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Narrowing the gap between climate science and adaptation action: The role of boundary chains

Christine J. Kirchhoff *, Maria Carmen Lemos, Scott Kalafatis

University of Michigan, School of Natural Resources and Environment, Ann Arbor MI 48109, United States

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ABSTRACT

Boundary organizations play a critical role at the interface between science and decision making. They create, protect and sustain an interactive space for co-production of science and decision-making while simultaneously bridging the two domains. In this special issue we advance the concept of boundary chains, whereby two or more boundary organizations link together synergistically to influence one another and to leverage each other's resources and strengths to achieve shared goals. In this process both the level of complementary and embeddedness between these organizations is critical for achieving these goals. Through a series of case studies focusing primarily but not exclusively on climate information use in the United States, we aim to advance scholarship in the field by examining innovation among boundary organizations and testing the boundary chain concept. In doing so, we focus on boundary chains both as a theoretical construct to re-think the structure, function, and adaptability of boundary organizations and as a practical strategy to further increase the usability of climate knowledge for adaptation action across a wider range of users.

The challenge

Solving the complex environmental problems that society faces requires participatory approaches that produce usable science and link that science to decision making. Empirical research shows that when scientists and information users collaborate in knowledge co-production the information that results is more usable for solving problems and supporting management decisions because the collaborative process helps align what users want with what science has to offer (Cash et al., 2006; McKinley et al., 2012; O'Mahony and Bechky, 2008; Lemos and Morehouse, 2005; Lemos et al. 2012). Beyond generating more usable knowledge, these approaches also open a dialogue between science and society that fosters creative solutions while minimizing the politicization of science and the scientization of policy (Gough, 2003; Guston, 1999).

In many of these interactive processes, intermediary organizations, called boundary organizations, play a critical role supporting interaction and exchange at the interface between science and decision making. By creating, protecting and sustaining an interactive space and by bridging science and society, boundary organizations establish a forum for differing perspectives and knowledge systems to interact and develop a mutual understanding while maintaining their own identities

* Corresponding author at: University of Connecticut, 261 Glenbrook Rd., Unit 3037, Storrs CT 06269-3037, United States. Tel.: +1 860 486 2771; fax: +1 860 486 2298.

E-mail address: ckirchhoff@engr.uconn.edu (C.J. Kirchhoff).

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(Guston 1999, 2001). Through this interactive workspace, boundary organizations help to bridge the different cultures of science production and use and broker science to decision-making (Guston, 2001).

Evidence documenting the use of different kinds of scientific knowledge – and climate information in particular – in decision making shows that boundary organizations have been increasingly effective at bridging and brokering usable information in support of decisions. For example, usability is increased through interactions between producers and users of climate information across a range of applications from disaster reduction (Kasperson, 2010) to water management (Kirchhoff et al., 2013). These interactions help to improve understanding, integrate different kinds of knowledge, and build capacity for use (McNie, 2013) as well as reduce barriers to use and reconcile the supply of information with users' demand (Sarewitz and Pielke, 2007).

While considerable research has examined how boundary organizations stabilize the boundary between science and society in general, and how they improve the usability of climate information in particular (see for example Bolson et al., 2013; Huitema and Turnhout, 2009), only recently have scholars turned their attention to the structure and sustainability of boundary organizations themselves and what we can learn from them. Recent advancements in this area suggest, for example, that a reliance on face-to-face interactions, while effective, may limit boundary organizations' potential to increase the production of science that supports the rapidly growing number and diversity of potential users (Kirchhoff et al., 2013). Likewise for users, resource intensive interactions can be burdensome, particularly for those without sufficient capacity to invest in long-term, face-to-face interactions with producers (Dilling et al., 2015; Kasperson, 2010; Kirchhoff, 2013). These findings have led to calls for research exploring innovative ways to sustain and expand interactions between producers and users across space and time that increase usability as much as face-to-face ones, but are less resource intensive and capable of serving a broader suite of potential users. Other recent work supports the notion that boundary organizations themselves innovate in different ways to respond to changing contexts or help shape the space within which they operate. Findings suggest that boundary organizations adapt by re-organizing and reframing problems and by establishing new directions and partnerships (Lemos et al., 2014; Parker and Crona, 2012). From this work emerged the concept of boundary chains which begins to account for the ways in which boundary organizations collaboratively shape their environments and enhance capacity to achieve shared goals.

Boundary chains are formed by purposefully and strategically connecting a series of boundary organizations that span the range between the production of information and its use in decision making (Lemos et al., 2014). As theorized in Lemos et al. (2014), boundary chains advance the work of individual boundary organizations through leveraging the complementary resources and strengths of two or more linked boundary organizations to achieve shared goals. In this configuration, boundary chains are primarily viewed as a means to reduce the resource demands of climate information co-production and to reach a wider range of users more efficiently and effectively than would be possible by a single boundary organization working on its own. Through a series of case studies, Lemos et al. (2014) showed that, at a minimum, linking two or more boundary organizations together decreased transaction costs – the level of effort invested by each organization for co-production and for forming and sustaining connections between scientists and users. For example, rather than having to start from scratch, building trust with different individuals or groups to increase their effectiveness as brokers and bridgers of climate information, organizations such as RISAs in the US or the UKCIP in the UK, could 'contract out' this function to another boundary organization that has already established trust with those potential users. Similarly, other kinds of costs such as distance between producers and users and perceived conflicts can be reduced through boundary chains, where each link, works to reduce or spread the costs across the chain.

And, while boundary chains were conceived in the context of climate information usability, the concept has potential to re-frame the ways in which we think about the structure, function, and adaptability of boundary organizations and the ways in which they build capacity and help solve complex environmental problems. For example, because boundary chains link boundary organizations with different missions and orientations along the continuum of science production to use, there is considerable room for different sorts of boundary interactions to occur that serve different purposes at different links in the chain. Although these links leverage complementary strengths and resources, they also embed science within different communities helping to influence and being influenced by those communities.

Our aim in this special issue is for these cases to provide robust empirical examples of different ways of fostering actionable knowledge for and broadening participation in decision making that critically advance scholarship on boundary organizations and boundary chains. In different ways, the contributions in this special issue reinforce the idea that boundary chains not only narrow climate (and other kinds of scientific knowledge) information gaps in support of adaptation but also build capacity and networks that enhance societal resilience more broadly (Bidwell et al., 2013; Kalafatis et al., 2015). This special issue largely focuses on boundary chains formed with the Great Lakes Integrated Sciences + Assessments (GLISA), a NOAA-funded Regional Integrated Sciences and Assessments Program (RISA) (for more information about RISAs see NRC (2010) and Pulwarty et al. (2009)). GLISA is a boundary organization that works to advance climate science in support of planning for and in response to climate-driven impacts in the Great Lakes region of the US (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) and Ontario, Canada. The special issue also includes examples from other regions such as boundary chains on ocean acidification and hypoxia in California, and a boundary chain bridging diverse users across an expansive geography in Alaska.

The contributions

Each paper included in this issue contributes to advancing scholarship on boundary organizations and boundary chains. In particular, they build on Lemos et al.'s (2014) conceptual work to advance new frameworks for assessing the effectiveness of boundary chains. They also extend work previously focused on individual boundary organizations to the context of collaborative boundary chains. For example, they touch on issues such as the production of usable knowledge, the use of alternative forms of engagement to build networks and enhance learning, and the role of policy entrepreneurs. The collection also expands our thinking about the role boundary organizations and boundary chains may play in serving marginalized communities and in bringing disparate groups together to tackle complicated environmental challenges. These articles additionally shed light on the challenges and opportunities boundary chains face such as obstacles to real policy change despite good fitness between knowledge and user needs, the importance of capacity building (particularly among new users), and the need to balance sustaining long-term partnerships that foster learning and change with the need for flexibility to adapt to changing conditions and priorities.

In their perspective for the special issue, Kirchhoff et al. (2015b) propose a new conceptual framework for exploring why and how boundary chains form and for evaluating their success in producing climate information usability. This work represents a theoretical extension of Lemos et al.'s (2014) introduction to boundary chains and their potential to increase the efficiency of individual boundary organizations' efforts to enhance the usability of climate information. Kirchhoff et al. (2015b) draw on both the international development literature and the literature on boundary organizations to support the proposition that successful boundary chains are those that create synergy. They argue that synergy across boundary chains depends on two interrelated conditions: complementarity and embeddedness. On the one hand, complementarity arises from differences between individual boundary organizations that make up the chain. By contributing different, but complementary inputs, boundary chains produce greater outputs than either boundary organization could deliver on its own. On the other hand, embeddedness is less about what boundary organizations bring to the boundary chain and more about how they influence or depend on each other. That is, embeddedness is greater when the choices and actions of one boundary organization in the chain are at least partially influenced by and dependent upon the choices and actions of another boundary organization in the chain. The authors illustrate the utility of the framework for evaluating the effectiveness of boundary chains with a series of case studies. Their results show that boundary chains with higher synergy led to greater climate information usability while cases with lower levels of synergy resulted in more mixed outcomes for climate information usability.

Typically, boundary organizations rely on face-to-face interactions to facilitate both knowledge transfer and the development and support of network connections. While face-to-face interactions are effective at building trust and facilitating the translation, mediation, and communication of climate science to potential users (Cash et al., 2006; McNie, 2013), they require significant resource investments from both producers and users of climate information (Kirchhoff, 2013; Lemos et al., 2012). As such, boundary organizations that produce climate information face limits in how many potential users they can serve through the medium of face-to-face interactions. The situation is compounded in Alaska where the Alaska Center for Climate Assessment and Policy (ACCAP) is tasked with serving a huge geography and large numbers of potential users. Kettle and Trainor's (2015) work with ACCAP provides promising evidence of how boundary organizations may overcome these constraints (distance, limited resources) through the use of remote forms of engagement (namely webinars) and boundary chains. Analysis of survey and interview data from webinar participants suggests that webinars hosted in a boundary chain context succeed in facilitating boundary work–communicating climate science, supporting dialogue about climate impacts and solutions, network building, and facilitating learning among different types of information users. Boundary chains – in this case, hosting of webinars at partner boundary organizations – enabled leveraging of complementary resources and networks and contributed to the effectiveness of this remote form of engagement.

Kirchhoff et al. (2015a) use longitudinal observational data, surveys and interviews to examine interactions between climate information producers and potential users and to characterize the benefits of a boundary chain. In doing so, their contribution adds depth to the body of work exploring boundary chains and their benefits. They focus on two boundary organizations in a boundary chain, GLISA, as a climate information producer, and the Huron River Watershed Council (HRWC), a non-governmental organization with ties to climate information users in the Huron River watershed in Southeast Michigan, USA. The authors uncovered a range of efficiency improvements that boundary chains create including: (1) speeding up the co-production process by increasing climate information usability for a variety of users over a short period of time, (2) improving climate information dissemination by users within user networks and improving climate literacy (of users) and resilience (in the watershed) without requiring additional organizational effort from either boundary organization, and (3) creating climate brokers within the chain who took the lead in identifying new audiences and introducing them to customized, relevant climate science. Ultimately, this paper speaks to the importance of boundary chains not only because they improve efficiency in climate information production and use but also for their role in improving climate literacy and resiliency more broadly.

Kalafatis et al. (2015) explore the emergence and continuation of climate adaptation within the City of Toledo, Ohio's water management efforts. Using thick description framed by the three streams of Kingdon's (1984) "multiple streams" model of policy change (problems, policies, and politics), the authors provide a detailed narrative of the resources that made these efforts possible. They pay particular attention to the role in the process played by a boundary chain the city formed with GLISA and the Great Lakes Adaptation Assessment for Cities (GLAA-C), an integrated assessment project assisting cities with increasing their knowledge about climate change and implementing adaptation responses. The authors emphasize the critical role played by two policy entrepreneurs promoting adaptation in the city, and detail how the flexibility of the boundary chain served these entrepreneurs' information needs both in the general awareness-raising portion of the process and later on with decision-specific information. In this case, owing to the work of one of these policy entrepreneurs, the boundary chain also served as a part of a broader support network that formed around adaptation in the region surrounding the city. The authors argue that the development of this polycentric network stretching beyond the city created an institutional resource that helped Toledo pursue adaptation without direct political support and sustain action through a particularly tumultuous period.

Through both general reflections on several years of project work and more detailed examples presented in two case studies of boundary chains, Briley et al. (2015) provide insights into the knowledge co-production process from the perspective of GLISA climate scientists. The authors identify three common barriers they have encountered in the process of developing usable climate information with other boundary organizations: (1) mismatched terminology used by scientists and stakeholders to describe the types of information that are available and needed for problem solving, (2) unrealistic expectations that stakeholders have regarding the development of climate information products for their problems, and (3) disordered integration when stakeholders want to bring climate information into decision-making processes. The authors explain that these barriers align with challenges associated with translation, interplay, and information fit described in social science literature on the "usability gap," highlighting the extent to which information providers face the same issues that stakeholders do in these processes. The authors present these overlaps as a potential opportunity because they argue that experienced information providers can represent sources of capacity. This capacity can, for example, reduce the challenge associated with managing uncertainty cascades surrounding adaptation decisions.

Meyer et al. (2015) reflect on the ongoing work of the California Ocean Science Trust (OST) to manage and advance the West Coast Ocean Acidification and Hypoxia Science Panel (OAH Panel) tasked with synthesizing scientific understanding of ocean acidification and hypoxia, contributing interdisciplinary perspectives, and linking science with decision making in California. They authors point out how the OST, OAH Panel and their partner organizations created different boundary chain configurations that served to advance different end goals. For example, forming a linked chain helped to advance specific scientific products while key chains and networked chains helped to translate science to local issues and interests and strengthen networks, respectively. While boundary chains effectively advance ocean science and link science with decisions, Meyer and colleagues note that links in boundary chains should be pursued judiciously to avoid the fate of trying to serve every need of every participant (Parker and Crona 2012). Finally, the authors provide compelling evidence that the goal of boundary chains may not always be to improve efficiency. Rather, in the ocean acidification and hypoxia case, more transactions (decreasing efficiency) between complementary boundary organizations actually enhanced the effectiveness of the boundary chains in achieving outcomes of interest (e.g., synthesizing understanding, incorporating differing perspectives, and improving links between science and decision making).

Finally, our last contribution examines the social role boundary chains can play in contexts of inequality and unequal distribution of information. A persistent challenge in adaptation is that too often discourse is dominated by elites and wealthier, well-educated communities while marginalized communities, who often bear the brunt of climate change impacts, are excluded from the conversation. Exclusion arises for complex reasons including lack of capacity – marginalized communities face other stresses that can leave little time or attention to deal with climate change – and a perception that climate change is a future phenomenon and not personally relevant. Tackling the challenge, Phadke et al.'s (2015) paper explores how boundary chains can play an important role in not only making climate information accessible and relevant to these under-represented communities but also in helping these communities exercise their voice in adaptation decisions. The authors describe a boundary chain comprised of university scientists linked with community partners and municipal decision makers in Saint Paul, Minnesota. Specifically, each link of the chain served a complimentary role: university scientists developing place-based scenarios that helped to personalize climate change impacts for individuals within each community, recruitment and training of respected community partners embedded in each community to facilitate engagement, and finally the execution of four neighborhood consensus conferences that helped to bring community priorities back to municipal decision makers. Their work demonstrates that boundary chains can built trust and social capital with local residents and bring new stakeholders into the adaptation conversation.

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