Received: 3 September 2024 | Revised: 10 January 2025 | Accepted: 16 January 2025

DOI: 10.1111/cobi.70023

Conservation Biology

CONTRIBUTED PAPER

A social network analysis of the European science–policy–society interface on biodiversity

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Article impact statement: Strengthening the science–policy–society interface is key for the effective implementation of the EU Biodiversity Strategy.

Funding information
HORIZON EUROPE, Grant/Award Number: 101059438

Abstract

Despite the wealth of evidence on biodiversity status, trends, and policy options in Europe, knowledge often fails to inform policy makers and decision makers effectively. Implementing the EU Biodiversity Strategy for 2030 will require the transformation of engagement and exchange between knowledge providers and policy and decision makers. This is one of the main goals of the forthcoming EU Science Service for Biodiversity. We sought to support this endeavor by mapping the landscape of actors at the biodiversity science–policy–society interface. We first compiled an extensive database of actors ($n = 215$) by combining existing databases, searching the web, and consulting experts. We then interviewed representatives of key organizations ($n = 28$) to elicit data about their network of relations with other organizations. Additional qualitative data were elicited from a subset of organizations ($n = 17/28$) focusing on the roles of different actors in knowledge cocreation and their potential contribution to the functioning of the Science Service for Biodiversity. The social network analysis mapped the interactions (and lack thereof) between 101 organized actors. Central to the network were EU organizations, other international and intergovernmental organizations, and one well-known public interest group. A more varied mix of organizations had the potential to act as bridges between unconnected actors, including private sector organizations, organizations dedicated to the management of ecological units, and science-based networks. The social network analysis also revealed 4 thematic communities emerging from the interactions among actors: biodiversity knowledge for EU policy-making; land ownership and management in agriculture and forestry; natural capital and sustainable development; and nature conservation and participation. Consistent with the results of the social network analysis, the qualitative data suggested that nonpolicy and nonscience actors have an important role to play in the dialogue and knowledge cocreation for biodiversity conservation and restoration. To strengthen the European science–policy–society interface on biodiversity, we recommend addressing gaps in themes and actor types, fostering cross-community dialogue, and supporting the further development of the network in terms of participants and potential intermediaries.

KEYWORDS
boundary organizations, coproduction, ecosystem services, governance, information network, natural capital, policy impacts, sustainability transformations

INTRODUCTION

As part of the Green Deal, the Biodiversity Strategy for 2030 by the European Union (EU) represents a comprehensive policy and legislative framework with the ambition to address the key drivers of biodiversity loss through transformative change. There are several challenges to the implementation of the many diverse goals of the EU Biodiversity Strategy for 2030, including funding availability, horizontal and vertical policy coherence, the effectiveness of spatial planning and ecological management, stakeholder engagement, and the shortcomings of the dominant economic and political systems (Hermoso et al., 2022; Lenti et al., 2023; Stoffers et al., 2024). These issues are, however, all underpinned by the inadequate flow of information between knowledge providers and decision makers (Lenti et al., 2023). Despite the wealth of scientific evidence on biodiversity status, trends, and policy options in Europe (IPBES, 2018), knowledge often fails to reach or influence policy makers and decision makers effectively. This gap is sustained by a range of causes, from timing or agenda misalignment between knowledge creation and policy needs to poor knowledge accessibility (e.g., copyright, irretrievability, format incompatibility).

Through the Knowledge Centre on Biodiversity (KCBD), hosted by the Joint Research Centre (JRC), the European Commission is committed to creating an infrastructure aimed at enhancing and sharing a European-wide biodiversity knowledge base, as well as fostering cross-sectoral policy dialogue (Viti et al., 2024). This includes centralized data platforms, such as the Biodiversity Information System for Europe (BISE). Actors such as Biodiversa+, Eklipse (Establishing a European Knowledge and Learning Mechanism to Improve the Policy-Science-Society Interface on Biodiversity and Ecosystem Services), and Oppla aim to collate and disseminate biodiversity research and translate it into adequate and effective policies. The Science Service for Biodiversity is being developed as the principal EU mechanism to facilitate a targeted and continuous dialogue between biodiversity knowledge holders and policy makers and enhance and mainstream the knowledge base for decision-making in all sectors (Appendix). In particular, the Science Service will answer knowledge requests from policy makers, build and enable knowledge networks around certain themes and issues, and work to transform the processes within and between science and policy-. The EU Horizon-funded BioAgora project is coordinating the development of the Science Service (https://bioagora.eu/).

To meet its objectives, the forthcoming Science Service for Biodiversity must leverage, strengthen, and engage with the network of existing actors and activities at the science–policy–society interface. This interface, however, is fragmented and dynamic, with a myriad of organized actors and individuals operating in various governance realms, including policy makers, governmental and intergovernmental organizations, research institutes, data management platforms, think tanks, civil society groups, private interest groups, and businesses (Nesshöver et al., 2016; Sarkki et al., 2014, 2020; Tinch et al., 2018; Watt et al., 2019). In addition to orchestrating European, national, and subnational actors, the Science Service must engage with a wider landscape of international entities, such as the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the newly established Global Knowledge Support Service for Biodiversity (GKSSB), the latter of which is expected to support the implementation of the Kunming–Montreal Global Biodiversity Framework.

Thus, we sought to map the community of organized actors involved in the biodiversity science–policy–society interface in Europe and explore the potential contribution of diverse actors to the implementation of the EU Biodiversity Strategy for 2030. Although previous studies have provided important evidence about national or topic-based biodiversity networks, or the inner social networks of a certain organization (e.g., Borg et al., 2015; Gogaladze et al., 2020; Juhola et al., 2024; Morin et al., 2017; Moshier et al., 2019), there is no research mapping the landscape of biodiversity actors at the EU level. We considered the following questions: Which actors operate at the biodiversity science–policy–society interface at the EU level and how can they be categorized based on their institutional position; how is the network of actors structured with regard to interactor relations; and what roles can actors play in knowledge cocreation and how can they potentially contribute to the functioning of the Science Service for Biodiversity?

We sought to provide insights to scholars, experts, and decision makers for navigating the landscape of actors in biodiversity governance, which comprises a diversity of knowledge forms and interests. In terms of its most direct impact, the findings support the identification of stakeholder types and elucidate their potential engagement in the forthcoming EU Science Service for Biodiversity, which will work to enable the transformative potential of the European science–policy–society interface on biodiversity.

CONCEPTUAL BACKGROUND

Science–policy interfaces are "social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, coevolution, and joint construction of knowledge with the aim of enriching decision-making" (van den Hove, 2007, p. 807). In other words, "the many ways in which scientists, policy makers and others link up to communicate, exchange ideas, and jointly develop knowledge for enriching policy and decision-making processes and/or research" (Young et al., 2013, p. 5). They are collaborative and nonlinear processes that open spaces "for debate over conflicting beliefs, values and interests" (Kelemen et al., 2021, p. 92). As such, they may be more or less formalized in terms of institutional arrangements and governance systems (e.g., well-established and recurring platforms vs. small, one-off interactions) and functions and aims (e.g., explicit vs. tacit). They can inform different levels (international, national, local) and different stages of the policy process (from agenda setting to policy evaluation) (Young et al., 2013). Outputs are also varied, taking the form of, among others, written reports, workshops, and dialogues (Miller & Wyborn, 2020). As dynamic entities, they

influence and are influenced by the wider environment where they operate, and they can change over time, for example, in terms of intents or actor composition and relations.

We adopted the term *science–policy–society interface* (sometimes referred to as science–policy–practice interface) to emphasize the engagement of actors other than scientists and policy makers. The strengthening of these interfacing processes is key to fostering and accelerating evidence-based decision-making and implementation associated with multiple actors cocreating knowledge and options for action via transdisciplinary engagement and colearning, which themselves represent part of the impact of such interfaces (Balvanera et al., 2020; McConney et al., 2016; Perrings et al., 2011; Young et al., 2013, 2014).

Knowledge cocreation entails the framing, collating, and dissemination of knowledge "through social interaction and change" (Forsyth, 2003, p. 104) and typically involves different actors (e.g., researchers and research organizations, experts and practitioners, interest groups, government organizations and their agencies, civil society organizations and citizen groups) (Tinch et al., 2018). Cocreation is often used as a synonym for coproduction, but it is more comprehensive in that it encompasses the entire temporal and conceptual process of transdisciplinary research (Hakkarainen et al., 2022). Cocreation at science–policy–society interfaces is metaphorically comparable to value chains where information and resources are exchanged in a nonlinear way and transformed into actionable knowledge (Wang & Ahmed, 2005). Schorr et al. (2021, p. 5) describe the concept of a global knowledge value chain as "the full range of intellectual tasks by which knowledge is produced and intertwined at the local, regional, and global levels required to comprehensively inform a specific desirable state or phenomena." Organizations participating in the science–policy–society interface may squarely fall into one type (e.g., science actor, policy actor, practitioner) or may be boundary organizations (i.e., organizations operating across multiple domains) (Pitt et al., 2018). Nonetheless, all organizations still maintain their own institutional positions, values, agendas, objectives, capacities, and needs (e.g., knowledge provision, data management, knowledge requesting, knowledge brokering, funding, capacity building, advocacy or lobbying) (Balian et al., 2012; Wang & Ahmed, 2005). Notably, within organizations, individuals may or may not fully align with organizational posture.

The governance and sustainability of science–policy–society interfaces are challenged by a lack of stable financial and personnel resources, mismatching time horizons and expectations between scientists and decision makers, and underdeveloped networking and communication capabilities across disciplines, sectors, and societal realms. A network-of-network approach has been suggested as a potential avenue to tackle these problems. This refers to the capacity of organizations to interact in and transform wider networks of actors by mobilizing existing relations, capabilities, and resources to boost the effectiveness and meaningfulness of science–policy–society interface processes (Kelemen et al., 2021). A well-structured network of networks enhances efficiency by fostering effective communication, collaboration, and resource sharing, which reduces redundancy and promotes inclusivity (SanClements et al., 2022). In this context, the role of the forthcoming EU Science Service for Biodiversity would be to mobilize and enhance the efforts of existing organizations, platforms, networks, and activities working at the biodiversity science–policy–society interface through a network-of-networks approach that can improve knowledge accessibility, reduce redundancies, fill gaps, and improve outreach to knowledge users (Juhola et al., 2024; Kelemen et al., 2021; Nesshöver et al., 2016; Sarkki et al., 2020). Because the governance of biodiversity issues is characterized by a "multiplicity of institutions, actors, and ideas, some compatible but other antagonistic" (Morin et al., 2017, p. 549), a key issue for science–policy–society interfaces and for the forthcoming Science Service is managing vested interests and ensuring inclusiveness while supporting evidence-based decision-making processes. This requires recognizing, navigating, and orchestrating the abovementioned diversity of actors, capacities, and interests. The success of science–policy–society interfaces is typically evaluated on their ability to produce credible (i.e., valid, reliable), relevant (i.e., timely, useful), and legitimate (i.e., value plural) outcomes (Heink et al., 2015).

METHODS

Data collection entailed an iterative process, including the compilation of a database of organizations operating at the biodiversity science–policy–society interface and questionnaire-based interviews conducted with selected key organizations (Appendix). The interviews aimed to collect data for a social network analysis and to collect qualitative data on the potential roles actors can play in knowledge cocreation and in the forthcoming Science Service for Biodiversity.

Building the stakeholder database

We compiled an extensive list of organizations and networks of organizations working at the science–policy–society interface related to biodiversity and sustainability issues. The focus of the search was actors operating at the EU level, although we also included relevant international, regional, and national actors for a total of 215 actors. This compilation furthered the work of 2 pan-European scientific projects funded by the Seventh Framework program of the European Union: Developing a Knowledge Network for EUropean expertise on biodiversity and ecosystem services to inform policy-making and economic sectors (KNEU, 2010–2014, grant 265299) and Eklipse (2016–2020, grant 690474). These 2 projects, which aimed to improve understanding and effectiveness of the EU biodiversity science–policy(–society) interface, compiled extensive databases of organizations and networks in Europe and provided considerations regarding the relevance of such actors in the landscape. Our database was further complemented by an extensive active search of the web for additional organizations, coupled with suggestions of relevant organizations provided by participants in the BioAgora project and by representatives of the organizations interviewed (see "Questionnaire-based

interviews with selected actors"). We iteratively developed 13 nonmutually exclusive types of organizations listed in the database based on their main ethos and agenda, as stated on their websites. The goal was to develop a synthetic, but comprehensive, categorization.

Questionnaire-based interviews with selected actors

From the database we compiled (see "Building the stakeholder database"), we selected organizations to be interviewed. The development of criteria for the selection and the selection itself were performed through deliberation involving all authors and other project participants. In order to be included in the interview sample, an organization had to be an important player in the biodiversity science–policy–society landscape, based on the opinion of the authors and on the findings of the Eklipse or KNEU projects; it had to be a long-term institution (e.g., no time-limited research projects); and it had to be working in a context directly related to nature and biodiversity issues, with a strong European presence or influence. The overall strategy was to select key actors while maximizing the diversity of actor types in terms of their societal roles and agendas. In particular, we did not stop the interviews until we had at least one representative for each of the 13 actor types identified through the database compilation (see "Database of actor types" in the Results). The actor-type conventions and other policy processes were, however, not included in the interviews because only 2 actors out of 215 were of this type. The composition of the final sample was well balanced, and there were no underrepresented types: science-based community or network (21%); business or sectoral organization and private interest group (14.29%); EU organization or agency (14%); public interest group (7%); science–policy or science–policy–society platform (7%); organization or network of organizations managing ecological units (7%); data platform or research infrastructure (7%); intergovernmental or international organization (7%); expert or practitioner community (4%); funding bodies for research or environmental funds (4%); science service (4%); and think tank or pararesearch organization (4%).

The final selection included both organizations expected to be part of the governance of the EU Science Service for Biodiversity (or otherwise highly involved) and organizations with no current involvement in or even knowledge of it. The interviews were conducted during the summer and autumn of 2023. The video calls lasted approximately 1.5 h each, although we did not use all the data collected during the interviews in our analyses. During the interview, the key representatives (e.g., director, chair, president) of the organizations were presented with a questionnaire administered using an online platform. In some cases, if no one from the organization was available for interview, the questionnaire was completed by the organizations' representatives in their own time.

To collect data for the social network analysis, the questionnaire elicited the frequency of contact of the organization with other actors: never (although the organization was known to the respondent), less than once a year, multiple times a year, or weekly. Frequency of contact was elicited for a list of 45 preselected actors. Respondents could state whether the listed organizations were unknown to them, and they were able to suggest additional organizations not listed in the questionnaire. Twenty-eight organizations answered the questions related to the social network analysis (response rate 65% of the original list of actors contacted). Of these 28 organizations, 17 were also asked additional qualitative questions (Table 1). The qualitative questions were administered to actors with no current direct engagement with the forthcoming EU Science Service for Biodiversity. The additional questions were designed to elicit information on the goal and added value of the organization in the science–policy–society landscape, and expectations about the forthcoming Science Service (in particular, what kind of actors should participate to make it effective, credible, and inclusive). There are no universal standards for acceptable minimal response rates or sample sizes in social network analyses (Guerrero et al., 2020). Our sample ($n = 28$) and response rate were in line with previous studies on similar research topics (e.g., 17 respondents and 50% response rate in Borg et al. [2015]; 43 respondents and 60% response rate in Moshier et al. [2019]; 88 respondents and 30% response rate in Juhola et al. [2024]). The sample ($n = 17$) for the qualitative analyses aligned with guidelines for qualitative research, where the guiding principle for sampling is data saturation (Bekele & Ago, 2022).

Social network and qualitative analyses

Social network analysis is a well-established method widely applied in multiple contexts, including environmental governance studies (Gómez-Mera et al., 2020; Guerrero et al., 2020). This method reveals the otherwise tacit network of relations between actors, either individuals or organizations. In the network, each actor (called a node) has a unique identifier and can be characterized by certain attributes (e.g., type of organization) (Table 2). The relational ties between nodes (called edges) can be undirected or directed (the latter is the case in our study) and characterized by attributes (e.g., frequency of communication).

To analyze the network, we used the software package Gephi 0.10 (Bastian et al., 2009). The degree of centrality and inbetweenness centrality were derived to determine, respectively, the actors with the greatest number of interactions and the actors who held the potential to act as intermediaries in the system. An unsupervised modularity algorithm (settings: randomize on, use wedge weights on, resolution 1.25) was used to identify clusters of nodes that were more densely connected together than to the rest of the network (Blondel et al., 2008). Community detection was thus based on the structure of the network and ignored the attributes of the nodes. The modularity results in Gephi vary each time the algorithm is run due to the inherent randomness in the way the algorithm operates. Due to the nature of the algorithm used to detect communities, findings should be interpreted based on the overall composition of the community, rather than on the placement of individual actors.

TABLE 1 Organizations interviewed for the social network and qualitative analyses of the European science–policy–society interface on biodiversity.

ID	Organization	Organization type	Data collected
1	Alternet Europe	Science-based community or network	Social network analysis data
2	Capitals Coalition	Business or sectoral organization and private interest group	Social network analysis data, open-ended qualitative data
3	Central and Eastern European Web for Biodiversity (CEEweb)	Public interest group	Social network analysis data, open-ended qualitative data
4	Committee of Professional Agricultural Organisations in the European Union and General Confederation of Agricultural Co-operative in the European Union (COPA-COGECA)	Business or sectoral organization and private interest group	Social network analysis data, open-ended qualitative data
5	Directorate-General for Agriculture and Rural Development (DG AGRI)	EU organization or agency	Social network analysis data
6	Directorate-General for Climate Action (DG CLIMA)	EU organization or agency	Social network analysis data
7	Directorate-General for the Environment (DG ENV)	EU organization or agency	Social network analysis data
8	Ecosystem Services Partnership (ESP)	Science-based community or network	Social network analysis data, open-ended qualitative data
9	Establishing a European Knowledge and Learning Mechanism to Improve the Policy-Science-Society Interface on Biodiversity and Ecosystem Services (Eklipse)	Science–policy or science–policy–society platform	Social network analysis data
10	EUROPARC Federation	Organization or network of organizations managing ecological units	Social network analysis data, open-ended qualitative data
11	European Agroforestry Federation (EURAF)	Expert or practitioner community	Social network analysis data, open-ended qualitative data
12	European Climate, Infrastructure and Environment Executive Agency (CINEA, including LIFE program)	Funding bodies for research or environmental funds	Social network analysis data
13	European Environment Agency (EEA)	EU organization or agency	Social network analysis data
14	European Network of Freshwater Research Organisations (EurAqua)	Science-based community or network	Social network analysis data, open-ended qualitative data
15	European State Forest Association (EUSTAFOR)	Business or sectoral organization and private interest group	Social network analysis data, open-ended qualitative data
16	Future Earth	Science-based community or network	Social network analysis data
17	Global Biodiversity Information Facility (GBIF)	Data platform or research infrastructure	Social network analysis data, open-ended qualitative data
18	Global Knowledge Support Service for Biodiversity (GKSSB)	Science service	Social network analysis data, open-ended qualitative data
19	Institute for European Environmental Policy (IEEP)	Think tank or pararesearch organization	Social network analysis data, open-ended qualitative data
20	Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research (eLTER)	Science-based community or network	Social network analysis data, open-ended qualitative data
21	International Network of Basins Organizations (INBO)	Organization or network of organizations managing ecological units	Social network analysis data, open-ended qualitative data
22	Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES)	Science–policy or science–policy–society platform	Social network analysis data
23	International Union for Conservation of Nature (IUCN) Europe	Intergovernmental or international organization	Social network analysis data, open-ended qualitative data
24	Oppla	Data platform or research infrastructure	Social network analysis data
25	Partnership for European Environmental Research (PEER)	Science-based community or network	Social network analysis data, open-ended qualitative data
26	The Taskforce on Nature-related Financial Disclosures (TNFD)	Business or sectoral organization and private interest group	Social network analysis data, open-ended qualitative data
27	United Nations Environment Programme (UNEP)	Intergovernmental or international organization	Social network analysis data
28	Wetlands International Europe	Public interest group	Social network analysis data, open-ended qualitative data

TABLE 2 Terms and definitions used in social network analysis.

Term	Definition	Meaning in this study
Social network	Social structure composed of nodes and edges, representing the relations linking multiple actors	Network showing the number of actors and their interactions in the context of the biodiversity science–policy–society interface, focusing on the EU
Nodes	Actors identified in the network	Organizational actors operating at the science–policy–society interface related to biodiversity, with a focus on the EU level
Attributes of nodes	Variables characterizing the actors of the network	Type of actor (e.g., business or private interest group; EU-related organization or agency; science-based community or network; see Table 1); geographical scale of operations (international, EU, pan-European, or national)
Edges	Relational ties between actors (i.e., lines connecting nodes)	Interactions between actors operating at the science–policy–society interface related to biodiversity, with a focus on the EU level
Direction of edges	Edges can be directed (i.e., the relationship has a direction from one node to another), undirected (no defined direction between the nodes), or mixed	Edges are directed, meaning actor A stated they had a relationship with actor B or vice versa
Attributes of edges	Variables characterizing relational ties between actors	Frequency of interaction (never, less than once a year, multiple times a year, weekly)
Out-degree	Number of edges leaving a node	Number of an actor's self-reported relations
In-degree	Number of incoming edges to a node	Number of relations an actor has, based on what declared by other actors
Degree centrality and weighted centrality	Number of edges a node is connected to; centrality can be measured as in-degree or out-degree centrality or as the sum of both; weighted centrality considers edge's attributes (weights)	Actor with a high degree centrality exhibits a high number of interactions in the network; in-degree centrality is based on how many times an actor is named by others (i.e., it excludes self-reported interactions); weighted centrality also factors in the frequency of relations between actors
Betweenness centrality	Number of times a node represents the shortest path between other nodes; a measure of the network's dependence on a given node	High betweenness centrality for an organization shows its potential to act as an intermediary in the network (i.e., its many relations and positioning in the network could be leveraged to bridge actors together)
Modularity	How well the network separates into clusters; higher modularity scores indicate a greater number of connections within communities and fewer connections between them	Thematic communities of actors (clusters) emerge based on network interactions

Open-ended questions were analyzed inductively with qualitative content analysis (Drisko & Maschi, 2015). This entails an iterative process of thorough reading and examination of the raw data, which is then condensed into themes. In our case, the analysis was mostly bottom-up and the grouping was not informed by a previous theory.

RESULTS

Database of actor types

The European science–policy–society interface related to biodiversity was a highly heterogeneous landscape. We identified 215 organizations and networks of organizations, which we grouped into 13 nonmutually exclusive types: business or sectoral organizations and private interest groups; conventions and other policy processes; data platforms or research infrastructures; expert and practitioner communities; funding bodies for research or environmental funds; EU organizations or agencies; intergovernmental and international organizations; networks of organizations managing ecological units (e.g., protected areas, basins); public interest groups; science-based communities or networks (including citizen science); science services; science–policy or science–policy–society platforms; and think tanks and pararesearch organizations (e.g., policy analysis). Each actor was assigned one main type and, if necessary, a secondary one. However, types were not mutually exclusive; rather, they were a primary description of the organization in comparison with other organizations. Many actors were represented by 2 or more types. The database was not intended to be an exhaustive, fixed list of actors universally relevant to the science–policy–society interface. Rather, it was to provide an overview of the main actors and actor types valid at the time the search was conducted. The list of organizations and their categorization is available in Zenodo (D'Amato et al., 2025).

Social network analysis of central actors

The social network analysis, based on data elicited from 28 organizations, resulted in 101 nodes (i.e., actors) connected by 657 connecting edges (network diameter = 4; average path length = 2.025; density = 0.058). This means

TABLE 3 The most central organizations at the European science–policy–society interface on biodiversity, based on in-degree centrality (≥14).

Organization	In-degree centrality
Directorate-General for the Environment (DG ENV)	26
European Environment Agency (EEA)	25
Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES)	23
European Regional Office of the International Union for Conservation of Nature (IUCN Europe)	23
European Policy Office of the World Wildlife Fund for Nature (WWF Europe)	22
Biodiversa+	21
United Nations Environment Programme (UNEP)	21
Food and Agriculture Organization of the United Nations (FAO)	20
EU Biodiversity Platform (EUBP)	18
DG for Maritime Affairs and Fisheries (DG MARE)	18
Knowledge Centre for Biodiversity (KCBD)	18
LIFE program	18
Intergovernmental Panel on Climate Change (IPCC)	17
Birdlife Europe and Central Asia	15
Biodiversity Information System for Europe (BISE)	14
Business for Nature	14
EU Business & Biodiversity Platform	14
EuroParc Federation	14
European Environment Information and Observation Network (Eionet)	14

that in addition to the list of 45 actors presented in the questionnaire, 56 more were spontaneously suggested by the interviewees. The main groups of actors in the network included science-based communities or networks (16.3% of actors in the network), EU organizations or agencies (15.3%), business or sectoral organizations and private interest groups (14.4%), public interest groups (12.5%), intergovernmental or international organizations (11.5%), science–policy(–society) interfaces (6.7), data platforms or research infrastructures (6.7%), and expert or practitioner communities (5.7%). The majority operated at the international (34.6%), EU (30.7%), or pan-European (25%) level. Only a small number were the European offices of international organizations (5.7%) or national-level actors (3.8%).

The organizations with the highest in-degree centrality (≥14, meaning actors mentioned by at least half of the respondents) are listed in Table 3 and are represented as the largest nodes in Figure 1. In-degree centrality indicated well-connected actors in the network. The results were the same for weighted in-degree centrality, although the ranking of the most central organizations varied slightly. The organizations with the highest betweenness centrality (>50) are presented in Figure 2 and Table 4.

We recorded 327 missing connections (i.e., respondents declared knowledge of an actor listed in the questionnaire but had no interaction with it) and 333 instances where respondents declared they were unaware of a listed actor. Actors known but not interacted with by 10 or more respondents were EuroMarine, the Ecosystem Services Partnership (ESP), the European Sustainable Development Network, the Intergovernmental Panel on Climate Change (IPCC), One Health Global Network, BirdLife Europe and Central Asia, the Committee of Professional Agricultural Organisations in the European Union and General Confederation of Agricultural Co-operative in the European Union (COPA-COGECA), the European Forest Institute (EFI), the Global Biodiversity Information Facility (GBIF), and the International Council for the Exploration of the Seas. Actors unknown to 10 or more interviewees were Green 10, the Network of Central Banks and Supervisors for Greening the Financial System, International Network of Basins Organizations (INBO), the Capitals Coalition, GKSSB, LifeWatch Eric, ESP, EuroNatur, the Forest Information System for Europe (FISE), the International Council for the Exploration of the Seas, NetworkNature, eLTER, EuropaBON, Oppla, the Society for Conservation Biology, and the Water Information System for Europe (WISE).

Four macro communities (Figure 3) emerged from the data based on the modularity algorithm, which identified patterns without human supervision (modularity score = 0.207, modularity resolution = 0.360, 7 clusters found in total, 3 of which had <3 nodes). The largest community (39.6% of network actors) concerned the cocreation of biodiversity data and knowledge between science and EU policy makers, including actors such as science-based organizations and networks, governmental and international organizations, data platforms, funding agencies, public interest organizations, think tanks, and science–policy(–society) interfaces. Examples of actors in this community are the Directorate-General for the

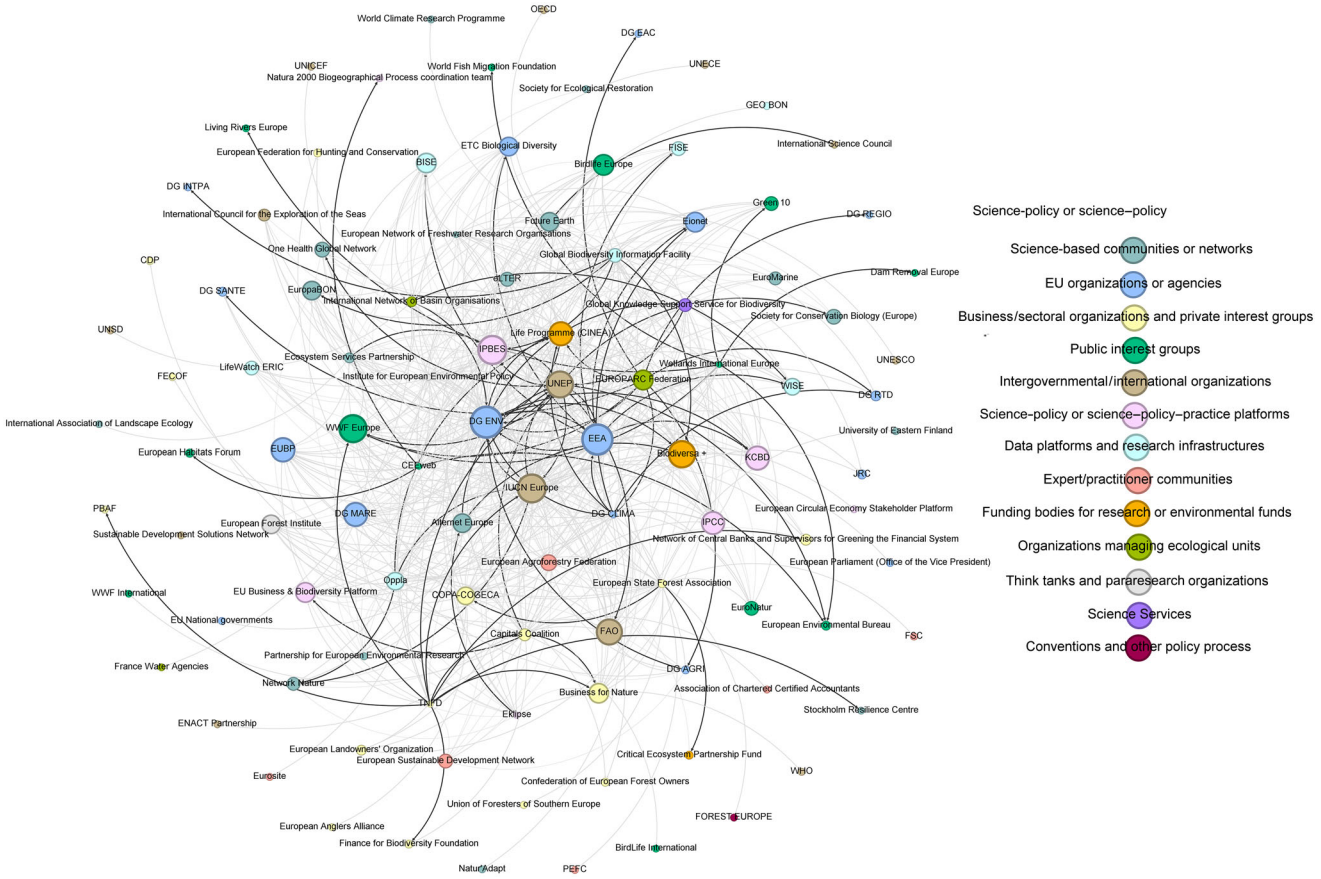

FIGURE 1 Network of central actors at the European biodiversity science–policy–society interface. The light gray arrows indicate interactions occurring at least once a year; the dark gray arrows indicate interactions occurring weekly; the node size is proportional to in-degree centrality. Note that categories are not mutually exclusive. Full names for acronyms are in D'Amato et al. (2025).

TABLE 4 Organizations with potential to act as an information intermediary at the European science–policy–society interface on biodiversity based on betweenness centrality (>50).

Organization	Betweenness centrality
European office of the International Union for Conservation of Nature (IUCN Europe)	520.0
European Environment Agency (EEA)	342.9
Directorate-General for the Environment (DG ENV)	213.0
European State Forest Association (EUSTAFOR)	169.1
EUROPARC Federation	165.5
United Nations Environment Programme (UNEP)	161.9
Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES)	156.1
Capitals Coalition	142.1
Future Earth	137.5
International Network of Basin Organisations (INBO)	110.7
Committee of Professional Agricultural Organisations in the European Union and General Confederation of Agricultural Co-operative in the European Union (COPA-COGECA)	99.9
Ecosystem Services Partnership (ESP)	59.4
Directorate-General for Climate Action (DG CLIMA)	56.8

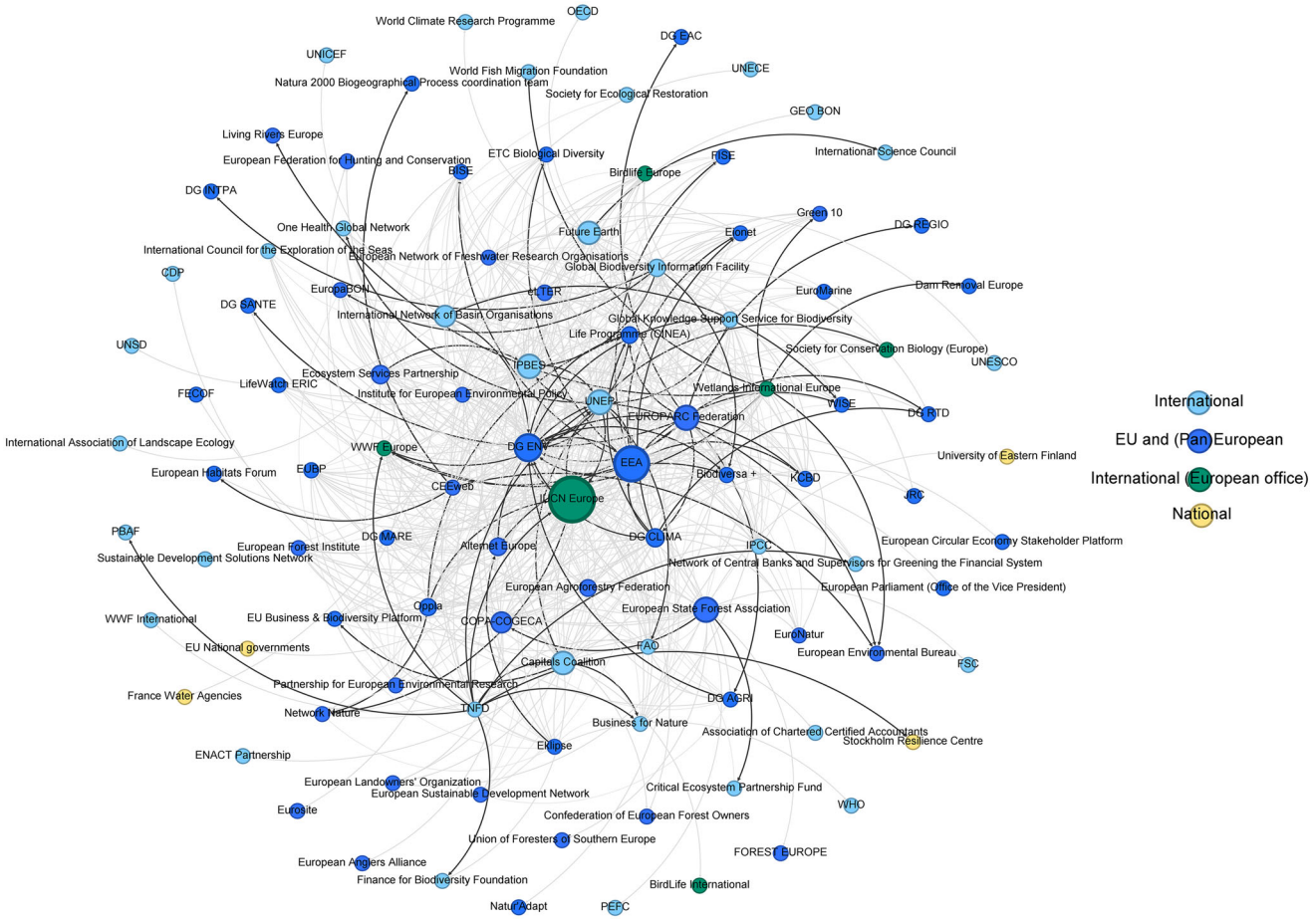

FIGURE 2 Network highlighting actors with the potential to act as intermediaries at the European biodiversity science–policy–society interface. The light gray arrows indicate interactions occurring at least once a year; the dark gray arrows indicate interactions occurring weekly; node size is proportional to betweenness centrality. Full names for acronyms are in D'Amato et al. (2025).

Environment (DG ENV), the Directorate-General for Maritime Affairs and Fisheries (DG MARE), the Directorate-General for Climate Action (DG CLIMA), the European Environment Agency (EEA), KCBD, BISE, Biodiversa+, the LIFE program, IPBES, Alternet Europe, Eklipse, GBIF, the Group on Earth Observations Biodiversity Observation Network (GEO BON), the World Wide Fund for Nature (WWF Europe), and IEEP. The second-largest community (24.3%) is related to land ownership and management in agriculture and forest systems. This community was dominated by private interest groups, such as COPA-COGECA, the European Agroforestry Federation (EURAF), the European State Forest Association (EUSTAFOR), the European Landowners' Organization (ELO), and the European Anglers Alliance (EAA). Other examples of actors in the community were the EUROPARC federation, the Directorate-General for Agriculture and Rural Development (DG AGRI), the European Regional Office of the International Union for Conservation of Nature (IUCN Europe), and EFI. The third community (23.4%) was associated with natural capital and sustainable development and was represented by actors such as Capitals Coalition, Business for Nature, and the Taskforce on Nature-related Financial Disclosures (TNFD). The smallest community (9.9%) was associated with nature and participation, with a focus on habitat conservation and restoration. This community was dominated by public interest actors, such as Wetlands International Europe, the European Environment Bureau (EEB), and the Central and Eastern European Web for Biodiversity (CEEweb); and included, for example, Eurosite (the network of conservation practitioners).

Actors and knowledge cocreation

Qualitative analysis of the statements provided by the organizations about their ethos revealed 5 nonmutually exclusive themes, with networking being an underpinning element of them all. The themes included acting as a science–policy–society interface to advance sustainability or biodiversity conservation, for example, by facilitating discussions on biodiversity and sustainability involving actors with different perspectives and values; bringing individuals and organizations together around specific topics and aims (e.g., knowledge creation and sharing, mainstreaming the value of nature in decision-making, capacity building); producing or gathering evidence and insights to support policy and decision-making, including standard

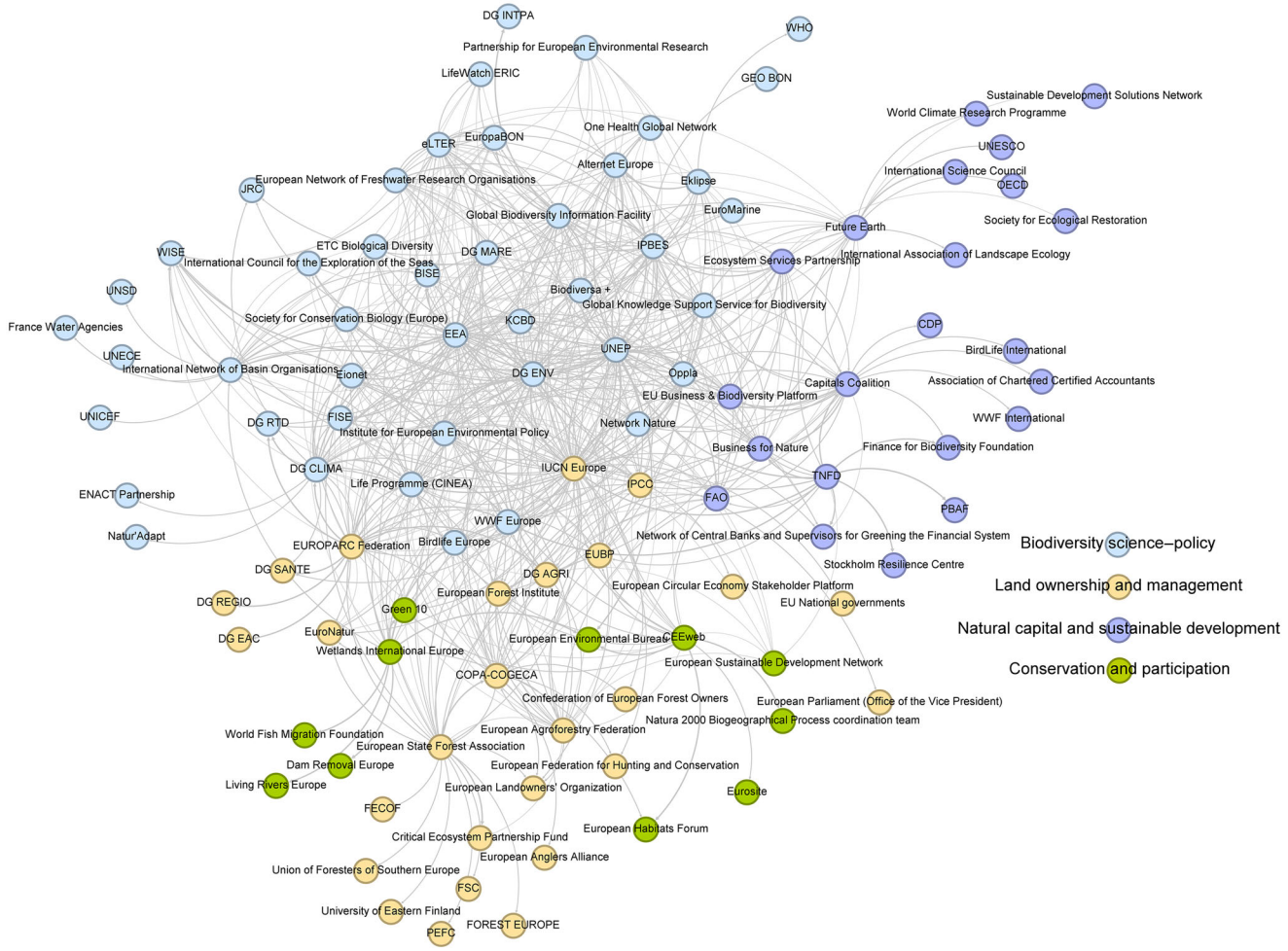

FIGURE 3 Thematic communities of actors at the European biodiversity science–policy–society interface as identified by the modularity algorithm. Full names for acronyms are in D'Amato et al. (2025).

setting; promoting the adoption of biodiversity-friendly and sustainable practices or management of resources, such as agroforestry or sustainable forest management; and representing and advocating for certain issues of private or public interest and thus influencing policies and their implementation.

In general, respondents suggested that although representatives from both the scientific and policy communities should be active participants, the forthcoming Science Service for Biodiversity should not be dominated by one side. As explained by one of the interviewees, a critical point in developing such a platform is that "research needs to be tailored to the policy implementation and to the needs of society in a timely manner." From the policy community, member-state- and EU-level representatives were considered relevant stakeholders, as were policy makers at the regional and local levels along with national agencies in charge of biodiversity protection. International organizations such as UN agencies were also mentioned.

Several respondents suggested the participation of various expert knowledge providers other than scientists, including conservation or other relevant nongovernmental organizations (NGOs), private land managers, strategic environmental and spatial planners, protected area managers and planners, field experts, experimental and innovation communities or projects showcasing good practices and real-life solutions and evidence-based results, and Indigenous peoples and local communities involved in the generation and use of biodiversity knowledge. Organizations other than those dedicated to science and policy were also mentioned for their potential role as brokers and intermediaries. This included, for instance, platforms dedicated to business viability and sustainability (e.g., chambers of commerce) as key actors in fostering cooperation with business organizations.

Some interviewees also suggested that the knowledge cocreated in the Science Service should be available to actors other than policy makers. As stated by one respondent, "the Science Service should be accessible to everyone, not just policy makers, but also people on the ground who are responsible for the concrete implementation of the strategy, and for knowledge brokers who can channel that knowledge further to 'laypeople'. It should be focused on how to better educate groups, and on the creation of knowledge groups and/or groups of implementors."

Some respondents indicated that with nonscience and nonpolicy actors involved in the Science Service, it would be necessary to address the risks of skewing the discussion toward dominant narratives to maintain fair, inclusive, and participatory processes. Moreover, one interviewee expressed the need "to consider the structure in which these actors interact to avoid current power and rigid structures that hinder the implementation of the strategy [i.e., the EU Biodiversity Strategy for 2030]", stating that "[t]his could also contribute to a more effective, credible and inclusive approach in which policy makers, science, practitioners and society have more balanced and constructive relations." To this end, organizations participating in the EU Science Service for Biodiversity would need "good communicators who have standing… but these people are hard to find and are busy."

DISCUSSION

The Science Service for Biodiversity is being developed to respond to the need for an institutionalized EU-level science–policy–society interface on biodiversity and ecosystem services (Kelemen et al., 2021). The effectiveness of such an endeavor, however, will be determined by several factors, such as its ability to engage stakeholders, its legitimacy, and its long-term financial viability. The composition of participants in the future Science Service is an important element because their institutional positions are likely to affect their motives and ability to influence the network and to collaborate with different stakeholder groups.

Our findings revealed a heterogeneity of actor types interacting with each other in the EU science–policy–society landscape. The most central organizations at the European biodiversity science–policy–society interface included EU organizations, namely, DG ENV, EEA, Biodiversa+, DG MARE, the EU Biodiversity Platform (EUBP), the LIFE program, and KCBD, and intergovernmental organizations, namely, IPBES, IUCN Europe, the United Nations Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), IPCC, and the European Policy Office of WWF Europe. However, a broader mix of actor types holds the potential to act as social or information brokers between unconnected actors. These included, in addition to IUCN Europe, EEA DG ENV, UNEP, IPBES, DG CLIMA, private sector organizations (EUSTAFOR, the Capitals Coalition, COPA-COGECA), organizations dedicated to the management of ecological units (EUROPARC Federation, INBO), and science-based networks (Future Earth, the Ecosystem Services Partnership). These types of organizations hold the potential to mobilize national or local implementors of the EU Biodiversity Strategy, such as land owners, farmers, foresters, park managers, business organizations, and local communities. The qualitative part of the interviews also confirmed expectations regarding the brokering role of nonpolicy actors, for example, those with business sustainability. Along similar lines, Stoffers et al. (2024, p. 13) suggest that NGOs, in the context of river restoration, "often also facilitate interactions and exchange among numerous other stakeholders." Considering the centrality measures recorded in our analysis, the role of data platforms and research infrastructures, such as BISE, FISE, and WISE, although not particularly low, could be further strengthened in the network. Some organizations had good in-betwenness centrality scores, but still remain unknown to or disconnected from a consistent portion of respondents, which reveals potential to further strengthen their position as intermediaries.

In regard to actor disconnection, it should be noted that not all organizations are required to interact with each other, if their work is not mutually relevant. In some cases, a lack of interaction may be due to the absence of trust, willingness to collaborate, or networking capacities and resources (e.g., Borg et al., 2015; Kelemen et al., 2021). Some actors, however, may not be well connected because they are recently established or extremely specialized in terms of issues or sectors. A high number of connections is not necessarily preferable to a few high-quality ones. In addition, some measures like in-betweenness centrality may reveal the actors most likely dealing with high levels of information flows, but this does not necessarily mean they would be willing to act as intermediaries.

Furthermore, social networks typically lack defined boundaries. Derived network and centrality measures are influenced by the number and type of organizations consulted for gathering the data (Guerrero et al., 2020). Cognizant of this limitation, we strove to interview different types of actors during the data collection process and carefully selected those who were widely recognized in the biodiversity science–policy landscape in Europe. Nonetheless, because we wanted to focus on actors operating at the European or international level, the network emerging from our analysis was almost equally composed of organizations representing international, EU, and pan-European levels, whereas few national organizations were identified in the network. The very nature of our method means that the resulting network fails to capture actors currently not well established and embedded in the existing network of interactions. Because networks are temporally dynamic, with new actors and relations emerging and others dissolving, our social network analysis only offer a snapshot. Given its limitations, the results of the social network analysis should not be interpreted as an evaluation of the performance of individual actors but rather as a mapping exercise at the network level that can be used to assess systemic gaps in actor types or themes. The results can be considered an extensive, rather than definitive and exhaustive, exploration. To complement the social network analysis, we developed a more extensive list of actors ($n = 215$) operating at the science–policy–practice interface collected through an iterative search. This open-access database can be used for future research on the science–policy interface (e.g., social network analyses, advocacy coalition studies) and, more practically, in the forthcoming EU Science Service for Biodiversity and by other practitioners to inform and diversify stakeholder engagement.

The results of the analysis revealing communities in the social network suggested the presence of underlying themes around which actors engage with each other. The largest community was related to the cocreation of biodiversity data and knowledge for EU policy-making, but other large themes that emerged

concerned ownership and management of agricultural and forest land and sustainable development through natural capital enhancement. The smallest community was related to habitat conservation and restoration. The underrepresentation of freshwater and marine organizations in the network, considering the centrality measures and the community detection, suggested a thematic area to be strengthened. This is particularly important because, although freshwater biodiversity is declining faster than that of terrestrial and marine systems, it receives less attention from actors working on biodiversity issues, as indicated by a relative lack of resources for both conservation and research (Stoffers et al., 2024).

Interviewees expected the forthcoming EU Science Service to be developed and managed in an inclusive way, with knowledge producers including nonscientists (e.g., expert knowledge) and knowledge users and beneficiaries extending beyond policy makers (e.g., citizens, interest groups). This is in line with the academic literature on the governance of science–policy–society interfaces, where success is determined by credibility, relevance, legitimacy, and iterativity (Cook et al., 2013; Heink et al., 2015; Sarkki et al., 2014). In practice, such levels of inclusivity are often difficult to establish and navigate in the face of tensions related to, for example, conflicting expectations of the role of science, value- and interest-based contestation of science and expertise, and competition between actors over overlapping responsibilities or roles (Ojanen et al., 2021). Furthermore, the integration and synthesis of different knowledge types: scientific, expert, traditional, or Indigenous (Stepanova et al., 2020) for decision-making remain challenging. However, an increasing body of work is dedicated to tackling how knowledge cocreation can navigate the tension between different perspectives, agendas, and values by balancing critically reflexive and solutions-oriented approaches (Dicks et al., 2017; Tengö et al., 2017), with the aim of transforming paradigms, practices, and institutions (Chambers et al., 2021). This, albeit time-consuming, can contribute to the development of ideas and actions for change that were unforeseen at the outset.

Overall, our findings suggest that nonpolicy and nonscience actors have an important role to play in the dialogue and cocreation of knowledge for the implementation of the EU Biodiversity Strategy 2030, for example, by acting as intermediaries or mobilizing their own social network. There are ways for the European science–policy–society interface to become a transformative engine for biodiversity conservation and sustainable development. Although this is one of the goals of the forthcoming EU Science Service for Biodiversity, it will also need the support of other initiatives and processes underpinning the science–policy–society interface at the international and national levels. Materializing such changes will require rethinking policy, science, and practitioners' agendas; mobilizing and redirecting financial resources and other capacities; and shifting practices and modi operandi.

Cross-community dialogue and exchange within the network have the potential to address several issues currently challenging biodiversity governance. The large community emerging from the social network analysis around the cocreation of biodiversity data and knowledge for EU policy-making is well positioned to begin tackling the inadequate flow of information challenging the governance of biodiversity issues. The communities focused on land management and sustainable development can be leveraged to improve policy coherence, integrate biodiversity concerns into economic sectors, mobilize funding, and support changes in land management practices. One way of achieving this could be through further understanding and employing the boundary objects (i.e., concepts that can provide a shared language or platform among different actors, e.g., ecosystem services, circular bioeconomy) at play within and across communities.

In further developing the science–policy interface on biodiversity, the network can be strengthened by addressing the underrepresentation of aquatic ecosystems and by supporting data platforms and certain private sector and science-based organizations in further consolidating themselves as network intermediaries. To explicitly address power dynamics, deliberative methods could help identify and engage more marginal and less recognized actors operating in the realm of biodiversity and related sustainability issues. This may include, for example, actors working in the social sciences (other than policy studies or economics and business management), humanities and health sciences, smaller NGOs, and local and Indigenous knowledge representatives. Stakeholder engagement strategies could include outreach programs, collaborative projects spanning multiple sectors, and the creation of dedicated working groups on neglected topics (Balvanera et al., 2020; Watt et al., 2019). Future studies should investigate the reasons behind missing connections among actors who are aware of each other (e.g., accessibility, power, trust), the gatekeeping or gatebreaking role of particularly well-connected individual people in the network, and the relationship between the network's structure and its transformative potential. Finally, further transdisciplinary research is required on how to reconcile inclusiveness and rigor in the context of knowledge cocreation at science–policy–society interfaces. In other words, there is a need for new ontologies, approaches, and test grounds to support knowledge integration and collaborative governance.

ACKNOWLEDGMENTS

This article was developed as part of the BioAgora project, funded by the European Commission Horizon Europe program (grant 101059438). The project aims to set up a European Science Service to help ratchet up the EU Biodiversity Strategy by providing timely and relevant scientific knowledge for decision makers. We thank E. Kelemen and M. Vandewalle for their support during the development of the questionnaire and the data collection.

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Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: D'Amato, D., Rantala, S., Korhonen-Kurki, K., Locher-Krause, K. E., Stoffers, T., Falco, E., Włodarczyk-Marciniak, R., Adamescu, M., Krauze, K., Orta-Ortiz, M. S., Dianoux, R., Grainger, M. J., & Young, J. (2025). A social network analysis of the European science–policy–society interface on biodiversity. *Conservation Biology*, e70023. https://doi.org/10.1111/cobi.70023