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Creating synergy with boundary chains: Can they improve usability of climate information?

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ABSTRACT

Boundary organizations facilitate and negotiate the interface between science production and use to improve information usability particularly for climate adaptation. To support the increasing demand for usable climate information and enable adaptation, boundary organizations themselves must innovate to foster more efficient production of usable science and more effective networks of producers and users. A recent innovation centers on the idea of boundary chains, whereby boundary organizations work together to increase efficiencies such as leveraging human and social resources. While this idea holds promise, more work is needed to better understand how and why boundary organizations work together to improve information usability and other beneficial outcomes. In this perspective for the special issue, we propose a new conceptual framework for exploring why and how boundary chains form and for evaluating whether or not they are successful. We then apply the framework to case studies that are discussed in more detail in this special issue. Our framework hinges on the notion that boundary chains that are successful are those that create synergy. In turn, synergy depends on a combination of complementarity, putting two kinds of inputs together results in greater output than either each engaging partner could deliver on their own, and embeddedness, the choices and actions on one side are at least partially influenced by and dependent upon the choices and actions of the other side and vice versa.

Introduction

Boundary organizations are critical players in the effort to advance the usability of science in decision making. Defined as organizations "that facilitate(s) the interaction between science producers and users and that stabilize(s) the science-policy interface"(Kirchhoff et al., 2013, p. 3.2), boundary organizations bridge and broker science to different types of users (e.g., decision makers, policy makers) helping to bridge the gap between the different cultures of knowledge production and use (Guston, 2001). Mostly, boundary organizations bridge or broker different types of knowledge produced by others though sometimes they broker applied knowledge that they produce themselves. Boundary organizations have become increasingly important at negotiating the interface between science production and use in ways that increase information

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usability. Yet, despite this growing role--especially for climate adaptation, there remains a disconnect between the supply of and demand for climate information (McNie, 2007; Pielke et al., 2007). Despite the rapid evolution of research studying the role of boundary organizations in supporting efforts to improve the use of climate information among a growing range of users in the past few decades (Bales et al., 2004; Bidwell et al., 2013; Bolson et al., 2013; Cash et al., 2006; Feldman and Ingram, 2009; Hansen, 2002; Hartmann et al., 2002; Kirchhoff, 2013; Lemos and Morehouse, 2005; McNie, 2013), there has been relatively less attention paid to exploring how boundary organizations themselves innovate and adapt to different environments to advance the generation and uptake of climate science for adaptation decision making (but see Kirchhoff et al., 2014; Lemos et al., 2014; McNie, 2013).

At the intersection between science and decision-making boundary organizations play multiple and changing roles in different contexts. And while the empirical scholarship focusing on what they are and what they do has grown significantly, their contextual character challenges theory building both in terms of the relationships between their main components (e.g., agents, boundary objects, institutions, rules, processes) and in terms of the outcomes they achieve. For example, there are many organizations that do not formally define themselves as boundary organizations but that for all intents and purposes often carry out these tasks (Boezeman et al., 2013; Franks, 2010; Lemos et al., 2014). If on the one hand, their ability to 'act like a boundary organization' may increase capacity for knowledge production and uptake, on the other hand, it may create its own set of problems. Indeed, by operating outside of the normative framework of what boundary organizations should do, these organizations may neglect some of their expected roles such as preserving the boundary between science and policy, controlling the quality of information across the boundary or keeping both sides not only accountable to each other but also accountable to the scientific/political realms of specific decision contexts. While improving the conceptualization and practice of the production of 'actionable' scientific knowledge have the potential to dramatically increase the use of science to inform decision-making (Kirchhoff et al., 2013), they can also muddy the waters between the normative principles that define what boundary organizations should be and do and their actual practice.

To date, the vast majority of scholarship in this area has focused on two broad categories: (1) improving the information generated by individual boundary organizations (e.g., producing knowledge that is credible, accurate, and salient (Cash et al., 2003; Hulme and Dessai, 2008; McNie, 2007) and (2) improving the boundary spanning process, that is, the way boundary organizations transfer and broker knowledge so that it is eventually applied (Buzier et al., 2010; Cash et al., 2003, 2006; Hegger et al., 2012; Jacobs et al., 2010; van Kerkoff and Szlezak, 2010). We seek to expand the scope of this scholarship by focusing on how boundary organizations themselves innovate in their boundary spanning and brokering roles and in so doing, may both increase the production of usable science and foster networks of producers and users of climate information. We particularly focus on understanding how boundary organizations synergistically work together by building partnerships with other kinds of boundary organizations, that is, by creating "boundary chains." These boundary chains may reduce the transaction costs of knowledge co-production by 'saving' time and leveraging the human and social resources normally required to build trust and legitimacy which is at the core of co-production of knowledge and decision-making (Lemos et al., 2012, 2014). By reducing the costs of knowledge co-production, boundary chains may also help to close the gap between science supply and demand (McNie, 2007; Pielke et al., 2007).

We define boundary chains as an association between boundary organizations that play different roles (e.g., co-producing information, facilitating interaction, brokering or bridging knowledge that gets used by decision makers or, in some cases, applying information themselves). Following on Lemos et al. (2014), in this paper, we focus on two main configurations of boundary chains: the *key chain*, in which boundary organizations link with one other organization focused on knowledge co-production, and the *linked chain*, where several linked organizations continuously intermediate knowledge between producers and users (Fig. 1).

In the next sections, we first discuss the changing role of boundary organizations from maintaining the separation between science and policy to more recent work as knowledge brokers that navigate the science policy divide. Then, we discuss our analytical framework for assessing the conditions necessary for improving climate information production and use. Finally, we apply that framework to a series of case studies and conclude with avenues for future research.

The changing role of boundary organizations

In the 1980s Gieryn (1983) persuasively argued that the problem of demarcating the boundary for science was not about defining its characteristics; rather, it was about efforts by scientists to set their work apart from non-scientific activities. He coined the term "boundary work" to define the efforts that scientists used to protect threats to science from within (e.g., fraud and pseudo-science). Over time, this narrow definition broadened to encompass the factors shaping the boundary between science and non-science and new, related concepts were introduced such as boundary objects and organizations (Guston, 2000). Boundary objects are mechanisms, processes, material things and even epistemologies that transcend the science/non-science divide and provide a means for producers and users of science to work together while maintaining their separate identities (Guston, 1999; Lynch et al., 2008). These objects, abstract or concrete, are malleable enough to satisfy local needs and constraints yet robust enough to sustain a common identity across the boundary (Star and Griesemer 1989). For example, a collection of project resources functions as a boundary object as participants adapt strategies to organize and share them in a usable format (Star and Griesemer 1989).

According to Miller (2001), the boundary organization concept is a peculiarly American construct, one that emerges from the "hyper differentiated" spheres of science and politics that exist in the United States. In practice, much of these early

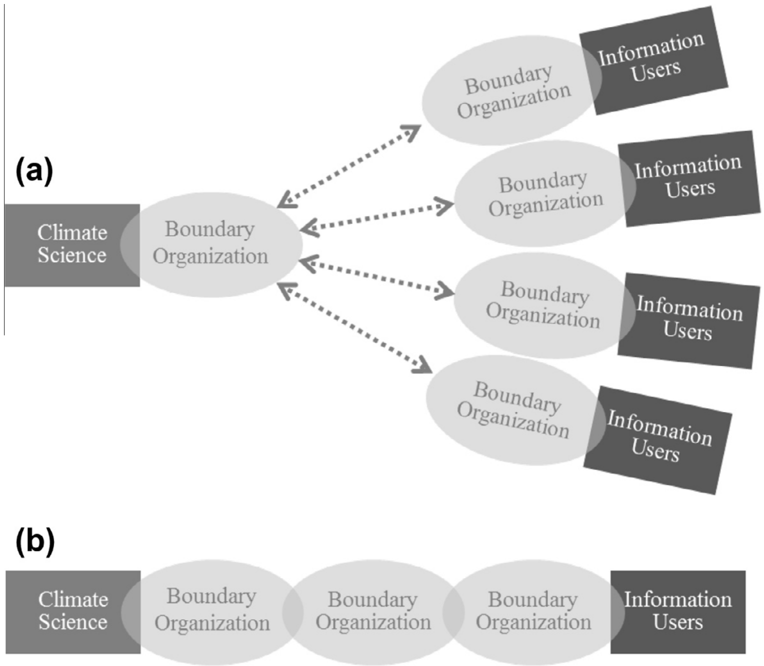

Fig. 1. Key chain and linked chain arrangements adapted from Lemos et al. (2014).

efforts to separate science from non-science activities were motivated by what scholars perceived were the mostly negative outcomes[1] of blurring the science-policy boundary, that is, the undue influence of politics on science (the 'politicization of science') and the over-reliance of science in the manufacture and implementation of policy (the 'scienticization of policy').

As stabilizers and bridgers between science and decision-making, boundary organizations have at least three characteristics: (1) they create a legitimizing space and, if appropriate, incentivize the production and use of boundary objects and standardized packages; (2) they create a collaborative work space for information producers, users and mediators; and, (3) they reside between the realm of knowledge production and the user's decision- or policy-making context with "lines of responsibility and accountability to each" (Guston 1999, p. 93; 2001). It is precisely because they act at this interface playing different functions that they have the ability to both bridge across and to protect the boundary between science and decision-making. In their bridging role, they facilitate the co-production of science and policy by brokering and tailoring scientific knowledge to different decision environments (Lemos and Morehouse, 2005). They may also bridge across different scientific disciplines or political jurisdictions and in so doing help to re-shape the context to promote better interactions between science and decision making (Meyer et al., 2015).

As brokers of knowledge, boundary organizations create structures that may contribute to the co-production of science and policy, first, by facilitating the collaboration between scientists and non-scientists (O'Mahony and Bechky, 2008); and, second, by creating a combined scientific and social order (Guston, 2001). For example, the United Kingdom Climate Impacts Programme (UKCIP) has achieved success as a boundary organization that facilitates collaboration between climate science, policy making and adaptation practice (Hedger et al., 2006; Hulme and Turnpenny, 2004; Turnpenny et al., 2011). Boundary organizations are also a "forum where multiple perspectives participate and multiple knowledge systems converge" (Carr and Wilkinson, 2005, p. 261). Finally, they provide specific functions (e.g., convening, translating, collaborating and mediating) that create space for the formation of peer communities around specific issues while, at the same time, allowing participants to maintain their professional boundaries and constituencies (Franks, 2010). Recent empirical scholarship focusing on the role of boundary organizations for co-production highlight their broad utility for facilitating science-policy interactions across different science-policy spheres, disciplines and sectors (see for example, sustainable land management (Franks, 2010), disaster reduction (Kasperson, 2010), urban sustainability (Owens et al., 2006), and ocean acidification (Meyer et al., 2015)).

Improving boundary chains to serve society

We propose an analytical framework that combines elements of two different theoretical propositions—one from the international development literature on how organizations partner effectively to create synergy and improve development

[1] Though see work by Jasanoff (1990) that explored how blurring the boundary between scientific advisors and regulatory agencies resulted in positive outcomes such as more productive policy making.

outcomes (Evans, 1996, 1997) and the other from work on increasing the usability of climate information by improving information fit and interplay (Lemos et al., 2012).

When investigating partnerships between public and private organizations that improved development outcomes, Evans (1997) suggests that there are two necessary conditions for synergy to occur between organizations with overlapping goals but distinct capabilities and constraints: complementarity and embeddedness. In Evan's conceptualization of complementarity, putting two kinds of inputs together results in greater output than either each engaging partner could deliver on their own. Applying Evan's concept to our analysis we argue that boundary chains build on each organization's strengths (e.g., in producing scientific information, in facilitation, in having established trust with potential users), to produce partnerships that together increase the potential for improved outcomes. For example, by leveraging trust and social capital across each involved organization, boundary chains are more likely to succeed in fostering knowledge co-production and use and to do so more efficiently. Having a basis of trust and social capital already established allows for interactions across the chain (e.g., between climate scientists and potential information users) to start earlier and to be more productive and influential. Moreover, because people's perceptions of information are malleable, in a situation where potential users might perceive scientific knowledge negatively (e.g., too uncertain or not fitting their decision needs), interactions across the boundary chain may shift these perceptions of information towards greater usability (Kirchhoff, 2013; Lemos et al., 2012; McNie, 2013).

The second necessary condition for synergy is 'embeddedness' that is, "ties that connect citizens and public officials across the public-private divide" (Evans, 1996: 1120). Rather than a rational calculation to maximize outcomes (e.g., by dividing labor according to efficiency), embeddedness means that the choices and actions on one side are at least partially influenced by the choices and actions of the other side and vice versa (Granovetter, 1985). Moreover, more than simple connections, embeddedness implies a kind of mutual dependency brought on by a clear division of labor (where one actor cannot do what the other one can and vice versa) and accountability (where confidence in each other's ability to follow through sustains the relationship). Our conceptualization of embeddedness mirrors Evan's though we apply it to ties between boundary organizations, producers, and information users. For example, boundary chains that include climate information suppliers linked with organizations and individuals who need climate information form the basis of a division of labor between them. On the one hand, climate science producers are able to provide inputs and services that potential users cannot generate themselves; on the other hand, potential users of climate information understand their own decision contexts much better than those producing climate information (Lemos et al., 2014). However, synergy will only exist if these two sides are willing to iterate (Lemos and Morehouse, 2005) across the boundary chain and are open to the changes this relationship can bring to the way they produce science and/or make decisions.

Complementarity and embeddedness "are not competing conceptions of synergistic relations" (Evans, 1996, p. 1123); rather they are mutually supportive towards knowledge co-production. Without complementarity, the motivation to form links of boundary organizations may be low. Even with complementarity, unless there is embeddedness, the chain may not foster synergy. In the context of synergistic relationships, interactions between producers and users in the chain may help overcome barriers to knowledge use (e.g., lack of fit or how information matches users' needs and negative interplay or how new information interacts with the older information that users currently employ) (see Fig. 2). Through dialogue, producers and users can better understand both perceptions of information needs and the limits of current science to meet them. They can also customize and adjust the delivery of scientific products (e.g., visualization, data formatting, and decision support tools) to better meet users' needs (see for example, the creation of customized climatologies for the City of Ann Arbor in Kirchhoff et al. (2015)).

In contrast, when external (or internal) pressures negatively impact embeddedness and complementarity, different benefits both in terms of lowered transaction costs and in terms of increasing the diversity and flexibility of users and networks will emerge (see Fig. 3). And while complementarity and embeddedness are necessary conditions for synergy, there may be other circumstances and conditions that make synergy possible in the first place (Evans 1997; Lemos and Agrawal 2006). In the context of boundary chains, we theorize first that competency (e.g., experience serving as a boundary organization or as an information broker), resources (e.g., funding, institutional/organizational inducements), politics and interests, and rules all shape synergy and co-production of knowledge and use. Rules in this conceptualization include how boundary organizations will engage, what each will contribute, and what each organization gets in return as well as rules that allow for both order and flexibility so as to not constrain innovation)(see Table 1).

In the next section, we briefly explore these relationships across a few case studies of boundary chains carried out in the context of the Great Lakes Integrated Sciences and Assessment (GLISA), a traditional boundary organization funded by the US government to foster climate information use in support of climate adaptation in the Great Lakes region of North America.

Creating synergy with boundary chains

In analyzing each boundary chain within GLISA, we find variation both in terms of synergy (i.e., embeddedness and complementarity) and in terms of desirable outcomes (see Table 2 for details about each case) with three cases scoring high levels of synergy, two medium and two low. While outcomes varied, the high synergy cases invariably led to higher climate information usability while the medium and low ones yielded a more diverse combination of outcomes, good and bad. As a whole, the boundary chain approach yielded three main positive outcomes. First it streamlined organizational, human and

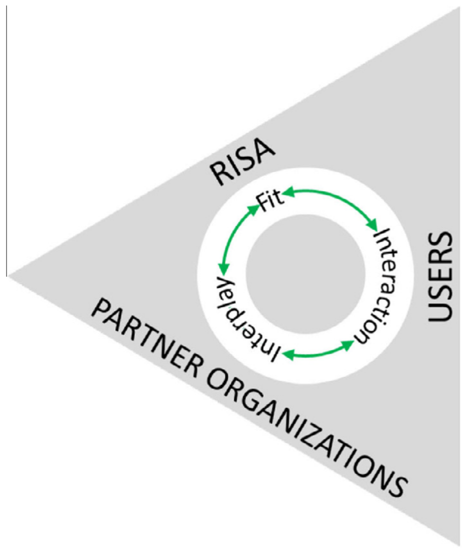

Fig. 2. Interaction space for improving fit and interplay and transitioning information from being potentially useful to being usable in adaptation decision making.

financial costs for engaging stakeholders and allowed for relative short lead times to start collaborations across different sectors; second, it provided for adaptive learning for participating boundary organizations (e.g., GLISA learned lessons across each chain building competency for the next, for more information see Briley et al. (2015)); and third, chains increased the diversity and flexibility of climate information users.

Overall, by engaging in boundary chains, each of the organizations collaborating with GLISA displayed two forms of complementarity. First, regarding knowledge production, each chain combined climate information (from GLISA) and non-climate information (from the linked organization) to support enhanced usability, be it in specific decision-making processes or in fostering greater awareness of the need to adapt to climate change impacts. For example, in the case of GLISA's partnership with the National Park Service (NPS), GLISA scientists provided climate projections and the NPS' Climate Change Response Program (CCRP) and Isle Royale Park provided specific information about the Park's ecosystems and conservation goals. The result was tailored scenarios co-produced by climate scientists and park service personnel whose interpretation and potential applicability was the result of continuous iteration between the two groups. Second, complementarity exists in

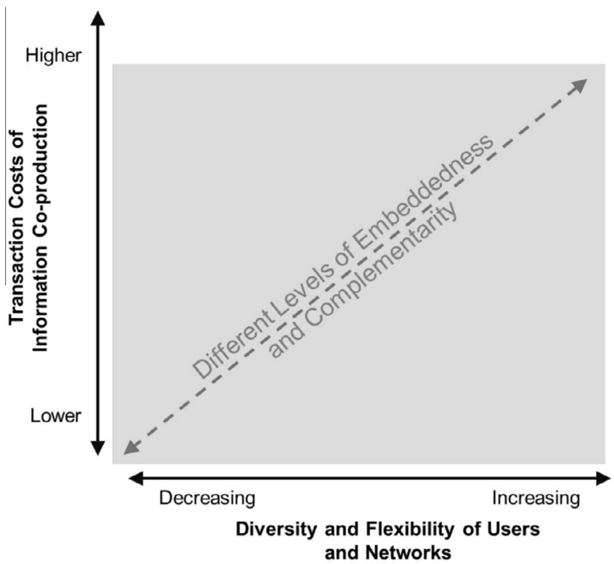

Fig. 3. How characteristics of boundary chains (i.e., different levels of embeddedness and complementarity) relate to transaction costs of information co-production and diversity and flexibility of users and networks.

Table 1
Characteristics of boundary chains that create synergy.

Characteristics	Definition
Complementarity	Mutually supportive relations between organizations with overlapping goals that leverage each other's strengths and compensate for each other's limitations
Embeddedness	Connections that produce familiarity in the face of difference and that smooth interactions but where there is a clear division of labor; each side influences the choices and actions of the other
Competency	Experience serving as a boundary organization or as an information broker
Resources	Funding, institutional/organizational inducements
Politics and interests	Whether politics and interests are in harmony or conflict with overall goals
Rules	About how boundary organizations will engage, what each will contribute, and what each organization gets in return; rules allow for both order and flexibility

Adapted from Evans (1996).

terms of the resources (tangible and non-tangible) that each organization brings to the table. For example, while in all cases GLISA provided each chain with financial and human resources to engage stakeholders, partner organizations supplied social capital, trust and legitimacy. For example, with the Northwest Horticulture Research Station (NMHRS) partnership, NMHRS needed GLISA's expertise as producers of climate information that could be tailored to individual user's (cherry farmers) specific decision contexts. Similarly, GLISA needed NMHRS's long-standing and trusted network of potential users. In this case, NMHRS facilitated conversations between Michigan cherry farmers and GLISA climate scientists; these conversations enabled both cherry farmers to learn about the climate science that GLISA produced and GLISA to learn about what climate risks they faced and what climate-relevant decisions they made. Ultimately, NMHRS and GLISA built on these interactions to co-produce climate information focusing on cherry farmer's greatest risks: warm early spring followed by freezing events that had the potential to destroy an entire cherry crop season. Without NMHRS's connections to cherry farmers, GLISA would not have known the type of information to produce or how to convey the information in a compelling way. Moreover, without GLISA's expertise, NMHRS would not have had access to tailored climate information to aid farmers in adapting to climate change.

Regarding embeddedness, higher levels were critical in shaping knowledge usability and in some cases resulted in new, unexpected benefits. For example, in the case of the GLISA-Huron River Watershed Council (HRWC) chain, ongoing interactions between GLISA and HRWC over multiple years generated new climate brokering capacities within HRWC that did not exist before. That is, HRWC staff now broker tailored climate information generated through the boundary chain partnership to others in HRWC's network independent of GLISA (Kirchhoff et al., 2015). In effect, HRWC's new competencies have increased the opportunity for fostering climate information use in the region beyond their relationship with GLISA. This spillover effect has not eliminated complementarity; rather, it has elevated complementarity to a new height wherein GLISA and HRWC continue to explore new areas of co-production while HRWC functions independently in areas where the chain has already run its course.

While the cases of high synergy for the most part display the conditions for positive outcomes, the cases with lower levels of complementarity and/or embeddedness, offer an opportunity to explore other characteristics that might inhibit or promote synergy. For instance, in the Illinois-Indiana Sea Grant (I-ISG)-GLISA key chain we observed low complementarity – the relationship was not mutually supporting – and low embeddedness – low connectivity coupled with low influence (the choices and actions on one side did not influence those of the other side). While low synergy is partly explained by low complementarity and low embeddedness, digging a little deeper we find additional factors that might have limited synergy such as lack of competency and a disregard for the norms that guide boundary chains. Regarding competency, I-ISG is experienced in university extension and in brokering different types of scientific information to policy- and decision-makers. However, I-ISG had very little experience with co-production, being more accustomed to producing information independently with input from but not in iterative collaboration with potential users. Regarding norms, the project for the most part, engaged little with each side of the chain (producers and users of knowledge), which left both sides unclear about what each other would contribute or what they would get in return. The Michigan State University Extension (MSUE) case featured high complementarity and embeddedness, but there were problems concerning the communication of climate information, mostly as a result of the high politicization of the issue of climate change in one of the targeted communities. For example, during one public meeting in the city of Bar Harbor about ten attendees, fueled by political interests bent on limiting opportunities for adapting to climate change, tried to disrupt the meeting to derail the discussion. While MSUE personnel were able to somewhat recover during the event, the process was less effective than expected. However, the experience provided an opportunity for adaptive learning as MSUE adjusted their approach for communicating and discussing climate information in the meetings it held in the city of Marquette, which were more successful in supporting the inclusion of climate adaptation in their master plan (for more information see, Beyea and Bode, this issue).

At this point, the experience with GLISA's boundary chains has shown that it can be a viable model not only to increase climate information usability but also to reach a broader community of users by leveraging resources and decreasing transaction costs (tangible and intangible). However, these cases have also shown that there maybe critical challenges in controlling the quality of the information transferred through the chain, enforcing accountability (of each organization to each other

Table 2
Boundary chains in the GLISA network.

Organization	Goal/stakeholder	Characteristics	Process	Outcome
Michigan State University Extension (MSUE)	To provide technical support for master plan development processes in Benton Harbor and Marquette, Michigan	Type: Key-chain Comp: High Embed: High	MSUE worked closely with GLISA to increase awareness regarding climate adaptation as both cities develop master plans. They organized community engagement sessions to get feedback from citizens. MSUE and GLISA collaborated in tailoring climate information and in designing the structure of the engagement so that it was sensitive to the interests and experiences of local citizens and officials. For example, following challenges with disruptive attendees of an initial public meeting in one location, MSUE, GLISA, and local clients adjusted the subsequent event so that it was more structured. They also reorganized the climate information presentation so as to frame discussion of future changes more positively and to focus on observed past changes rather than on predictions of future climate. In the case of Marquette, GLISA's climate scientists have also provided assistance in tailoring historical climatologies and future projections to address locally relevant vulnerabilities	Both communities now have a self-assessment of climate readiness for nine critical areas along with GIS maps of existing vulnerabilities The city of Marquette has completed its master plan with MSUE support
Illinois-Indiana Sea Grant (I-ISG)	To support the City of Chicago's efforts to incorporate changes in winter-weather events into their ongoing climate adaptation work	Type: Key-chain Comp: Low Embed: Low	I-ISG identified data that GLISA could provide, such as the influence of climate change on the frequency and intensity of ice storms and heavy, wet snow events. They used previously existing social capital with the Environmental Coordination Office for the city to establish a relationship and raise the issue of the need to consider the impact of ice storms in city planning. In addition to GLISA information, I-ISG used their own research data and climate data from other sources to inform the report they wrote for the city	While the extent to which these activities will lead to climate information use by decision-makers is uncertain at this point since the tie to the city (the City's environmental coordinator) has since left city government. Yet these initial meetings are, at a minimum, fostering awareness of climate impacts and of GLISA's products among a wider range of stakeholders
Northwest Michigan Horticulture Research Station (NMHRS)	To provide assistance to the local cherry industry that was greatly affected by variable spring weather in 2012. Compile climate information to help the cherry industry make choices about risk mitigation and resource appropriation. Foster understanding of extreme weather events and climate variability	Type: Key-chain Comp: Medium Embed: Medium	GLISA and NMHRS organized interactive, face-to-face sessions with cherry farmers to present climate information and discuss how future change might affect the sector GLISA and NMHRS developed information targeted to address cherry growers' concerns about climate change and early spring budding followed by destructive freezing events	This project helped prompt the creation of the first crop insurance program for cherry growers Moving forward, the organization expressed an interest in having GLISA help inform discussions in the non-farming community about farmers' experiences with climate change
Toronto and Region Conservation Authority (TRCA)	To support both farmers and those responsible for municipal shoreline management in the Region of Peel, Ontario	Type: Key-chain with a networking function Comp: Medium Embed: Medium	The TRCA collaboration with GLISA was part of a much broader project in the Region of Peel. GLISA provided support and climate information and the TRCA sought to leverage its collaboration with GLISA to link with other information-producing organizations like the Great Lakes Environmental Research Laboratory (GLERL). They have also collaborated with local Universities in Ontario to foster climate adaptation awareness	In the future, connections with GLISA and GLERL could represent an additional link in the chain of tailoring climate information. TRCA has used this project to recruit other funding sources to continue their work

(*continued on next page*)

Table 2 (*continued*)

Organization	Goal/stakeholder	Characteristics	Process	Outcome
The Nature Conservancy (TNC)	To perform an expert solicitation to better understand the performance of best management practices under climate change	Type: Key-chain with a networking function Comp: Low Embed: Low	TNC has looked at its relationship with GLISA as a means to identify a pool of regional experts with whom they can engage to better understand the performance of different best management practices for assessing the potential impacts of climate change on GL ecosystems. Rather than provide information, it is GLISA's own networks that are helping to support TNC's work	GLISA has helped strengthen TNC's connections with other small grant recipients like MSUE and has linked them to a post-doc at Wayne State University who can provide them with methodological support for their expert elicitation effort
Huron River Watershed Council (HRWC)	To add climate impacts to the range of problems it targeted within the scope of a stakeholder group around water management challenges in the Huron River watershed	Type: Key-chain with an intersection with a linked chain network Comp: High Embed: High	The partnership developed under a long-term co-production process in which scientists from GLISA interacted with the HRWC through monthly meetings over the course of an 18 month project. These face-to-face meetings served three professional working groups: urban forestry and storm water management (Ann Arbor); dam operation (watershed) and hazard planning (Washtenaw county)	Each working group published a report with suggestions for their professional networks. The HRWC is now using a second year of GLISA funding to include climate change in hazard planning in the watershed
National Park Service Climate Change Response Program (NPS-CCRP)	To bring together park officials and other experts to develop and explore four divergent, but plausible scenarios of future climate and ecological responses to support current and future decision-making needs Other organization: Isle Royale National Park	Type: Linked-chain Comp: High Embed: Medium	In this case, GLISA is one link in a longer chain formed by NPS, their CCRP and the Isle Royale Park. NPS and their Climate Change Response Program's facilitation role greatly lessened the level of interaction with Isle Royale that was necessary. Through repeated interactions, information provided by GLISA was translated by NPS's Climate Change Response Program into a frame that would more easily fit Isle Royale's actual approach of making decisions. NPS provided links to other sources of scientific expertise that would be needed to help interpret the implications of GLISA's climate projections. In the critical workshop session where all of these links came together, representatives from Isle Royale gave feedback to the representatives of GLISA and NPS, which ultimately resulted in their current information needs being more directly met	Participation in this scenario-planning process also revealed that despite the tight focus of the original adaptation question, a much broader range of climate impacts and management consequences are at play. To continue this relationship, officials from NPS and GLISA scientists have written a research proposal (funded by NOAA in 2014)
Great Lakes Adaptation Assessment for Cities (GLAA-C)	To bring researchers and practitioners together to support the creation of actionable programs for climate adaptation in cities in the Great Lakes region. Other organizations: Ann Arbor, Dayton, Flint, Kingston, Thunder Bay, Toledo	Type: Linked-chain Comp: High Embed: Medium	GLISA and GLAA-C worked with the cities to develop tailored climatologies. These climatologies are based on summaries of local temperature and precipitation observations and include seasonal and annual mean presentations of information. In addition, basic measures of extremes are extracted from the observations. They specifically respond to stakeholder requests for narrative descriptions of "what has happened." The chain also engaged the participation of another organization, Headwaters Economics, to tailor socioeconomic data to support the cities' adaptation decisions. (For more detail, see http://graham.umich.edu/glaac/). GLAA-C with GLISA support has developed a decision support tool to help cities in the region access climate information (climatologies and homoclimes) and learn what cities have done to adapt	Because of this relationship, many of the cities are seeking small grants from GLISA to deepen the relationship in the next round of competition (Dayton, Kingston, Toledo, etc.). Other cities in the region that have networked with our target cities have also written proposals

and to science and decision-making), dealing with the politics and interests around climate adaptation that ebb and flow, and sustaining the chains as financial and human resources dwindle.

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