



A bibliometric and systemic literature review of biodiversity finance

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ABSTRACT

This study presents a short bibliometric analysis of biodiversity finance, exposing a literature fragmented across researchers, institutions, and journals. Six focal areas emerge, with Conservation, Conservation Finance, and Ecosystem Finance prominent. Thematic emphasis revolves around biodiversity challenges and the inefficiency of financial mechanisms in addressing them. Our analysis reveals an exploitable gap in the lack of finance-led solutions. We advocate for recognising finance's pivotal role in tackling biodiversity challenges, emphasising capital access facilitation and risk mitigation. Collaborative efforts between finance and other disciplines are crucial for driving positive change in biodiversity conservation and restoration.

1. Introduction

The Kunming-Montreal Global Biodiversity Framework (CBD, 2022) aims to mitigate threats to biodiversity and was adopted following the 15th Conference of Parties to the UN Convention on Biological Diversity in December 2022. One of the overarching goals is to close the biodiversity finance gap, estimated to be as much as \$500 billion per year. This coincides with the increased scrutiny of Central Banks in assessing and managing systemic risks associated with biodiversity loss.¹

Academic researchers, prominent in climate finance research, have spearheaded recent efforts to focus on biodiversity finance. Karolyi and Tobin-de la Puente (2023) lay out a framework to identify the risks related to biodiversity loss, how those risks might be priced, and provide suggestions on how the investment required to address biodiversity loss might be raised. Flammer et al. (2023) focuses on the intermediation of private and blended private–public capital to finance biodiversity conservation. Using deal-level data, they empirically examine the characteristics of projects that attract different forms of capital. Giglio et al. (2023) examine the risks associated with biodiversity loss on economic activity and asset prices, finding evidence of biodiversity risk being priced in equity markets.

While supervisory authorities globally have become increasingly focused on financial risks related to the environment, there has been less focus on biodiversity. Regardless, researchers at the Dutch and French Central Banks have been at the forefront of highlighting the economic and financial risk associated with biodiversity loss. Van Toor et al. (2020) outline the important policy-related issues of biodiversity loss for regulators. Biodiversity loss harms economic activity. Consequently, financial institutions will be required to manage their risks to biodiversity loss via their lending activities. Svartzman et al. (2021) empirically assess the links between biodiversity loss and financial instability in France, finding that for French financial institutions, 42 percent of the securities' value held comes from issuers that are highly dependent on at least one ecosystem service.

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¹ “Destroy nature, and you destroy the economy”. Frank Elderson, Member of the Executive Board of the ECB and Vice-Chair of the Supervisory Board of the ECB, in an interview with the Financial Times <https://www.ecb.europa.eu/press/inter/date/2023/html/ecb.in230608~7247c0aaca.en.html>.

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At the same time, sovereign wealth funds, pension funds, and asset managers are now concentrating on how the companies they invest in account for biodiversity in their business activities. This is exemplified by Norges Bank Investment Management (NBIM), which manages the world's largest sovereign wealth fund. In 2021, NBIM published a new companies expectations document on biodiversity and ecosystems.² NBIM has been at the forefront of mitigating climate and environmental risks in their portfolio, publishing expectations documents that outline what companies should do to manage the challenges and opportunities on issues, including climate change and ocean sustainability, to ensure they continue as investments by the fund.

While recent attention has focused on biodiversity finance, as noted by Karolyi and Tobin-de la Puente (2023), much early research on the importance of nature and biodiversity to the economy was published in journals in the 1990s.³ We should also acknowledge the very significant body of work in the accounting area around topics adjacent to biodiversity finance. Zhong et al. (2016) provides a useful survey of the first two decades of natural resource/capital accounting research, and papers such as Cormier and Gordon (2001), Clarkson et al. (2011), and Edgley et al. (2015) have pushed forward on extinction and biodiversity accounting. In some regards, it would be fair to see accounting as having developed farther in relation to the incorporation of biodiversity concerns than has finance, despite the close relationship between the disciplines.

Bearing this in mind, we suggest several questions emerge which we endeavour to answer. Knowledge of an area's basic geography is a prerequisite for navigating through and beyond existing thinking.

1. Who has been conducting biodiversity finance research?
2. What topics have they been examining?
3. In which journals have they been publishing?
4. Which institutions are most prominent?

Our main finding is that research is very internationally diversified, and both authorship and outlet are quite fragmented. The University of Queensland is the leading institution, with at least one author on 7 percent of the articles, followed by Colorado State University. There is no single dominant journal, with articles published across a range of conservation, environmental, and economic journals, highlighting the interdisciplinary nature of the topic. Ecological Economics is the only economics or business journal in the top 10. The US, UK, and Australia are the most productive countries, but there is no clear leader, either individual, institutional, or journal in the topic. Hence, there is an opportunity for individual researchers and research teams to easily reach the forefront of an emergent topic that affects every citizen globally.

2. Data

The search was conducted on the Scopus database over the period 1988 to 2023, with data collection being in January 2024, using the keyword string "Biodiversity and finance". All subject areas were included. The bibliographic data from these articles was then exported for analysis.

We also include grey literature in our bibliometric analysis for two reasons. First, in 2023 research on biodiversity finance has had renewed focus. Hence, there are numerous unpublished working papers, which are likely to be very relevant and at the forefront of research. Second, we acknowledge an enhanced focus on biodiversity finance by policy and regulatory researchers, which may not appear in academic journals. To identify the grey literature, we begin by searching Google Scholar with the search phrase "biodiversity and finance". We specify both abstracts and body of text search criteria. This generates a list of 698,000 results. Within this list, there are 92 pages of citations with links, just over 900 results, with the remainder being raw citations. We manually review these articles and download 149 relevant PDFs for articles not published in academic journals.⁴ Next, we import the PDFs into Scholarcy, an AI-powered abstract and reference list extraction tool. We then manually check and clean the citation data from Scholarcy,⁵ remove articles not written in English and duplicates, leaving 137 articles with full bibliometric information, including abstracts and reference lists (7,981 total references). This list was combined with the Scopus data to provide a final corpus of 706 entries.

3. Analytic approach

We apply bibliometric analysis, due to the broad scope of the review and the relatively large dataset (Donthu et al., 2021). Following Donthu et al. (2021), we include performance analysis, scientific mapping, and network analysis in our bibliometric analysis. First, we summarise and analyse author, country, and institutional productivity and impact (performance) based on the combined bibliographic database. To analyse research themes (scientific mapping and network analysis), we specify coupling, creating thematic clustering of documents using a variety of elements. This analysis is then supplemented and enriched using word clustering and trend topic maps based on abstract information. The analysis was conducted using VosViewer and the R package Bibliometrix of Aria and Cuccurullo (2017).

² "Biodiversity and ecosystems: expectations of companies", <https://www.nbim.no/en/responsible-investment/our-expectations/climate-and-environment/biodiversity-and-ecosystems/>.

³ "(Wilson et al., 1988)" an edited book is the earliest source we can find that includes research on biodiversity finance.

⁴ We make available as an appendix, in CSV format, our final dataset.

⁵ Mainly spelling errors, inconsistent dates, and missing data.

Table 1

Leading authors, institutions and countries.

Authors	Articles	Institutions	Articles	Countries	Articles
Miller DC	8	The University Of Queensland	50	USA	84
Seidl A	7	Colorado State University	20	United Kingdom	50
Armsworth PR	6	Instituto Chico Mendes	18	Australia	28
Possingham HP	6	Boston University	16	Germany	28
Dempsey J	5	Oxford	15	China	23
K Kedward	5	Cambridge	14	Brazil	14
Ring I	5	University Of Botany	13	Netherlands	14
Thompson BS	5	University of California- Davis	13	France	11
Van Den Heuvel O	5	University Of British Colombia	12	Canada	9
Atkins J	4	Stanford	11	India	9

Authors and Countries here relate to corresponding authors; institutions are for all authors.

Table 2

Types.

Document type	Count
Article	351
Grey	135
Book chapter	70
Review	61
Conference paper	33
Book	21
Note	14
Survey	11
Letter	5

Table shows the distribution of source types in the corpus.

Table 3

Leading journals.

Sources	Articles
Grey	61
Ecosystem Services	16
Biological Conservation	15
Conservation	13
Biology/Journal Of Environmental Management	
Land Use Policy	12
Science	11
Conservation Letters	10
Ecological Economics/Environmental Management Forest Policy And Economics	9

4. Findings

4.1. Performance analysis

Publications on the topic of biodiversity finance have increased markedly. In 2022 and 2023, there are 97 and 108 articles, respectively, growing from an average of three per annum in the 1990s, eleven per annum in the 2000s, and twenty-six per annum in the 2010s (see Fig. 1) (see Tables 2 and 3).

Table 1 shows the most prolific authors, institutions, and countries on the topic of biodiversity finance. The most prolific author is Daniel C. Miller with eight papers, followed by Andrew Seidl with seven. Comparing countries,⁶ the USA is the highest performing with eighty-four papers, followed by the United Kingdom with fifty papers, and Australia and Germany, each with twenty-eight papers. One Australian institution, the University of Queensland, is associated with the most papers, followed by Colorado State University.

In terms of journals, performance is fragmented, with Ecosystem Services, Biological Conservation, Conservation Biology, Journal of Environmental Management, Land Use Policy, Science, and Conservation Letters, all publishing between ten and sixteen articles

⁶ In thirty-four cases, we were not able to identify national affiliation.

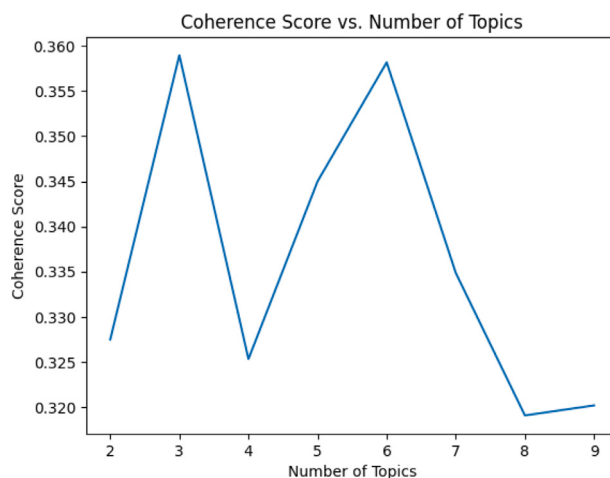


Fig. 1. Coherence plot.

Table 4
Cluster membership—abstract co-occurrence.

1	TLS	2	TLS	3	TLS
land	832	climate	543	protected area	608
forest	803	future	543	investor	583
payment	540	sustainable development	499	population	560
degradation	511	technology	494	instrument	514
livelihood	505	commitment	469	increase	428
deforestation	459	agenda	459	size	391
emission	448	science	442	amount	356
mitigation	447	chapter	410	conservation finance	329
carbon	444	life	352	uncertainty	324
scheme	442	topic	320	return	322
4	TLS	5	TLS	6	TLS
species	1030	biodiversity loss	891	habitat	563
convention	678	business	630	standard	453
program	644	progress	476	range	410
effectiveness	606	actor	450	performance	405
capacity	489	implication	428	basis	379
group	484	field	417	private sector	377
type	435	bank	402	guidance	366
report	411	driver	383	participation	362
biological diversity	399	insight	353	health	347
provision	388	financial institution	327	requirement	342

The table shows the top 10 words in each cluster, by total length strength, formed from the abstract and title of the corpus.

on the topic. Of the Economic and Business journals, only *Ecological Economics* features in the top 10 outlets. Grey literature, referring here to working papers in outlets such as SSRN or from Central Banks and policy bodies, is of clear import as an outlet. To a great extent this reflects the rapidly evolving and rather new nature of this area and reinforces the need for researchers to cast their net widely in seeking relevant literature.

The most highly cited research pieces are two books, [Wilson et al. \(1988\)](#) with over 4,000 citations, and [Pearce and Moran \(2013\)](#) with over 2,000 citations. In terms of journal article performance, two Science papers ([Brooks et al., 2006](#) and [Malhi et al., 2008](#)) achieved over 1,000 citations. Both articles are focused on biodiversity conservation, including its financing. Several papers in the PNAS also feature in the top 10, as does another Science paper. Our conclusion, on noting this and on examining the articles, is that biodiversity and climate degradation, as opposed to finance-based solutions, are driving the leading cited sources.

4.2. Mapping the field

We employ two approaches to uncover the main areas of research in the corpus. The first involves an analysis of the abstracts to examine both the most frequent words and phrases and evaluate their co-occurrences. The second approach utilises text-as-data modelling, specifically Topic Modelling, to more formally assess the “hidden” clusters of words and thus the topics being addressed. For full technical details and insights into how topic modelling can be employed to surface topics, refer to [Asmussen and Møller](#)

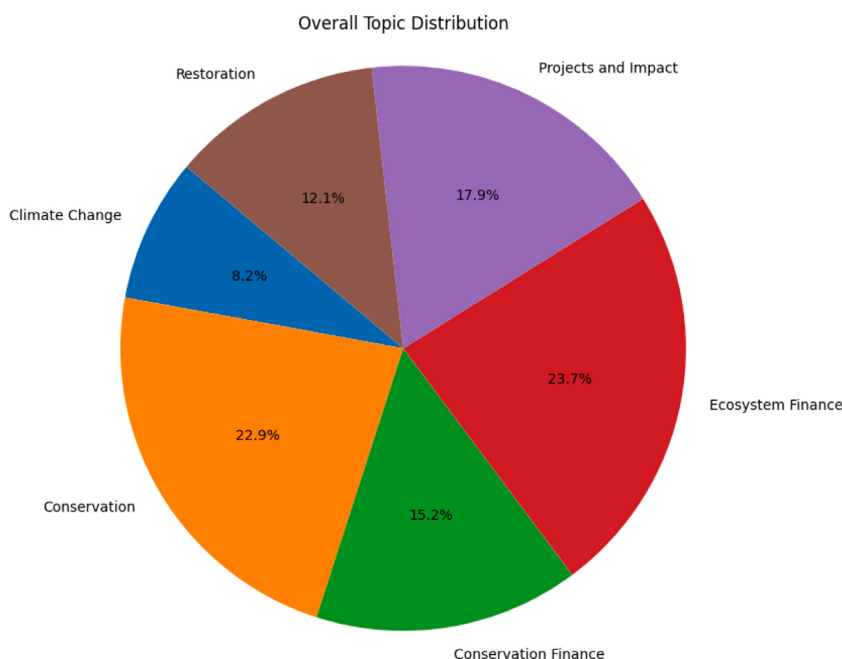


Fig. 2. Distribution of topics.

(2019) for a discussion of implementing a literature scan using Topic Modelling, with Corbet et al. (2019) and Long et al. (2022) as implementations in finance research. We use the well-known Latent Dirichlet Allocation (LDA) approach by Blei et al. (2003).

4.3. Topic modelling

We use LDA topic modelling to surface hidden structures. The coherence plot in Figure suggests that 6 topics exhaust the field. This is confirmed with an analysis of Intertopic Coherence.⁷ A feature of topic modelling is that the researcher needs to interpret the meaning of the topics. Given the top 10 dominant words in each topic⁸ We adopted the names for the topics (Climate Change, Restoration, Project and Impact, Ecosystem Finance, Conservation Finance, and Conservation). Shown in Fig. 2 is the overall distribution. Research on Conservation, Conservation Finance, and Ecosystem Finance is most prominent, reflecting 22.9%, 15.2%, and 23.7%, respectively. The evolution of these topics over the years, reported in Fig. 3, shows that while most topics have been consistent in prominence over time, Conservation has decreased in importance, accompanied by an increased focus on Conservation Finance.

4.4. Abstract analysis

Using the JavaScript-based Vosviewer package, we created a network of co-occurrences of words or terms from the abstracts and titles of the corpus. These are shown as a network in Fig. 4. The clusters are formed by reference to the total link strength of the nodes, with each node having the total links to all members of the network. For further information, refer to the Vosviewer handbook, Section 2.⁹ Shown in Table 4 are the top 10 words or terms for each cluster and their link strength. Link strength here can be used as a proxy for the overall importance of a node (term). Six clusters are identified here. It is not possible to create an exact mapping from these clusters to those raised from the topic modelling, but some congruence is evident. What is noticeable is that there are evidently much fewer terms around finance than we see in the LDA approach. This is not surprising—the Vosviewer approach is essentially a one-shot approach, examining linkages and creating nodes. In comparison, LDA models topics as distributions over words, and documents as mixtures of these topics.

⁷ We also checked 3 topics, but the intertopic coherence and perplexity analysis suggested it to be inferior to 6.

⁸ These are Topic 0: ['financ', 'financi', 'biodivers', 'green', 'sustain', 'environment', 'develop', 'wildlif', 'conserv', 'includ'] Topic 1: ['conserv', 'biodivers', 'financ', 'develop', 'fund', 'protect', 'polici', 'govern', 'manag', 'use'] Topic 2: ['biodivers', 'develop', 'sustain', 'financ', 'impact', 'manag', 'project', 'area', 'environment', 'use'] Topic 3: ['biodivers', 'develop', 'conserv', 'fund', 'financ', 'financi', 'environment', 'countri', 'risk', 'ecosystem'] Topic 4: ['forest', 'ecosystem', 'land', 'conserv', 'biodivers', 'servic', 'protect', 'carbon', 'use', 'restor'] Topic 5: ['climat', 'chang', 'land', 'develop', 'biodivers', 'adapt', 'impact', 'countri', 'use', 'agricultur'].

⁹ www.vosviewer.com/documentation/

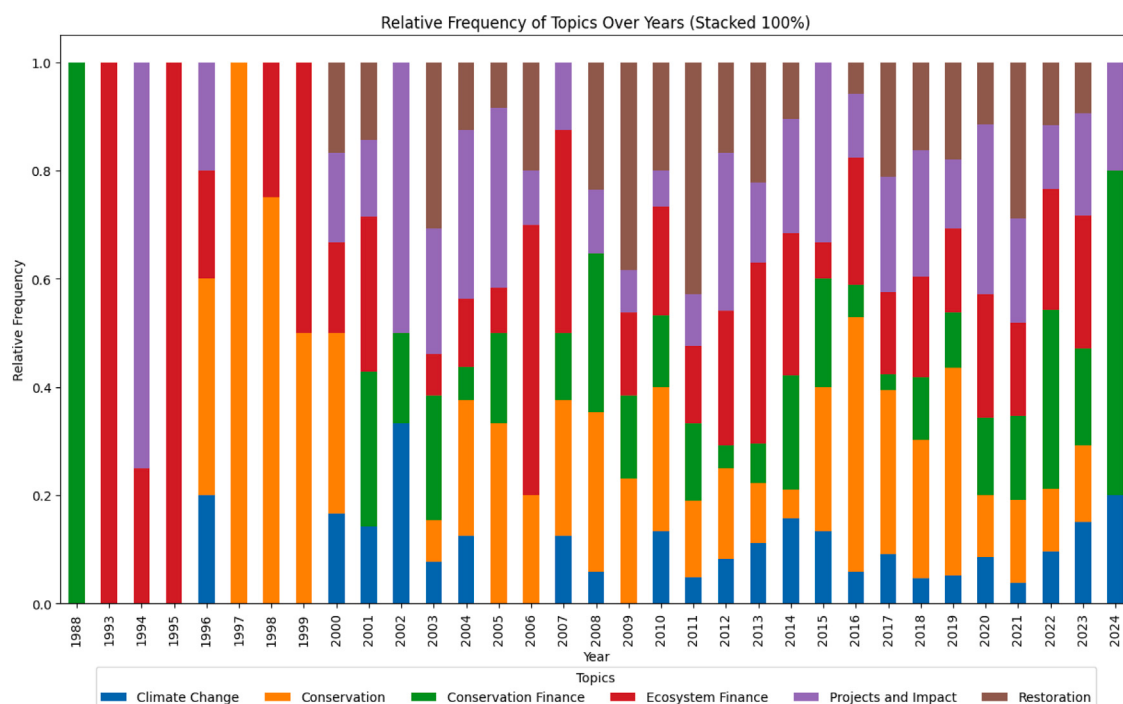


Fig. 3. Evolution of topics over time.

5. A look forward and a research agenda

Despite a renewed focus on biodiversity finance, the topic was first examined over thirty years ago. This study aims to provide an evaluation of the research that has taken place in the intervening period. We employ two main approaches: performance analysis and science mapping.

The results of the performance analysis reveal that research is fragmented, highly interdisciplinary, and international, with no clear leading research team or journal outlet. Science mapping uncovers four key themes. Restoring nature is among the largest challenges facing mankind, and it is one that we have not comprehensively addressed. While the cost of saving nature is estimated to be over \$700 billion per year (Karolyi and Tobin-de la Puente, 2023), the current annual expenditure is less than \$150 billion per year. Given this tremendous financing gap and the importance of the topic, the recent efforts by leaders in the finance academic profession to draw attention to the topic are particularly welcome. The importance of this intervention is stark when we consider how astonishingly fragmented research on biodiversity finance has traditionally been.

This provides some potentially rich areas for research and academic entrepreneurship.

First, there is a conspicuous gap in finance-led solutions in the literature. Recognising finance's pivotal role in tackling biodiversity challenges is critical to conservation and restoration of biodiversity. In particular, we urge greater numbers of studies focusing on facilitating investment capital access facilitation and risk mitigation.

Second, We urge universities to establish dedicated research-led centres focused on biodiversity finance and biodiversity risk. Given the interdisciplinary nature of this research, we encourage the development of initiatives to bring researchers together. A crucial part of this is explicit rewarding of those that take risks in so researching.

Third, publishers must become aware of the renewed focus on biodiversity finance and its likely exponential growth as a topic of interest for researchers and policymakers. There is also an opportunity for specialised journals to encourage the development of new frameworks, theoretical models, and risky empirical studies. This, in many ways, mirrors the climate finance approach and should bear similar fruit.

CRedit authorship contribution statement

Mark C. Hutchinson: Investigation, Visualization, Writing – original draft. **Brian Lucey:** Conceptualization, Writing – review & editing.

Data availability

Data will be made available on request.



Fig. 4. Network of abstract and title word cooccurrence.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.frl.2024.105377>.

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