TRANSFORMATIVE LEARNING NETWORKS

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ABSTRACT

In this paper, we consider how learning networks build capacity for system transformation. We define learning networks as inter-organizational voluntary collaboratives that nurture professional expertise, and describe their potential to catalyze systemic change by disrupting old habits, fostering new relationships, and providing freedom to experiment. We underscore the complexity of designing, facilitating, and sustaining learning networks, noting four distinct ways learning networks can foster systemic resilience, 1) social-psychological 2) engineering 3) social-ecological, and 4) emancipatory. We then describe our research methods and introduce four learning network case study analyses, in order of their age and relative progress towards transformation:

- National Alliance for Broader Impacts (NABI)
- 100 Resilient Cities Network (100RC)
- Fire Adapted Community Learning Network (FAC Net)
- START (Global Change SysTem for Analysis, Research & Training)

After describing each network's origins, approach to promoting transformative change, and structure, we apply three exploratory questions across our cases:

- How do network facilitators "netweave" within and across participating sites?
- Is there evidence of organizational learning taking place in each network over time?
- What transformative capacity do we see developing in each network?

We conclude by describing the contribution of this analysis to a framework we are developing to explore how learning networks foster resilience within, between, and across scales.

Keywords: Capacity; Learning Networks; Networking; Transformation; Transitions; Communities of Practice; Social Learning; Netweaving; Netweavers; 100 Resilient Cities; Fire Adapted Communities Learning Network; National Alliance for Broader Impacts; START.

Transformative Learning Networks

INTRODUCTION

This paper aims to extend our understanding of how learning networks contribute to system resilience. Effective learning networks develop an open culture of inquiry and trust, a willingness to take risks in order to extend learning opportunities, transparency required to test and challenge embedded values, and the capacity to create shared meaning and understanding. We explore four networks, focusing on how they are designed and facilitated to operate across scales and their potential to build transformative capacity. Our cross-case analysis considers network facilitation – which we call "netweaving" - and organizational learning as key features of learning networks, and consider how a network can promote resilience and transformative capacity building.

BACKGROUND

Like the idea of sustainability, the concept of resilience has been around for a long time and has many meanings across disciplines and fields of practice (Goldstein, 2011). Resilience has been used to refer to resistance to unwanted change, an ability to "bounce back" from shocks, the capacity to adapt in order to retain desirable system traits, and even the ability to transform a system altogether (Brown, 2014; Walker & Salt, 2006). Here we identify how different approaches to resilience thinking are each grounded in distinct communities of practice. We then consider how learning networks can weave different approaches to resilience together to achieve a synthetic, potentially transformative outcome. We take a comparative perspective, embracing the idea that resilience has different valid meanings informed by different disciplinary ways of knowing, and consider four distinct meanings of resilience, each with distinct foundations and practitioner communities.

The first of these is *social-psychological resilience*, associated with the personal strengths of individuals who are able to withstand or respond positively to major challenges by drawing on personality traits such as autonomy, intelligence and self-esteem (Maclean, Ross, Cuthill, & Witt, 2016; Manyena, 2006). Social-psychological resilience is often attributed with groups who respond well to stress or shocks by relying on collective capacities, such as strong family ties or shared social capital (Kulig, Edge, Townshend, Lightfoot, & Reimer, 2013; Maguire, Hagan, & others, 2007).

Similarly, *engineering resilience* describes a system's ability to resist disturbance and 'bounce back' consistently and predictably (Holling, 1973), such as the capacity of a material to absorb energy during deformation and bounce back by releasing this energy elastically (Hollnagel, 2006). This can apply to an engineered structure like a bridge or to an ecological system like a forest, which many early ecologists thought of as occupying a single steady equilibrial "climax" condition (Clements, 1936). Engineering resilience is less attentive to the possibilities of human agency and choice than social-psychological resilience, but the two ideas share assumptions that resilience is an ability to resist disturbance and achieve optimal productivity and efficiency.

Over the past forty years, ecologists have been abandoning this commitment to the predictability and control of engineering resilience in favor of recognition of the irreducible complexity and uncertainty of *social-ecological resilience* (Folke, 2006). Rather than always returning to a single, optimal equilibrium, a resilient social-ecological system

adapts to stressors and shocks by absorbing disturbance and reorganizing as it is undergoing change (Biggs, Schlüter, & Schoon, 2015). This is dynamic process of renewal and regeneration as the system alternates between different regimes or basins of attraction, known collectively as a stability landscape (Folke, 2006; Gunderson, Holling, Pritchard, & Peterson, 2002; Walker, Holling, Carpenter, & Kinzig, 2004). Cross-scale interactions within and between systems create the possibility of emergence and surprise in social-ecological systems, as local actors and processes self-organize, and exert influence across wider spatial scales and longer timeframes.

Like social-psychological resilience, *transformative resilience* emphasizes the interplay between structure and agency, although not in service of recovery and stability. Transformative resilience is the practice of recreating systems through the exercise of collective power (Manyena & Gordon, 2015). Transformative communities challenge the way unquestioned power is supported by task-oriented, instrumental knowledge (Lukács, 1971) by asking the question 'resilience of what and for whom?' This enables them to effectively think through internal and social factors such as social difference and structural inequality (Brown, 2014), explore hidden possibilities, and become something new and qualitatively different. As a practice, transformative resilience can seem more as a form of wisdom or intelligence than a form of knowledge, since each community defines system parameters and relationships on their own terms, using experience which is contingent, contested, and only partially sharable (Goldstein, 2009).

Learning Networks

Learning networks can be seen as one of many inter-organizational, voluntary, collaboratives that are being proposed as a way to promote resilience. Learning networks focus on nurturing professional expertise in fields such as environmental management, public health, and education (Dolle, Gomez, Russell, & Bryk, 2013) and are often attempted when deeply-rooted obstacles to institutional change have proven resistant to both top-down or bottom-up change strategies (Butler & Goldstein, 2010). Their relatively loose, nimble management structure is intended to promote ongoing adaptation as their membership becomes more confident and experienced, as new needs and opportunities are recognized, and as resources and institutional support requires.

Learning networks rely on effective design and ongoing facilitation to function effectively. The practice of "netweaving" enables integration across multiple scales and builds social capital, which can enable learning networks to persist through the vicissitudes of sponsor funding and political climate. This endurance can enable learning networks to affect transformative change, which can often be slow-moving or punctuated and may occur only when rare windows of opportunity for adaptation enable networks to rapidly mobilize resources and disseminate innovation across sites (Pelling, 2010).

Effective learning networks amplify the potential for transformative change by combining place-based innovations with community-spanning interactions and exchanges (Butler & Goldstein, 2010; Goldstein, 2012; Goldstein & Butler, 2009, 2010). Each participating site in these networks defines problems in its own way, accommodating local contexts and contingencies to generate distinct strategies and solutions. This autonomy is balanced with a network-wide coherence that advances collective action across organizational, temporal, and spatial scales. Learning networks can disrupt old habits and foster new collaborative relationships, reinforcing participants' shared ties and purpose while providing freedom to experiment with innovative approaches. Fundamentally

different kinds of learning take place within, between, and across network levels, and even across different network initiatives. Learning networks are bridging organizations, since they bridge between different ways of learning, knowing and operating in order to bridge to desired alternative futures.

Challenges of Learning Networks

Many of the features that provide learning networks with transformative potential also make them difficult to organize and maintain. While learning networks may knit together distinct ideas of resilience practice, it's not easy to create collaborative processes that can overcome tensions and conflict between different definitions of resilience. For example, efforts to recover quickly or persist in response to a specific shock or stress can reduce resilience by hindering structural changes when a system is approaching a critical threshold (Walker & Salt, 2006). Learning networks require a high level of engagement and commitment in order to identify deep-rooted problems and coordinate disparate actors to implement solutions that are both site-specific and network-wide. Maintaining this level of engagement in a learning network is especially difficult because they:

- are voluntary and often not recognized as part of member's work responsibilities;
- operate at multiple scales and rely on coordination and multiple approaches to maintain connection and dialogue;
- promote change in a turbulent institutional environment, where opportunities to make change are shifting and fleeting;
- are reliant on support from multiple sponsors and supporting organizations, and;
- are lightly resourced and staffed and vulnerable to changing funding priorities.

Below we examine key questions about how networks are designed and facilitated to foster transformative capacity and how they engage in organizational learning to remain nimble and adaptive.

METHODS

This study is methodologically guided by action research (Baum, MacDougall, & Smith, 2006; Chevalier & Buckles, 2013) and qualitative in-depth case study approaches. We apply an interpretivist point of view that learning networks are social systems best understood by those within them (Goodson & Phillimore, 2004). The authors played cooperative and interactive roles in the networks with levels of embeddedness ranging from formal employment, serving as a steering committee member or advisor, or as an invited researcher and collaborator. Each of the four cases are in the early stages of analysis and are the subject of longer term research. Interpretivist qualitative researchers focus on quality and richness of the data and the means of acquiring the data. For the purposes of this study we utilized a common research protocol centred on semi-structured responsive interviews (Bernard, 2011; Lofland, Snow, Anderson, & Lofland, 1984; Rubin & Rubin, 2005; Weiss, 1995) conducted with netweavers and network members in each network. Additional insights were gained from participant observation of network meetings and documents. A common protocol provided an ease with which to look across cases to examine structural and processual aspects. Analysis of individual cases was guided by

grounded theory (Glaser & Strauss, 1967) with an emphasis on promoting emergent themes and insights (Law, 2004). Cross-case synthesis was conducted collaboratively and focused on themes that provided the greatest insights into resilience and transformative capacity building.

CASE STUDIES[1]

National Alliance for Broader Impacts (NABI)

The National Science Foundation (NSF) has, for some time, required research proposals to articulate "Broader Impacts" that demonstrate societal benefit of research, in response to increasing expectations that public investments in research yield direct economic and social benefits. Universities, where most of publicly funded research takes place, have found themselves ill-equipped to address broader impacts requirements. The path to success was stymied by systemic deficits such as lack of researcher training to address broader impacts, unsupportive reward structures, and challenges in establishing necessary partnerships in the context of stable disciplinary silos. In 2012 the NSF reaffirmed their policies by making substantial changes to their guidelines.

As part of this change, the National Alliance for Broader Impacts was established in 2013. An interdisciplinary and inter-institutional collaborative group of scholars convened to propose the network, which was funded by the NSF in 2014. NABI aims to create a community of practice and foster sustainable and scalable institutional capacity and engagement in broadening the impact of research to benefit society.

Network Approach to Change

NABI works to build individual capacity by fostering conditions for social learning and innovation by cultivating a set of practices and creating a new professional identity whose focus is to navigate the boundary between science and society. Through NABI, these boundary professionals access a support structure in which they can learn ways to create change at their home institutions. The network also brings together its membership and partner organizations to work towards systemic change through actions such as providing better guidance from federal funding agencies to better support broader impacts and by creating opportunities for researchers to get training and support.

Network Structure

The NABI structure is a loose web of connections and relationships, with a variety of activity hubs. Connections between the various parts of the network are supported by netweaving activities carried out by many network actors. At the time of publication, the network has 600 members, with a wide range of engagement. An annual conference-style Summit is the network's central event, and is designed to encourage connection and learning, which is sustained between Summits by an active listserv. Activity hubs include: the principal netweaver along with a small logistical staff based at University of Missouri; a steering committee that represents member interests and identifies strategic direction and activities of the network; an advisory board works to keep the network broadly relevant;

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[1] More detailed descriptions of origin, history and structure for each case is presented in comprehensive detail in *Transformative Learning Networks* (Goldstein et al. forthcoming - APLU, 2016)

and recently developed subcommittees that tackle specific domains and needs within the network, such as financial planning, event planning, and connecting with federal entities. Some members participate in the network and represent complementary professional organizations, funding agencies, and university consortiums.

Rockefeller Foundation 100 Resilient Communities (100RC)

The 100RC network is focused on building resilience in city governments around the world. The Rockefeller Foundation (hereafter, Foundation) defines resilience as the "capacity of any entity—an individual, a community, an organism, or a natural system—to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from disruptive experience" (Rodin, 2014, p. 3). 100RC is one of seven Foundation resilience initiatives, centred around what is described as "increasing dynamism and volatility" that makes people, communities, and systems vulnerable to natural and manmade catastrophic events (Rockefeller Foundation, 2015). The Foundation supports the network with a dedicated staff and serves as the network hub, providing support to 100 member cities.

Network Approach to Change

The Foundation has identified city governments as the fundamental unit for identifying and responding to resilience challenges as they contain a majority of the world's population, and have ongoing and strained demands on infrastructure making them vulnerable to acute and long-term stresses. The key problem they identified was fragmentation within city departments and inadequate resources to scale solutions, guide regional and global collaboration (Lipper, 2015). To address these obstacles the Foundation created a learning network to build knowledge and resilience capacity in city governments (100RC, 2015). Each participating city received grants and services valued at $1 million over a two-year period to support the work of a *Chief Resilience Officer* (CRO). The CRO is responsible for creating and a city-wide resilience strategy built upon the 100RC resilience framework, and serves as the primary link between the city and the network.

Network Structure

After a city is selected through a competitive application process, they hire a CRO to lead resilience efforts at the local level and coordinate with Platform Partners who are part of a "marketplace" of vetted organizations and research institutions. CROs are paired with Rockefeller staff Relationship Managers who act as liaisons between 100RC, CROs, and Platform Partners.

The 100RC organization supports international CRO summits, collaborations, and initiates network-wide activities. This organizational structure resembles that of many foundations and corporations in that it relies on a management hierarchy to set general policy: CROs provide feedback to their Relationship Managers, who share that information with other Relationship Managers as well as higher-level 100RC management, who then may adjust their overall strategy.

Fire Adapted Communities Learning Network (FAC Net)

The FACNet formed in 2013 partially in response to one of the three goals of the National Cohesive Wildland Fire Management Strategy (hereafter, Cohesive Strategy) to create fire adapted communities. Modelled after and partnered with the longstanding U.S. Fire Learning Network, the FACNet is a joint effort between NGOs and federal agencies whose aim is to create adaptable and resilient fire adapted communities on the ground while

addressing system-level challenges, barriers and complexities to community-based management of natural resources. The FACNet aims to be responsive to local conditions and contexts while scaling up best practices.

Network Approach to Change

The creators of FACNet recognized the social and ecological complexities of wildfire management required an approach that allows for more local autonomy while promoting coherence with federal guidelines and policies. Lessons learned from other fire-related strategies and collaborative restoration communities of practice indicated that in-person, peer-to-peer learning and sharing venues are critical to identifying and scaling-up best practices. Accordingly, the FACNet was designed to maximize knowledge sharing among sites and support adoption of novel techniques and approaches that account for local contexts while addressing national resource management strategies and policies.

Network Structure

The FAC Net is composed of *core* members who are selected by network staff and a coordinating team and *affiliated* members who are self-selected individuals and groups. All members are dedicated to collective action to solve complex social problems that require time and adaptive capacity – a "generative social-impact network" (Plastrik, Taylor, & Cleveland, 2014). The network was designed as a hub-and-spoke network. It started out with eight hub and pilot communities and currently consists of seventeen such community sites that include individuals, groups and business partners. Applications for network membership are considered based on existing fire adapted activities, strength of connection to other fire adapted programs and projects, and commitment to implementing, assessing and sharing the work they are doing to increase their communities' resilience to wildfire.

A FAC Net staff of netweavers facilitate and manage the network, providing resources to network members, facilitating relationships with members across the network and with other networks and projects, curating documents and information produced by the network and generally running the day-to-day tasks of facilitating and growing a network. The network is principally coordinated by the Watershed Research and Training Center (the Watershed Center), a community-based non-profit organization in Hayfork, California that promotes healthy forests and communities. The FAC Net also includes a team of advisers and researchers from agencies, organizations, and universities – collectively known as the Coordinating Team – that help inform the network about other fire-adapted work and programs as well as the latest knowledge about learning network structure and function. Working in conjunction with the Network staff, member communities help steer the direction of the network by refining and adding to the core operating principles and voicing their needs.

Global Change System for Analysis, Research & Training (START)

In 1990, a series of scientific reports highlighted the urgent need to involve developing countries in conducting regionally based research that would promote better understanding of the global climate system and that would address significant gaps in knowledge of impacts and vulnerabilities at regional, national, and local levels in the developing world. A meeting of the International Geosphere Biosphere Programme in

Bellagio, Italy in 1990 recommended that a system of regional networks focusing on analysis, research and training would be the most effective way of ensuring regional collaboration on global change science and research. START was created in 1992 under the sponsorship of the International Council for Science and its four international global change science programs as the capacity building arm of the global change programs' work in Africa and Asia-Pacific. In 2009, START modified its governance structure and officially incorporated as an independent NGO.

Network Approach to Change

START's programs and activities help to create and strengthen existing networks, engage regional scientists in global assessments, train the next generation of scientific leaders, and promote knowledge sharing. A regional network approach was seen as necessary to account for differences in biogeography, socioeconomic systems, and climate and obtain a truly global perspective and understanding of change in the earth system. Responding effectively to the challenges of global change requires that capacity be developed from regional to local scales, to support broad-scale, informed decision-making.

A fundamental purpose of these regional networks was "to mobilize scientific manpower and resources to address the scientific questions concerned with global change" and to provide a framework to support regional syntheses and scientific assessments of relevance to policy development. Specifically, this network design provides a mechanism to: 1) conduct research on regional aspects of global change; 2) assess the impacts of the regional findings; and 3) provide regionally important integrated and evaluated information to policy-makers and governments (IGBP, 1998).

Network Structure

The network structure supports a 'hub and spoke' approach that is "South-South", between developing countries, and "North-South", between developed and developing countries. The International START Secretariat, located in Washington, DC USA, coordinates START programs and network activities. International START Secretariat staff collaborate with representatives from a system of regionally based centers and affiliated partner institutions in Africa and Asia-Pacific to carry out joint initiatives and advance common goals. START and regional partners align themselves on the basis of complementary skills, expertise and interests, which they bring together for the goal of sustained and consistently productive engagement. START's activities within each region are overseen by regional committees composed of scientists and members of national and regional bodies. This distributed system of active regional centers and affiliates enables START to strengthen partnerships, innovate needs-driven programming and expand implementation capacities and local legitimacy in the regions in which it works. The aim is to foster nimbleness and responsiveness to emerging needs and questions, strategically positioning START and partners to take on new roles, responsibilities and challenges.

DISCUSSION

Netweaving

Netweavers are well-connected network actors who support the health of a network and facilitate change from within using non-hierarchal means to knit together social dynamics and structural realities of a network. They aim to enhance communication, facilitate connection and bolster collaboration in support of learning and development of

network members and the network as a whole (Holley, 2012). These netweavers are aware of and connected to the networks around them, identify mutual interests and challenges, strategically connect people to address interests and challenges, and generally work to make the networks more robust. Netweavers tend to navigate the tensions of organizations in flux by facilitating the flow of information and building social ties that enable learning (Reed et al., 2010); they initiate activities that build community and promoting a shared professional identity as the foundation for common practice and purpose. Netweavers – in many ways – serve as the catalysts for self-organizing groups; the nucleating actors in a network.

Though our research team settled on Holley's "netweaver" (Holley, 2012) as our organizing concept to describe these complex network actors, a plethora of complementary conceptions – collaborative capacity builders (Weber & Khademian, 2008), process catalysts and systems conveners (Wenger-Trayner, Fenton-O'Creevy, Hutchinson, Kubiak, & Wenger-Trayner, 2014) – lead to a lack of a clearly accepted description for what exactly a netweaver is and does. While the host of definitions provided us with grounding in and understanding about these actors, we found ourselves uncertain about a common language to discuss netweavers in our networks – particularly since different kinds of netweaving took place within, between, and across the networks. Despite these challenges, we identified some shared characteristics among netweavers in the four networks. For example, CROs in the 100RC can be thought of as netweavers in that they actively work in their cities to bridge gaps in resilience understanding and practice while developing relationships with city administrators, elected officials, and business entities. Similarly, local leaders in FAC Net communities are often referred to as the community "sparkplug" for their efforts at developing and fostering relationships with local officials and the public. From the network-wide perspective, network leaders in each of our networks actively bridge connections between existing programs and people working in similar domains.

The design and purpose of each network were also associated with different approaches to mediating the tension between local and network-wide identity. While netweavers in three of the networks (NABI, FAC Net, START) emphasized remaining responsive to member needs at local scales, netweaving in the 100RC network emphasized assisting CROs in different cities to pursue a common planning and implementation approach. The most effective netweavers and netweaving activities appear to include horizontal, vertical and diagonal facilitation (e.g., relationships, peer-to-peer exchanges, multiple communication channels and opportunities, etc.) as well as bridging other related – but outside-the-network – programs and initiatives. Successful netweavers tended to welcome inclusivity and the diversity of perspectives and unique contexts of network sites, facilitate information exchange and relationship-building across scales, value transparency, and see network tensions as opportunities and demonstrate a willingness to address them while being supported by and supportive of the network. Netweaving was less effective when relationships were rigid, limiting the flexibility required for ongoing network adaptation.

Transformative Capacity

Investigating transformative capacity is about more than acquisition of new skills and relationships – it is about identifying network characteristics that contribute to capacity for qualitative change in perception, practices, and social-ecological processes. Across the

four cases we consider transformative capacity by focusing on changing identity and innovative practices.

In the NABI case, transformative capacity is tightly coupled with the network's cross-scalar functions of moving information and building connection across several types of boundaries, individual, institutional, and national scales. At an individual scale the network cultivates a sense of new professional identification and bonds between actors as they work to develop a new domain and set of professional practices. The network existence and activities empower individuals with agency, expertise and connections to support them in instigating institutional changes. There is some evidence that the network may be having an influence at an institutional scale, when members were called "to advocate with the mission of creating a society that values science" and to "engage politicians". An overarching sense of moral obligation is revealed in the key netweaver's words about leveraging the network "…for changing my community and making things better for my kids and impacting my institution ..." NABI cultivates the skills required to navigate across boundaries and access the tension between them as a stimulus for creativity and change.

The 100RC case hones the transformative lens by examining how the network struggled to generate opportunities for collective action and impact. The case uses a qualitatively structural assessment of network *connectedness*, relating primarily to limited member access to each other for learning due to difficulties in fostering peer-to-peer connections between CROs beyond those with with close geographic proximity. A deeper assessment has to do with *quality* of connection positively associated with a network's capability to generate momentum towards collective actions, development of a shared story, and organizational learning. Shared experience and position within the network appear to be key conditions of quality learning outcomes that was limited to isolated pairs of CROs - the dispersed nature of the network reduced opportunities for peer access and enhanced the CRO's inability to resolve the needs of both local government and the network leadership. Connectedness and quality of connectedness are not themselves considered transformative capacity, rather the ability to leverage connectedness into capacity for action is associate network potential for transformation. Difficulty in fostering cross-network connectivity in 100RC must be examined in the context of the network's recent establishment and uncertain future, due to the 2-year contract period of CROs. This uncertainty may constrain CRO investments in cultivating quality connections within the network and consequently their ability to engage in development of a shared story. However, there is evidence that some CROs succeeded in brokering relationships and actions across well-established local silos at the city level because their liminal position within city governments.

The FAC Net case applies a social-ecological systems lens to analyze transformative capacity. The FAC Net cultivates a strong shared social identity centred on desired change in both ecological and social systems, which are described by Wilson and colleagues (2013) as transformative characteristics within a social ecological system. The network appears to stimulate change among localities and regions. There is also ample evidence of productive use of network feedback mechanisms, which is associated adaptation of the network itself in response to changing conditions and intentional reflexive processes. The START case is similar to FACNet in providing evidence of critical or triple-loop learning which centers on strengthening of skills and capacities at the individual level

and scales up to strengthening organizations in ways that intentionally account for power, politics, structure and agency. As the oldest network in this study, START also provides an example of how a network adapts to support a consistent vision of transformation over time.

Shared themes of transformative capacity emerge from our cross-case analysis. The nested cross-scalar nature of these structures is identified as an important support for transformation across all four cases. This nested structure combined with intentional reflexive activity – examined in some depth in the FACNet and START cases as triple-loop or transformational learning – suggests that network capacity to support transformation at multiple scales may be enhanced over time. Socially mediated learning that crosses multiple scales within a network may be a fruitful path to investigate levers of transformation. The practice of boundary navigation is also essential to understanding cross-scalar integration and quality of peer-to-peer connections.

Organizational Learning

We define organizational learning as the way an organization develops, retains, and exchanges knowledge through shared stories and through institutional memory. Organizational narratives illustrate the role of shared stories in developing institutional memory noting that, "… as stories evolve, richer understanding of the phenomenon is developed, and new integrated approaches to solving problems are created. Stories themselves become the repository of wisdom – part of the collective mind/memory." (Crossan, Lane, & White, 1999, p. 529).

Comparing each of the four cases in the context of organizational learning highlights three features that support the health and long-term transformative potential of learning networks. The first, is a need for spontaneity of communication and opportunities for feedback within the network, which is necessary for netweavers to respond effectively to the needs of network members, providing them with a maximum variety of opportunities to coordinate across scales. Secondly, a capacity to flexibly adjust the network's structure over time is central to a network's overall operating capacity, as it represents part of the "dynamic" quality that makes networks different from other types of organizations. Thirdly, the ways in which network leadership actively fosters a shared network identity and purpose is an ongoing theme in both the network literature and in these case studies. The following discussion draws from each of the four cases to describe organizational learning as a useful theoretical tool for understanding change processes in learning networks, building on these three core observations.

The NABI case draws heavily on the concepts of developmental adaptation, built on the study and practice of developmental evaluation (Patton, 2011) and collective identity to discuss the progress of organizational learning across the network. Key observations point to the presence of open communication and comfort with the unknown as supportive of organizational learning in NABI – conditions supported by the network leadership in coordination with formalized feedback. Even with formal feedback structures in place, observations indicate that open discussions between the steering committee and network members – which often includes directly asking how can NABI better serve the membership – are equally if not more influential in decision making. The network's

frequent opportunities for dialogue can lead to group identity building, a key to organizational learning, and can lead to the potential for collective action across scales.

In FAC Net there is evidence of progress towards "second loop learning", which is achieved through questioning of standard operating procedures that leads to shifts in underlying practices. Reflective feedback is observed as a critical mechanism for this type of organizational learning and the responsiveness of the network managers to the feedback and tensions in the network is critical to correcting and guiding network scale processes. The Network staff's openness and commitment to receiving active and ongoing feedback on network scale operations supports organizational learning and offers the membership tacit permission to spontaneously collaborate and develop additional partnerships and projects.

The START case draws on a classic understanding from studies of efficiency and decision-making in which organizational learning is tied to individual learning and builds network capacity through the process of social learning (March & Simon, 1993). Successes in START's organizational learning processes are observed in network-wide retreats in which staff, the Board of Directors, and regional representatives participate. Central to the processes of social learning and communication, these events also contribute to collective identity building that supports the network when participants return to their sites of origin. START has made great strides in becoming an adaptive organization by adopting processes that are supportive of organizational resiliency and learning over time.

100RC fostered a vibrant organizational learning culture among its netweavers in New York and at satellite ofices around the world, although in some instance there appeared to be difficulty in passing information "upstream" in the network at the point where CROs interface with the network leadership via city Relationship Managers. CROs that had more of a mentoring rather than consultant-client relationship with their Relationship Managers were better able to engage in bi-directional feedback and the exchange of information. This underscores how networks need to cultivate an organizational structure that permits reflexivity and periodic restructuring to appropriately align netweaving relationships.

CONCLUSIONS

In this study we examined how four learning networks enhance system resilience in the domains of city governance, wildfire protection, climate adaptation, and the broader impacts of scientific research. In this conclusion, we summarize what we have learned from these networks about these cross-cutting themes of transformative capacity, netweaving, and organizational learning, and briefly reflect on the implications of this study for thinking about how learning networks can enhance resilience.

In our cases, the most consistent transformative feature was how interaction between sites supported expression and adoption of a new professional identity. In the NABI network, the emergence of a specialty in broader impacts, along with an expression of its moral purpose, enabled members to identify best practices and support collective efforts to influence national research funding and oversight. FAC Net also engaged its members in ways that supported a common identity of community fire adaptation, grounded in a social-ecological perspective on community and place. START's focus on strengthening individual skills and capacities was notable for having an explicitly

emancipatory component, addressing entrenched power dynamics and the political constraints on collective action. In contrast to the other cases, we did not observe high potential for collective action and impact in the 100RC network, although Chief Resilience Officers (CROs) did have an explicitly defined, shared identity and were able to make remarkable achievements in a very brief time period in many cities.

In each network we examined, there were designated netweavers who performed a crucial nucleating role by supporting individual members and promoting overall network health. Netweavers operated at different scales of network action, from site-based netweaving by the 100RC CROs and Relationship Managers, to regional netweavers coordinating learning exchanges in the FAC Net, to network-wide netweaving in NABI. While netweavers in three networks (NABI, FAC Net, and START) were able to respond flexibly to the tension between supporting individual sites and promoting overall network objectives, netweaving in the 100RC network was relatively rigid, with relationships pre-determined and subordinated to a chain of command. This exacerbated tensions between local and network-wide identity and objectives. Netweaving requires an ability to operate within and across participating sites without eliding differences between them. Netweavers who were more fluid in operating across the different network levels were more capable at facilitating information flow, forging social ties that enabled members to identify shared interests and challenges and engage in group learning, and promoting a shared professional identity.

In each of our cases, capacity to engage in organizational learning was essential to ongoing network adaptation. Three network features associated with organizational learning were apparent: 1) multiple opportunities for communication and feedback; 2) encouragement to experiment with different approaches to network interaction; and, 3) whole-network meetings where network governance was explicitly addressed. Organizational learning was supported by opportunities for rapid feedback between netweavers and members, both through formal evaluation and regular and open communication. While all four cases observed instances where network procedures and practices were examined and altered, some difficulty in bilateral communication was noted at the interface between city Relationship Managers and CROs. In addition, networks that encouraged members to take the initiative to experiment with different ways to collaborate were observed to adapt their procedures more readily, such as in FAC Net, where the Network staff encouraged its members to develop additional partnerships and projects, such as subnetworks, and then once the approach showed promise encouraged other members to adopt and adapt it. Finally, annual meetings that engaged network members in critical deliberation about network governance were more successful in addressing underlying tensions and getting agreement on new approaches, such as the annual retreats involving START staff, Board of Directors, and regional representatives.

If there is a synthetic conclusion we can provide from this set of comparative case studies, it is that networks function best when they are designed and facilitated with a soft touch. People participate in learning networks in order to bring about system change, so they need to have the freedom to bound and define their system as it is, as well as how they think it ought to be. This sensemaking process is often more like storytelling than formal analysis, since network members not only define system parameters, they also define their place and purpose within it, and their role in bringing about a desired transformation. In a multi-sited and multi-level learning network, this is happening in many places at once,

amidst many perspectives on how to bound a system in space and time and what actors and organizations to take into consideration, and these perspectives will not be entirely coherent with one another. Alternative system futures are co-constructed in different sites in ways that are grounded in real world conditions, informed by multiple epistemologies, and shaped by power-laden choices about what system, whose resilience, for what purpose and to what aim. Prescribing a specific approach to professional practice across network membership can only short-circuit this process of discovery.

This is not to say that instrumental reason - the primary ingredient of "engineering resilience" - cannot contribute to fostering transformative capacity. Instrumental reason has a critical role in most forms of professional practice – certainly for our network's community fire organizers, "broader impacts" specialists, and climate change adaptationists, as well as for CROs. What is essential for a well-functioning network seems to be to find a way to include the scientific and analytical impulse within engineering resilience alongside the other forms of resilience described in the literature review. Promoting social-psychological resilience is essential to fostering individual well-being and sense of efficacy of network members. Social-ecological resilience brings nature into close association with culture, and provides a powerful framework for promoting cross-scalar integration in a non-deterministic world. Emancipatory resilience is the creative energy that impels our ability to question existing ways of doing and being, to imagine a better alternative, and to focus attention and action on bringing about this better future.

These different resilience definitions are usually described as being mutually exclusive, since they are informed by different disciplinary paradigms and grounded in different communities of practice (Berkes & Ross, 2013; Goldstein, 2009). In a learning network, a soft touch in design and facilitation can focus on fostering transformative capacity, without the need to subordinate one form of resilience to another. A learning network not only supports maintaining heterogeneity across sites and scales, it also mediates the relationship between sites with divergent conceptions of the system, connecting them in ways that can promote higher-order coherence as well as community autonomy. A key to this is maintaining coherence between system stories, which may otherwise have different starting points, alternative possible futures, key characters, and plot trajectories (Cronon, 1992).

This kind of transformative capacity is neither individual nor collective, but both, an outcome associated with both site-based experimentation and the relationships that are cultivated across sites. Cross-site cohesion and site-specific autonomy are in productive tension, just as the "system" in which a learning network is embedded is a social relation as well as a material reality: both real and symbolic, or material-semiotic, performed within a learning network rather than just discovered. This understanding of social-ecological systems combines the determinism of structural and biophysical constraints with freedom of imagination and active meaning-making, a kind of structuration (Giddens, 1984). Netweavers and network members actively contribute to the constitution of the system, of which they are a part, in order to act within it and change it – and the system, while undergoing transformation, only continues to exist as a coherent whole while they continue to make and re-make it.

Well-functioning learning networks do not rely on defining and enforcing a uniform perspective. A well-designed network is essentially heterogeneous – it encompasses multiple perspectives across site and across scale. From this perspective, good netweaving

employs a soft touch by mediating between different ways of system knowing, being, and organizing without collapsing them into one perspective, and organizational learning enables ongoing adaptation, as needs and perspectives evolve and different participants come into the network. Transformative capacity is not just the sum of similar efforts at different sites and scales or a least common denominator between them, but rather is emergent from interaction between the partially-shared understandings within and between sites, and across scales of the learning network.

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