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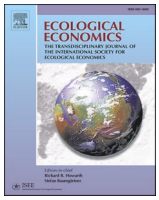

ANALYSIS

Has "Ecological Economics" betrayed its roots? Revealing its state, internal tensions and evolution through a multi-level and multi-scale bibliometric assessment

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ABSTRACT

This paper uses a mixed methods approach to investigate the development of Ecological Economics (EE), combining a critical literature review with quantitative bibliometric analysis. It maps the intellectual trajectory of the field, its thematic shifts and its authorship networks from inception to the present time. Three phases are identified: (i) 1983–1997: the founding period; (ii) 1998–2011: the establishment of ecosystem services' valuation; and (iii) 2012–2024: the contemporary EE, characterized by internal tensions and increasing integration into mainstream environmental initiatives. Our findings reveal a global surge in interest in the field, accompanied by an expansion in the intellectual scope and research themes, as well as a broader geographic distribution of authors. This is associated with the emergence of numerous new journals, with Ecological Economics maintaining a central, albeit declining, position. Our research shows that while EE began as a critique of neoclassical economics, during its establishment phase it embraced market-based solutions and monetary valuation. However, contemporary trends indicate a critical reassessment of these approaches, with a shift towards exploring issues such as climate justice, degrowth and social metabolism. This dynamic evolution highlights the ongoing importance of EE as a platform for transdisciplinary research that challenges conventional economic thinking.

1. Introduction

Over the past four decades, Ecological Economics (EE) has emerged as a transdisciplinary field aiming to address ecological and socio-economic challenges. Born from a critique of neoclassical economics, EE synthesizes insights from natural and social sciences with systems thinking to overcome reductionist approaches and confront today's multifaceted environmental and societal crises (Costanza et al., 1997). Unlike the abstract focus of neoclassical economics on prices and exchange mechanisms, foundational EE offers a concrete and material way of analyzing the economy, emphasizing the interdependence between ecological and socio-economic systems (Gerber and Scheidel, 2018; Kallis and Norgaard, 2010).

The origins of EE are rooted in intellectual contributions from figures such as Georgescu-Roegen (1906–94), whose thermodynamic perspective illuminated biophysical limits of economic processes, and Kenneth Boulding (1910–93), who popularized the "Spaceship Earth" metaphor. These thinkers, alongside institutional economists such as K.W. Kapp (1910–76) and systems ecologists such as H.T. Odum (1924–2002), inspired the formal establishment of EE, with the foundation of the International Society for Ecological Economics (ISEE) in 1988 and its journal, Ecological Economics, in 1989. This institutionalization marked EE's commitment to framing the economy as an open system embedded within the closed biophysical boundaries of the biosphere (Costanza and Daly, 1987). This initial vision took shape around key debates, such as those concerning the issue of scale and the dichotomy between "weak"

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and "strong" sustainability. Advocates of weak sustainability argued that human-made capital could, in theory, substitute for natural capital (Pearce, 1987). This belief implies that perpetual economic growth could be achieved through continuous technological progress, a stance also referred to as "technological optimism" (Costanza, 1989). In contrast, the vision of strong sustainability emphasized the non-substitutability of natural capital, asserting that human-made assets cannot replace depleted natural resources (Daly, 1996). Prudent technological pessimism informed advocates of strong sustainability, who placed great importance on non-linear, dynamic processes that characterize complex systems, leveraging on the notions of "threshold", "resilience" and "panarchy" (Holling, 2001). These concepts underscore the inevitability of biophysical limits to growth. Consequently, in the early phases of the field's development, prominent ecological economists have advanced perspectives known as "post-growth", "beyond growth" or "steady state economics" (Daly, 1993, 1996). Other key debates that shaped the field's early history concerned methodological pluralism in evaluation, equitable resource distribution, and environmental justice (Daly, 1992; Martinez-Alier, 2002; Røpke, 2004).

1.1. Research questions & scope

However, as EE matured, questions arose as to whether it remained aligned to its original aspirations, and criticism began to emerge (Røpke, 2005; Söderbaum, 2011). Critics observe that by the late 1990s, the field began to pivot towards empirical and policy-oriented approaches, emphasizing concepts such as "ecosystem services" and "natural capital" which gradually gained widespread acceptance among ecological economists (Spash, 2013; UNEP, 2011). This had led, and continues to lead, several scholars to express concern that, by doing so, there is a risk of reinforcing the very approach that EE had initially challenged: the idea of endless economic expansion through the increasing commodification of Nature (Melgar-Melgar and Hall, 2020; Söderbaum, 2013; Spash, 2015, 2024). The aim of this paper is to explore these tensions by analyzing the intellectual development of EE, in order to address the following timely research questions:

- How has EE evolved in terms of key themes, journals, and authorship patterns, and what does it reveal about the field?
- Has the field diverged from its foundational principles, as some critics claim?
- What are the wider implications for the future direction of EE?

Previous research has reviewed the field of ecological economics using different approaches such as extensive literature reviews (e.g. Costanza and Limburg, 2010; Lundgren, 2022; Martínez-Alier and Muradian, 2015; Røpke, 2005; Spash, 2013), multivariate statistical full-text analysis (Kretschmer et al., 2024) and bibliometric citation or discourse analysis (e.g. Costanza et al., 2004, 2016; Plumecocq, 2014). While previous studies have examined aspects of EE through either quantitative or qualitative lenses, none have systematically combined both approaches across the entire body of literature, a gap our work directly addresses. Firstly, our study combines two methods: Bibliometric Network Analysis (BNA) and a critical, ad hoc, literature review of influential publications. The latter offered valuable insights and tools to design the bibliometric investigations effectively and added depth to our interpretation of bibliometric results. Secondly, the scope of our research is broader than that of previous studies. Previous studies focused primarily, or even solely, on the reference journal for the field (Ecological Economics), therefore it was not possible to determine whether the observed dynamic changes were due to shifts in the field of EE or changes in the management of the journal (Costanza et al., 2016; Kretschmer et al., 2024; Plumecocq, 2014). By contrast, our BNA provides coverage of the wider EE academic field, with additional analyses focusing specifically on the journal. Thirdly, although analogous endeavours have been undertaken in sub-disciplines of EE (Drupp et al., 2020), no prior publication has provided a comprehensive multi-faceted bibliometric assessment —encompassing both static and dynamic approaches— of all the hallmark aspects of the field (authors, collaboration patterns, research areas, journals). Lastly, none of the aforementioned studies covers a time period of comparable length. We are able to trace the evolution of EE over more than forty years, from its roots in the early 1980s to the mid-2020s. For these reasons, we argue that our study offers an unparalleled perspective on the current state of the field and its historical evolution, enabling us to address the research questions more effectively.

1.2. A brief historical perspective of core tensions in Ecological Economics

The issue of whether ecological contributions to humans should be the object of monetary evaluation can be considered one of the major factors that have sparked debate over the field's direction in recent decades (Gowdy and Erickson, 2005; Melgar-Melgar and Hall, 2020; Pirgmaier, 2021). Supporters of the concepts of "natural capital" and "ecosystem services" argue that these frameworks highlight the role of ecological processes in creating economic value and help inform policymakers (Costanza, 2024; Daly, 2020). Landmark works such as Costanza et al. (1997) provided an exemplification of "calculating nature" estimating ecosystem services' global value at $33 trillion annually. This approach gained momentum through frameworks such as the Millennium Ecosystem Assessment (MEA) and TEEB (The Economics of Ecosystems and Biodiversity), which standardized valuation methodologies to promote environmental protection within market systems (MEA, 2003; UNEP, 2011). Supporters of this pragmatic approach, often named "new environmental pragmatism", see these tools as crucial for bridging ecological insights into policy frameworks (Spash, 2013, 2015). By aligning sustainability with economic priorities, proponents believe EE can influence decision-making more effectively and garner broader institutional support. However, critics argue that these approaches risk undermining EE's foundational principles by commodifying nature and reducing complex ecological and cultural relationships to monetary terms (Gómez-Baggethun et al., 2010; Muradian and Gómez-Baggethun, 2021; Pascual et al., 2023). They argue that the field could gradually be reabsorbed into neoclassical economics if its focus shifts from the biophysical foundations of the economy to the economic foundations of the biosphere (Hall and Klitgaard, 2018; Melgar-Melgar and Hall, 2020; Söderbaum, 2013).

Martínez-Alier and Muradian's (2015) critique emphasizes that monetizing ecosystems fosters market-based solutions such as "habitat trading" or "net positive impact" policies, which may perpetuate exploitation rather than supporting conservation. These approaches often prioritize short-term gains, sidelining intrinsic, cultural, and ethical values central to ecological systems. Martinez-Alier (2002) emphasizes ecological values and social justice, arguing that many aspects of ecosystems—such as biodiversity and cultural significance—cannot be adequately captured by market valuation. In the same vein, Van Den Bergh (2001) highlights the limitations of valuation methods such as "willingness to pay," which reflects individual preferences rather than ecological functionality. In this vein, the Barcelona School of Ecological Economics and Political Ecology (Villamayor-Tomas and Muradian, 2023), and the Degrowth movement, emphasize the concept of "social metabolism", which empirically highlights the biophysical impossibility of infinite growth within a finite environment. They recover the notion of "post-growth" (Daly, 1996), arguing that sustainable development cannot coexist with growth-driven economies. These scholars advocate for reducing consumption, particularly in high-income economies, to prioritize ecological restoration, social equity, and human well-being (Mastini et al., 2021; Hickel and Kallis, 2020; Kallis, 2018). Furthermore, this school reinforces the dimension of environmental justice in EE (Martinez-Alier, 2002). Empirical evidence shows how environmental conflicts in peripheral regions, where low-value raw materials are extracted while waste and environmental degradation accumulate,

are generated by economic growth in the Global North (Dorninger et al., 2021; Villamayor-Tomas and Muradian, 2023). These dynamics are encapsulated in concepts such as "Ecologically Unequal Exchange" and "Ecological Debt", which are identified by many critical ecological economists as significant barriers to achieving socio-ecological justice (Corsi et al., 2024; Spash, 2024; Villamayor-Tomas and Muradian, 2023). Finally, Spash contends that this shift represents a retreat into what he terms "unstructured and uncritical methodological pluralism" (Spash, 2013). He warns that emphasizing market-oriented tools risks compromising EE's identity, as the field increasingly measures success by political acceptance rather than scientific rigor or ecological coherence. Spash and others fear that EE is moving closer to mainstream economics, adopting tools and frameworks that replicate neoclassical assumptions about growth, substitutability, and technological optimism. This debate encapsulates a broader tension within EE: whether to prioritize pragmatic tools that integrate with mainstream frameworks or to uphold its foundational critiques of market-driven paradigms and ecological oversimplification. We aim to identify if and how this debate is reflected in EE's scientific publications, in the relation between authors and in the emergence or establishment of research topics within the EE community over time.

2. Material and methods - bibliometric network analysis

2.1. Bibliometric tools used

Bibliometrics allows a macroscopic overview of academic literature, exploring authors, journals, organizations, and countries over time, but also the discourse of the field based on keywords. It is a quantitative approach based on mathematical and statistical tools analyzing research trends, interrelationships, developments, and impacts in a given research field (Pendlebury, 2008). The BNA was performed using VOSviewer software (version 1.6.18) (Van Eck and Waltman, 2010, 2014). The inter-country collaboration map was performed using Biblioshiny, a tool from the R package Bibliometrix (Aria and Cuccurullo, 2017). Table 1 describes the terminology used within the VOSviewer network maps (Van Eck and Waltman, 2023), while Table 2 describes all the analyses performed in this study.

Table 1
Terminology used in VosViewer software (Van Eck and Waltman, 2022).

Term	Description
Items or nodes	Objects of interest (e.g., publications, keywords, authors). In each network map, they can be weighted according to different parameters. In the VOS mapping, items with stronger relationships are placed closer together, while those with weaker or no relationships are positioned further apart.
Link	Connection or relation between two items (e.g., co-occurrence of keywords).
Link strength	Attribute of each link, expressed by a positive numerical value. For example, the case of co-authorship links, the higher the value, the higher the n. of publications the researchers have co-authored.
Network map	Set of items connected by their links. The more connected an item is, i.e. the higher the number of links, the more central its position in the network map.
Clusters	Groups of items included in a map. One item can belong only to one cluster. The number of clusters in each analysis is determined by the resolution parameter: the higher the resolution value, the higher the level of detail and the number of clusters. In our BNA, a resolution of 1 (default option) was used for all analyses. The VosViewer algorithm partitions the network such that the number of links within clusters is maximized and the number of links between clusters is minimized. Therefore, clusters are groups of items that are strongly connected to each other while being relatively weakly connected to items in other clusters.
Number of links	Number of links of an item with other items. The more connected an item is, i.e. the higher the number of links, the more central its position in the network map.
Total link strength (TLS)	The cumulative strength of the links of an item with other items.

The bibliometric analyses we have carried out can be divided into static and dynamic analyses (Table 2). Static analyses address the question, "What is the current state of the field?" by providing a cumulative overview based on the entire Scopus database. In contrast, dynamic analyses explore "How has Ecological Economics evolved over time?", focusing on the field's historical development and thematic shifts. As can be noticed in Table 2, the static analyses include a co-occurrence analysis of keywords, which also examines documents published in the journal Ecological Economics (Section 3.1.5). This specific focus evaluates how well the journal reflects the broader field in terms of key themes, as identified through our citation analysis of sources (Section 3.1.3). Dynamic analyses, on the other hand, involve segmenting the Scopus database into three distinct subperiods to perform a multiscale analysis. This segmentation enables a comparative examination of trends and patterns across different phases of the field's evolution. The details and rationale for the chosen timeframes are elaborated in Section 3.2.

Each bibliometric analysis applies thresholds to identify the 20 most significant items and their network relationships (with the exception of the citation analysis of documents, which highlights the top 10 items). The definition of "significant" varies depending on the type of item being analyzed (e.g., journal, author, keyword) and is detailed in the "Description" column of Table 2. The choice of 20 main items strikes a balance between providing comprehensive insights into the field's key trends, patterns, and associations while maintaining visual clarity and analytical conciseness. This threshold ensures that only the most relevant items emerge from the data, enabling a focused examination of their interrelationships and network metrics, which reveal critical insights into the structure and evolution of the field. In some figures, fewer than 20 items may be displayed due to the default VosViewer option, "show only connected items." However, the complete dataset of the top 20 items, along with relevant metrics such as total link strength, number of documents, citations, normalized citations, and average publication year, has been fully analyzed and is discussed in the results. To ensure transparency and replicability of the study, comprehensive tables—reporting all threshold values, the total number of identified items, and the software parameters used—are provided in Supplementary Material 1 (hereafter referred to as SM1).

2.2. Bibliographic research and data collection

In order to conduct a thorough bibliometric analysis, it is crucial to define the scope and parameters of the data collection process. To do so, a systematic search was conducted on November 11th, 2024, using Scopus and Web of Science. The search string, ""Ecological Economics" OR "Economía Ecológica"", targeted titles, abstracts, and keywords (Scopus) and topics (Web of Science). This approach ensured broad coverage, including relevant documents in Spanish. Scopus search resulted in 5804 documents in total while the Web of Science search resulted in 1667. Thus, we decided to use the Scopus database, as this allowed a more comprehensive exploration of the academic literature on EE. The bibliometric data was exported as .csv files, selecting "Citation information", "Bibliographical information", "Abstract & keywords", and "Include references". Our analysis excluded the "book chapters" document type (1470) from the total of 5804 exported documents due to the presence of outlier values that would have significantly distorted the results (see Fig. A1 in the SM1). All the other document types were retained in the database. The total number of documents actually considered in our study is therefore 4334 (Scopus database, excluding book chapters). Finally, further analyses were conducted on a subset of the data represented by documents published by the Ecological Economics journal, to evaluate the extent to which the latter is representative of the broader field (1284 documents).

Table 2
Bibliometric analyses used in this study, from VOSviewer (Van Eck and Waltman, 2018).

Bibliometric analysis	Scope of application	Description	Graphical outputs
Citation analysis of documents	Static (full Scopus database)	Reveals the 10 main publications up to today (based on n. of citations).	Table 3
Citation analysis of sources	Static (full Scopus database)	Reveals the 20 main sources up to today (based on n. of documents published to highlight most productive sources).	Fig. 2, Table in SM1
Co-authorship analysis of authors	Static (full Scopus database)	Reveals the clusters of co-authorship among the 20 main authors (based on n. of citations) that have at least 5 documents published (to avoid overestimating the importance of occasional highly cited co-authors who are not the ones driving the development of the field).	Fig. 3, Table in SM1
Co-occurrence analysis of keywords	1. Static (full Scopus database + detail of the Journal Ecological Economics) 2. Dynamic (Scopus database is segmented in 3 sub-datasets)	Reveals the 20 main "author keywords" (based on n. of occurrences) and their co-occurrence links. These represent the number of publications in which two linked keywords appear together in the title, abstract, or keywords list, reflecting key research themes and patterns.	Fig. 4, Fig. 6, Tables in SM1
Bibliographic coupling analysis of authors	Dynamic (Scopus database is segmented in 3 sub-datasets)	Reveals the level of association among the 20 main authors (based on n. of citations) that have at least 5 documents published (to avoid overestimating the importance of occasional, highly cited authors). Bibliographic coupling links are based on how often two authors cite a common third author in the same document. The idea is that the more documents two authors share in the reference lists of their academic production, the more similar (and related) these two authors are. Together with co-citation analysis of authors, it can be used to identify intellectual structures within a field and to study their evolution based on frequently coupled authors.	Fig. 7, Table in SM1
Co-citation analysis of cited authors	Dynamic (Scopus database is segmented in 3 sub-datasets)	Reveals the level of association among the 20 main authors (based on n. of citations) that have at least 5 documents published (to avoid overestimating the importance of occasional, highly cited authors). The idea is that the more two authors are co-cited by other authors, the more similar (and related) these two authors are. Together with bibliographic coupling analysis of authors, it can be used to identify intellectual structures within a field and to study their evolution based on frequently co-cited authors.	Fig. 8, Table in SM1

3. Results and discussion

3.1. Static bibliometric assessment

3.1.1. Annual scientific production

Fig. 1a shows the relative weight of the journal Ecological Economics throughout the years, while Fig. 1b analyses temporal trends in scientific production in both Scopus and the journal. As can be seen, in the past the journal accounted for more than half of the total yearly scientific output on EE, specifically in 1992, 1994, and the three years around the turn of the millennium (Fig. 1a). However, its quantitative weight has fallen; by 2015, it accounted for a third of Scopus's annual scientific output, and by 2023 (the last full year of the database) it accounted for less than a tenth (Fig. 1a). This recent decline in the journal's quantitative dominance is the result of the different temporal trends in academic production displayed by the two databases (Fig. 1b). The Scopus database shows a consistent growth trend since the 1980s, which can be closely reflected in a linear model ($R^2 = 0.89$). In contrast, the journal's growth trend cannot be approximated by linear growth ($R^2 = 0.37$). More accurate regression models for both Scopus and the journal are represented by cubic regressions (Fig. 1b). Fig. A4 (SM1) shows how the topic has grown exponentially since the journal started publishing in 1991 until around 2015. The exponential regression model indeed provides a good fit for both Scopus and the journal for this period (Fig. A4). This was followed, in Scopus, by a plateau in the last decade, whereas the journal has shown a clear downward trend (Fig. 1b). Nevertheless, it is noticeable that slightly less than one third of all scientific documents on EE in Scopus have been published by the journal Ecological Economics, highlighting its historical role as a reference for the field (Fig. 1a). In the SM1, we provide a breakdown of scientific publications by document type in both Scopus (Fig. A2) and the journal (Fig. A3).

3.1.2. Bibliometric analysis of documents

Table 3 presents the 10 most cited documents in the field of EE, which span a broad range of topics. These include milestones works such as the development of a taxonomy to classify ecosystem services (De Groot et al., 2002; Gómez-Baggethun and Barton, 2013; Engel et al., 2008; Kremen, 2005), as well as theoretical contributions on the complexity (Holling, 2001) and resilience of socio-ecological systems (Adger, 2000) or attempts to link ecological research to human well-being (Pejchar and Mooney, 2009). Noteworthy are also recent empirical studies that examine the risks associated with continued economic growth, including model-based projections of resource use and carbon emissions, as well as input-output analyses of international trade (Hickel and Kallis, 2020; Lenzen et al., 2012).

3.1.3. Bibliometric analysis of sources

The network map presented in Fig. 2 illustrates the prominence of main scientific sources publishing on EE. It reveals a highly centralized structure, with the journal Ecological Economics positioned as a central attractor. Thus, our analysis confirms that this journal retains its dominant status in the field, as it is not only one of the oldest nodes in the network (average publication year: 2011.09), but also the most productive, contributing over 60 % of the publications produced by the 20 most prolific sources in the field. In terms of citations, its influence is even more pronounced, accounting for more than 75 % of the citations among the sources analyzed. Moreover, it has the highest total link strength (TLS), highlighting its significant influence and centrality within the network. The journals with the oldest average publication years are the International Journal of Sustainable Development (2008.68) and Biological Conservation (2010.68). These represent early contributors with few publications and lower network influence (low TLS) in the current landscape; though Biological Conservation stands out for its higher citation frequency, suggesting a more niche impact. Other established sources such as Ecological Modelling and Environmental and Resource Economics demonstrate stronger network connectivity and higher citation rates relative to their size. Among the most recent sources analyzed, i.e. those that have acquired their relevance for the field in the most recent average year, Environmental Science and Pollution Research (2021.76), Sustainability (Switzerland) (2020.3), Ecological Indicators (2019.71) and the Journal of Cleaner Production (2019.08) have emerged as key drivers in the recent evolution of EE.

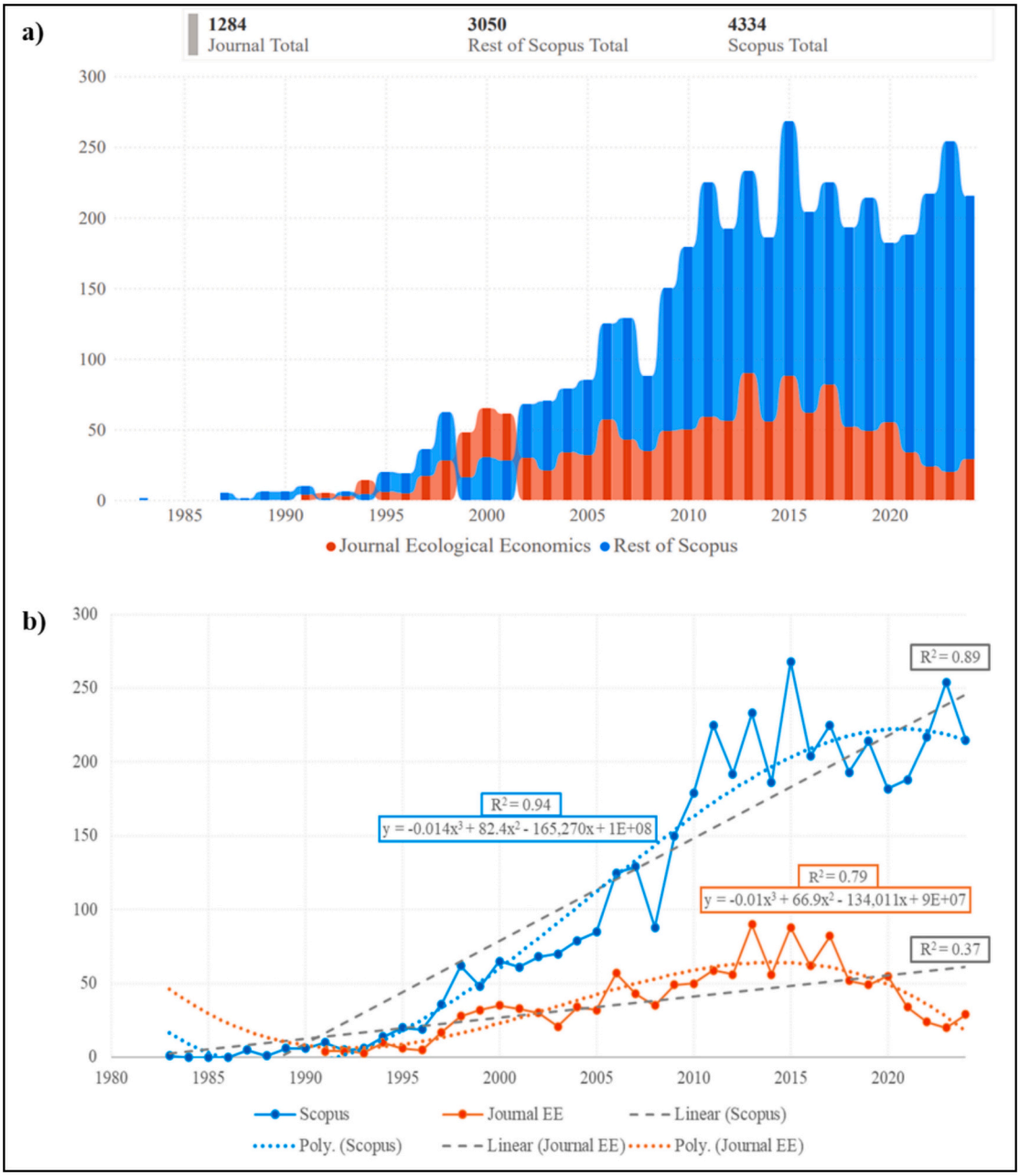

Fig. 1. Annual scientific production of documents on EE in Scopus (blue) and the Ecological Economics journal (red). Fig. 1a presents the relative weight of the journal compared to the entire Scopus database throughout the field's history (each time the red area is above the blue area, it indicates that the journal produced more scientific documents than the rest of Scopus that year). Fig. 1b provides a detailed view of the temporal trends in scientific production, highlighting the fact that linear regression models fit Scopus but not the journal, and providing cubic regression best estimates for both. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Alongside these, the Journal of Environmental Management (2014.95) and Shuengtai Xuebao (2015.02) are contributing to the current landscape of the field. Notably, Ecological Indicators, the Journal of Environmental Management and the Journal of Cleaner Production are cited more frequently than their productivity, indicating that their published documents are highly relevant on average. In contrast, Shuengtai Xuebao and Sustainability (Switzerland) are more prolific but receive fewer citations, suggesting a disparity between output and visibility. However, Sustainability (Switzerland) stands out for its strong interdisciplinary connections (high TLS), while Shuengtai Xuebao exhibits lower TLS, possibly due to a broader, less tightly connected focus. While Chinese sources, particularly Shuengtai Xuebao, exhibit relatively low citation counts and TLS given their volume of publications, their contribution to the field should not be overlooked, as 3 out of the 20 most influential sources in our analysis are Chinese.

3.1.4. *Bibliometric analysis of authors*

The network map illustrates the relevance of main authors publishing on EE. The first major finding of this analysis is the identification of Costanza as the most influential figure in the field. His central position in the network, extensive connections with both foundational and contemporary authors, and his top ranking in terms of document output and total link strength (TLS) underscore his unparalleled influence in the field today—despite ranking second in total citations. However, his low average publication year (2004.34, second oldest in Fig. 3 after Wilson) indicates that his leadership in the field was largely established decades

Table 3
Most cited documents in the field of Ecological Economics.

Document	Journal	Title	N. of citations
De Groot et al. (2002)	Ecological Economics	A typology for the classification, description and valuation of ecosystem functions, goods and services	3366
Adger (2000)	Progress in Human Geography	Social and ecological resilience: are they related?	3041
Holling (2001)	Ecosystems	Understanding the Complexity of Economic, Ecological, and Social Systems	2799
Rennings (2000)	Ecological Economics	Redefining innovation—eco-innovation research and the contribution from ecological economics	1980
Engel et al. (2008)	Ecological Economics	Designing payments for environmental services in theory and practice: An overview of the issues	1674
Gómez-Baggethun and Barton (2013)	Ecological Economics	Classifying and valuing ecosystem services for urban planning	1222
Kremen (2005)	Ecology Letters	Managing ecosystem services: what do we need to know about their ecology?	1055
Pejchar and Mooney (2009)	Trends in Ecology & Evolution	Invasive species, ecosystem services and human well-being	1042
Hickel and Kallis (2020)	New Political Economy	Is green growth possible?	875
Lenzen et al. (2012)	Nature	International trade drives biodiversity threats in developing nations	824

ago. The second result of this analysis is the identification of the cluster of co-authors composed by Kallis, Gómez-Baggethun, and Pascual (bottom-left in Fig. 3) as the cluster of authors which gained the highest influence in the most recent years, signalling a recent shift in the research landscape. Kallis, in particular, although ranking third in terms of absolute citations (totalling 2977), ranks first (83.65) when these are normalized to account for the fact that older documents have had more time to receive citations than more recent documents, positioning him well above Costanza (75.92). The following authors are De Groot (55.47), Martìnez Alier (51.76), Wilson (51.11) and Gómez-Baggethun (48.10), highlighting an almost symmetrical distribution of normalized citations between the bottom-left and the middle-up clusters of authors. However, the inclusion of average publication years in the analysis clearly shows that the bottom-left cluster is the one that is gaining momentum today. Indeed, among the top 20 cited authors, those with the latest average publication year are Gómez-Baggethun (2014.5), Kallis (2013.71) and Pascual (2013.33). The fact that the authors in this newer cluster are much closer to foundational figures with poor TLS (such as Martinez-Alier) than to highly influential authors such as Costanza or Wilson suggests that they are attempting to bridge foundational and emerging issues by exploring tools and methodological stances that differ from those used by the most cited and integrated authors in the field. Moreover, despite his recent average publication year, Kallis is already second only to Costanza in terms of documents published, suggesting that he has rapidly emerged as a new leading figure in EE. The citation and network metrics reveal further details. De Groot and Wilson combine moderate published documents with high citation and TLS values, signifying focused but impactful contributions that are well-integrated into the EE discourse. In contrast, authors such as Bateman, Baumgärtner, Engel, Røpke and Spash achieve substantial citations despite negligible TLS, suggesting impactful but less interconnected contributions, possibly reflecting a more specialized focus. Notably, the gender and geographical imbalances in EE's co-authorship patterns are striking. Only two women—Engel and Røpke—feature among the top twenty most cited authors, reflecting a significant gender gap in EE scholarship. Coupled with the dominance of Global North institutions, this highlights the persistent underrepresentation of women and scholars from the Global South. Finally, the fact that only 13 of the 20 most cited authors are connected, as shown in Fig. 3, highlights that the

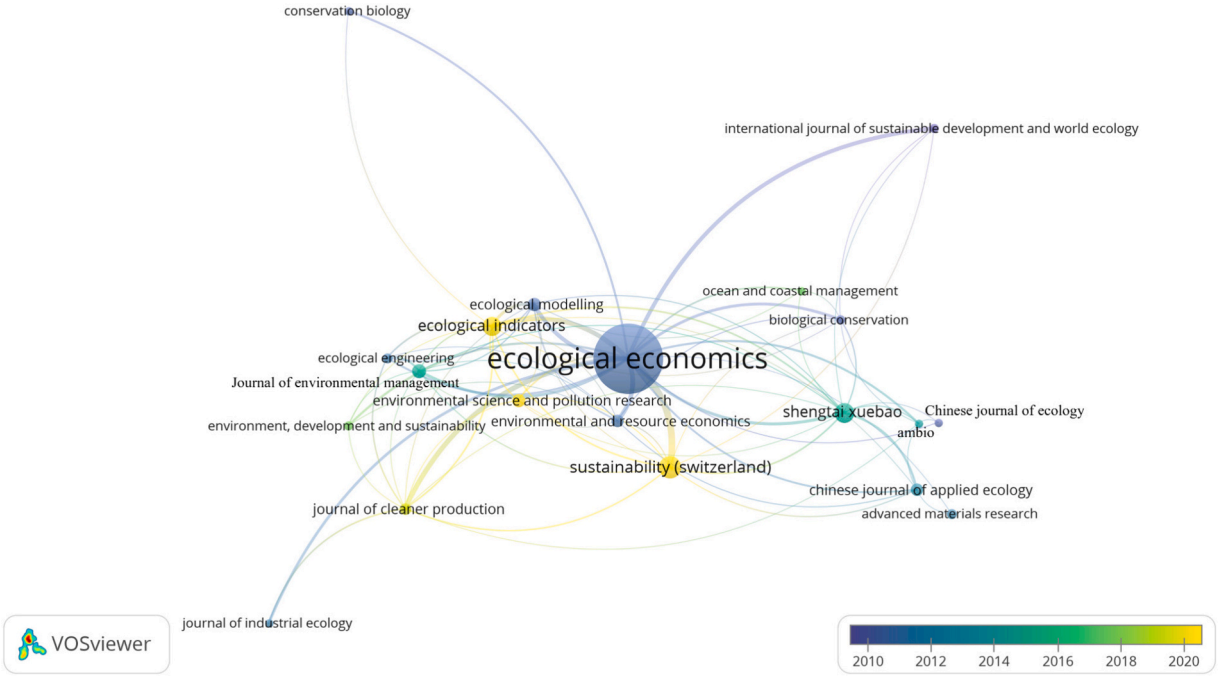

Fig. 2. Citation network of sources. The top 20 sources by number of documents are displayed. The size of the nodes is based on the number of documents published. Links denote citation links, weighted by strength. The colour gradient depicts the average publication year of documents in each source. See Supplementary Material 1 for all numerical data on documents, link strengths and citations.

structure of the field appears to be rather fragmented, with some of the most established researchers operating with limited integration of the approaches and goals of their peers.

3.1.5. Bibliometric analysis of keywords

The network map shown in Fig. 4 provides an overview of authors' keywords for both the whole Scopus database (Fig. 4a) and the journal "Ecological Economics" (Fig. 4b). The two analyses show similar results, suggesting that the journal can be considered a reference in the field, not only in terms of documents published and citations received (Fig. 2), but also in terms of research trends and topics (Fig. 4). In both analyses, central topics such as "sustainability" and "sustainable development" are consistently positioned close to "ecological economics", reflecting their foundational role in the field. Early discourse in EE was shaped by foundational themes such as 'methodology,' 'valuation,' and 'cost-benefit analysis.' While terms such as 'valuation' and 'contingent valuation' remain moderately frequent, their lower TLS suggests a specialized, rather than integrative, role within the broader network. These were among the earliest research themes in EE and continue to play an important, albeit less integrative, role in contemporary discussions. Both analyses are consistent in pointing at "degrowth" as the keyword with the highest average publication year (2018.41 in Scopus and 2016.55 in the journal). Other recent research themes appear to be those related to "climate change", with the addition of "ecological compensation" in Scopus and "institutions" in the journal. While "climate change" shows high levels of occurrences and TLS, suggesting a more mature integration in the debate, the other two have similar metrics, with moderate occurrences but low TLS, suggesting that their influence is still in the making. On the other hand, keywords such as "ecosystem services" and "natural capital" not only have high occurrences but also strong TLS, underlining their centrality and interdisciplinary appeal. The interdisciplinary appeal of 'ecosystem services' and 'natural capital' has encouraged collaboration between economists and ecologists, making these concepts pivotal to EE research. The average publication year of the keyword "ecosystem services" is 2014.43 in Scopus and 2012.1 in the journal (mid-high range) effectively connecting some among the oldest keywords (such as "valuation" and "contingent valuation") with more contemporary topics (such as "ecological compensation" and "climate change"). "Climate change" and "biodiversity" feature prominently, with high TLS relative to their occurrences, reflecting their importance in connecting global environmental challenges with the field's conceptual frameworks. Conversely, "degrowth" shows a mismatch between occurrences and TLS, with moderate occurrences but a lower TLS than terms such as "ecosystem services" or "sustainability", suggesting that it is gaining traction as an important research topic but is not yet as widely connected across the network. In both Scopus and Ecological Economics, "degrowth" and "ecosystem services" are almost at opposite ends of the network map. This suggests different origins and that they belong to very different thematic clusters. In this regard, while "degrowth" emerges in conjunction with historical themes such as "methodology", "sustainability" and "sustainable development", "ecosystem services" is deeply associated with the themes of "valuation", "contingent valuation", "biodiversity" and "conservation".

3.2. Dynamic bibliometric assessment

To examine the historical evolution of the field more closely, a dynamic analysis was conducted by dividing the Scopus database into three subperiods (Fig. 5). The temporal segmentation is informed by two key findings highlighted in our static analysis. First, given the results of the co-authorship analysis, and corroborated by a critical literature review, Costanza and Kallis have been identified as key contributors to the development of the field, as they are both leaders of the two most prominent clusters (Fig. 3). Second, the results of the co-occurrence analysis of keywords reveal a distinct thematic contrast within the field. On one side of the network map are research areas dealing with "ecosystem services" and "valuation", while on the other side there are more recent research areas focusing on policy-related issues, such as the debate between "economic growth" and "degrowth" (Fig. 4). That is why we've chosen Costanza's and Kallis's milestone publications in their

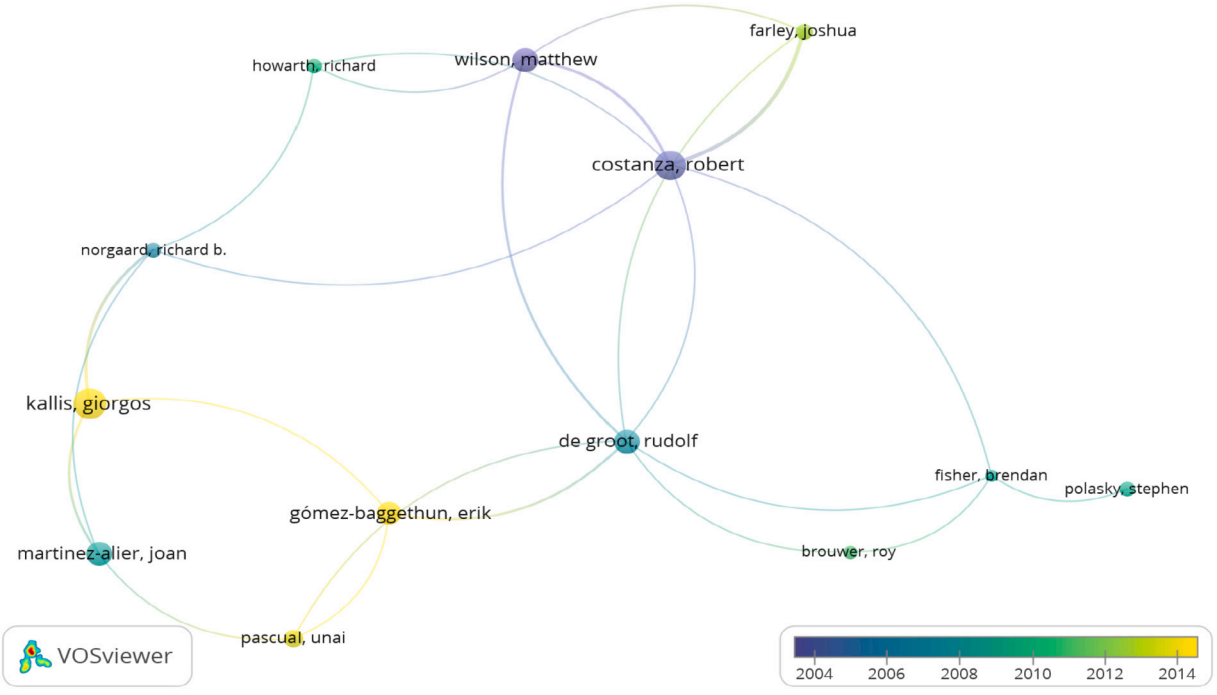

Fig. 3. Co-authorship of authors. The top 20 most cited authors (among those with at least 5 documents published) have been selected. Only connected items are displayed. The size of the nodes is based on normalized citations, to account for the fact that authors that started publishing during the early phases of EE had more time to get cited compared to more recent authors. Links denote co-authorship links, weighted by strength. The colour gradient depicts the average publication year of each author. See Supplementary Material 1 for all numerical data (documents, link strengths and citations) on all 20 items.

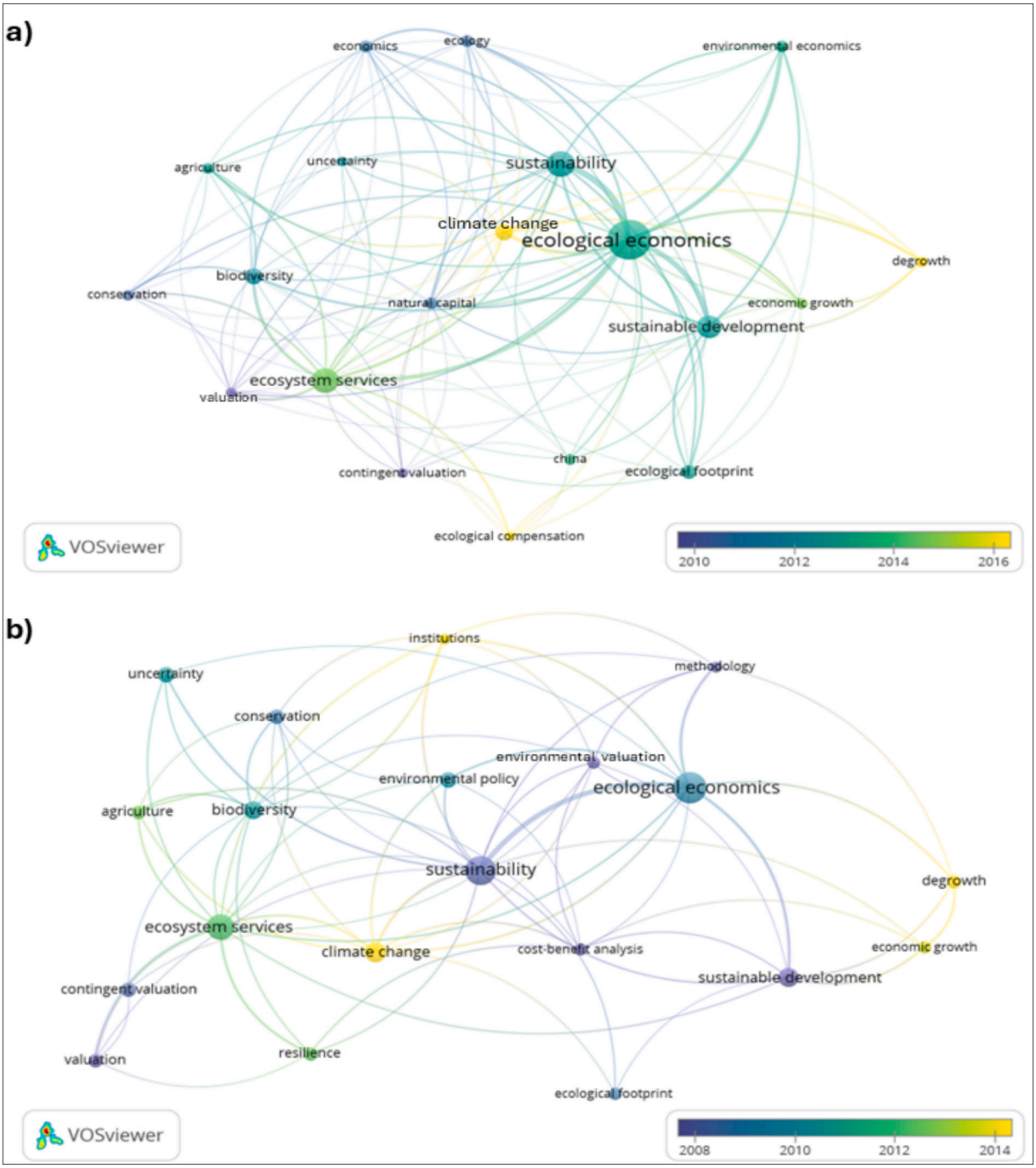

Fig. 4. Keywords co-occurrence analysis. The top 20 "author keywords" by number of occurrences are displayed in each network map. Fig. 4a shows the analysis applied to the whole Scopus database, while 4b shows the same analysis focused on the "Ecological Economics" journal. The size of the nodes is based on frequency of occurrence. Links denote co-occurrence links, weighted by strength. The colour gradient depicts the average publication year of each keyword. See Supplementary Material 1 for all numerical data on occurrences and link strengths.

two different areas of research (namely "ecosystem services" and "degrowth", respectively) to segment the Scopus database into three subdatasets of roughly equal length:

- 1983–1997: This subperiod spans from the first Ecological Economics (EE) document recorded in the database to the publication of the landmark article "The Value of the World's Ecosystem Services and Natural Capital" (1997). This article is not only Costanza's most cited publication (source: Scopus), but also marked a pivotal moment in the conceptualization and recognition of ecosystem services.
- 1998–2011: Beginning after Costanza et al. (1997), this subperiod concludes with the publication of Kallis's seminal article "In Defense of Degrowth" (2011) in the journal Ecological Economics. This work is one of Kallis' most cited publications (source: Scopus), challenging dominant trends in the valuation of ecosystem services and natural capital and advocating for alternative frameworks to address socio-ecological crises. The contrast between Costanza's and Kallis's milestones reflects a growing tension in the field. It is also worth noting that in the same years, the launch of The Economics of Ecosystems and Biodiversity (TEEB) initiative, a major effort to bring ecological economists into mainstream policy initiatives by linking ecosystem

services to policy-making, further divided the community of ecological economists.

- 2012–2024: This subperiod captures the contemporary evolution of the field in the wake of two publications (Kallis, 2011; UNEP, 2011) that, despite their very different conceptual approaches, both had a significant impact on ecological economists. We believe that the tension between these two landmark publications played a key role in bringing the field's internal divisions and contradictions to the fore.

Although the duration of the three subperiods is similar, they differ greatly in terms of the number of documents they contain. Adopting the same approach as in the static analysis, whereby book chapters are not included, the first subperiod includes 129 documents, the second 1434, and the third 2771. This shows a nearly linear growth of scientific production in the first subperiod, an exponential trend in the second and a stagnant one in the third (see Fig. A5 in the SM1).

We believe that our approach to periodizing EE's history, based on our static bibliometric results and a critical ad hoc literature review, is further strengthened by the timeline of ISEE presidents (Fig. 5, bottom timeline). In stark contrast to the trend of ecosystem services and monetary valuation sparked by Costanza's article during the final year of his long presidency of the ISEE (Costanza et al., 1997), the intellectual focus of more recent ISEE presidents, such as Fischer-Kowalski or Gómez-Baggethun, seems to have shifted towards areas of research such as social metabolism, environmental justice, methodological pluralism, and degrowth. Nevertheless, a different periodization of EE's history was investigated for the purpose of exploring the sensitivity of the results to the use of different dates in the definition of the subperiods. We based this alternative periodization on milestone policy documents which had the potential to deeply impact global social and environmental governance and therefore research trends on EE, such as the Millennium Development Goals and Sustainable Development Goals (UN, 2000; UN, 2015). The results of this alternative periodization, which we have called "policy-based segmentation" as opposed to our "research-based segmentation", are mostly consistent with our original findings regarding the evolution of the field (see Appendix). This lends robustness to our dynamic results and further validates our approach to investigating temporal trends in EE. Complete details of the comparison between the two analyses are presented in Table A1 in the Appendix, while the full set of calculations, including the tables with the total identified items, all threshold values, and the software parameters used in the new bibliometric analyses are provided in the Supplementary Material 2 (hereafter referred to as SM2).

3.2.1. *The evolution of the field's core themes, topics and research areas*

The network maps in Fig. 6 show the evolution of the main research trends and themes throughout the field's history. The top two keywords, both in terms of number of occurrences and TLS, and which are common to all subperiods, are "ecological economics" and "sustainability". With regard to the other main themes, "natural capital" seems to gradually lose its relative influence in the debate as we move from the first subperiod (where it ranks third in TLS) to the third (eleventh). The opposite is true for "ecosystem services", which appears directly as one of the most important themes in the second subperiod and increases its influence even further in the third (ranking second in terms of number of occurrences). In the first subperiod, the clusters highlight the initial ambition of EE to bridge topics from previously distinct fields, such as "post-normal science", "ecology", "political ecology", "institutional economics" and "complex system theories". These are the roots of the EE approach. From the second subperiod onwards, other key themes take their place, such as "sustainable development", "ecosystem services",

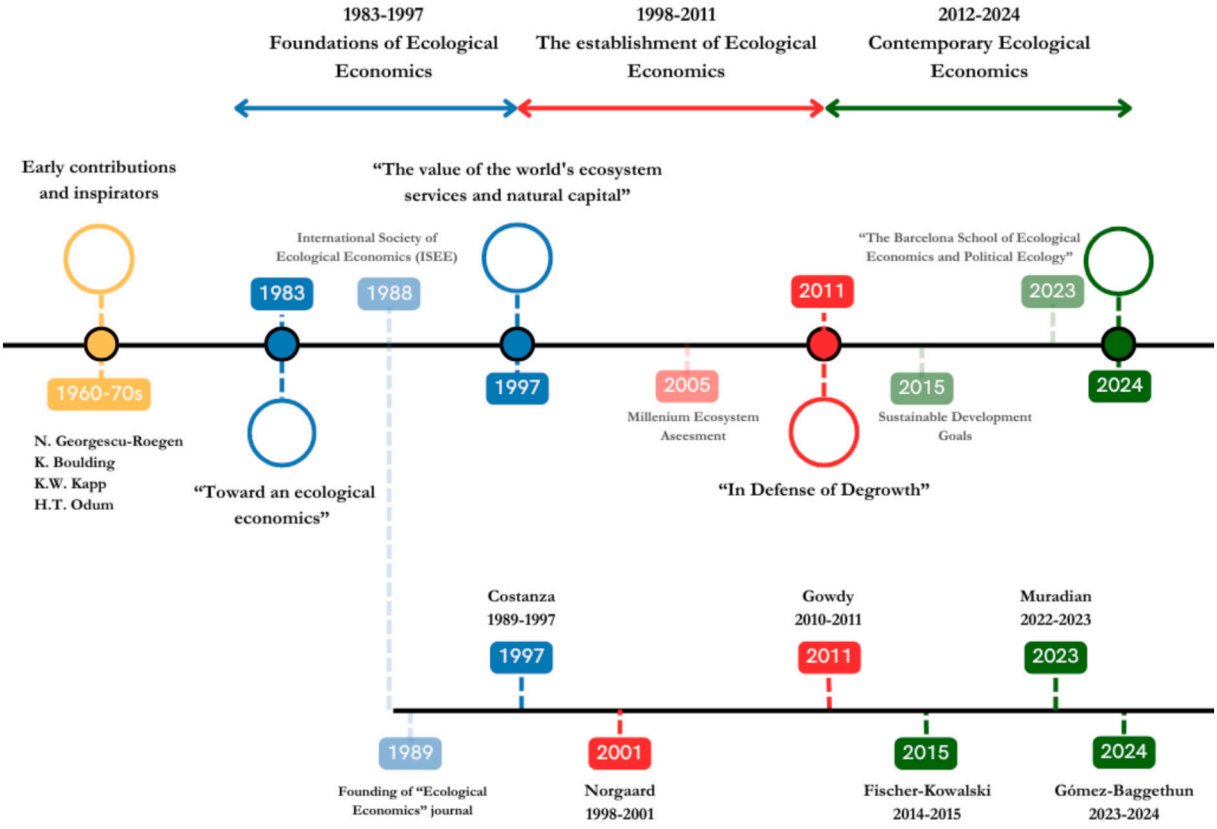

Fig. 5. Timeline of Ecological Economics institutionalization as a research field, with detail (bottom timeline) of selected presidencies of the International Society for Ecological Economics (ISEE). All presidencies lasted 2 years except Costanza (9 years) and Norgaard (3 years). The two timelines explain the reasons behind the segmentation of the field in the three chosen subperiods.

"economics" and "environmental economics". It can also be seen that keywords such as "biodiversity" and "climate change" make a huge leap in terms of TLS between the second and third subperiod, underscoring the field's responsiveness to contemporary environmental challenges and its engagement with global policy discourses. Similarly, brand new research themes appear in the third period, such as "degrowth" (which has quickly become relevant to the field, ranking eighth in TLS for the subperiod), "circular economy" and "ecological compensation" (with lower TLS). This suggests a recent diversification in the research interests of ecological economists and their engagement in the policy debate.

3.2.2. *The evolution of the intellectual structures of the field*

The network maps shown in Figs. 7 and 8 show bibliographic

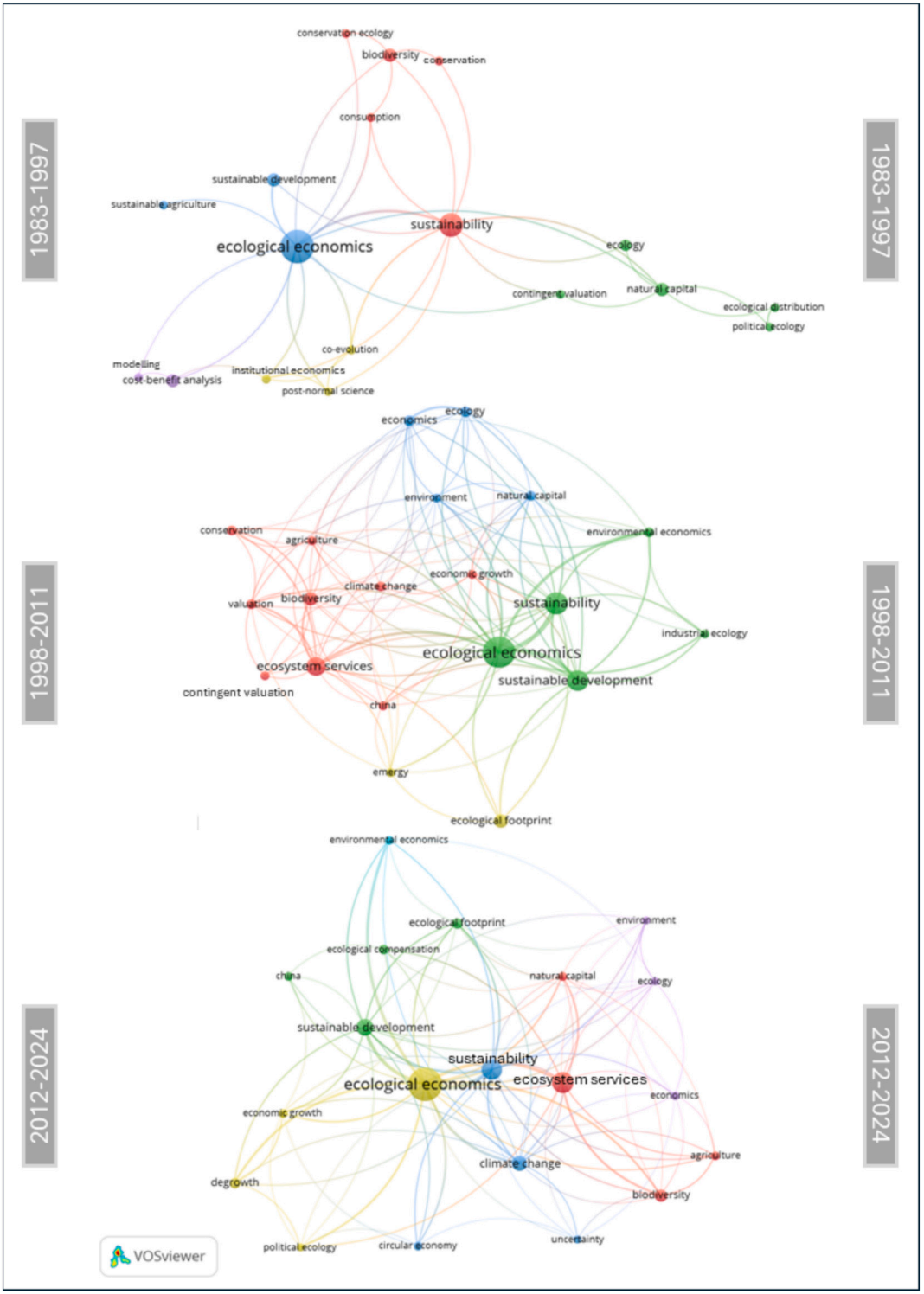

Fig. 6. Keywords co-occurrence patterns, dynamic evolution. The top 20 "author keywords" by number of occurrences in each period are displayed. The size of the nodes is based on frequency of occurrence. Links denote co-occurrence links, weighted by strength. Colours indicate different clusters. See Supplementary Material 1 for all numerical data on occurrences and link strengths.

coupling and authors' co-citation analysis, respectively. These can both be used to investigate how the intellectual structures of the field have changed throughout its evolution. However, some methodological differences between the two should be acknowledged. While bibliographic coupling links newer authors who cite the same older authors and is therefore forward-looking, co-citation analysis groups older authors based on how they are co-cited in newer literature and is therefore backward-looking. Consequently, being more sensitive to emerging clusters, bibliographic coupling is better suited to identifying new authors and publication clusters in each subperiod. Conversely, co-citation analysis is better suited to highlighting historically relevant authors. Regarding the former (Fig. 7), the first subperiod shows a horizontal and fragmented structure, with very diverse clusters of authors and limited relatedness; notably, foundational authors such as Costanza (most cited

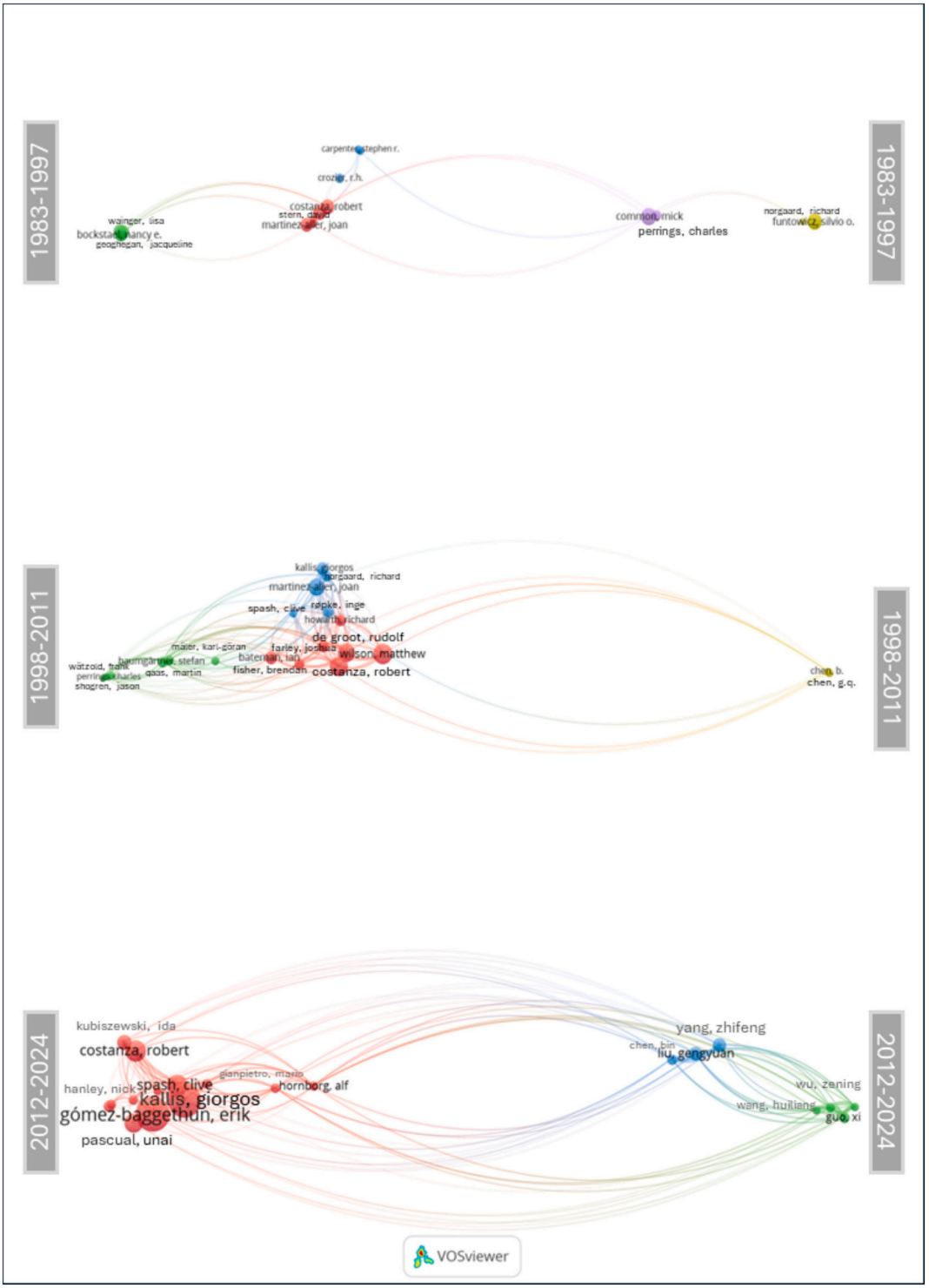

Fig. 7. Authors' bibliographic coupling patterns, dynamic evolution. The top 20 most cited authors, among those with at least 5 documents published (threshold is reduced to 1 for the first subperiod) have been selected in each subperiod. Only connected items are displayed. The size of the nodes is based on the total number of citations received by an author in the subperiod. Links denote bibliographic coupling links, weighted by strength. Colours indicate different clusters. See Supplementary Material 1 for all numerical data (documents, link strengths and citations) for all 20 items in each subperiod.

in the subperiod) and Martínez-Alier appear very close in the network map. In the second subperiod, two clusters of authors begin to emerge at the heart of the network (demonstrating their interconnectedness): one led by Wilson (the most cited author in this subperiod), Costanza and de Groot, and another led by Martínez-Alier and Kallis. Although Kallis has far fewer citations than authors such as Wilson, he has a similar level of TLS, showing a trend of rapid integration in the network. Moreover, the first stages of the formation of an independent cluster from China are visible, albeit with only two authors. The third subperiod is characterized by the inclusion of several new Chinese authors such as Guo and Yang, who form two very interconnected, distinct clusters, which make these authors achieve the highest levels of TLS in the subperiod. However, their relevance in terms of citations still seems limited. A striking finding is that more than 50 % of the total citations of the top 20 authors of the third subperiod go to four authors: Gómez-Baggethun, Kallis, Pascual and Spash. Compared to their high number of citations, these

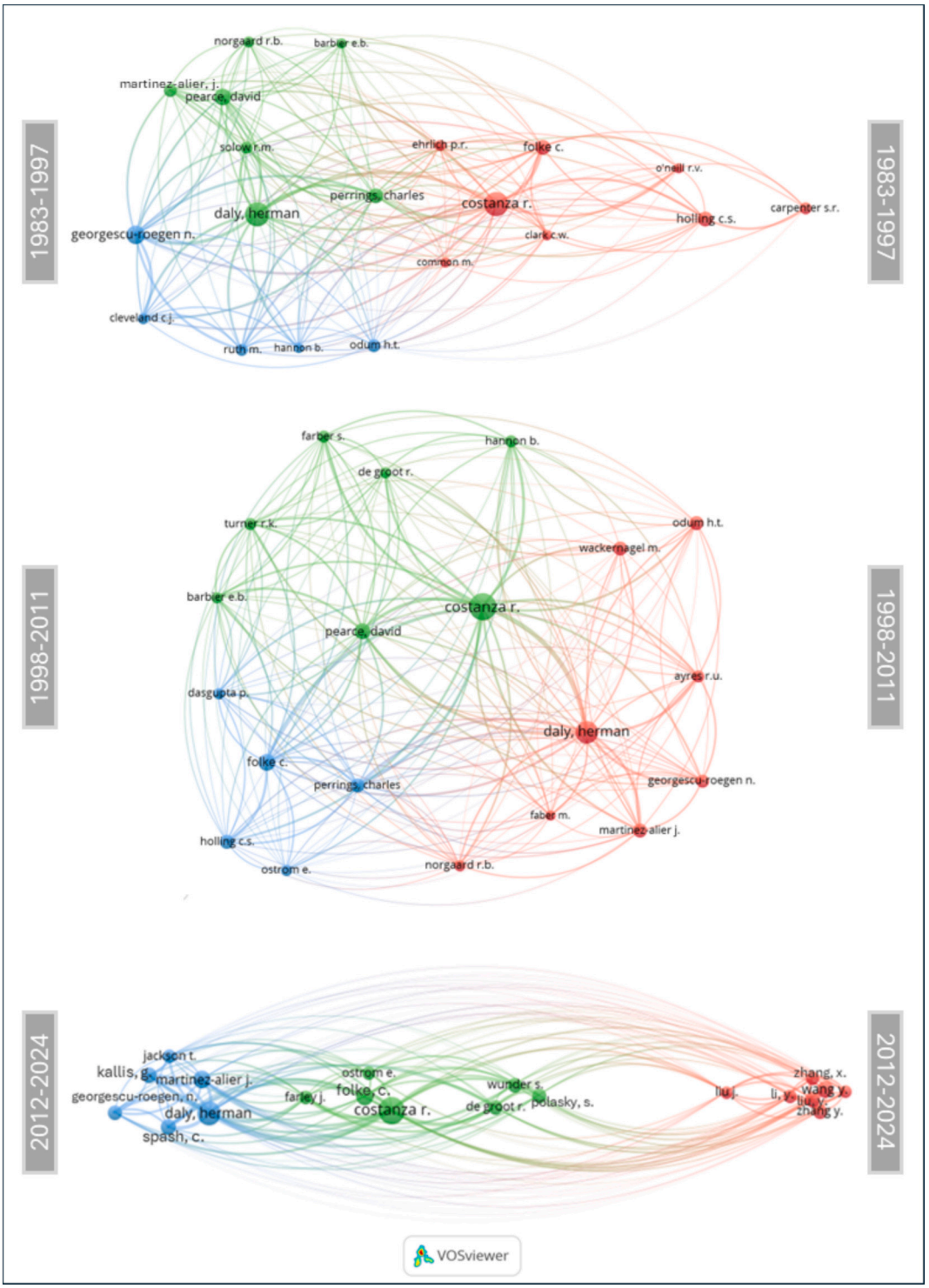

Fig. 8. Authors' co-citation patterns, dynamic evolution. The top 20 most cited authors in each subperiod are displayed. The size of the nodes is based on the number of citations made to a cited author. Links denote co-citation links, weighted by strength. Colours indicate different clusters. See Supplementary Material 1 for all numerical data on link strengths and citations for each subperiod.

authors have a low TLS, indicating a relatively high degree of independence and a research focus on specific topics that have recently received much attention. Giampietro and Hornborg are near the center of the network, connecting opposite sides (unrelated authors) and thus demonstrating an open and interdisciplinary approach with a broad focus but modest impact (TLS). Costanza is always in the top four cited authors in all the three subperiods. However, we can observe huge fluctuations in his TLS value: it is quite low in the first subperiod, it rises sharply in the second subperiod (ranking first in TLS), only to weaken again in the last subperiod. As for the other highly cited authors who dominate the centre of the network in the second subperiod, such as Wilson, de Groot, Haworth, Farley, it is worth noting that they are not even present in the third subperiod. These results clearly point out a profound change in key trends and patterns of EE research between the second and third subperiods.

Compared to the bibliographic coupling, the co-citation networks (Fig. 8) are less fragmented and more cohesive, suggesting a higher degree of integration among scholars (especially in the early and intermediate phases of the field's development). The first significant difference from the previous analysis is the emergence of a new key figure in the field: the foundational author Daly. Throughout the history of the field, Daly appears second only to Costanza in terms of citations and strength of co-citation links (in fact, leading citations in the first subperiod). Costanza and Daly form the core intellectual structure of the field in all three periods (always in different clusters), effectively representing the backbone of ecological economics and its internal tensions. These are reflected in the polarization of the main authors into two clusters, each led by one of the two authors (Fig. 8). It can be observed how Costanza's relative influence peaks in the second subperiod (very high TLS value), while Daly, who seems to be closer to authors such as Kallis, Spash and Martinez-Alier, catches up in the third subperiod. Other interesting differences with bibliographic coupling are the relatively strong integration of early inspirators such as Georgescu-Roegen (reflecting niche foundational contributions that are still relevant to the field today) and the increased influence of authors such as Folke and Martinez-Alier. Folke emerges during the second subperiod as a major contributor with significant metrics (both in terms of citations and TLS), reflecting a shift in intellectual focus from theoretical frameworks to applied research in ecosystem management. Martinez-Alier's prominence increases significantly in the third subperiod, when he ranks third in terms of both citations and TLS. This reflects the growing contemporary interest in the unequal distribution of ecological resources and in environmental justice. This aligns with a broader shift towards interdisciplinary and policy-oriented research, as evidenced by the rise of Spash and Kallis in the TLS ranking.The emergence of a large cluster of Chinese authors in the third subperiod confirms the findings of the bibliographic coupling analysis, and seems to turn the field's dual polarization into a tripartite one.

3.2.3. The evolution of cross-national collaboration patterns among researchers

The countries' collaboration map (Fig. 9) shows the evolution of co-authorship patterns. The map provides further evidence of the increasing importance of Chinese sources and authors (from the second subperiod onwards), which was already observed in our bibliometric analysis of sources (Fig. 2) and authors (Figs. 7 and 8). While the early and establishment phases are characterized by few cross-national collaborations, mainly between the Global North and English-speaking countries (USA, UK and Australia), the third subperiod shows a huge rise in cross-national collaborations (Fig. 9). Here, the role of the central "hub" (connecting authors from different countries around the globe) no longer seems to be played by the USA, while several other countries become important nodes in the growing network of global co-authorships that now spans all five continents. In this respect, Spain, Germany, Canada, the Scandinavian countries and, above all, China have recently taken on a prominent role. As a result, contemporary developments in EE seem to be associated with more extensive international collaboration, in which European authors play a central role and Chinese authors have become the most productive and increasingly integrated. Moreover, compared to earlier stages in the field's history, the contemporary intellectual structure of the field is more conducive to the inclusion of authors from the Global South and peripheral countries in international scholarly collaborations.

4. From inquiry to insight: aligning findings with the research questions

4.1. How has EE evolved in terms of key themes, journals, and authorship patterns, and what does it reveal about the field?

The evolution of EE reveals a dynamic trajectory characterized by both continuity and transformation. Today's wide diversification of sources (Fig. 2) aligns well with EE's transdisciplinary ethos, but also reflects broader changes. Notably, the journal Ecological Economics no longer covers the full breadth of the field, either in terms of the number of publications (Fig. 1), or in its ability to fully represent the current diversity of topics within EE (Fig. 4). However, despite accounting for less than a tenth of all EE publications on Scopus in 2023 (Fig. 1), the journal remains the most cited source and serves as the central node connecting thematically diverse contributors (Fig. 2). The journal's increased emphasis on pragmatic frameworks such as "ecosystem services" and neoclassical tools of analysis such as "contingent valuation" (Fig. 4 and SM1), supports critiques of its "mainstreamization" (Söderbaum, 2013; Spash, 2013, 2020). While this editorial shift promoted wider political engagement and policy relevance, it diluted the journal's critical and pluralist identity. The rise of emerging journals with relatively high total link strength despite lower citation counts, such as Sustainability (Switzerland) and Ecological Indicators (Fig. 2 and SM1) illustrates this trend well. As a result, EE appears increasingly responsive to global policy discourses, engaging with mainstream environmental challenges such as climate change and biodiversity loss (Fig. 4). However, this thematic expansion may have come at the expense of early foundational debates. It is worth noting the growing geographical diversity of authors, with Chinese scholars emerging strongly in the third subperiod (Figs. 7, 8 and 9). Despite forming numerous productive clusters of association (Figs. 7 and 8), Chinese contributions often exhibit a strong pragmatist orientation grounded in ecomodernism and focus predominantly on domestic applications (Yang and Yang, 2019; Zhang et al., 2014; Zhang et al., 2022) This limits their integration into global co-authorship networks compared to European scholars. Conversely, European scholars, especially those from Spain, occupy a central position in cross-national collaborations (Fig. 9). This can be understood from the point of view that these authors have played a central role in promoting critical theoretical perspectives and world-based assessments that have had a major academic impact (Hickel and Kallis, 2020; Pascual et al., 2023; Villamayor-Tomas and Muradian, 2023). It can therefore be argued that European authors now form the backbone of contemporary EE, playing a key role in its global development (as further confirmed by Figs. 3 and 7), whereas in the previous two subperiods this role belonged to foundational figures such as Costanza and Daly (Figs. 8 and 9). However, despite increasing patterns of diversity and collaboration, structural inequalities persist in the trajectory of EE. The limited representation of women and Global South scholars in leadership roles, highlighted by both co-authorship and co-citation networks (Figs. 3 and 8), underscores barriers to inclusivity that should be addressed to promote an evolution of EE in line with its founding principles of equity and transdisciplinarity.

4.2. Has the field diverged from its foundational principles, as some critics claim?

The extent to which EE has diverged from its founding principles

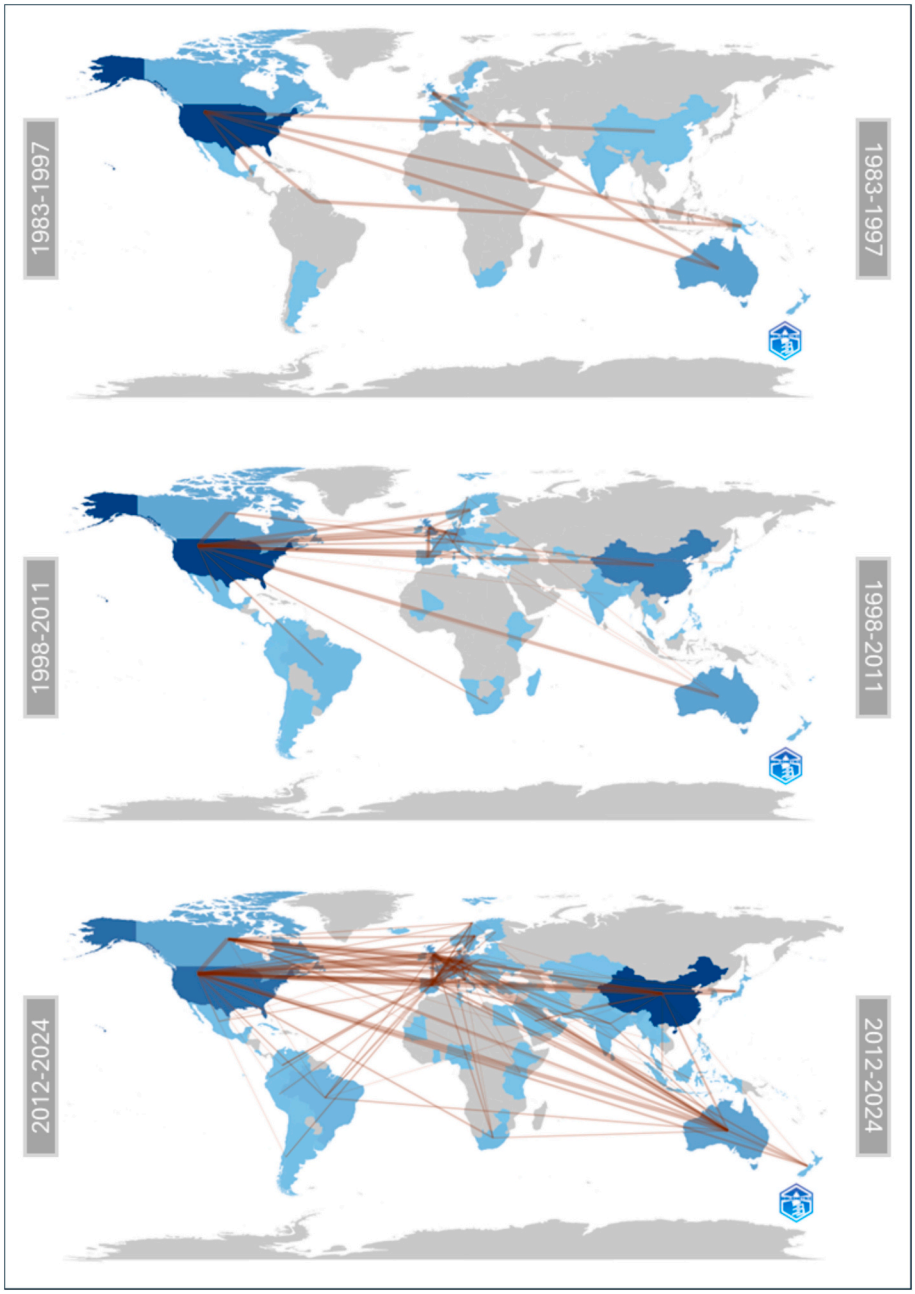

Fig. 9. Cross-national collaboration patterns, dynamic evolution. The size of the arrow represents the number of co-authored documents with other countries (edges). The darkness of the country indicates the total number of documents published by the country. First period: Minimum n° of edges for a country to display its connections: 1. Second period: Minimum n° of edges for a country to display its connections: 3. Third period: Minimum n° of edges for a country to display its connections: 3. Non-connected countries are those below the threshold but having co-authored documents during the period. All data are available in SM.

remains a contentious issue. In its foundational phase (1983–1997), the field was deeply rooted in the critique of neoclassical economics, emphasizing sustainability, complexity and ecological distribution issues (Fig. 6). The early contributions of two dominant authors in the first subperiod, Daly and Costanza (Fig. 8), based on biophysical economics and critiques of market-based approaches exemplified the field's early commitment to challenging dominant economic paradigms (Costanza, 1989, 1991; Daly, 1992). However, as our keywords' co-occurrence analysis shows, the subsequent establishment period (1998–2011) marked a significant thematic shift towards ecosystem services valuation (Fig. 6). The widespread adoption of ecosystem service valuation, exemplified by Costanza et al. (1997), together with an increasing dialogue with "environmental economics", signalled a move towards valuation and monetization that facilitated policy engagement (Fig. 6). Our analysis of Table 3 confirms this trend, with the majority of the most cited documents focusing on valuation methods and quantitative analysis belonging to the second subperiod. Critics argue that this empirical pragmatism risked undermining EE's foundational transdisciplinary and critical ethos (Schoppek, 2020; Spash, 2020). While these trends persist today (with "ecosystem services" and "climate change" remaining prominent themes in the third subperiod), our analysis suggests a recent reconnection with critical perspectives. For example, in Fig. 6, "valuation" and "contingent valuation"—longstanding keywords in EE—have declined in prominence during the third subperiod. Moreover, sidelined approaches such as "political ecology" regain relevance in the same subperiod, and critical perspectives such as "degrowth" become relevant research themes (Fig. 6 and SM1). Co-authorship patterns further confirm this trend, highlighting the transition from historically

influential figures such as Costanza, Wilson and De Groot, who shaped the initial focus on ecosystem service and natural capital valuation, to newer thought leaders such as Kallis and Gómez-Baggethun (Fig. 3). These latter scholars have revitalized the critical edge of the field over the last fifteen years by foregrounding socio-ecological justice and degrowth (Gómez-Baggethun, 2020; Kallis, 2011, 2018). These authors promote the critical use of those valuation tools that have gained great relevance during the establishment phase of EE, emphasizing the need to adopt multiple valuation languages to capture different value dimensions (Pascual et al., 2023), while at the same time recovering foundational EE ideas and critical policy perspectives (Daly, 1992; Martinez-Alier, 2002). This trend is further confirmed by our citation analysis of documents (Table 3), where the three most recent entries (Hickel and Kallis, 2020; Gómez-Baggethun and Barton, 2013; Lenzen et al., 2012) are papers offering critical perspectives on the notions of continuous economic growth and ecosystem services valuation. Overall, these findings highlight that despite the field's empirical turn towards "new environmental pragmatism" and its increasing involvement in mainstream initiatives such as the TEEB (Söderbaum, 2013; Spash, 2015), EE has demonstrated adaptability and reflexivity. The emergence of critical perspectives on growth and valuation signals the field's ability to evolve while re-engaging with its foundational critiques.

Ultimately, our analysis reveals a poignant tension: even as Ecological Economics demonstrates a vibrant intellectual evolution and a return to its critical roots, its overarching mission to steer the global economy onto a sustainable path remains clearly unfulfilled. The relentless increase in environmental degradation and the mainstream economic discipline's continued celebration of growth, epitomized by the 2025 Nobel Prize, attests to a profound failure to alter the course of economics in practice. This sobering reality, however, does not negate the field's value; rather, it underscores the urgency of its purpose. The very fact that EE continues to expand, challenge its own assumptions, and cultivate a critical spirit in the face of this macro-level failure is a testament to its resilience and its indispensable role in the ongoing struggle for a viable future.

4.3. *What are the wider implications for the future direction of EE?*

Ecological economics stands at a critical juncture, marked by ideological tensions, a dynamic journal landscape, emerging research trends and evolving patterns of co-authorship. The future direction of the field will depend on its ability to reconcile competing perspectives while seizing new opportunities for integration and innovation. One of the central tensions shaping the future of EE is the debate between the valuation of ecosystem services and critiques of utilitarian environmentalism or environmental pragmatism. Leading figures such as Costanza, whose work emphasizes the policy utility of monetary valuation frameworks, argue that these tools are essential for integrating ecological considerations into decision-making processes (Costanza, 2024). However, critics such as Gómez-Baggethun and Muradian warn that these approaches risk commodifying nature and undermining the ethical foundations of EE (Gómez-Baggethun and Ruiz-Pérez, 2011; Muradian and Gómez-Baggethun, 2021). This tension, evident in the polarization of co-authorship and co-citation clusters (Figs. 3 and 8), reflects wider debates about the compatibility of economic growth with ecological limits. The green growth versus degrowth debate further encapsulates these divisions. Scholars such as Hickel and Kallis (2020) emphasize the biophysical limits to growth and advocate for a radical rethinking of economic structures and consumption patterns, particularly in the Global North (Table 3 and Fig. 6). In contrast, proponents of green growth argue that technological innovation and efficiency gains can decouple economic growth from material consumption and environmental degradation (Schandl et al., 2016). As a result, the field appears to be divided on the pathways to achieve sustainability. Fragmented as it is by such disputes, the future of EE will be determined by its ability to remain faithful to its original goals of fostering interdisciplinarity and inclusiveness (Costanza, 1989, 1991), around which its internal cohesion could be restored amidst the diverse viewpoints of today's leading authors. Maintaining the field's current commitment to issues such as climate change, biodiversity and the circular economy (Fig. 6), while increasing the representation of women and scholars from the Global South, seems critical to ensuring that EE reflects the diverse challenges and perspectives of the global community. These go beyond an overfocus on valuation tools for ecosystem services and require a complex range of analytical methods and the bringing together of diverse competencies in collaborative efforts. This is something that is clearly already happening in the contemporary subperiod (Table 3, Figs. 6–9) and is therefore a hopeful sign for the future of the field. In this regard, while it is beyond the timeframe of the data collected in our research, we consider the recent launch of the political ecological economics perspective (Kallis et al., 2025a, 2025b – Preprint) to be significant external validation of our findings. This emerging framework aims to synthesize the various critical approaches within ecological economics that we identified, most notably the degrowth and post-growth approaches, social metabolism analysis, and structural critiques of economic growth relating to cost shifting, exploitation, and appropriation. Its attempt to consolidate the disparate strands of the degrowth literature into a coherent new foundation for economics directly resonates with the patterns and trends revealed by our research.

In terms of its broader future implications, it may be argued that while the original goals of EE—particularly its early warnings about global environmental resource depletion and its emphasis on advancing strong and absolute sustainability perspectives—were once regarded as overly distant, idealistic, or excessively forward-looking, this is no longer the case. With mounting evidence that numerous ecological boundaries have already been transgressed (Planetary Boundaries Science, 2025), the urgency underpinning the field's foundational concerns has become increasingly apparent, and holds the potential to gain progressively stronger resonance within particular spheres of public debate. This growing awareness is already catalyzing a wave of cross-disciplinary initiatives focused on planetary boundaries and post-growth transformations, engaging scholars, policymakers, business leaders, and civil society actors who are progressively converging around the central tenets of ecological economics (Kallis et al., 2025a, 2025b; Planetary Boundaries Science, 2025).

5. Conclusions

Our research suggests that the field of ecological economics is at a critical juncture. The intellectual realignment presently taking place in the field is evidenced, first and foremost, by the growing influence of scholars who are critical of the commodification of nature and the reliance on market-based instruments in environmental governance. This criticism has been prompted by the widespread adoption of the concept of "ecosystem services" as the basis for environmental policy schemes. Furthermore, the increased density and geographical spread of cross-national collaboration patterns, now spearheaded by European authors, underscore a notable change in leadership and an expansion of scope. This is connected to the growth of new academic journals around the world, and the increase in the number of academic papers on EE, which has made the journal Ecological Economics less dominant than it used to be. Finally, research areas are emerging that radically question the feasibility of our economic models and advocate pluralistic and qualitative approaches to development and valuation (e.g. degrowth, social metabolism, alternative valuation platforms). Therefore, we argue that a new generation of scholars seems determined to reaffirm the foundational principles of EE — ecological limits, societal equity, and environmental justice — and reconnect the field with its roots, albeit generally in ways that are more integrative than disruptive with respect to neoclassical analytical frameworks. In conclusion, while the future of EE remains uncertain, our findings have demonstrated its capacity to recognize and overcome its limitations through openness and self-

criticism. We argue that this evolution has strengthened its integrative approach, which is essential for any field seeking to address the complex and interconnected sustainability challenges of the 21st century.

CRediT authorship contribution statement

G. Corsi: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization, Validation. **R. Guarino:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Conceptualization. **E. Muñoz-Ulecia:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Data curation. **U. Grande:** Resources, Data curation, Software. **E. Buonocore:** Supervision, Resources. **A. Sapio:** Supervision, Resources. **P.P. Franzese:** Supervision, Resources.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Following the suggestion of a reviewer, the three dynamic bibliometric analyses (see section 3.2 of the manuscript) have been replicated using an alternative periodization in order to explore how sensitive the results are to different ways of segmenting the Scopus database. This alternative periodization is called “policy-based segmentation” because it is based on milestone policy documents that could profoundly affect global social and environmental governance, and therefore research trends on EE. According to this segmentation, the Scopus database is divided into the following three subdatasets:

- 1983–2000: This subperiod spans from the first Ecological Economics (EE) document recorded in the database to the publication of the landmark policy document “United Nations Millennium Declaration” (UN, 2000), establishing the 8 Millennium Development Goals or MDGs.
- 2001–2015: Beginning after the publication of the MDGs (UN, 2000), this subperiod concludes with the publication of the other milestone policy document capable of impacting global governance, i.e. the “United Nations 2030 Agenda” (UN, 2015), establishing the 17 Sustainable Development Goals or SDGs. The aim is to investigate the potential impact of the MDGs initiative on EE research trends.
- 2016–2024: This final sub-period covers the latest developments in EE following the replacement of the MDGs initiative by the far more ambitious SDGs targets. The aim is to investigate the potential impact of the launch of the “United Nations 2030 Agenda” (UN, 2015) on EE research trends.

Adopting the same approach as in the manuscript, whereby book chapters haven't been included, the first subperiod of this segmentation includes 304 documents (129 in our original periodization), the second 2138 (1434 in our original periodization), and the third 1892 (2771 in our original periodization). Despite these quantitative differences, in-depth comparisons between the two sets of dynamic results reveal that the two segmentations yield consistent findings, highlighting analogous trends in the evolution of ecological economics (for all details, see SM 2).

A.1. Keywords co-occurrence analysis

The keywords' co-occurrence analysis based on the “policy-based segmentation” of the Scopus database provides results that are closely aligned with those derived from the “research-based segmentation” used in the manuscript. In the second and third subperiods, the sets of the 20 most significant keywords differ by only 10 % (two keywords) and 5 % (one keyword), respectively (Table A1). In the first subperiod, the divergence is larger (55 %), but this is due solely to the inclusion of three additional years in the policy-based segmentation. This extension leads to the appearance of keywords such as “ecosystem services,” “environmental valuation,” “ecosystem management,” and “environmental policy,” which do not appear in the corresponding period under the “research-based segmentation” because this trend had not yet taken off (see SM2). This confirms the validity of our approach which uses Costanza's article (Costanza et al., 1997), as a discriminant. Rank correlation analysis further confirms the similarity between the two segmentations. Spearman rank correlation coefficients for the 20 most significant keywords (ranked by TLS) in the second and third subperiods are high (0.79 and 0.89, respectively), indicating that not only are the sets of keywords largely overlapping, but the relative importance of the terms is also similarly ordered. The correlation is lower for the first subperiod (0.64), which, as noted, is attributable to the broader temporal coverage in the “policy-based segmentation”. Overall, the second and third subperiods capture evolving research themes in EE in a consistent manner across both segmentations, reinforcing the robustness of the results of our keywords' co-occurrence analysis.

A.2. Authors' co-citation analysis

A similar consistency emerges from the co-citation analysis of cited authors. The comparison between the two segmentations reveals only limited variation in the sets of the 20 most significant cited authors. As shown in Table A1, the first subperiod is more consistent than in the case of keywords' analysis, exhibiting a difference in the two sets of five cited authors (25 %). In the second subperiod, the two sets differ by 15 % (three authors), and in the third by 10 % (two authors). This trend is further strengthened by the high values of the Spearman rank correlation coefficients for this analysis, which measure the similarity in the ordering of cited authors by TLS (Table A1). The first subperiod shows the highest rank correlation (0.95),

indicating a stronger alignment in the relative ranking of cited authors than in their composition. The second and third subperiods follow with slightly lower, though still strong, correlations of 0.88 and 0.80, respectively (see SM2). These results suggest that while there are minor variations in the specific composition of top cited authors, the underlying structure and dynamics of the intellectual landscape remain stable across the two segmentation approaches. Notably, here the high correlation begins in the first subperiod, which reinforces the robustness of the observed trends from an early stage of the field's development and supports the validity of our analysis across the entire timeframe.

A.3. Authors' bibliographic coupling analysis

In the case of bibliographic coupling, greater variability emerges although some consistency can still be acknowledged. The sets of the 20 most significant authors differ by 55 % (11 authors) in both the first and third subperiods, while the second subperiod shows only a 15 % difference—indicating that this central phase captures a shared core of references across both segmentations. This consistency in the second subperiod supports the reliability of the observed thematic trends at the midpoint of the temporal analysis (i.e., the rise of authors dealing with ecosystem services and monetary valuation). The Spearman rank correlation coefficients reflect a clear progression over time in the similarity of author rankings (always ordered by TLS) between the two segmentations: from a very low correlation of 0.11 in the first subperiod, rising to 0.56 in the second, and reaching a near-perfect correlation of 0.98 in the third. Therefore, it can be argued that in the second subperiod, the relatively low Spearman rank correlation coefficient is offset by a high degree of author overlap, whereas in the third subperiod, although author overlap remains limited (with only 45 % of authors shared), this is offset by strong convergence in author prominence within each set (see SM2). This finding implies that although the two segmentation strategies may highlight different individual authors due to changes in the timeframes considered, they reflect a converging understanding of intellectual influence. This is especially true for the third subperiod, where both capture similar trends, such as the growing prominence of Chinese scholars or the rise of the "Barcelona school" of ecological economics (although the latter is more evident in the "research-based periodization"). The larger differences observed in bibliographic coupling results between the two segmentation approaches can be explained by the methodological nature of bibliographic coupling itself. Indeed, unlike co-citation analysis, which is backward-looking (groups older authors based on how they are co-cited in newer literature), bibliographic coupling is forward-looking (it links newer authors that cite the same older sources). For this reason, bibliographic coupling is extremely sensitive to emerging authors and newer publication clusters. As a result, recently published documents dominate the bibliographic coupling network for a given period. So, if the temporal boundaries of the segment change, the set of included documents and their references can shift substantially, especially in rapidly evolving fields. Consequently, the relative visibility of certain authors in the "research-based segmentation" (such as those belonging to the Barcelona school of ecological economics) may be diminished simply due to which documents fall inside or outside the defined period.

In summary, despite some minor differences, primarily due to methodological reasons, we contend that the high Spearman rank correlation coefficients (especially for the second and third subperiods) resulting from the comparisons of the two segmentations across all three dynamic analyses are sufficient to conclude that, although the two segmentation strategies inevitably differ in some of the items identified—owing to the distinct time intervals used—they both capture analogous trends in the evolution of ecological economics. Therefore, the two approaches to dividing the database produce, for our purpose, similar results regarding the evolution of EE's core research areas and intellectual structures. This consistency is particularly significant, as it lends additional robustness and reliability to our findings.

Table A1
Recap of the types of comparison (and associated metrics) performed on the two sets of dynamic results from the two chosen methods of segmenting the field of EE.

Type of comparisons	First subperiod	Second subperiod	Third subperiod
Timeframes in the "research-based segmentation"	1983–1997 (14 years)	1998–2011 (13 years)	2012–2024 (12 years)
Timeframes in the "policy-based segmentation"	1983–2000 (17 years)	2001–2015 (14 years)	2016–2024 (8 years)
N. of total documents in the "research-based segmentation" (excluded book chapters)	129 (129)	1476 (1434)	4199 (2771)
N. of total documents in the "policy-based segmentation" (excluded book chapters)	304 (304)	2245 (2138)	3255 (1892)
% of top 20 items changing in the two segmentations (keywords' co-occurrence analysis)	55 %	10 %	5 %
% of top 20 items changing in the two segmentations (authors' co-citation analysis)	25 %	15 %	10 %
% of top 20 items changing in the two segmentations (authors' bibliographic coupling analysis)	55 %	15 %	55 %
Spearman rank correlation coefficients between the two segmentations (keywords' co-occurrence analysis)	0.64	0.79	0.89
Spearman rank correlation coefficients between the two segmentations (authors' co-citation analysis)	0.95	0.88	0.8
Spearman rank correlation coefficients between the two segmentations (authors' bibliographic coupling analysis)	0.11	0.56	0.98

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2025.108845.

Data availability

Data will be made available on request.

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