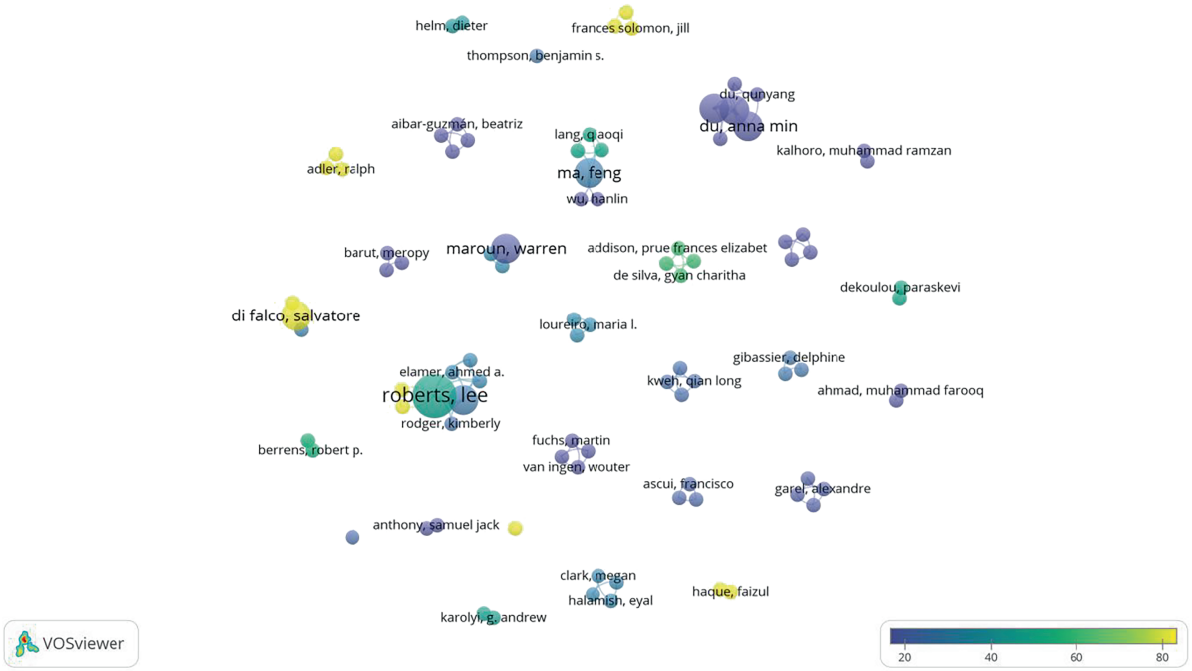

FIGURE 5 | Co-authorship network of biodiversity risk in financial research. Note: The color bar at the bottom right represents the scale of citations, ranging from blue (lower citation counts) to yellow (higher citation counts).

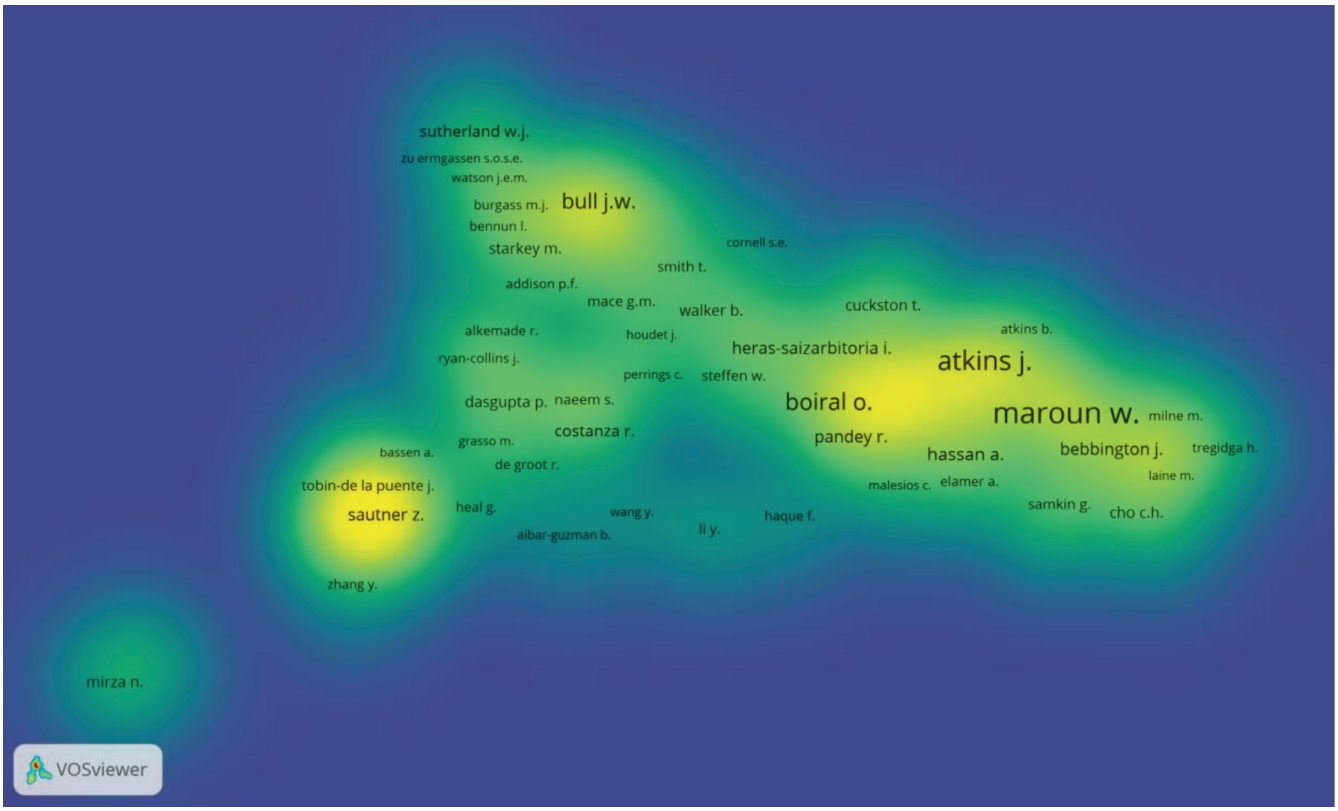

FIGURE 6 | Co-citation network of influential studies on biodiversity risk and finance.

most dominant keyword in the dataset. The largest and most connected nodes include natural capital, sustainability, risk assessment, environmental economics, and ecosystem services, which together constitute the conceptual core of biodiversity risk in finance research. Peripheral yet emerging themes such as corporate social responsibility, policymaking, and governance approaches indicate growing, yet still limited, attention to ethical dimensions.

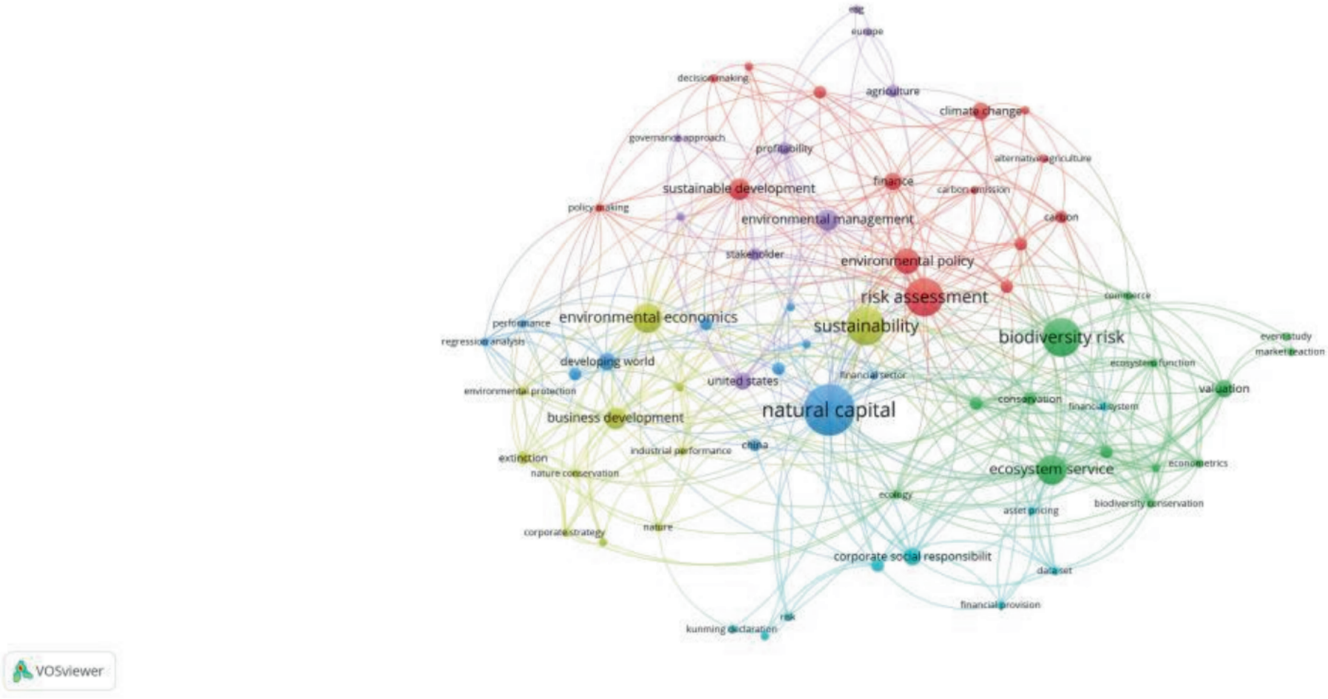

FIGURE 7 | Keyword co-occurrence network of biodiversity risk in financial research.

4 | Limitations of Existing Literature and Future Research Avenues

4.1 | Limitations From Thematic Analysis

4.1.1 | Lack of Standardized, Interoperable Biodiversity Risk Metrics

A recurring and widely acknowledged challenge across the biodiversity–finance literature is the absence of unified, decision-useful metrics for assessing biodiversity risk. Unlike climate risk, where standardized measures such as CO_2-equivalent emissions provide a common denominator, biodiversity is inherently multidimensional, spatially and temporally heterogeneous, and lacks a consistent unit of financial translation (Schipper et al. 2020).

Currently used science-based tools, including the Mean Species Abundance (MSA), Biodiversity Intactness Index (BII), and the CBF offer valuable insights into ecological degradation, but they are rarely interoperable and often lack sectoral granularity or alignment with financial time horizons (de Carvalho et al. 2023; Coqueret et al. 2025; Garel et al. 2024). While MSA and BII are rooted in ecosystem science and conservation biology, their integration into financial risk systems is constrained by complex data requirements, limited geographic resolution, and difficulty in mapping them directly to firm-level exposure or value at risk.

In contrast, NLP and text mining approaches aim to infer biodiversity exposure by analyzing corporate disclosures and publicly available news sources (Giglio et al. 2025). For instance, He et al. (2024) use NLP to quantify biodiversity attention and disclosure density in Chinese annual reports, constructing a textual exposure index. However, such approaches face their own limitations: they depend on the presence (rather than the substance) of disclosure, often capture semantic noise, and are highly sensitive to inconsistent terminology and reporting styles (Bhattacharyya and Yang 2019).

Both measurement paradigms, science-based and data-driven, offer complementary insights but suffer from a lack of standardization and limited translation into decision-useful indicators for investors or regulators. To move forward, future research must focus on developing harmonized biodiversity KPIs that are both scientifically robust and financially interpretable. This entails incorporating dynamic ecological baselines, probabilistic thresholds for ecosystem collapse, and modeling upstream, downstream, and Scope 3 biodiversity dependencies, potentially through satellite-enhanced life-cycle assessments, EXIOBASE, and other input–output ecological models. Ultimately, advancing biodiversity risk measurement will require deeper integration across ecological science, financial modeling, and ESG reporting frameworks (Zhu et al. 2024). Without this, biodiversity will remain a "known unknown" in sustainable finance, acknowledged in principle but unmeasured in practice.

4.1.2 | Insufficient Empirical Coverage Across Financial Markets

While equity markets have received growing attention, biodiversity risk remains underexplored across other financial sectors, with limited evidence. Becker et al. (2025) find that EU and UK banks charge higher syndicated loan spreads to borrowers with high biodiversity risk, indicating emerging nature-related risk premia. Similarly, Hadji-Lazaro et al. (2024) report that over 40% of French institutional portfolios are exposed to firms

highly dependent on ecosystem services or with large biodiversity footprints, posing systemic risk. Meanwhile, an early study by Mulder and Koellner (2011) finds that most large banks are in the early stages of integrating biodiversity risk, with few applying concrete tools or policies in lending or investment decisions. In China, Yang and Li (2025) find that biodiversity risk increases firms' reliance on short-term debt, raising default risk and financial instability. Despite these contributions, empirical coverage of biodiversity risk pricing remains sparse across bonds, credit derivatives, sovereign ratings, and insurance markets.

4.1.3 | Weakness in Disclosure Quality and Assurance

Biodiversity disclosures are predominantly qualitative, symbolic, and lack standardized metrics, limiting their value for financial decision-making. Disclosures are often reputational in nature, responding to NGO pressure or compliance norms rather than being grounded in ecological materiality (Ackers and Adebayo 2024; Anthony and Morrison-Saunders 2023; Atkins et al. 2023). Haque and Jones (2020) show that most European firms issue generic, unverifiable biodiversity disclosures with minimal quantification or external assurance, often detached from financial or governance reporting. Roberts, Nandy, et al. (2022) found similarly poor disclosure quality across global firms, including many scoring zero on biodiversity metrics. Even where GRI frameworks are applied, disclosures tend to support symbolic compliance rather than enforceable accountability. Barker and Mayer (2025) emphasize the absence of a biodiversity equivalent to the income statement, calling for "externality accounting" to capture ecological impacts systematically. To improve transparency and comparability, future efforts should focus on third-party assurance, machine-readable ESG formats, and regulatory frameworks such as TNFD.

4.1.4 | Fragile Economic Case for Biodiversity-Inclusive Instruments

Many biodiversity-related financial instruments, such as credits, bonds, and offsets, remain underdeveloped, facing a significant financing gap and lacking robust design frameworks (Karolyi and Tobin-de la Puente 2023). There also remains limited empirical analysis on the efficiency of biodiversity-related financial instruments in balancing biodiversity impact with financial returns, particularly in terms of how different structures, such as pure private capital and blended finance, navigate this trade-off (Flammer et al. 2025). Future studies should evaluate biodiversity-linked products using portfolio simulations and real-world impact tracking. Focus is needed on KPI enforceability, investor engagement, and whether these instruments deliver on double materiality promises.

4.1.5 | Underutilization of Data Science and Technology

Despite advances in satellite imagery, geospatial AI, and remote sensing, biodiversity risk in finance research rarely leverages these tools. Very few studies employ science-based biodiversity risk metrics (Coqueret et al. 2025; Garel et al. 2024). Instead, most rely on text analysis of corporate disclosures or news sources (Cherief et al. 2025; Giglio et al. 2025; He et al. 2024). Data silos between ecologists and financial analysts persist, limiting progress in biodiversity finance, despite longstanding ecological science and minimal engagement from top finance journals (Karolyi and Tobin-de la Puente 2023). Next-generation research should pilot interoperable APIs for biodiversity monitoring, blockchain-based biodiversity credit registries, and AI-driven impact classifications. Integration of geospatial data into credit scoring and asset management platforms is vital for enabling dynamic biodiversity risk integration.

4.1.6 | Limited Recognition in Systemic Risk and Macroprudential Frameworks

Despite growing recognition, biodiversity risks are still largely absent from central bank stress tests, sovereign ratings, and macroprudential tools (Hadji-Lazaro et al. 2024). Hill Clarvis et al. (2014) show that environmental risks, such as natural resource overuse and ecosystem degradation, can significantly impact trade balances and GDP yet remain largely excluded from sovereign credit rating methodologies. Research should model biodiversity as a contributor to systemic financial instability, e.g., testing its propagation via supply chains, capital flows, and interbank exposure. Inclusion in macroprudential regulation, systemic risk buffers, and Basel frameworks deserves priority. Sovereign risk models incorporating biodiversity resource constraints are particularly urgent.

4.2 | Theoretical Gaps and Conceptual Synthesis of Biodiversity and Financial Risk

Biodiversity risk is gaining traction in financial discourse but remains undertheorized. Most studies translate ecological degradation into conventional firm-level risk categories using asset pricing or event study approaches, or they explain disclosure behavior through institutional, legitimacy, or stakeholder theories (Ackers and Adebayo 2024; Hassan et al. 2022; Hassan et al. 2020; Roberts, Hassan, et al. 2021). These frameworks help explain why firms disclose, but they often treat biodiversity loss as an external reputational or regulatory issue. They do not explain how biophysical changes propagate through financial systems and balance sheets. This anthropocentric framing limits biodiversity to the margins of ESG reporting, rather than recognizing it as a core driver of financial stability (Atkins et al. 2023; Cherief et al. 2025; Jérôme and Poretti 2025).

Recent conceptual developments as double materiality (Cherief et al. 2025; Jérôme and Poretti 2025) and extinction accounting (Atkins et al. 2023) acknowledge the reciprocal links between nature and finance. However, these remain fragmented and weakly operationalized. They often lack clarity on transmission mechanisms, feedback loops, or governance structures through which biodiversity loss becomes financially material. Similarly, ecological–economic perspectives highlight dependency and threshold dynamics but rarely connect with financial risk models or corporate decision-making systems.

TABLE 6 | Future research agenda for biodiversity risk in financial studies.

Category	Items	Suggested research questions
Thematic analysis	Measurement	• How can science-based and text-mining metrics be integrated into standardized biodiversity KPIs? • What are the trade-offs between ecological precision and financial interpretability in biodiversity metrics? • How can satellite or life-cycle models be translated into firm-level financial risk indicators?
	Market impacts	• How does biodiversity risk affect pricing in sovereign debt, insurance, and bank capital markets? • Are biodiversity risk premia observable across asset classes, geographies, or investor types? • How do markets respond to biodiversity-related shocks beyond equity channels?
	Disclosure quality and assurance	• Do biodiversity disclosures influence investor behavior or credit spreads? • How can assurance mechanisms improve the credibility and comparability of biodiversity data? • What role can TNFD-aligned reporting play in disclosure standardization?
	Financial instruments and investment viability	• What are the risk–return characteristics of biodiversity-linked bonds or credits? • How can biodiversity KPIs be embedded into loan covenants and fund performance benchmarks? • What makes biodiversity-related instruments financially viable and scalable?
	Data science and technology integration	• How can AI and satellite data enhance biodiversity risk modeling in finance? • Can blockchain be used for real-time biodiversity impact verification? • How can biodiversity geodata be integrated into portfolio dashboards or credit scoring tools?
	Systemic risk and macroprudential tools	• How do biodiversity risks propagate through banking, trade, and capital networks? • Should central banks include biodiversity in macroprudential stress tests? • How can biodiversity thresholds inform capital adequacy ratios or systemic buffers?
Research theory	Theoretical development	• How can biodiversity be theorized as both a risk and a resilience asset? • What theoretical models explain its role in long-term firm value and financial stability? • How can extinction accounting or double materiality be operationalized in financial models?
Methodology	Methodological innovation	• What are the best-suited causal methods for biodiversity–finance studies? • How can mixed methods (e.g., NLP + financial data) improve explanatory power? • How do different econometric strategies handle temporal, spatial, and sectoral biodiversity risk?

To address these gaps, this review proposes an eco-financial transmission framework. It integrates ecological economics, systemic risk theory, and corporate governance. The framework conceptualizes biodiversity loss as a biophysical–financial feedback loop. Ecosystem degradation reduces ecological assets and service flows, which in turn affect firms' cash flows, collateral values, and cost of capital. Financial responses such as lending, investment, or disclosure can then either reinforce or mitigate ecological outcomes (Coqueret et al. 2025; Giglio et al. 2025; Hadji-Lazaro et al. 2024; Kennedy et al. 2023). Governance

serves as the mediating infrastructure, translating ecological signals into financial recognition via risk committees, fiduciary duties, and reporting standards (Garel et al. 2024). This synthesis reframes biodiversity risk not merely as an ethical issue but as a structural transmission channel between ecological systems and financial markets. It offers a novel theoretical bridge between ecological dependency and capital allocation.

The future research should focus on theorizing biodiversity as a financial transmission channel that extends beyond reputational or regulatory considerations by leveraging tools from systemic risk analysis, contagion theory, and macrofinancial modeling. It should also aim to operationalize the concept of double materiality to assess how biodiversity influences investor decision-making and fiduciary responsibilities, particularly within biodiversity-sensitive sectors. Furthermore, biodiversity needs to be reframed as a form of natural capital or resilience asset, drawing on strategic management theories such as the resource-based view and dynamic capabilities. Finally, integrating ecological threshold models such as tipping points and planetary boundaries into credit risk assessments, valuation frameworks, and long-term asset pricing will be essential for capturing the systemic implications of biodiversity loss.

4.3 | Methodological Limitations in Financial Approaches to Biodiversity Risk

While there has been a rise in empirical work, particularly in equity markets, much of it remains limited to correlational designs, cross-sectional regressions, and event studies (Ali et al. 2024; Capelli et al. 2025; Garel et al. 2024). These methods rarely account for causal inference, spillover effects, or endogeneity in risk transmission. Additionally, data quality is highly variable: biodiversity metrics are either missing, unstandardized, or not aligned with financial reporting cycles, which weakens the robustness of empirical claims (Bach et al. 2025; Ma et al. 2024). Moreover, asset class coverage is skewed; credit markets, sovereign risk, private equity, and insurance are severely underexplored. Biodiversity risk is often treated as a firm-level ESG feature, rather than a systemic exposure embedded in capital markets, investor strategy, or financial intermediation (Flammer et al. 2025; Lang et al. 2023).

Accordingly, potential directions for future research are outlined below. Specific future research questions for each category are provided in Table 6.

Future research should apply advanced causal econometric techniques such as difference-in-differences, instrumental variables, or regression discontinuity design to disentangle biodiversity risk effects from other ESG or environmental factors. Empirical work can also expand into debt markets, bank risk modeling, and sovereign risk pricing by leveraging datasets like credit default swap spreads, credit ratings, and central bank disclosures. Additionally, integrating quantitative financial data with geospatial and ecological datasets, including remote sensing and land-use models, will be critical for capturing physically grounded biodiversity risks. Finally, improving the temporal resolution of biodiversity–financial datasets will enable regulators and market participants to detect lagged effects and critical thresholds, supporting more proactive risk management and policy interventions.

5 | Conclusion

Biodiversity-related financial risk has emerged as a critical frontier in the intersection of ecological and financial systems (Organisation for Economic Co-operation and Development 2023). This SLR synthesizes and critically evaluates 103 peer-reviewed studies to assess the current state of biodiversity finance research, with a specific focus on risk-related dimensions. The findings reveal a field in rapid evolution, yet still lacking theoretical cohesion, methodological maturity, and empirical depth in several key areas.

The review exposes significant gaps in the field. First, theoretical underdevelopment remains a challenge. Most studies rely on frameworks from financial economics, stakeholder theory, or institutional theory, which, while valuable, inadequately address the complex, nonlinear, and systemic nature of biodiversity loss (Hadji-Lazaro et al. 2024; Karolyi and Tobin-de la Puente 2023; Kennedy et al. 2023; Nedopil 2023). Integration of systems thinking, ecological economics, and sustainability science remains rare. Few works engage with concepts like planetary boundaries, extinction accounting, or double materiality in a cohesive manner (Azizi et al. 2025; Becker et al. 2025; Cherief et al. 2025; Maroun and Atkins 2018). To move the field forward, this review introduces an eco-financial transmission framework that conceptually connects biodiversity loss to financial risk through three reinforcing channels: valuation, governance, and disclosure. By integrating ecological economics, systemic risk theory, and corporate governance, this framework explains how biodiversity degradation propagates through financial institutions and markets, providing a new conceptual basis for future research. This synthesis moves beyond descriptive mapping toward a structural understanding of biodiversity as both a biophysical and financial phenomenon.

This review also contributes by grounding biodiversity risk–finance debates in explicit ethical frameworks. By applying deontological, consequentialist, and virtue ethics perspectives, it shows that biodiversity risks are not only financial exposures but also moral duties and institutional virtues (Barker and Mayer 2025; Roberts, Georgiou, et al. 2023). This ethical reframing extends existing work on extinction accounting (Cuckston 2018; Maroun and Atkins 2018), providing a normative foundation for future disclosure and governance standards.

Second, most existing studies rely on disclosure/news-based proxies or event study methodologies (Cherief et al. 2025; Giglio et al. 2025; He et al. 2024). While useful, these approaches often fail to capture underlying exposure to biodiversity-related risks, particularly in data-poor or regulatory-light contexts. There is a pressing need for more sophisticated, causal research designs including longitudinal analyses, machine learning applications, and mixed-methods approaches that combine financial and ecological data sources.

Third, based on a thematic analysis of relevant existing articles, this review contributes to the literature by offering a structured

roadmap for future scholarship. It recommends developing integrative theoretical models that capture the intersection of ecological thresholds and financial risk and advancing empirical methods capable of addressing the complexity, uncertainty, and spatial heterogeneity of biodiversity-related exposures. Future research should also investigate how biodiversity risk is priced across asset classes, including sovereign debt, insurance, and banking, with a greater focus on market responses beyond equities and the emergence of biodiversity risk premia. In addition, policy-relevant research that supports the implementation of frameworks such as the TNFD should be enhanced, alongside efforts to strengthen the role of biodiversity in ESG analysis, natural capital accounting, and financial regulation. Finally, promoting inclusivity by extending research across diverse geographies, sectors, and governance regimes remains essential for building a comprehensive understanding of biodiversity risk in finance.

This review provides a structured synthesis of biodiversity risk in finance, integrating conceptual analysis with bibliometric evidence to highlight key theoretical and methodological patterns across disciplines. Although it incorporates bibliometric linkages, future research could undertake more in-depth bibliometric analyses to further map the intellectual structure and evolution of biodiversity risk–finance scholarship.

For practitioners, this review underscores the urgent need to embed biodiversity into risk management, investment strategies, and regulatory compliance. Financial institutions must not only improve their disclosure practices but also invest in capacity building to understand the long-term materiality of biodiversity loss. For policymakers, the findings support the need for stronger alignment between financial regulation and global biodiversity goals, including those articulated under the Kunming–Montreal Global Biodiversity Framework.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Endnotes

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[3] Throughout this review, "biodiversity risk" and related terms (e.g., "ecological risk" or "nature-related risk") are used interchangeably to capture the wide range of concepts associated with the risks to biodiversity and nature that are relevant in finance research.

[4] The literature search was conducted with a cutoff date of April 2, 2025.

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