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RESEARCH BRIEF

Exploring the role of boundary work in a social-ecological synthesis initiative

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Abstract

Inter- and transdisciplinary collaboration in environmental studies faces the challenge of communicating across disciplines to reach a common understanding of scientific problems and solutions in a changing world. One way to address current pressing environmental challenges is to employ a boundary work approach that uses activities across borders of separated field of research. But how can this look like in practice? In this research brief, we self-evaluated the boundary work approach in a synthesis group on socio-ecological systems, based on an online survey with participants. Here, we discuss how boundary work can be used to integrate the knowledge from natural and social scientists both working on social-ecological systems. We found participants were selected to be acted as boundary spanners and were willing to cooperate for solving multidisciplinary issues regarding the understanding, management, and maintenance of ecosystem services. A social-ecological network analysis framework served as a boundary concept and object for communication and knowledge integration. Being familiar with a joint boundary concept like ecosystem services prior to the working group event supported the communication of participants. These results indicate that synthesis initiatives could strategically leverage boundary work through the careful selection of members, with the inclusion of boundary spanners, as well as prior joint identification of boundary concepts and objects.

Keywords Social-ecological network analysis · Ecosystem services · Interdisciplinarity · Collaboration · Knowledge coproduction

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Introduction

In view of the interconnectedness of humans and nature, interdisciplinary scientific collaboration—understood as the integration of conceptual frameworks and theory from different disciplines (Zscheischler et al. 2017)—allows for a meaningful interaction between environmental, social, and economic sciences that is necessary for the study of the full spectrum of human interactions and well-being associated with changes in ecosystem services (ES). Yet, a major challenge in making this collaboration effective is that scientists (and practitioners) from different disciplines usually do not talk the same "language" and often have different interpretations of similar terms and concepts (Lang et al. 2012; Robinson 2008). This is relevant, as they first have to develop a mutual agreement on key terminology before they can enter into an effective working mode and thus have new insights or create new knowledge to make sure they talk about the same things.

They also possess different types of knowledge and, even if they are interested in exchanging and discussing different and new ideas, they somehow have to find each other and physically or virtually come together. We call these temporarily created and agreed differences boundaries, defined as "barriers in cooperation and understanding as a result of different forms of academic and non-academic expertise as well as diverging facts and opinions, interests and values." (Opdam et al. 2015). Boundaries can have a physical (material, technological, or spatial arrangements), social (social relations), or cognitive (ideas, interpretations, or beliefs) dimension (van Broekhoven et al. 2015). Hence, to make interdisciplinary knowledge generation possible, these boundaries have to be crossed, and new spaces at the borders of the disciplines need to be filled (Toomey et al. 2017).

There are several theoretical frameworks on boundary work or boundary management. Clark et al. (2016) defined three key attributes for effective boundary work: (1) meaningful participation in agenda setting and knowledge production, (2) governance arrangements that assure accountability, and (3) the production of boundary objects. In comparison, Cash et al. (2003) defined that boundary management should enhance the salience, credibility, and legitimacy of the information that is produced, as well as three functions—communication, translation, and mediation—that make such boundary management possible. Also, Parker and Crona (2012) depicted boundary management as a dynamic process in a complex "landscape of tension."

We understand boundary work here as the "active process of 'traffic' across the borders (boundaries) of the separated domains, wherein some of the boundaries may also become temporarily blurred" (van der Steen and van Twist 2013:34). It has been promoted to cross boundaries between science and non-science (Gieryn 1983), between different sources of knowledge (Clark et al. 2016), between knowledge and action (Adem Esmail et al. 2017), and between experts and decision-makers (Huitema und Turnhout 2009; Cash et al. 2003). Boundary work is composed of different boundary elements. In this study, we follow the framework of Mollinga (2010) who defines boundary work as composed of three different types of work: (1) the development of *boundary concepts*, (2) the configuration of *boundary objects*, and (3) the shaping of *boundary settings*. We amplify this framework by adding *boundary spanners* and *boundary organizations*. *Boundary settings* are the conditions in which people from different disciplines can collaborate (Mollinga 2010). The people that connect different knowledge pools or communities within these settings are called *boundary spanners* (Matous and Wang 2019). The activity to work together connecting different knowledge pools and communities is called *boundary spanning*. This boundary work is then facilitated by using *boundary concepts*—concepts that help thinking and communicating complex issues across different disciplines (Mollinga 2010)—and creating or using *boundary objects*—devices or methods all involved people can work with although potentially having a different view or interpretation of it (Star and Griesemer 1989; Mollinga 2010). We defined *boundary concepts* here as fostering communication while *boundary objects* are integrating knowledge from the different boundaries. Lastly, boundary work may take place within *boundary organizations*—organizations that intermediate between actors from different spheres and involve the participation of actors from different sides of a boundary (Guston 2001) (see Fig. 1).

Considerable work has already been done on the different boundary elements. Boundary organizations that mediate science and policy spheres have been analyzed, such as "synthesis centers," which have been pushed by the desire to find interdisciplinary solutions to environmental challenges such as the Synthesis Centre for Biodiversity Sciences of the German Centre for Integrative Biodiversity Research (sDiv/iDiv) at the Universities of Halle, Jena, and Leipzig (Baron et al. 2017; Rodrigo et al. 2013). Boundary settings such as the Intermountain West (IMW) Initiative (Mattor et al. 2014), as well as the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES), have also been identified (Scarano et al. 2019). Boundary spanning activities of river basin management projects have been addressed (Slob and Duijn 2014) and boundary spanners have been identified, e.g., in watershed partnerships in Arizona (Muñoz-Erickson et al. 2010) or among farmers in Indonesia (Matous and Wang 2019). Boundary work has been used to assess the design and assessment of watershed investments (Adem Esmail and Geneletti 2017) or geodesign processes (Gottwald et al. 2021). However, most literature so far has focused on boundary objects: the resilience concept (Baggio et al. 2015; Steger et al. 2018), simulation models in water management (White et al. 2010), biodiversity and green infrastructure (Garmendia et al. 2016), stewardship (Peçanha Enqvist et al. 2018), network maps (Hauck et al. 2015), leverage points (Abson et al. 2017), simulation games (van Pelt et al. 2015), and serious games (Jean et al. 2018). Especially in ES research, ecosystem services indicators (Saarela und Rinne 2016) have been identified as a boundary object and landscape services as a boundary concept (Westerink et al. 2017). Broadly, ES have been identified as both boundary objects (Abson et al. 2014; Steger et al. 2018) and boundary concepts (Alonso Roldán et al. 2019; Schleyer et al. 2017), depending on the individual understanding of the terms. Lundgren (2021) recently discussed whether and how novel concepts in environmental studies can be usefully understood as boundary objects.

Most of this research focuses on boundary work at the science-policy interface (e.g., Bednarek et al. 2018; Leimona et al. 2015; Scarano et al. 2019). Boundary elements are usually mentioned without empirically reflecting with

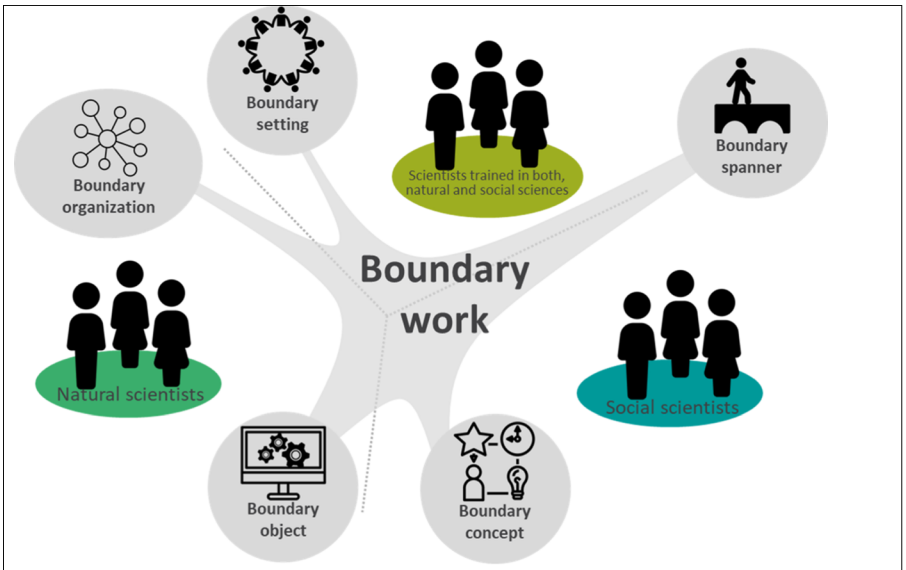

Fig. 1 Application of the boundary work approach to a synthesis study, giving examples of boundary elements for a synthesis group focused on the integration of concepts from landscape ecology, socio-ecological systems, and ecosystem services (sLandServ). Source: own illustration with Icons from the Noun Project. *sLandServ ("Linking Landscape Structure to Ecosystem Services") is a synthesis group developed within the German Synthesis Center for Biodiversity Science (sDiv)

Boundary element	Definition	Examples
Boundary organizations	Organizations that intermediate between actors from different spheres and involve the participation of actors from different sides of a boundary (Guston 2001).	sDiv - Synthesis Centre for Biodiversity Sciences (the host of sLandServ).
Boundary settings	Settings or conditions in which people from different disciplines and spheres can collaborate (Mollinga 2010).	Workshops and Working groups (like sLandServ), support/tools for data management.
Boundary concepts	Concepts that help thinking and communicating complex issues across different scientific disciplines and societal spheres (Mollinga 2010).	Concepts of Ecosystems Services (ES) and Social-Ecological Systems (SES).
Boundary objects	Devices or methods that all involved people can work with although having a different view or interpretation of it (Star und Griesemer 1989).	Social-ecological network analysis (SENA) as a method, operationalising the SES concept.
Boundary spanners	People that connect different knowledge pools or communities (Matous und Wang 2019).	Participants of the workshops who are able to make connections between boundary concepts and objects. For sLandServ, spanners are those able to connect between socio-ecological systems, network analysis and ecosystem services).

the involved researchers or stakeholders if these elements really served as boundary elements. This approach thus uses boundary elements as a buzzword. Despite the recognition that synthesis initiatives act (or may act) as boundary institutions and despite some investigation of their experiences and outcomes (Hampton und Parker 2011; Lynch et al. 2015), no work has been done so far analyzing how the different elements of a boundary approach work in a synthesis initiative and how successful synthesis initiatives can be in facilitating boundary work.

To fill these gaps in this research brief, we aim to describe the perception of the use of boundary work among different scientific disciplines in a synthesis initiative. We define synthesis initiative as an approach to creating new knowledge through heterogeneous working groups that bring together diverse views and insights on existing but disparate data, methods, theories, and tools. We discuss the following questions: What does boundary work look like in practice? How can boundary work be used to integrate natural and social scientists working on social-ecological systems? What boundary elements (e.g., boundary objects, boundary concepts, boundary settings) are used and needed? Using the example of a synthesis group, the sLandServ ("Linking Landscape Structure to Ecosystem Services") developed within the German Synthesis Centre for Biodiversity Science (sDiv), we reflect on which boundary elements were present and useful in this group. Particularly, we identify the boundaries and boundary elements to shed light on how a boundary approach can help to promote collaboration in an interdisciplinary setting. We begin by describing the existing boundaries between the actors in our group, followed by describing our methodology for self-evaluation. We then discuss the boundary elements used and if we considered them as helpful for this kind of cooperation. To improve research practice, we conclude with some general recommendations in terms of boundary work for interdisciplinary or synthesis groups that aim to bridge their knowledge systems and engage in knowledge co-production.

The sLandServ synthesis group on social-ecological system as a case study

The German Centre for Integrative Biodiversity Research (iDiv) based in Halle, Jena, and Leipzig is a research center focused on science for the sustainable management of our planet's biodiversity. sDiv is iDiv's Synthesis Centre for Biodiversity Sciences, where the aim is to develop new ideas and insights by integrating diverse knowledge, data, methods, theories, and tools. One of sDiv's central instruments is international and multidisciplinary working groups that aim to tackle major challenges in biodiversity science. In 2017/2018, a working group focused on understanding how landscape structure influences the provision of ES (the sLandServ group) met twice for 1-week summer and winter workshops in Leipzig to discuss and develop new knowledge on how landscape structure affects ES provision, by being explicit about the spatial socio-ecological processes that generate ES benefits. The group tried to understand how landscape structure drives ES supply, i.e., the capacity of an ecosystem to provide ES (Burkhard et al. 2012), ES demand, i.e., ES desired or required by people (Villamagna et al. 2013), and ES flows connecting supply and demand areas. The strong social-ecological framing of this problem required a diverse group that spanned multiple disciplines and perspectives. The 16 invited researchers were from seven countries on five different continents; they had been trained in different scientific disciplines, including natural and social sciences, and use different methods for their research. They also were in different stages of their career. The identified boundaries of the group, therefore, are spatial distance and disciplinary, methodological, and experiential diversity. Although English was the working language, it was not the mother tongue of all participants.

The two workshop organizers acted initially as the boundary spanners of the sDiv group as they invited researchers from different disciplines and institutes for their participation, as well as iDiv as the synthesis initiative that prescribed these rules. If we think of boundary spanners as "people who connect diverse knowledge pools," then all of the participating researchers can also be seen as potential boundary spanners as all of them crossed their disciplinary boundaries and engaged in combining and integrating existing and co-producing new knowledge.

The reflection process

To support our reflection and to examine if there was in fact effective and successful boundary work in our synthesis group, we developed a short self-evaluation survey to assess whether (a) besides country of origin and language, the main boundary between the participants was their disciplinary background; (b) the workshop setting served as a boundary setting; (c) the ecosystem services (ES) concept served as a boundary concept; and (d) the social-ecological network analysis (SENA, see Box 1 and Fig. 2) served as both a boundary object and a boundary concept.

The survey (see Appendix 1) was conducted between February 18 and March 8, 2019. Sixteen of the 17 invited participants of the sDiv workshops filled in the complete questionnaire. Ten of them participated in both workshops in December 2017 and July 2018, and six participated in just one of the workshops. Participants were asked about (1) their disciplinary background, main research fields, and methods; (2) new things they learned during the workshops; (3) their use and opinion about SENA and the ES concept; and (4) the usefulness of the ES concept, SENA, and the sDiv Group as boundary concept, object, and setting. After data collection, the results were analyzed using descriptive frequency measures for the closed questions and doing cross-tabulation to explore relations among different variables. The open questions were coded thematically deducing items that were mentioned and summarized into larger categories (Bryman 2012). The overall results were further discussed and reflected among the co-authors—all of whom were workshop participants—in the writing process of this research brief.

Box 1 Social-ecological network analysis

Network models consist of nodes and links (vertices and edges). They can be used to represent basically any kind of system that consists of components of various sorts, and different relationships that connect the components to each other. The history of describing and analyzing human actors and their social relationships as social networks are long, with some of the key academic literature published in early 1900 (e.g., Moreno and Jennings 1938). Similarly, network analysis has a long history in ecology, where network-centric analyses of food webs have been published since at least the early 1970s (e.g., May 1972). Fairly recently, following in the wake of interdisciplinary studies of social-ecological (or coupled human–nature) systems, network thinking and modeling have been used to study human–nature relationships (e.g., Janssen et al. 2006). An integrated social-ecological network perspective comes with several potential benefits. It provides a common model that can accommodate both social and biophysical entities seamlessly, although such modeling needs to be done in a theoretically and methodologically informed way to be of substantial value (Bodin et al. 2019). Several recent reviews have identified several other benefits, e.g., diagnosing the conditions that enhance environmental governance and management, but also pinpointed challenges for the future, such as the better integration of ecological research or the analysis of change over time, and linking network structures to outcomes (Sayles et al. 2019; Kluger et al. 2020)

Boundary work in the sLandServ Group—lessons learned

Disciplinary boundaries of the group

Our working group was clearly multidisciplinary, with several boundaries among participants. Eleven researchers identified themselves as natural scientists, two as social scientists and three as both social and natural scientists (cognitive dimension). Within these broader categories, people were trained in different scientific disciplines—ten were trained in ecology while six were trained in other scientific disciplines (i.e., physics, agricultural science, biology, economics, geography, physics, and political science). In addition, nine participants were trained in more than one discipline.

In their scientific work, participants used different methods. These included Geographical Information System (GIS) analysis, statistical analysis, modeling, and, to a lesser extent, social network analysis and comparative content analysis. While the natural scientists used mainly modeling, GIS, and statistical analysis, the social scientists used social network analysis and comparative content analysis. The multidisciplinary participants used more diverse

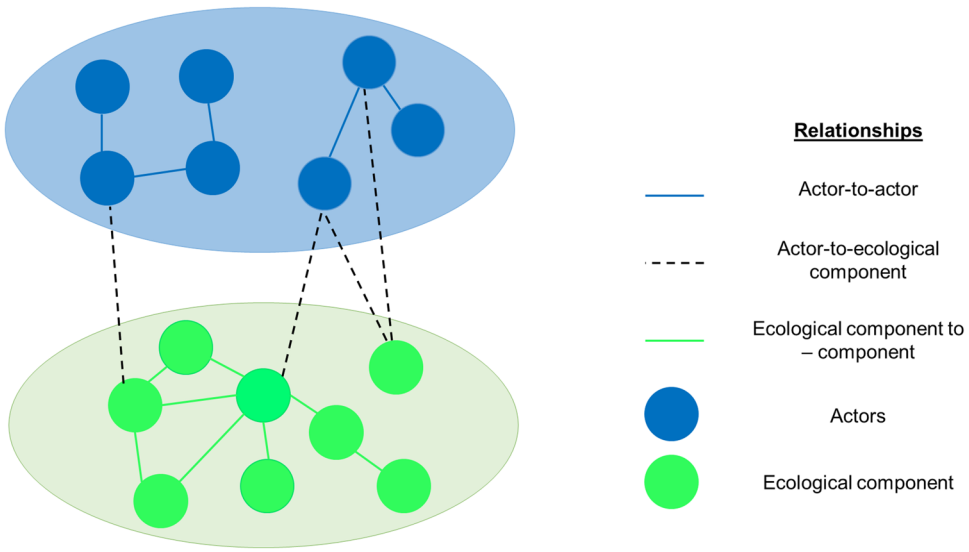

Fig. 2 A multilevel network model. Adapted from Bodin et al. (2020)

methods including modeling, choice experiments, qualitative comparative analysis (QCA), social network analysis, comparative content analysis, GIS, and statistical analysis. Therefore, besides country of origin (physical dimension), language, and different career stage (social dimension), the disciplinary background (cognitive dimension) seemed to be the "main" boundary between the participants.

Boundary concepts and objects: the ecosystem services concept and social-ecological network analysis

Despite the identified boundaries, the common starting point for the participating researchers was that all of them were already working with the ES concept (Millennium Ecosystem Assessment (MEA) 2005). It turned out to be a boundary concept, being recognized by most participants as relevant to support communication between natural and social scientists. The main reason for the ES concept to be seen as a boundary concept was the integrative and bridging function across social, economic, and ecological sciences of the concept that helped to find common ground and structure thoughts.

SENA was assessed as both a boundary concept and a boundary object. The participants saw it slightly more often as a boundary concept used for communication than as a boundary object to integrate knowledge. This may be due to the fact that the final visualized networks, which could be used for active discussion at this point, were not produced during the workshop. Reasons for SENA being a boundary concept were that it is understandable to everybody, is amenable to visualization possibilities, and is not too complicated to learn. Reasons for seeing SENA as a boundary object that integrates social and natural sciences were due to the attributes of the method which contains bridging elements and therefore facilitated communication due to a common understanding. It became clear that the line between boundary concept and object is thin and maybe go along with each other, as the literature demonstrated for the ES concept identified as both a boundary concept (Schleyer et al. 2017)—just as in this case study—and as a boundary object (Abson et al. 2014; Steger et al. 2018).

Both the ES concept and SENA have the potential to connect different scientific backgrounds and cross the boundaries between natural and social sciences (Fig. 3).

Natural scientists in the group were mainly familiar with landscape modeling and simulations. For them, the ES concept helped to represent and communicate the landscape structure via its effects on ES into networks. Social scientists in the group perform governance research with social network analysis. For them, the ES concept served to integrate a spatial perspective of ES supply and demand into the network. Therefore, ES as a boundary concept helped both groups translate their work and make it understandable to the other group. SENA then turned out to be a suitable methodology to integrate both natural and social scientists. The method served as both a boundary concept and a boundary object, relevant for analysis and communication, providing a common language all scientists were able to work with. The social-ecological networks created by the group may serve also as boundary objects to facilitate further actions, such as supporting discussion with local stakeholders or scientific colleagues. For this, it has to be used continuously in practice in both worlds (Bechky 2003).

At least in our synthesis group, boundary work was useful in bringing together social and natural scientists, and more specifically that ES and SENA were crucial boundary concepts and/or objects to link landscape structure, governance, and network concepts, as well as qualitative and quantitative research analyses. We saw that boundary concepts and objects are important for communication between different groups and for integrating different knowledge. That the ES

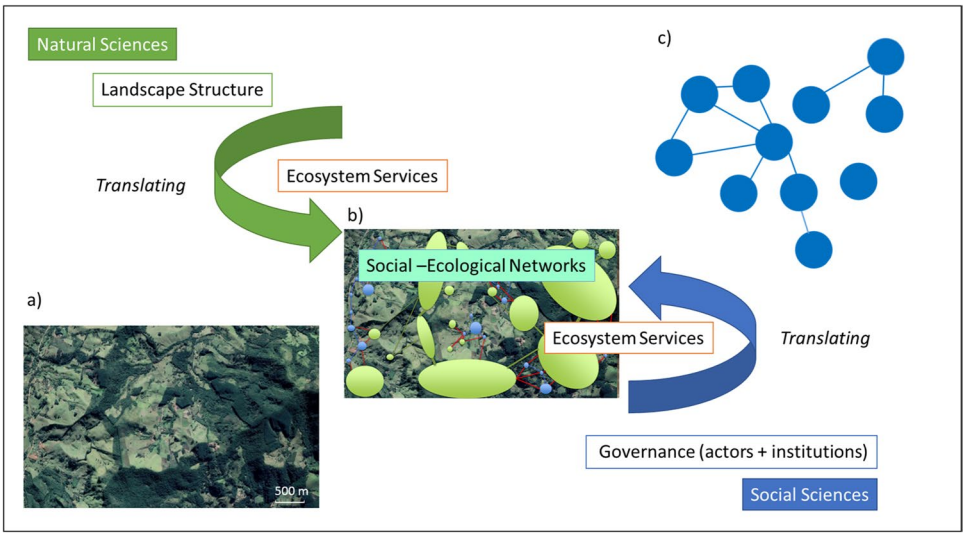

Fig. 3 Social-ecological networks connection between natural and social sciences via ES in the sLandServ workshops modified from Metzger et al. (2021) showing (a) forested agricultural landscape, (b) ES supply and demand network, and (c) demand network

concept helped communicating is similar to the findings of Boeraeve et al. (2018) and Kull et al. (2015). As all participants were familiar with and had worked with the ES concept before, it was easier for them to communicate and cross boundaries. If this had not been the case, probably more time would have been needed to find a common conceptualization to understand each other.

The sDiv group as a boundary setting

The sDiv workshops were a useful boundary setting as they helped to cross the physical dimension of the boundary and promoted people from different continents to meet in person, but the usefulness of this approach depended heavily on a few factors. Particularly, it was a suitable setting due to the interdisciplinary and intergenerational composition of the group, as well as the format which gave enough time and space for open discussions. The existence of boundary spanners from the beginning of the process (iDiv and the workshop organizers), bringing the participants to work together, and the willingness of the other participants to eventually act as boundary spanners in the discussion process enabled them to cross their disciplinary and methodological boundaries. We define boundary spanners not only as people who bring both worlds together, but as people who really engage to work in both worlds. This is in line with Crowston et al. (2015) who see boundary spanners as translators of information across disciplines and emphasize their participation in inter and transdisciplinary working groups. Therefore, group composition and meeting format, choosing boundary spanners strategically and allowing equal contribution from each group member, are essential to foster a boundary approach within scientific synthesis, making possible creative and associative thinking (Scheffer 2014; Rodrigo et al. 2013).

Our findings also meet challenges for collaboration at the science–policy interface mentioned by Balvanera et al. (2020) such as addressing the interconnectedness of ecosystems and people to tackle the planetary crisis and dealing with complexity of the science–policy interface. Teams diverse in career level, expertise, and sectors are needed (Gustafsson et al. 2019; Washbourne et al. 2020) as much as interdisciplinary engagement and the co-production of understanding and knowledge.

Future directions

In this research brief, we reflected on the boundary work and its elements in our working group. Given the limitations of the methods which were based on self-assessment through an online survey and the reflection of the authors during the writing process of this manuscript, no general conclusion for other synthesis working groups can be drawn. Furthermore, it was beyond the scope of our research to investigate the possibility of iDiv/sDiv as a boundary organization, as well as the power dynamics between early and established researchers. With the disclosure of our reflection process, we want to animate scientists to reflect on their interdisciplinary working processes and to improve research practice.

In this respect, more similar and deeper work has to be done to assess boundary work, e.g., by elaborating a more extended survey and applying it to more interdisciplinary research groups and different synthesis initiatives, or to test and identify more boundary concepts, as the ES concept in our case. Parker and Crona (2012), e.g., propose external reviews of boundary organizations.

In particular, we understand there is still a need for more knowledge on which boundary elements are used and needed, as well as which boundary elements should be considered already when designing inter- and transdisciplinary collaboration. When proposing synthesis groups or selecting/financing groups, the following questions should be addressed: Do we need to consider all presented boundary elements (concept, object, spanners, setting) for having a successful group? Are some elements more important, e.g., having a useful boundary concept, or are they of equal value? Is it sufficient to have boundary spanners and a boundary concept or a boundary object for establishing an effective boundary setting?

When discussing the question "who the boundary spanners were," we noticed that the role of boundary spanning seems to be dynamic over time. For some boundary spanners, this role is obvious right from the start (e.g., the sDiv group "founders" bringing together researchers from different disciplines on purpose) but for others, their role was situation dependent and evolved during the process of group work. So, the initial spanners may play an important role in helping the other participants also engage as spanners but inversely, the initial boundary spanners could also stop playing this role, depending on how the workshop develops.

There is also a need for a deeper reflection on how boundary work can be used for transdisciplinary work, which means focusing research not only on interdisciplinary research groups but also on groups where scientist cross the boundary to stakeholders from different societal groups or with policy decision-makers. This is especially important for the use of the ES concept as a boundary element to motivate its uptake in decision-making processes and to use not only conceptually but also instrumentally (van Oudenhoven et al. 2018). Using ES indicators (Saarela and Rinne 2016) instead of the more abstract ES concept could be one solution.

From the experience of our synthesis group and insights from the survey, we provide the following advice for other synthesis working groups:

- Explicitly and purposefully incorporating boundary elements—especially a "good" boundary setting which purposefully plans the integration of boundary concepts and objects into the workshop design in advance of the research endeavor to improve its opportunities for success (see also Mattor et al. 2014 for transdisciplinary research).
- Have a "good" proportion of people who can function as boundary spanners from different disciplines of origin, more or less balanced in numbers, to guarantee the integration of ideas. Future research could have a closer look at the dynamic nature of boundary spanners. Spanners may perform best when feeling secure and confident that they are able to translate between different boundaries and that their input is accepted and understood by people on both sides of the boundary. It would be interesting to find out if and how spanner roles could be stimulated, or if they are merely intrinsically motivated. A big imbalance in the number of participants between social and natural scientists may make it more difficult to cross boundaries due to bias toward the more represented area. This may be considered at the very beginning of the group formation by paying careful attention to the invited participants' skills and by specifically integrating social scientist (Washbourne et al. 2020).
- Reflecting on the definition of boundary elements, especially the distinction between boundary concepts and objects. There are a variety of interpretations and they often are blurred. We solved this by defining boundary concepts as fostering communication while boundary objects are integrating knowledge from the different boundaries.
- Being familiar with a joint boundary concept like ES before starting working helps to start communication among people and makes it easier to find a boundary object for knowledge integration.
- Developing a boundary object together or thinking about it before organizing an event may lower the risk of bringing a boundary object that is specific to only a few disciplines. However, deciding about this aspect before the event is an alternative that needs to be tested.

Our study case and analysis of boundary work in the sLandServ synthesis initiative contributed to a better understanding of how a boundary approach can help to promote knowledge co-production in an interdisciplinary setting. For future work in research and practice, we identified two important aspects to consider. First, there is a need for more knowledge on which boundary elements are used and needed in synthesis initiative, particularly for social-ecological research, for what specific objectives, and how well they perform in reaching these objectives. This involves investigating possible methods to assess and document boundary work, and for analyzing boundary work in the context of transdisciplinarity. Second, we call for a more formal and explicit consideration of boundary work in the development of synthesis working groups since this approach has great potential to improve the success of these groups. We hope that our reflection of boundary work in the sLandServ synthesis group will inspire further research on how to ensure synthesis initiatives maximize the successful integration across disciplines.

Appendix 1

sDiv LandServ Questionnaire

Dear colleagues,

To evaluate the performance of the sDiv working group LandServ you are participating in we would like you to fill in our short questionnaire.

The questionnaire is addressed to find out about boundary work and will hopefully result in a joint journal article.

Responding to the survey takes approximately **5 minutes**. The information you enter is automatically saved. Your answers are anonymous and will be dealt with in a way that respects your privacy.

For more information, please contact Barbara Schröter (barbara.schroeter@zalf.de).

Thanks a lot for your support!

Claudia, Jonathan and Barbara

1. What is your disciplinary training?

2. Do you consider yourself as a natural scientist or a social scientist?

a) I am a natural scientist
b) I am a social scientist
c) I am both, a natural and a social scientist

3a. Do you think you are more an analytical thinker or a creative thinker?

d) I am more an analytical thinker
e) I am more a creative thinker

3b. Look at the ballerina. In which direction does it rotate for you?

http://dieprojektmanager.com/linke-und-rechte-gehirnhaelfte-test/

a) It rotates clockwise
b) It rotates counter-clockwise

3c. Can you make the direction change if you look some time longer, or not?

a) Yes, I can make the rotation change

b) No, I cannot make the rotation change

4. What is your main research field?

5a. Which kind of data do you mainly work with in your research?

a) Qualitative data
b) Quantitative data
c) A mix of qualitative and quantitative data

5b: Which methods do you currently use for data analysis?

a) Modelling
b) Impact Assessment
c) Economic Experiments
d) Choice Experiments
e) Social Network Analysis
f) Comparative content analysis
g) GIS analysis
h) Qualitative Comparative Analysis
i) Statistical Analysis
j) Other methods

6. In which of the sDiv LandServ Group workshops did you participate in?

a) I participated in the winter workshop (December 11-15, 2017)
b) I participated in the summer Workshop (July 2-6, 2018)
c) I participated in both workshops
d) I participated remotedly in the summer workshop
e) I participated remotedly in the winter workshop
f) I participated remotedly in both workshops

7. What was the most important new thing you learned during the workshops?

8. How familiar were you with Social-Ecological Network Analysis (SENA) before coming to the first workshop?

a) not at all familiar
b) slightly familiar
c) somewhat familiar
d) moderately familiar
e) very familiar

9. How often did you use Social-Ecological Network Analysis (SENA) in your research before coming to the first workshop?

a) never used it
b) rarely used it
c) occasionally used it
d) used it frequently
e) used it very frequently

10. How familiar were you with the Ecosystem Services (ES) Concept before coming to the first workshop?

a) not at all familiar
b) slightly familiar

c) somewhat familiar
d) moderately familiar
e) very familiar

11. How often did you use the Ecosystem Services (ES) Concept in your research before coming to the first workshop?

a) never used it
b) rarely used it
c) occasionally used it
d) used it frequently
e) used it very frequently

12a. How useful do you consider Social- Ecological Network Analysis (SENA) as a method for integrating natural and social sciences during the sDiv Landserv workshops?

a) not at all useful
b) slightly useful
c) somewhat useful
d) useful
e) very useful

12b. Why was SENA a useful method for integrating natural and social sciences? /Why was SENA not a useful method for integrating natural and social sciences?

13a. How useful, do you think, was Social- Ecological Network Analysis (SENA) as a communication tool in the workshop?

a) not at all useful
b) slightly useful
c) somewhat useful
d) useful
e) very useful

13b. Why was SENA a useful communication tool?/ Why was SENA not a useful communication tool?

14a. How much, do you think, the Ecosystem Services (ES) Concept supported communication between natural and social sciences during the sDiv Landserv workshops?

a) not at all
b) slightly
c) moderately
d) very
e) extremely

14b. Why did the Ecosystem Services (ES) Concept support communication between natural and social sciences/ Why did the Ecosystem Services (ES) Concept not support communication between natural and social sciences?

15a. How useful, do you think, was the sDiv Landserv group as a setting for collaborative work of natural and social scientists?

a) not useful at all
b) slightly useful
c) somewhat useful
d) useful
e) very useful

15b. Why was the sDiv Landserv group a suitable setting for collaborative work of natural and social scientists?/ Why was the sDiv Landserv group not a suitable setting for collaborative work of natural and social scientists?

16. For capturing our network in the last two questions, please enter your name.

17 a. Whom of the participants of the sDiv Landserv group had you been working with before the first workshop? (Please tag everyone and indicate yourself)

17b. Whom of the participants of the sDiv Landserv group have you will likely cooperate with more closely from now on? (Please tag everyone and indicate yourself)

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Data Availability The dataset generated and analysed during the current study is not publicly available due to sensible information protected by law but are available from the corresponding author on reasonable request.

Declarations

Ethics approval This work was approved by the University of Queensland under Human Research Ethics Approval number 2019000012.

Conflict of interest The authors declare no competing interests.

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