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ORIGINAL ARTICLE

The role of ad hoc networks in supporting climate change adaptation: a case study from the Southeastern United States

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Abstract To examine the factors that support adaptation within a regional and sectoral context, this article explores five climate-sensitive sectors in North and South Carolina (Forestry, Government Administration, Tourism, Water Management, and Wildlife Management) and the role of partnerships, collaborations, and networks in facilitating climate adaptation and related activities. Drawing from 117 online questionnaires and interviews with sector leaders across the Carolinas, the article highlights several key functions of networks in regard to supporting adaptation—intra-sector information sharing; monitoring, data collection, and research; and education and outreach. Furthermore, the analysis examines how climate networks in the region have facilitated the development of bonding, bridging, and linking social capital while also noting factors that have constrained the growth and success of both intra- and cross-sector collaboration. Although no formal, or discrete, state or regional cross-sector climate change network exists in the Carolinas, climate adaptations and capacity-building efforts have been supported by ad hoc and decentralized networks, emerging collegial partnerships within and across sectors, and collaborative efforts to pool expertise and resources. The role of different forms of social capital within these networks is discussed in the context of a contentious political environment where support for activities designed to address climate change is limited. These findings enhance our understanding of the social factors and relational processes that shape and influence capacity to adapt to climate change.

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Introduction

Adaptation to climate change encompasses a wide range of individual and collective adjustments within socio-ecological systems that are taken in preparation for, or in reaction to, a climate stress event (Smit et al. 1999). Adaptation includes activities that are taken to reduce existing and potential vulnerabilities and actions that build the adaptive capacity of individuals or groups to enact such activities (Adger et al. 2005). Adaptive capacity is described as a vector of resources and assets "that represent the asset base from which adaptation actions and investments can be made" (Adger and Vincent 2005, p. 399; Engle 2011; Parry et al. 2007). In other words, although specific adaptation measures may not be enacted in a system that has yet to experience significant pressure to adapt, existing resources, knowledge, or networks within that system can be examined to assess the potential of adaptive capability under future stressors (Pahl-Wostl 2009). It is therefore important to identify what builds adaptive capacity or, similarly, what functions as barriers or limits to adaptations (Adger et al. 2009).

Although policy strategies to address global climate change have traditionally been crafted at the federal or international level, it is expected that climate impacts will be experienced—and most effectively responded to—at the local and regional level (Ostrom 2012; Zimmerman and Faris 2011). Accordingly, adaptation efforts aimed at moderating the effects of climate change are enhanced by distinct analysis of climate impacts with particular regard for specific areas and with context-specific resources,

capacities, and challenges in mind (Füssel 2007; Park et al. 2012). Between 2010 and 2012, the Carolinas Integrated Sciences and Assessments (CISA) team assessed existing and planned climate adaptation activities in North and South Carolina, hereafter the "Carolinas" (Lackstrom et al. 2012). The project focused on identifying existing climate concerns, responses to climate change, and the assets and resources that exist to support the capacity to adapt.

Findings from the CISA regional assessment indicate that few stand-alone climate change projects exist across the Carolinas and existing initiatives are constrained, in part, by public and political environments that range from mildly supportive to contentious (Lackstrom et al. 2012). A growing political opposition toward actions to address climate change in the region has resulted in many of the existing or planned climate change activities being scaled back, mainstreamed into other efforts, or both. With few organizations in the Carolinas explicitly discussing and engaging in climate change adaptation, ad hoc partnerships are allowing decision makers to take advantage of opportunities and utilize existing networks to address climate change concerns. While multiple factors influence overall capacity to adapt to a changing climate, this article specifically highlights how building ad hoc climate adaptation networks is emerging as a strategy to increase the capacity of decision makers, organizations, and sectors to adapt to climate variability and change within unsupportive, and sometimes adversarial, political, and social contexts. Two overarching research questions serve to advance conceptual understanding of the ways that different types of networks influence the capacity of the Carolinas region to adapt to climate variability and change.

- How do networks support climate adaptation and what form do they take?
- What factors influence the development of climate networks?

The role of networks in supporting climate adaptation

Adaptation involves anticipating and mitigating potential threats and damages while also taking advantage of relevant opportunities and is one element of reducing vulnerability (Eakin and Luers 2006; Smit and Wandel 2006; Yohe and Tol 2002) and enhancing resilience (Carpenter and Brock 2008; Pahl-Wostl 2009). A number of variables have been theorized to influence the capacity of socio-ecological systems to adapt to climate change, including the production and use of relevant knowledge (Fuerth 2009; Olsson and Folke 2001), flexible and equitable governance structures (Sales 2009), progressive institutional practices and decision-making processes (Adger et al. 2009; Parry et al. 2007; Quay 2010), technology (Folke et al. 2002), and human and social capital (Adger 2003; Wolf et al. 2010). The lack or presence of these factors can serve as barriers or facilitating elements depending on the context in which they are enacted.

Because the ability to adapt involves interactions and activities within broader networks of socio-ecological systems, it is most often conceptualized as a collective phenomenon influenced by factors like trust and social capital (Adger 2003; Pelling and High 2005). As such, governance regimes, institutional cultures, and communication patterns, as well as cooperative systems of planning and management are often prominently featured as critical determinants of adaptive capacity (Agrawal 2008; Brown et al. 2010). Given that many of these functions and processes are facilitated via formal and informal networks of individuals and organizations, robust and efficient networks of action have been noted as a significant "hallmark" of successful climate change adaptation (Wilby and Vaughan 2011).

Within a climate adaptation context, collaborative networks provide substantial benefits to the actors and organizations involved. Networks serve as a mechanism through which information is exchanged, expertise is combined, and knowledge is co-produced among individuals with multiple perspectives and experiences (Wilby and Vaughan 2011; Moser et al. 2008). They provide opportunities to pool and mobilize resources, distribute political, social, and financial risk, and connect multi-scalar governance levels to coordinate effort and maintain support (Pelling and High 2005; Smit and Wandel 2006; Wilby and Vaughan 2011). Furthermore, networks allow diverse actors to negotiate conflict, build consensus and trust, identify complementary adaptation goals, and enable collective action (Ford and Smit 2004; Juhola and Westeroff 2011). As Moody and Paxton (2009) point out, social networks studied in conjunction with social capital provides insight into social structure as well as context. As such, networks help to facilitate social capital among participants, defined by Woolcock and Narayan (2000) as "the norms and networks that enable people to act collectively" (p. 226).

Social capital has been hypothesized to serve numerous functions within social systems (Adger 2003). A useful characterization of the nature and value of social capital has been proposed by Szreter and Woolcock (2004) who outline three primary types of social capital: bonding, bridging, and linking. *Bonding social capital* reinforces ties and connections between closely related or homogenous groups and serves to strengthen such ties and relationships. *Bridging social capital* encourages links between diverse groups who share some common element, and *linking social capital* facilitates such connections between diverse

groups from different power or authority gradients. Different types and strengths of social capital can influence the nature and extent of collective action that occurs within a given system. Furthermore, social capital bonds develop and evolve over time, demonstrating temporal and spatial heterogeneity within fluid networks of interaction (Pelling and High 2005).

Additionally, social capital can emerge from both formal and informal networks. Organizational management scholars have conceptualized organizations and networks in terms of "ordered networks and patterned interactions" that constitute (1) the "legitimate" processes of an organization (formal networks) and (2) the "shadow" or self-organizing systems of informal and sometimes covert activities (Shaw 1997). Both formal and informal networks have been noted as contributing to the learning, idea generation, and coordination needed to support adaptive capacity (Boyd and Osbahr 2010). The recent informal "actor networks" identified by Moser (2007) that have developed to fill the void left by the US "federal leadership vacuum" in regard to national climate change policy illustrate the role informal networks can play in supporting adaptive capacity. In this article, we focus attention on understanding the nature of climate networks in the Carolinas and analyzing how these networks work to meet critical needs to promote and support adaptation when a formal networking structure is absent. In particular, we ask questions regarding how and when climate networks form, what function these networks play, what factors influence the formation of networks, as well as what types of social capital are emerging within these systems to support climate change adaptation (NRC 2010).

Methods

The Carolinas provide a salient region to study climate adaptation networks given that both states experience considerable climate variability and include a diversity of ecosystems (Konrad and Fuhrmann 2012). Climate change concerns include greater variability in temperature and precipitation in the region, more extreme flooding and droughts, and sea-level rise (Konrad and Fuhrmann 2012; Kettle 2012). In addition, North Carolina and South Carolina share key challenges and vulnerabilities, which center on land use change, coastal development, and water management. Climate change and variability across the Carolinas are likely to interact with existing non-climate stressors and impact water resource management, economic activities related to forestry and tourism, wildlife management, and services provided by local- and state-level governments (Napton et al. 2010).

Five climate-sensitive sectors in North and South Carolina (Forestry, Government Administration, Tourism, Water Management, and Wildlife Management) were selected in order to investigate adaptation actions within the Carolinas. These sectors were selected because of their sensitivity to climate variability and change and significance to regional and local economies. One hundred and seventeen individuals participated in coupled online questionnaires and semi-structured interviews, conducted from June to September 2011. These individuals were selected for their leadership and involvement in climate change-related issues in the region. They represented perspectives across North Carolina and South Carolina and different types of organizations (academic, public, private, non-profit) working at different geographic scales (local, state, southeast) (see Table 1 below).

The online questionnaire focused on the use of climate information and existing or planned activities to address climate concerns or impacts. Follow-up interviews were used to obtain in-depth information about climate-related activities and the factors that supported or constrained climate change adaptation efforts. Open-ended text from the web-based questionnaires and interview transcripts was imported into QSR *NVivo* for coding and content analysis. To evaluate the networking aspect of capacity building in the Carolinas, the analysis presented here centers on identifying and examining themes related to (1) the significant processes through which knowledge and resources are shared, (2) the existing opportunities for partnerships and joint projects, and (3) the ways in which networks have supported the development or implementation of climate activities. Specifically, we looked for evidence of bonding, linking, and bridging social capital. Authors conceptualized bonding ties as relationships between peers within sectors (i.e., water utility or forest managers) while linking ties refer to connections between sector members operating at different management levels (i.e., local, state, or federal government officials). Bridging ties are those that occur across sectors or groups with different interests or management responsibilities. Lackstrom et al. (2012) provide details about participant selection and recruitment, the development of the online questionnaire, the interview protocol, and the coding process.

Findings

Adaptation activities and the political-social context

Adaptation activities across the Carolinas are predominantly devoted to problem detection and awareness, information gathering, and developing response options and alternatives. Individuals and organizations across all

Table 1 Study participation by organization type, sector, and geographic scale

	Forestry (21)	Government (36)	Tourism (22)	Water (14)	Wildlife (24)	Total (%)
Organization type						
Academic	2	5	5	0	1	13 (11)
NGO/NPO	8	4	9	2	12	35 (30)
Private	1	2	2	7	0	12 (10)
Public	10	25	6	5	11	57 (49)
Geographic scale						
Local–NC	0	14	13	1	0	28 (24)
Local–SC	1	2	3	1	0	7 (6)
State–NC	6	9	2	1	9	27 (23)
State–SC	6	3	3	3	5	20 (17)
Carolinas	0	5	1	4	3	13 (11)
Southeast	8	3	0	4	7	22 (19)

study sectors are pursuing planning projects on greenhouse gas emission reduction (mitigation), public education and outreach, and the collection of climate impact data. Although related research and pilot projects (e.g., ecological alteration initiatives, deploying new technologies) are beginning to receive greater support, these efforts appear to be limited to coastal areas where there is greater observational evidence of sea-level rise and ecological impacts. These findings are consistent with other research, which indicates that the vast majority of current activities fall in the "understanding" and "planning phases" (Bierbaum et al. 2013; Moser and Ekstrom 2010).

Study participants indicated that public and political opinions and support heavily influenced the type and intensity of activities selected to address climate change concerns and the resources available to support such efforts in the region. For example, participants stated that results from the 2010 state and local elections in North Carolina signified a shift in the state's political climate and increased skepticism and hostility toward climate-related efforts among elected officials at the state and, in some cases, local level. Leaders in South Carolina expressed similar views, such as this Wildlife sector interviewee:

> The main constraint is, well of course money is always a constraint, time is also a constraint, but the big constraint is the political atmosphere. It is just such a regressive anti-science, antigovernment, sort of anti-everything atmosphere that is very difficult, almost a paranoid sort of situation that is very difficult to get some people in some groups to take this stuff seriously and I think that is the biggest hurdle.

A number of other participants stated that public leaders and elected officials have recently cited difficult economic conditions as a justification to halt resource- or time-intense programs intended to address climate change, although it is unclear whether such cuts are a reflection of economic reality or ideologically motivated. As such, activities that can lead to demonstrated economic benefit (e.g., cost savings with energy efficiency mitigation procedures) are often prioritized over adaptation projects with uncertain results. Sector leaders also noted that a lack of political and public support was the primary constraint inhibiting adaptation activities. Many interviewees commented that key groups, elected leaders, or campaigns that discredit climate science played a sizeable role in curtailing climate-related activities and wide-scale collective initiatives around adaptation. Reflecting on the reaction of local leaders upon the release of a state-level report on sea-level rise in the Carolinas, one Government Administration sector interviewee noted:

> The reaction was, this is going to damage real estate property values, not how are we going to, as responsible human beings, address the issue [sea level rise]. It was, you are going to damage our economy at this vulnerable stage talking about 3 feet of sea level rise. So that was their reaction and of course the next step was to cast doubt on any of the information in the study and to basically attack the messenger.

Within this context, building human and social capital through networks and partnerships was consistently identified as a major asset and need to build capacity to adapt to climate change, particularly under fiscal and political constraints. Study participants noted that activities supported by multiple organizations, or by credible and respected local leaders, generally were less politically polarizing. However, formal, top-down systems and structures to encourage these networks are generally absent in the Carolinas region, leading to the formation of less centralized and more unofficial collectives of social capital.

These early efforts demonstrate emerging networking strategies to build capacity and overcome constraints in unsupportive political environments. The following section discusses these networks within each sector and examples of cross-sector collaborations.

Sector-specific networks: using bonding and linking ties to support climate action

Mainstreaming climate change concerns into existing projects or organizational responsibilities was highlighted as a key strategy by study participants in order to overcome challenges posed by weak public and political support in the Carolinas. As a part of these mainstreaming efforts, decision makers are utilizing existing intra-sector networks to incorporate climate change issues into current projects or programs and are taking advantage of new and emerging opportunities (Table 2). These efforts are drawing on and fostering existing bonding and linking ties within sectors. Three key functions of these networks include internal information sharing; monitoring, data collection, and research; and education and outreach.

Internal information sharing

Attending conferences, interacting via shared meetings, and maintaining open and direct lines of communication were consistently identified as important mechanisms to sustain accessible, relevant, and trusted sources of information sharing for all sectors, a key component of adaptive capacity. Both Water Management and Forestry have particularly well-established avenues for facilitating information exchange and increasing awareness of climate change among sector members because of strong and closely connected professional networks developed over long careers within the sector. The Center for Sustainable Tourism at East Carolina University provides webinars and other resources to educate members of the Tourism sector about sustainability, renewable energy best practices, and how weather- and climate-related factors can affect tourism businesses and destinations.

Monitoring, data collection, and research

The need for regional and locally specific information to document "baseline" conditions and impacts associated with changes to both ecological and social systems has prompted a host of organized data collection, monitoring, and research activities. These efforts are viewed as important given the lack of consensus regarding future climate trends in the southeastern United States, which often confound efforts to prepare for climate change. To address these concerns, collaborative research has convened academic researchers and sector leaders to establish synergistic research projects and expand existing knowledge and information bases. For example, the US Forest Service Eastern Forest Environmental Threat Assessment Center and the Southern Research Station (SRS) have developed decision support tools for forest resource and land managers. Projects from the SRS include the Southern Forest Futures Project, The Template for Assessing Climate Change Impacts and Management Options (TACCIMO), and other efforts to develop adaptation strategies and disseminate information to aid resource management and planning.

Public education and outreach

Study participants expressed that public education and outreach play a critical role in facilitating and strengthening public support for climate change adaptation, thus building networks of communication and collective action among members of the community. Although each sector has tailored outreach efforts to connect with its most salient issues, common goals were identified across each of the sectors, including disseminating basic information about climate patterns, climate science and indicators, and the potential impacts of long-term climate change or increases in extreme weather conditions or events. With political and public support for climate change activities lacking, some interviewees indicated that education–outreach activities are being used strategically to garner broader support among the public and to bridge networks of actors involved in climate adaptation. For example, in order to bolster support for climate-related initiatives in the Wildlife Management sector, one study participant stated that connecting with religious leaders was important in the Carolinas because they are respected in the community and can effectively link climate change to moral issues of concern. Similarly, another participant found that including private sector perspectives can enhance credibility by ensuring trusted people are co-delivering messages about the economic importance of addressing climate change. These comments highlight the importance of understanding context, and the attitudes and concerns of specific audiences, when disseminating climate change information.

Cross-sector collaborations: emerging bridging activities

While sector-specific networks are facilitating first steps toward climate change mitigation and adaptation, a handful of cross-sector networks are emerging across the Carolinas to *bridge* mutual interests and promote interactions across different sectors and organizational levels. Such local- and regional-based networking efforts are viewed as an

Table 2 Sector-specific networks, their capacity-building functions, and aspects that support them

Sector	Prominent networks	Capacity-building function	Supported by
Forestry	*Professional associations* National Association of State Foresters; NC & SC Forestry Associations; Society of American Foresters	Sharing information, data, and best practices (e.g., fire risk, long-term forest management under changing climate conditions)	Collective training opportunities, long-term career employees, decision support services available via associations
Government administration	*Regional and local level partnerships* Piedmont Triad Sustainable Communities Planning Project *Professional associations* ICLEI; Urban Sustainability Director's network; US Conference of Mayors	Planning and project development with themes around sustainability, energy efficiency, transportation, and comprehensive planning	Multi-level and regional activities facilitated by incentives, mandates, and funding opportunities
Tourism	*Hospitality interest groups* Local green building councils; NC & SC hospitality and lodging associations *Outdoor recreation interest groups* Parks & recreation associations; nature-based tourism associations	*Hospitality interest groups* Sustainable tourism planning and project development as well as promotion of "green" practices and businesses *Outdoor recreation interest groups* Cross-agency collaborations on land conservation, environmental protection, or resource management	Local champions or initiatives that focus on niche marketing
Water management	*Professional associations* American Water Works Association; water utility and professionals associations	Sharing information, data, and best practices (e.g., technical expertise, drought mitigation efforts, climate impacts on water availability and quality)	Collective training and educational opportunities, conferences
Wildlife management	*Multi-agency and multi-organizational partnerships* Federal and state resource agencies *Regional and local level partnerships* Albemarle-Pamlico Conservation in Communities Collaborative	Pooling resources and expertise for project development and implementation; research, monitoring, and knowledge exchange	Initiatives to address common environmental concerns, restoration and conservation projects as well as numerous non-profit collaborators

effective strategy for pooling resources and expertise in order to take a first step toward enhancing adaptive capacity. Although these cross-sector efforts are not widespread across the Carolinas, these bridging activities represent emerging efforts and the complex challenges involved in establishing and maintaining multi-party, multi-level partnerships. Many of these efforts have focused on developing and implementing specific and targeted issues within communities, such as energy efficiency, including the Energy Efficiency and Conservation Block Grant (EECBG) Program and the US Department of Housing and Urban Development's Sustainable Communities Regional Planning Grant (SCRPG) Program. Additionally, restoration and conservation projects and environmental collaborations, such as the Albemarle-Pamlico Conservation in Communities Collaborative, Cape Fear Arch, Uwharrie Conservation Partnership, and the Southern Appalachian Forest Coalition, often entailed regional coalitions. These targeted efforts include a wide range of federal, state, and local agencies as well as non-profit organizations and academics.

The Alligator River National Wildlife Refuge project illustrates how access to networks provides connections to information, expertise, and resources that can directly lead to capacity-building efforts. The refuge spans 154,000 acres in the Albemarle-Pamlico Estuary in North Carolina. The Nature Conservancy and the US Fish & Wildlife Service are collaborating to evaluate how different adaptation strategies may increase the resilience of the refuge and other coastal ecosystems to sea-level rise, saltwater intrusion, and coastal erosion. Duke Energy was a key funding partner, donating $1.25 million to the project, and other governmental agencies like the US Army Corps of Engineers and local municipalities have been involved in

the project. Efforts include installing oyster reefs and salt-tolerant trees and plugging ditches to address issues of saltwater intrusion and erosion. The project demonstrates the important role networks play in facilitating the pooling of human capital (scientists, policy makers, resource managers), financial capital, and natural capital to implement on-the-ground efforts. This project also adds to the growing body of knowledge about climate change and coastal ecosystems and provides greater visibility and public understanding of projects intended to address climate-related issues, thus enhancing information sharing and learning and reducing the potential for duplication of efforts across sectors.

Discussion

Adaptation and networks within sectors

Existing intra-sector networks across the Carolinas are being used to facilitate climate change action in the absence of large-scale, formal climate adaptation initiatives (Table 1). These sector-specific networks serve a central role in using and strengthening *bonding* social capital among members of each sector to advance climate adaptation activities. In several instances, *bonding* ties facilitated the building of intra-sector partnerships and projects with the potential to develop innovative climate change solutions. In other cases, such partnerships have served to build *linking* social capital, by establishing multi-scalar collaborative initiatives among regional sector leaders and local affiliates. These partnerships are helping to build climate change knowledge networks and data collection and monitoring systems for documenting climate-related changes. Two additional outcomes from these intra-sector networks are worth noting. First, climate change challenges are often "legitimized" within a sector when included in institutionalized, professional communities of practice. Second, some efforts have led to ad hoc sub-networks that coalesce to address particular climate change concerns within those sectors.

Network building has occurred in several manners across the Carolinas. Some sectors are working on climate change issues almost exclusively via established professional networks. For example, the Forestry and Water Management sectors typically address climate change issues within existing management and network structures, such as professional organizations. These sectors have specific missions and tasks related to resource management, decades of experience managing climate variability and risks, and established information and monitoring networks to support decision makers. Others have assembled new multi-party groups tied to broader intra-sector networks devoted to related issues of concern. Sectors like Government Administration, Tourism, and Wildlife Management demonstrate a greater diversity in terms of the pathways through which climate change is addressed, utilizing opportunities around institutionalized networks designed to support community sustainability, energy efficiency, or "smart" growth and development to integrate climate change into planning processes. These few examples demonstrate that network building in the Carolinas does not follow one standard blueprint and seldom results in organizational systems that have the same form or function.

Factors influencing the development of networks

Study participants identified a variety of factors that influenced the development of partnerships and networks to address climate concerns. Access to funding and financial incentives was among the most commonly identified factors enabling the development of networks. For example, numerous participants in the Government Administration sector identified the EECBG Program as an essential mechanism for connecting community members and government agencies and strengthening *bonding* and *bridging* social capital that can lead to energy efficiency and emission reduction projects. While the federal government appears to be a main funding source for climate-related projects, grants from private and non-profit organizations have also supported regional collaborations and projects for specific topics and sectors.

Although access to financial resources plays a key role in the development of specific projects and collaborations, interviewees also noted that the presence of pre-existing intra-sector networks, such as professional associations, regional leadership teams, research institutes, and training programs, has helped to advance action on climate change by providing avenues to enhance interagency collaboration between sector organizations, build new lines of communication, and assemble diverse professionals around common sector problems and concerns. Interviewees frequently discussed the importance of regional conferences and workshops as providing opportunities for information sharing and network building around climate concerns and related activities. These opportunities allowed sector leaders to "mainstream" topics around climate change into existing sector activities and priorities.

State and federal land and natural resource managers frequently noted that federal resources and guidance (such as Executive Order 13514) have helped to support climate adaptation networks around specific issues and encourage collaborative efforts to address climate change in long-term planning efforts, such as policies that require inter-agency collaboration and the pooling of resources (Bierbaum et al. 2013; C2ES 2012). For example, the USDA Forest Service

Southern Research Station in Asheville, NC, provides research findings and planning tools to prepare for climate change impacts within the Carolinas' forests. The organization has completed extensive research on more localized impacts and has several decision support tools available for use by forest land managers at multiple scales, encouraging multi-level *linking* activities among forestry sector members.

Many study participants in North Carolina noted the key role played by the North Carolina Interagency Leadership Team (ILT) in initiating *bridging* activities across the state. The ILT consists of individuals representing six state agencies and five federal agencies. The initial driver to form the group was to facilitate the implementation of transportation projects in the state by bringing together multiple agencies to enhance collaboration. One member in particular advocated that this multiple-agency group provided a unique opportunity to consider how climate change would affect transportation projects, as well as other agency interests and programs. In March 2010, the ILT and the North Carolina Department of Environment and Natural Resources sponsored the conference: "Planning for North Carolina's Future: Ask the Climate Question"—the most widely referenced conference among all North Carolina study participants (Lackstrom et al. 2012). The workshop convened state-level and nationally known scientists and over 400 decision makers to help leaders incorporate climate change into their long-term planning decisions. One government planner stated that "it was probably the most significant conference on climate change adaptation for non-technical personnel ever held." As this example demonstrates, interagency cross-sector coordination often involves information sharing, collaboration to reduce duplicative activities, discussion regarding best practices, and the pooling of resources or expertise.

Across all five sectors, participants noted how financial resources, existing intra-sector networks and relationships, federal-level policies and guidance for specific sectors, and key individuals or organizations have helped to foster networks that support adaptation activities. While ad hoc climate networks have emerged and benefited from the opportunities described above, participants also articulated that political conflicts and the subsequent lack of coordination and communication across multiple scales and sectors pose barriers to adaptation, decreasing opportunities to develop *bridging* social capital in particular. In North Carolina, opposition to a state-led sea-level rise assessment and management strategy led to an organized campaign to discredit sea-level rise science. This opposition is consistent with a larger organized social movement across the United States to challenge and discredit climate change science (Jacques et al. 2008), which has, in part, contributed to declining public concern about climate change (Brulle et al. 2012) and an increasing politicization of climate change issues (McCright and Dunlap 2011). Such unsupportive or hostile political environments, like those that exist currently in the Carolinas, limit opportunities to develop formal, cross-sector, multi-scalar initiatives that help facilitate the necessary development of all three forms of social capital within existing institutional structures. Earlier bridging efforts started at the ILT conference mentioned above have been tempered since the time of our study. The dynamic nature of such organized and interactive cross-sector networks limits building adaptive capacity and demonstrates the shifting character of policy priorities across multiple levels of governance.

Conclusion

The goals of this analysis were to examine the factors that influence the development of climate adaptation networks, the form and function of those networks, and how networks contribute to climate adaptation efforts in the Carolinas. In a political context where opposition to climate change policies and actions appear well organized and have grown increasingly vocal, it is difficult to initiate and implement broad-scale adaptation within the region. As such, our study indicates that an integrative, focused, and stable climate change network does not currently exist in the Carolinas. The mobilization of intra-sector networks represents one strategy to respond to climate threats in the absence of formal, structured mechanisms and processes. The use of existing relational channels has facilitated the development of tailored climate information and activities for specific constituents and interest groups and has helped to mainstream climate change adaptation efforts into existing planning initiatives. These sector-specific, ad hoc networks serve to facilitate information sharing; encourage collaborative monitoring, data collection, and research; and enhance public education and outreach. Despite the lack of broad-based public or political support, a few cross-sector networks have formed within the region, at times leading to collaborative adaptation projects, although the stability of such networks is tenuous. Where such networks have formed, they have benefited from funding opportunities, federal-level initiatives, and leadership provided by key individuals or organizations at the regional or local levels. Study participants considered the networks and partnerships that emerged through these efforts as vital assets in allowing groups to overcome limited public and political support, fragmented regulatory and administrative environments, and constrained resource availability. Accordingly, this research suggests that both intra-sector and cross-sector social networks play essential roles in the facilitation of adaptive capacity on a regional scale.

This project highlights the importance of identifying and examining the linkages between social networks and different types of social capital (Moody and Paxton 2009) and how joint effects influence adaptive capacity. Given the fractious political context of the two states, adaptation activities are facilitated within existing and emerging networks through the use and enhancement of *bonding and linking* social capital. At the same time, adaptation activities strengthen *bonding* ties among sector participants as they allow voluntarily participation in those areas that resonate the most with the values and perspectives of sector members and constituents (Lackstrom et al. 2012). However, while intra-sector networks help to build *bonding* and *linking* social capital, formal structures to help *bridge* across sectors and build public support for adaptation are limited and not sustainable so that institutionalized structures are not currently evident. The unsupportive and unreceptive political climate of the Carolinas may therefore limit the development of a significant form of social capital necessary for more effective collective climate adaptation networks across sectors and across the region. For example, research participants suggested that formal structures that facilitate inter-agency planning and coordination (leading to *bridging* social capital) in the Carolinas would encourage multi-dimensional research projects, stakeholder dialog, and conflict resolution, and more efficient and integrated policy, reporting, and assessment processes that are currently lacking in the region.

Viewing adaptation as a social–institutional process, and as encompassing multiple potential pathways, strategies, and actions, can provide a useful framework in thinking about future research and assessments of capacity in the Carolinas (Downing 2012). This study demonstrates that social networks that form around climate change adaptation in the region exhibit notable heterogeneity. Therefore, measurement of network structures and linkages between key actors alone does not suffice to elucidate the diverse characteristics, purposes and outcomes of social networks in the region. Although understanding the structural arrangement of networks is important, this case study has shown that different forms of social capital are mobilized to perform various network functions, which influence the type, nature, and extent of adaption activities that emerge. Furthermore, social capital is utilized and developed within distinct sectoral communities, each with unique norms and culture that influence how and when capital is formed and negotiated.

From a policy perspective, a number of questions remain about the efficacy of current local, decentralized climate networks in coordinating climate response efforts at the scope and scale required to reduce regional vulnerability and enhance resilience. It is yet to be seen whether current climate networks and initiatives in the region are sustainable. Future research might investigate whether and how current sector-specific or project-based networks can be integrated into larger, "scaled-up" networks and systems and whether networks dissolve once explicit tasks are complete or gain momentum as stakeholders expand efforts into other relevant areas. For partnerships and networks that continue to develop, it will be important to ask what components of social capital facilitated their growth or longevity and examine the local, regional, or federal policy or institutional factors that inhibit or enable multi-sector *bridging* functions. Given the multiple viewpoints and interests within diverse sectors, researchers might ask how groups with different or conflicting values and motivations negotiate priorities and sustain cross-sector efforts over the long-term. Finally, future research might explore how the functions of social capital and networks in politically unsupportive environments like the Carolinas compare to experiences in more supportive contexts. Such research might yield critical clues regarding how and when specific social capital functions are necessary, under what circumstances, and the contextual factors which influence the efficacy of the adaptation initiatives that emerge.

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