

Understanding learning and action in place-based climate adaptation workshops

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## ABSTRACT

Addressing today's complex environmental challenges requires learning, collaboration across sectors, and long-term collective action. This dissertation examines the role of place-based climate adaptation workshops can play in helping communities as they grapple with the current and anticipated effects of anthropogenic climate change. The manuscript contains five chapters. The introduction (Chapter 1) presents the phenomenon of place-based climate adaptation workshops and offers an overview of the research in this dissertation. Chapters 2, 3, and 4 are stand-alone manuscripts. Chapter 2 draws upon surveys with participants in 33 workshops that took place in the United States between 2017 and 2020 to identify perceptions of meaningful outcomes and effective workshop elements. Chapter 3 describes a comparative case study that delves more deeply into 30 of the workshops from Chapter 2 and includes interviews with facilitators and local organizers to identify which workshop characteristics were most often associated with subsequent adaptation-related planning and action. In Chapter 4, we examine learning processes and outcomes in eight additional adaptation workshops held in communities in the United States from 2021 and 2023 by testing a hypothesized learning typology and exploring how it aligns with the theory of Organizational Knowledge Creation.

Our findings suggest that workshops contribute to learning, strengthened feelings of efficacy, and deepened relationships, which, in turn, can yield meaningful planning and action outcomes. We suggest that workshops also expand reference groups and foster norms around climate change adaptation. We identify a range of factors that are associated with higher-performing workshops, including the presence of a local champion, co-design of workshop with participants, sustained support from workshop organizers or a backbone support organization, and a suite of effective facilitation techniques. Our exploration of learning in climate adaptation workshops indicated that learning takes place within distinct declarative, procedural, and relational domains and across tacit and explicit dimensions. We found no differences in participants' learning outcomes between in-person and online workshops. Our findings suggest that effective workshops could be designed to help participants articulate, share, and combine disparate sets and forms of knowledge. In the conclusion (Chapter 5), I synthesize our findings and reflect on my Ph.D. experience.

# Understanding learning and action in place-based climate adaptation workshops

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## GENERAL AUDIENCE ABSTRACT

Tackling the kinds of intertwined social and environmental problems facing the world today requires that groups collaborate, coordinate, and learn together to take long-term action. One place where communities are coming together to learn, plan, and prepare to act is in climate adaptation workshops. These events are designed to help communities as they grapple with the current and future effects of human-caused climate change. My dissertation focuses on these workshops, the kinds of learning that takes place in them, and the actions that happen as a result. The introduction (Chapter 1) describes place-based climate adaptation workshops and offers an overview of the research in this dissertation. Chapters 2, 3, and 4 are stand-alone manuscripts. Chapter 2 explores what workshop participants think were meaningful outcomes and effective workshop elements of the process in which they participated. Chapter 3 goes deeper into a subset of the workshops from chapter 2 and tries to identify which workshop features were most often linked to planning and action. In Chapter 4, we examine learning processes and outcomes in eight additional adaptation workshops held in communities in the United States from 2021 and 2023. We examine the kinds of learning that takes place and the ways that knowledge is shared within a group.

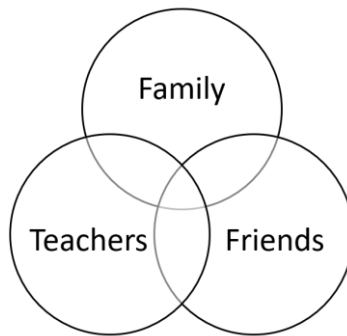
Our findings suggest that workshops contribute to learning, empower participants, and deepened relationships, which, in turn, can yield meaningful planning and action outcomes. We suggest that workshops can also contribute to a shared identity around climate change adaptation. We identify a range of factors that are associated with higher-performing workshops, including the presence of a local champion, co-design of workshop with participants, sustained support from workshop organizers or dedicated community organizations, and a suite of effective facilitation techniques. Our exploration of learning in climate adaptation workshops indicated that important aspects of learning for adaptation involve facts and figures, processes, and learning about the group of individuals involved in adaptation. Each of these elements have easily articulated elements, as well as aspects that are less easily shared. One way workshops can help advance adaptation is by guiding groups as they make their knowledge more readily sharable. We found no differences in participants' learning outcomes between in-person and online workshops. Our findings suggest that effective workshops could be designed to help participants articulate, share, and combine disparate sets and forms of knowledge. In the conclusion (Chapter 5), I synthesize our findings and reflect on my Ph.D. experience.

## Dedication

To those described by Figure 0.1.

In particular, this is for Emily Rose. You have a place at the heart of this corny venn diagram, and you have a place deep within my own heart. Thank you for making our tiny apartment into a refuge during the darkest days of the pandemic, for sharing in the splendors and subtleties of nature, and for inspiring me every day with your relentless dedication to creating a compassionate, sustainable, flourishing, and joyous world.

**Figure 0.1: This dissertation's for you.**



## Acknowledgements

For much of my life, the expression “I couldn’t have done it alone” felt, to me, like a mere truism. Completing this doctoral program has transformed that sentence from a trite bromide to a foundational truth that is the bedrock of this dissertation. It’s always been true, of course, but this PhD program has helped me see its truth with extraordinary clarity. Therefore, in no particular order, I’d like to acknowledge and thank a small fraction of the people who’ve helped me along the way. It may take a village to raise a child, but it has also taken a considerable number of folks to help me see this work through its very long gestation.

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Jenn Brousseau... I could not have dreamed of a better colleague to accompany me throughout this program. Through countless hours of Zoom interviews, of fiddling with Qualtrics and QuestionPro and R, of sharing papers, observing workshops, taking classes, sharing leadership roles in student organizations, swapping pet-sitting duties, watching woodcocks, etc., I always knew I had a great partner who would be there with encouragement, advice, insight, and support just when I needed it most. I look forward to a career’s worth of Slack messages ahead! And to the other members of the Stern Squad past and present—thanks for the camaraderie, support, hikes, mental maps, feedback, tater-tots, and t-shirts. Kelley Anderson, Emily Thorpe, Malia Pownall—it’s been a treat to learn with and from you all.

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I wish to acknowledge the critical support of the National Science Foundation’s Advancing Informal STEM Learning program—grant number 1810851.

Finally, and at the risk of redundancy with the dedication, to Mom, Dad, Anna, and Becca. Growing up in a loving and supportive family nurtured my love of learning and laid the groundwork for this work. It warms my heart to see my young niece, Juniper, living in a similar environment.

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## **Attribution**

The work contained herein is primarily my own. However, Chapters 2, 3, and 4 are journal article manuscripts written with co-authors. The co-authors contributed to the manuscripts by offering feedback on research design, clarifying ideas, suggesting alternative framing, improving the writing, and reorganizing arguments and key concepts. Jennifer Brousseau also contributed to data collection and analysis. The co-authors are listed in the order that they will appear in journal articles; the order of authorship represents each author's level of contribution. Chapter 2 was under review at the time of defense, and the remaining manuscripts will be submitted for publication soon.

## Chapter 1

### Introduction

Communities around the world are already confronting the worsening consequences of anthropogenic climate change and preparing for a more turbulent future (IPCC, 2022). As they grapple with current and future disruptions, individuals and groups are engaging in an undertaking called climate change adaptation, which is “the process of adjustment so that negative impacts of climate change can be reduced or avoided” (van Valkengoed and Steg, 2019, p. 158). It is a complex and mighty task that requires coordination across sectors, flexibility, and ongoing learning (Runhaar et al, 2017).

One way some communities are preparing to face climate change is through place-based climate adaptation workshops. We define place-based climate adaptation workshops as *convenings or series of convenings designed to help multiple stakeholders develop strategies for adapting to climate change in a specific place* (Stern et al, 2023). Although these processes vary widely, they often feature professional facilitators help shepherd communities through a process of convening stakeholders, presenting local climate change impact projections, and jointly developing a plan to reduce vulnerability and increase resilience (Brunner, 2012).

The implementation of climate adaptation workshops has blossomed in the past decade, as organizations and local governments strive to incorporate climate change in their planning (Brunner, 2012). However, there remains much to be learned about what constitutes best practices in conducting climate adaptation workshops and how to translate workshop-related planning to action.

An important aspect of how adaptation workshops can contribute to planning and action is learning that takes place within workshops. Learning is a critical tool for communities coping with climate change and the panoply of related wicked problems besetting the globe (Suškevičs et al, 2018; Plummer et al., 2017; Rittel and Webber, 1973). It can contribute to changes in practice, to altered policies, to restructured institutions, and eventually shifts in environmental conditions (Suškevičs et al, 2018; e.g. Borrini-Feyerabend 2006; Armitage et al 2012; Bromley, 1991; Paavola 2007; Koontz and Thomas, 2006; Plummer and Armitage, 2007). Learning is also slippery and amorphous, and we have much to learn about what drives learning and how to define, measure, and link learning to outcomes (Armitage et al, 2008; Crona & Parker, 2012; Suškevičs et al, 2019).

This research primarily examines learning within place-based climate adaptation workshops: what aspects of workshops and broader contextual factors contribute to learning, what kinds of learning takes place in adaptation workshops and how those processes unfold, and what difference learning can make. Each of the three central chapters herein represents a manuscript crafted for independent publication.

**Chapter 2** describes participant perceptions of effective elements and outcomes from workshops across a wide range of locations and formats. It seeks to answer the following questions:

- 1) What do participants in place-based climate adaptation workshops believe they have accomplished?
- 2) What elements of these workshops do participants believe most catalyze outcomes?

Broadly, we found that workshop participants reported learning, strengthening their sense of efficacy, and deepening relationships with other workshop attendees. They also identified specific climate actions resulting from the workshop, such knowledge dissemination efforts and projects that were implemented.

**Chapter 3** describes a comparative case study of 30 adaptation workshops, using surveys, interviews, and archival review. It seeks to address the following question:

- 1) What characteristics of place-based climate adaptation workshops are associated with higher degrees of planning and action?

We situate our findings within a team-process framework and find that higher-impact workshops featured local champions who advanced workshop efforts. Workshops also benefited from sustained post-workshop support from backbone support organizations or workshop organizers. While helpful, co-design of workshop processes and products by organizers and participants was not always necessary for advancing workshop outcomes. Together, these features helped spur action by deepening relationships, strengthening collective efficacy, and fostering the creation of shared vision and understanding among workshop participants.

**Chapter 4** focuses on learning processes and outcomes within eight climate adaptation workshops and proffers a framework for incorporating theory-driven learning outcomes into workshop planning. It addresses the following research questions:

- 1) What kinds of learning result from climate adaptation workshops?
- 2) What learning processes are associated with adaptation workshops?
- 3) What workshop elements are associated with learning?

We found that adaptation workshops yield learning within declarative, procedural, and relational learning domains and can enhance motivation and feelings of efficacy among workshop participants. Participants reported instances of conversions between tacit and explicit knowledge and linked learning to a broad range of workshop elements. We found no meaningful differences in respondents' self-assessed learning between online and in-person workshops, nor between individual workshops. These findings suggest that a range of workshop formats can support meaningful learning. We suggest that processes that seek to advance collaboration to address complex challenges may benefit from attending to explicit and tacit dimensions of declarative, procedural, and relational learning domains.

**Chapter 5** concludes this dissertation and offers a brief synthesis of cross-cutting themes that span the individual manuscripts and a personal reflection on the experience of undertaking this work.

Taken as a whole, this research seeks to shed additional light on the ways we can effectively work together to address challenging environmental issues and how we can learn from—and with—each other to achieve meaningful action and lasting positive change.

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## Chapter 2

### **Participant perspectives on effective elements and impacts of climate change adaptation workshops in the United States.**

Caleb O'Brien, Marc Stern, Jennifer Brousseau, Lara Hansen, Bruce Hull

#### **Abstract**

Communities in the United States are increasingly relying on place-based climate adaptation workshops to aid attempts to prepare for—and cope with—climate change, but there is limited empirical evidence about what participants believe these workshops can achieve and what elements they find most valuable. To begin addressing this gap, we sought to understand participant perceptions of effective workshop elements and outcomes across a wide range of locations and workshop formats. We surveyed participants in 33 place-based adaptation workshops that took place in the United States between 2017 and 2020. We sought to understand participants' perceptions of the outcomes of these workshops and the workshop elements that drove those outcomes. Results suggest that workshop participants commonly believed that they learned, strengthened their sense of efficacy, and deepened relationships with other workshop attendees. Participants identified specific climate actions resulting from the workshop, including knowledge dissemination efforts and project implementation. We argue that effective adaptation workshops can also expand reference groups and foster norms around climate change adaptation.

#### **Practical implications**

Place-based climate change adaptation workshops are an increasingly common approach used by communities to prepare for the impacts of climate change. Place-based adaptation workshops, which we define as *convenings or series of convenings designed to help multiple stakeholders develop strategies for adapting to climate change in a specific place*, vary widely in duration, structure, and scope, but they generally share some common attributes, such as facilitating groups to jointly assess risk, identify vulnerabilities, and design strategies for action. Workshops may focus primarily on specific sectors, such as natural resource management or urban planning, or they may bring together diverse stakeholder groups to focus on vulnerabilities, risks, and opportunities for action across sectors. In this study, we sought to understand prior participants' perceptions of the outcomes of place-based adaptation workshops they attended and the attributes of the workshops they felt were most important for catalyzing meaningful outcomes.

We conducted online surveys with participants and interviews with facilitators and local conveners of 33 place-based climate adaptation workshops conducted between 2017 and March 2020 in the United States that lasted at least half a day and involved at least 10 participants. We excluded processes that encompassed entire states or larger regions, thereby limiting the sample to those focused on specific geographies within which tangible adaptation activities could reasonably take place.

The 33 workshops were attended by a total of 914 participants, 57% of whom responded to our survey. We interviewed 67 facilitators and local conveners. Twenty of the workshops were focused on adaptation for specific natural areas, such as national parks or forests. Nine focused on urban settings, with two focusing on natural resources within an urban context (i.e., incorporating adaptation into a city's urban tree management plan and a university grounds management plan). One workshop focused on small communities within a broader rural context, and another included a mix of rural and urban communities. Seven of the workshops took place in California, three occurred in Colorado, and the remaining workshops took place within a mix of 17 other states.

Our results reflect participants' perceptions that place-based adaptation workshops could achieve meaningful outcomes in at least four broad areas: *Learning, relationships, efficacy, and actions*. Participants reported learning both as individuals and within groups. This included learning *new information* about climate change and projected impacts; *new skills*, including how to enact strategies to adapt to climate change or where to access resources, and *new perspectives*, including shifts in thinking to encompass different geographic and temporal scales. Most participants felt they *strengthened relationships* during adaptation workshops. Participants reported that these changes occurred both within and across organizations and disciplines. In some cases, these enhanced relationships resulted in the formation of new groups or collaboratives, or improved communication within the network of people working in climate adaptation in the area. Participants also indicated that the workshops they attended enhanced feelings of *self- and collective-efficacy*. That is, they felt that the workshop strengthened their belief that their actions will have an impact, both as individuals and as a group working together. Finally, participants identified three kinds of actions that resulting from workshops: *intermediate products* stemming from workshops, such as workbook outputs and assessments,; *plans, projects, and initiatives*, such as incorporating climate adaptation into formal planning documents or changes to practice; and actions related to *knowledge distribution*, such as sharing informational resources or giving presentations about climate adaptation. Fifty-eight percent of respondents reported that the workshop they had attended contributed to local climate adaptation actions. Only 2% of respondents reported that the workshop they attended did not advance adaptation in the area, and 41% expressed uncertainty.

Participants' perceptions of workshop elements that positively influenced outcomes can be broadly categorized as relating to opportunities for *varied interactions with a diverse group* of participants; the availability of *useful materials and opportunities to practice* using them; the roles of *high-quality facilitators*; and a focus on *real-world, local applications linked to ongoing responsibilities* or projects. Participants valued workshops where attendees brought a range of backgrounds, roles, and areas of expertise. They also valued seeing both new and familiar faces at workshops and having time to both strengthen existing relationships and develop new ones. They valued variety in the kinds of opportunities for engagement during adaptation workshops, including breakout groups, expert presentations, open discussion, report-outs of breakout activities, and time for networking and collaboration. They especially valued opportunities to try out tools, data, and other materials shared during the workshop. Participants also highlighted the value of high-quality facilitation in adaptation workshops and identified a range of useful roles facilitators can perform, including creating a structure for the workshop with a clear agenda and objectives; advancing the workshop by keeping people on track, taking notes, and organizing logistics; sharing their own expertise and helping frame the overall orientation of the workshop; and enabling positive social processes by balancing power dynamics and promoting participation. Finally, participants valued workshop content oriented around real world applications linked to their ongoing work, responsibilities, and projects. This included a focus on concrete examples, locally applicable research, success stories, specific strategies tailored to their context, and scenario planning that focused on exploring a range of possible futures.

Our findings suggest that as the need for climate adaptation grows, place-based workshops could play an important role. Effective workshops convene key actors with diverse perspectives and provide tools, examples, and data calibrated to the needs of the participants. They can advance learning for adaptation, strengthen networks, enhance feelings of efficacy, and contribute to a range of action outcomes.

## Introduction

Climate change adaptation is “the process of adjustment to actual or expected climate and its effects in order to moderate harm or take advantage of beneficial opportunities” (IPCC, 2022, p. 5). Although there is no one-size-fits-all approach to climate change adaptation, some similarities have emerged in the ways different regions and sectors are planning for adaptation. These approaches include engaging stakeholders in the process; sharing best practices; and promoting iterative, action-oriented learning (Bierbaum *et al.*, 2013). Organizations and communities are increasingly relying on educational and capacity-building events, such as place-based climate adaptation workshops, to aid these efforts (Biagini *et al.*, 2014). We define place-based adaptation workshops as *convenings or series of convenings designed to help multiple stakeholders develop strategies for adapting to climate change in a specific place.*

Adaptation workshops vary widely in duration, structure, and scope, but they generally share some common attributes, such as convening groups to jointly assess risk, identify vulnerabilities, and design strategies for action (Brunner & Nordgren, 2012). Workshops may focus primarily on specific sectors, such as natural resource management (e.g., MCrum *et al.*, 2009; Stein *et al.*, 2014) or urban planning (e.g., McEvoy, van de Ven, Blind & Slinger, 2018), or they may bring together diverse stakeholder groups to focus on vulnerabilities, risks, and opportunities for action that transcend sectors (Plate *et al.*, 2020; Tuler, Dow & Webler, 2020). Workshops may also serve as spaces where groups deepen relationships and share knowledge (Stern *et al.*, 2023).

Given the scale at which climate adaptation will likely be necessary over the coming decades, there is a need for additional empirical evidence about the practices that make it effective. In response to this need, we address the following research questions:

- 3) What do participants in place-based climate adaptation workshops believe they have accomplished?
- 4) What elements of these workshops do participants believe most catalyze outcomes?

## Literature review

Climate adaptation is a process, not merely a destination, and as such, it can challenge concrete or linear conceptualizations of outcomes and success (Vogel *et al.*, 2014). The breadth of contexts in which adaptation efforts are undertaken further complicates aspirations for universal metrics of adaptation success (Ford *et al.*, 2015; Leiter *et al.*, 2019). However, studies of adaptation initiatives and related collaborative processes have identified several broad categories of outcomes that could be indicative of successful adaptation (Smit & Wandel, 2006; Owen, 2020). These outcomes reduce vulnerability by strengthening social, economic, and environmental systems. They also enhance adaptive capacity, which is the ability of a system to respond to, cope with, or recover from hazardous conditions (Owen, 2020; Smit & Wandel, 2006).

Drawing on insights from prior research, we focus on four categories of outcomes that might result from climate adaptation workshops: learning outcomes, relationship outcomes, efficacy outcomes, and action outcomes (Bandura, 2000; Stern *et al.*, 2023). These elements are thought to be necessary, but not sufficient, for the successful management of climate adaptation processes (Baird *et al.*, 2016; Thaker *et al.*, 2016; Tabara *et al.*, 2010). They can unfold at individual and collective levels and in a nonlinear manner (McEvoy, van de Ven, Blind & Slinger, 2018). These outcomes may also influence one another. For example, collective learning could result in strengthened relationships among participants, and



undertaking adaptive actions could, in turn, contribute to enhanced feelings of efficacy (Doherty & Webler, 2016). Each outcome area is discussed in greater detail below.

### ***Learning outcomes***

We consider three domains of learning: declarative, procedural, and perspective-shifting knowledge production (Kaiser & Fuhrer, 2003; Nguyen *et al.*, 2019; Wals & Corcoran, 2006). Declarative knowledge relates to understanding of facts, information, concepts, or interactions (Cooke, Salas, Cannon-Bowers & Stout, 2000). It is akin to “know-what” knowledge and to Bloom’s factual and conceptual dimensions of knowledge (Anderson & Krathwohl, 2001; Garud, 1997). In a climate adaptation context, relevant declarative knowledge could include understanding climate projections for a geographic area and the risks to different categories of valued assets. Procedural knowledge relates to understanding the “steps, procedures, sequences and actions” necessary to undertake an action and aligns with “know-how” knowledge (Cooke *et al.*, 2000, p. 153). Procedural knowledge relevant to climate adaptation could include methods and techniques that help individuals and groups respond to current and projected climate impacts, such as knowledge about how to use structured decision-making tools or how to implement alternative irrigation strategies during a drought (Truelove *et al.*, 2015). Perspective-shifting knowledge describes altered meaning structures or frames of reference (Mezirow, 1997). Wals & Corcoran (2006) identify four perspectival shifts for sustainability, which are potentially relevant for climate adaptation: transdisciplinary (including perspectives of different professions, or academic disciplines), transcultural (understanding perspectives across cultural, racial, ethnic, religious and other boundaries), transtemporal (broadening the perspective to include the past, present, or future), and transgeographic (adopting a perspective considering a wider or different geographic scale). Perspective shifts can be triggered by changes in declarative or procedural knowledge, but do not automatically follow from learning within those domains.

Learning can occur at individual and collective levels. Individual learning occurs independently within a person, such as when someone reads a book about climate change adaptation, or when a group of interested citizens attend a documentary screening and each draw their own conclusions. In contrast, Gerlak and Heikkila (2011) define collective learning as a group process that may include acquiring, evaluating, and sharing knowledge within a group as well as the products resulting from the process, such as shared ideas and understandings. Collective learning and related concepts, such as social learning, are thought to be especially important for environmental management (Armitage *et al.*, 2008; Newig *et al.*, 2010). In a dynamic social-ecological systems context, collective learning might lead participants in a planning process to develop a more comprehensive, shared understanding of all stakeholders’ priorities and to select different adaptive actions as a result (Suškevičs *et al.*, 2018).

Declarative, procedural, and perspective-shifting learning by individuals or a collective are on their own often insufficient for spurring collective action (Hansen *et al.*, 2003; Heberlein, 2012; Kellstedt *et al.*, 2008). Other attributes of collaborative processes—such as relationship attributes of the collective, efficacy beliefs, values, and norms—and contextual factors—such as political climate or salient environmental impacts—are also critical variables linked to decision making and behavior (Bandura, 2000; de Vente, 2016; Stern, 2000; Stern, 2018).

### ***Relationship outcomes***

Relationships profoundly influence collective processes (Powell & Grodal, 2005; Provan & Milward, 1995; Nowell *et al.*, 2017; Stern & Coleman, 2015). Climate adaptation workshops and related community-based climate change adaptation planning processes can instigate shifts in the network structure and the qualities of relationships among the actors involved in climate adaptation (Baird *et al.*, 2014). Potential changes to the quality of relationships include dimensions of trust (Coleman & Stern, 2018), awareness of network function and structure (Schiffer & Peakes, 2009), and perceptions of goal alignment (Drath *et al.*, 2008), among other aspects. These shifts in relationships can, in turn, influence

other outcomes. For example, in a study of a multi-stakeholder sea-level rise management initiative in Maryland, Teodoro and colleagues (2021) found that relationships built on a foundation of reciprocal understanding, respect, and influence were associated with enhanced understanding of climate risk, impacts, and potential adaptive actions. Climate adaptation workshops offer one tool to influence the relational attributes of a collective, through a range of workshop elements, such as facilitated dialogue, small-group work, or informal conversations during breaks. These elements could allow workshop participants to establish and evaluate new connections and deepen existing ties within an adaptation-related context. Strengthened networks and deepened relationships constitute an important outcome of adaptation workshops and may contribute to other critical outcomes, such as feelings of efficacy, learning and action.

### ***Efficacy outcomes***

People are more likely to act if they believe their actions will have impact, i.e., if people have a strong sense of efficacy (Bandura, 1982, 2000; Milfont, 2012; Thaker *et al.*, 2016). Changes in beliefs about efficacy thus constitute another possible workshop outcome. Efficacy beliefs can involve perceptions of both individual and collective capacities. Self-efficacy beliefs encompass a person's perceptions of their own ability to carry out a specific action and achieve desired outcomes (Bandura, 1982). Collective-efficacy beliefs relate to an individual's assessment of a group's overall capacity to do and achieve the same (Bandura, 2000).

In the domain of climate adaptation, van Valkengoed & Steg (2019) found that people's self-efficacy beliefs were positively associated with adaptive behaviors such as seeking information about climate-related hazards, supporting climate adaptation policies, or taking preparatory actions. Similarly, other researchers have found that higher levels of perceived collective efficacy were correlated with greater collective climate action, including participating in community activities to safeguard water resources (Thaker *et al.*, 2016). Research suggests that learning can contribute to feelings of efficacy by building on prior experiences, abilities, and goals. Increased feelings of efficacy can, in turn, contribute to enhanced learning in an iterative "success cycle" (Brooks & Shell, 2006; Seel, 2011, p. 551). Thus, the combination of deepened knowledge and strengthened efficacy beliefs could synergistically spur adaptive action when aligned with participant goals. This process may be especially powerful when relationships and commitments are also strengthened. However, while belief in efficacy may spur more action, it does not guarantee the action taken will reduce climate vulnerability. Evaluations of the degree to which actions actually reduce climate vulnerability were beyond the scope of this study.

### ***Action outcomes***

Scholars have articulated a broad range of adaptation-relevant actions that vary depending on the specific context within which adaptation is taking place (Biagini *et al.*, 2014; Owen, 2020; Stults & Woodruff, 2017). These include capacity building and educational efforts; management and planning initiatives; organized advocacy and outreach; changes to practice, such as improved soil management techniques or integrated pest management; reforms to policies, codes, and zoning requirements; provisioning of information or adaptation technology; developing warning/observing systems; conducting research; and installing physical or green infrastructure. Although some adaptation workshops may aspire only towards educational outcomes, many are designed to move toward plans and actions within these action strategy areas. Adaptive actions can be taken by individuals (such as someone seeking information about climate projections in order to reduce their vulnerability or planting different crop varieties) or collectives (such as groups developing an adaptation plan or drafting new policies).

### ***Attributes of successful climate adaptation workshops***

Evidence suggests that specific elements of an adaptation workshop's design and content could promote outcomes that help advance adaptation. Across a range of professional-development and social-ecological contexts, scholars have identified attributes of events that are associated with enhanced outcomes. These

elements include delivering materials matched to participant needs; eliciting long-term commitments; and promoting highly interactive processes, establishing clear objectives, and providing sustained support after the event (Lauer *et al.*, 2014; Roche *et al.*, 2009).

Effective facilitation can advance workshop outcomes through a range of avenues, including by fomenting deliberative processes, promoting trust, keeping participants on task, and helping collectives balance scientific understanding with other priorities (Coleman & Stern, 2018; de Vente *et al.*, 2016; Turner *et al.*, 2016). A recent study of the perceptions of climate adaptation workshop facilitators identified consensus-based valued practices for conducting climate adaptation workshops (Stern *et al.*, 2023). These included strategies for before, during, and after a workshop. Prior to a workshop, key suggestions included identifying local champions; deepening facilitators' understanding of participant values, culture, goals, and knowledge; developing locally-relevant examples; and understanding contextual factors, such as extant management and planning structures. To effectively conduct adaptation workshops, facilitators suggested emphasizing clear goals and objectives, adjusting information and materials to match participants' level of knowledge, drawing on skilled presenters, sharing relevant success stories and using current and complete information. Additional suggestions included setting clear rules for interaction to ensure everyone has a voice, building in time for open discussion, being flexible and equipped with backup plans, eliciting commitments for post-workshop actions, and keeping the agenda realistic. Suggested strategies post-workshop included sharing relevant materials, such as documentation of workshop outcomes and priorities, developing a concrete plan for post-workshop action including roles, responsibilities, and timelines for future steps.

This study seeks to identify the learning, relationship, efficacy and action outcomes that participants in place-based climate adaptation workshops believe resulted from the gathering they attended. We also seek to identify the attributes of adaptation workshops that participants indicate were most important for catalyzing those outcomes.

## Methods

We selected candidate workshops for the study through several avenues. First, we solicited workshops from a panel of expert adaptation-workshop facilitators who participated in a related Delphi Study designed to elicit expert opinion on best-practices for adaptation workshops (Stern *et al.*, 2023). This Delphi study was conducted from February 2019 to March 2020 with 22 adaptation workshop facilitators. In addition to the workshops identified by Delphi participants, we sent out calls on listservs and platforms used by adaptation workshop facilitators, including the Climate Adaptation Knowledge Exchange (CAKE) and the American Society of Adaptation Professionals (ASAP). Finally, we sought additional workshops via snowball sampling; we asked the facilitators of adaptation workshops in our sample for suggestions about additional workshops to include, and we followed leads with other workshop facilitators. Our goal was to identify as many workshops as possible that fit our criteria, described below. We included workshops that were conducted between 2017 and March 2020. We selected this range to allow enough time for meaningful action to result from a workshop, but not so much time that participants would be unlikely to recall specifics about the event. Data collection for this study took place between July 2020 and March 2021. We included workshops attended by multiple stakeholder groups that took place within the United States, involved at least 10 participants, and lasted for a least half a day. We excluded processes that encompassed entire states or larger regions, thereby limiting the sample to those focused on specific geographies within which tangible adaptation activities could reasonably take place. After interviewing workshop facilitators to assess the suitability of candidate workshops, we worked with facilitators to obtain contact information for workshop participants. We then emailed participants an invitation to an online Qualtrics survey. We emailed a follow-up reminder to nonrespondents one week later and sent a final request two weeks after our initial email. These research protocols were approved by the Virginia Tech Institutional Review Board.

### *Survey overview*

The survey contained both closed- and open-ended questions related to respondent perceptions of workshop elements and outcomes, their involvement in climate adaptation efforts, and the current state of adaptation efforts in the area. We analyzed open-ended questions to identify concepts, themes, insights, and nuances beyond those captured by closed-ended items. The lead author coded these responses through an iterative process of identifying and refining themes, then augmenting with additional codes on subsequent passes through the data (Bailey, 2017; Miles *et al.*, 2018). The codes were discussed and vetted with co-authors throughout the coding process. Here, we describe the key measurements and analyses associated with each research question.

*RQ1: What do participants in place-based climate adaptation workshops believe they have accomplished?*

We assessed learning, relationship, efficacy, and action outcomes through open- and closed-ended questions. We first asked participants to opine on any meaningful outcomes that they felt happened specifically because of the workshop and that might not have happened otherwise. These write-in responses were coded qualitatively.

We further assessed perceived self- and collective efficacy using closed-ended survey items. We asked participants to respond to the question: “Did the workshop enhance any of the following things for you?” for the following items:

- Your confidence that you can work effectively on adaptation in your area
- Your confidence that the people working on adaptation in your area can achieve success

Response categories were composed of a three-point Likert-type scale, with answer choices *Not at all*, *Somewhat*, and *A great deal*.

To further assess action outcomes, we first screened respondents by asking them whether they still lived or worked in the workshop’s target location and whether they felt they could meaningfully comment on what has happened since the workshop. This was done to account for individuals who may have moved away or became disengaged after the workshop. We asked those who passed the screening, “Did the workshop help stimulate adaptation actions in the area?” Response categories were composed of a four-point Likert-type scale, with answer choices *Not at all*, *A minor amount*, *A moderate amount*, and *A major amount*. We included an additional response option: *I am unsure of the workshop’s impact*. For each item, we report the percentage of respondents selecting each option across all workshops.

*RQ2: What elements of adaptation workshops do participants believe most catalyze workshop outcomes?*

We assessed participant perceptions of effective workshop elements through one open-ended and one closed-ended question. The open-ended question asked survey respondents to opine on the most effective components of the workshop they attended. Responses to this question were qualitatively coded. We then presented survey participants who still lived and worked in the workshop focal area and felt that they could comment on workshop outcomes with five workshop elements identified as important drivers of workshop outcomes in prior research (Stern *et al.*, 2023). We asked them to indicate the extent to which each element had a positive influence on workshop outcomes. The elements were:

- The quality of the facilitator
- Pre-existing relationships between workshop attendees
- Realistic strategies developed during the workshop
- Commitments that people made during the workshop
- Leadership by specific individuals after the workshop

Response options were *No meaningful positive influence*, *A minor positive influence*, and *A major positive influence*. For each item, we calculated percentages for the extent of positive influence. We also calculated the proportion of respondents who selected each response option from each workshop. We share the range for all workshops with response rates of 50% or higher. Although there is no agreed-upon

standard for a minimum adequate survey response rate, we feel that if at least half of those who attended a workshop responded to our survey, the range of their answers would capture much of the breadth of participant experiences and perspectives for each workshop (Babbie, 1973; Draugalis *et al.*, 2008).

## Results

We identified 33 climate adaptation workshops that met our criteria, which were attended by a total of 914 participants. Attendance ranged from 10 to 61 participants, averaging 28. Workshops were held in-person and ranged in duration from a half day to four days. Some of the multi-day workshops were noncontiguous, such as a two-day vulnerability assessment followed weeks or months later by a follow-up planning workshop. Others included activities outside the workshop itself, such as preliminary planning calls or sustained support from workshop organizers after the workshop. Several convenings were structured as a series of shorter sessions that occurred at regular intervals. Nine workshops took place in 2017, eight in 2018, 11 in 2019, and five in 2020. Twenty workshops were focused on adaptation for specific natural areas, such as national parks or forests. Nine focused on urban settings, with two focusing on natural resources within an urban context (i.e., incorporating adaptation into a city’s urban tree management plan and a university grounds management plan). One workshop focused on small communities in a broader rural context, and another included a mix of rural and urban communities. Seven of the workshops took place in California, three occurred in Colorado, and the remaining workshops took place within 17 additional states. Details on each workshop are provided in Table 2.1. We received 431 responses to our survey, for a global response rate of 57% of the participants for whom we had contact information. Response rates from participants in specific workshops were variable. In 21 of the 33 workshops, our response rates were at or above 50%. Workshops whose response rate fell below this threshold are indicated with an asterisk in Table 2.1 and were excluded from workshop level-analyses. To examine possible impacts of the non-response bias in our sample, we compared respondents and nonrespondents by professional sector for the subset of workshop participants for whom we had this information (269 workshop participants, representing 29% of total participants). We categorized these participants within seven sectors: Federal government (n=45), state government (n=65), local government (n=26), academia (n=59), nonprofit (n=53), tribal (n=17), and private sector (n=4). We ran a chi-square test of independence to examine the relationship between sector and survey response. The result was statistically significant,  $X^2(6, N = 269) = 19.91, p = .003$ . Post hoc analysis suggested that workshop attendees affiliated with local government disproportionately responded to the survey, whereas attendees affiliated with academic institutions disproportionately did not respond. Other groups did not differ in their response rate.

**Table 2.1. Overview of climate adaptation workshops**

	State	Year	Focus	Duration	# Respondents/ # Participants emailed
1	SC	2017	Natural area	4 days	5/16 <sup>a</sup>
2	CO	2017	Natural area	3 days	9/21 <sup>a</sup>
3	GA	2017	Urban setting	1 day	10/18
4	CA	2017	Natural area	4 days	16/22
5	CA	2017	Natural area	2 days	4/7
6	WI	2017	Natural area	2 days	32/43
7	GA	2017	Natural area	2 days	13/15
8	CA	2017	Natural area	1 day	7/18 <sup>a</sup>
9	CA	2017	Natural area	2 days	8/19 <sup>a</sup>
10	ME	2018	Natural area	2 days	7/23 <sup>a</sup>
11	FL	2018	Natural area	2 days	13/17

12	NC	2018	Urban/Rural setting	9 3–4-hour sessions	11/35 <sup>a</sup>
13	NY	2018	Natural area	2 days	17/23
14	MI	2018	Natural area	1.5 days	16/25
15	WY	2018	Natural area	3 days	8/14
16	VA	2018	Urban setting	1 day	10/33 <sup>a</sup>
17	CA	2018	Natural area	.5 days	5/10
18	AK	2019	Rural setting	4 days	8/28 <sup>a</sup>
19	CO	2019	Urban setting	1 day	4/7
20	FL	2019	Urban setting	5, 2–3-hour sessions	10/24 <sup>a</sup>
21	TX	2019	Urban setting	2 days	12/33 <sup>a</sup>
22	CO	2019	Urban setting / Natural area	1 day	18/23
23	NE	2019	Natural area	2 days	18/31
24	WI	2019	Natural area	2 days	17/25
25	NM	2019	Natural area	3 days	8/10
26	SD	2019	Natural area	3 days	7/12
27	ID	2019	Urban/Rural setting	1 day	6/19 <sup>a</sup>
28	CA	2019	Natural area	1 day	16/27
29	AK	2020	Rural setting	3 days	4/19 <sup>a</sup>
30	MD	2020	Urban setting	6, 1.5-2-hour sessions	11/22
31	CA	2020	Urban setting / Natural area	3 days	20/31
32	MD	2020	Natural area	2 days	34/55
33	AZ	2020	Natural area	2 days	22/28

<sup>a</sup> Indicates adjusted survey response rate below 50%

## Workshop outcomes

### Learning outcomes

Open-ended responses about learning were first categorized as individual or collective. Individual learning outcomes were described by the respondent as occurring within a single person. Learning outcomes were considered collective outcomes when participants explicitly stated that the change in knowledge or understanding was shared by more than one participant. Individual outcomes were further coded as procedural, declarative, or perspective-shifting learning outcomes. Few of the collective outcomes were easily classifiable as procedural, declarative or perspective-shifting. For example, one respondent noted that “*We also have a shared understanding and language,*” clearly reflecting collective learning, but not distinguishing between declarative or procedural knowledge, nor indicating a collective shift in perspective. Only four responses coded as collective learning were further classifiable. In each case, they aligned with procedural knowledge. For example, one respondent described a group’s newfound understanding of “*the use of forestry management as a specific tool for achieving climate adaptation and mitigation.*”

Individual and collective learning outcomes across all 33 workshops are described in Table 2.2. The most frequently reported learning outcomes were enhanced knowledge about climate projections and adaptation processes. Seven respondents reported generic learning outcomes, such as “*I learned a lot.*” We did not report these responses among the outcomes described in Table 2.2. Two respondents reported

unique declarative learning outcomes, also not included in the table: *learning that affirms current approaches* and *learning about areas beyond the control of workshop participants*.

**Table 2.2. Individual and collective learning outcomes**

Knowledge domain		Learning outcome	Example	n
Individual	Declarative	Knowledge about climate projections & impacts	<i>I learned about current research looking at which tree species that are not currently dominant in my region will do well in warmer climate conditions.</i>	43
	Procedural	Knowledge about how to adapt to climate change	<i>I got a much deeper understanding of the challenges facing our urban forests and some of the ways to mitigate the impacts of climate change on this vegetation.</i>	50
		Knowledge about where to access resources for climate projections and adaptation	<i>Better understanding of what knowledge base is available about our forest, climate projections for... our region, and what climate analog regions to look at given those projections.</i>	17
		Understanding of the skills, tools, and processes for climate adaptation	<i>I learned about a rapid climate vulnerability assessment and how to conduct one.</i>	14
		Understanding about how to communicate effectively about climate change and adaptation	<i>I learned a greater sense of how to convey the importance of the climate issue to the people my organization represents.</i>	14
		Knowledge about engaging in collective action processes	<i>I think it was informative for me as an early-career researcher (late-stage PhD student) to see how multiple organizations (state and federal government scientists, academic researchers, etc.) came together and identified common goals and priorities when it came to climate change.</i>	5
	Perspective shifting	Shifts in focus or broader changes in thinking and understanding	<i>The Emergency Manager got a broad perspective with which to prioritize the City's preparedness efforts for countering the various threats/risks.</i> -- <i>The realization that culture and cultural impacts aren't normally part of the CC conversations, workshops, etc. and it was important to change that.</i>	30
Collective	Development of shared understandings among participants	<i>Collaborative thinking, including getting differing points of view from folks in differing workplaces.</i> -- <i>We were able to work together to assess potential impacts... to key resources. We also came up with some management strategies to respond to those impacts, and in some cases, came to the realization that we needed to "let some things go" that would be out of our control.</i>	39	

### Relationship outcomes

Seventy-nine participants (18% of respondents; including participants from 84% of workshops) described strengthened networks and relationships in response to the open-ended prompt. Participants reported that these changes occurred both within and across organizations and disciplines. In some cases, these enhanced relationships resulted in the formation of new groups or collaboratives. For example, one respondent wrote: *“I met several folks at the meeting that I’m now actively collaborating with.”* Three respondents highlighted improved communication – for example, *“The most important thing was getting people from the various groups... in the same room talking about the same thing. We often talk past each other in these important issues, and the workshop both helped us to build relationships, and started a common vocabulary, or at least expectations for how future conversations might happen.”* Six respondents felt that the workshops they attended offered opportunities for potential progress toward diversity, equity and inclusion (DEI) outcomes. One respondent noted, for example: *“The workshops were very important for bringing Native American concerns for vulnerable natural resources to the fore. Workshops help to build solidarity and collaboration between the BLM and USFS on one side and members of the concerned public, other agencies, etc.”* Five respondents reported that workshops strengthened the network of actors engaged in climate adaptation by spreading norms around adaptation: *“One outcome was a demonstration of the [staff’s] commitment to climate change adaptation. It is really important to see this engagement and commitment and should represent an example for other land managers.”*

### Efficacy outcomes

Participants indicated that the workshops they attended enhanced feelings of self- and collective-efficacy. In response to closed-ended survey items 35% of respondents reported that the workshop they attended enhanced their sense of self-efficacy a great deal, and 33% of respondents indicated the same impact on their sense of collective efficacy (Table 2.3). Ninety-six percent of survey respondents felt that the workshop they attended at least somewhat enhanced their sense of self- and collective-efficacy. Five respondents focused on enhanced feelings of self-efficacy in their open-ended responses. For example, one respondent noted, *“I gained confidence and was inspired to include considerations for climate change in my work.”* Another explained strengthened feelings of collective efficacy: *“One of the exercises about what we could do in our current role to improve/strengthen combating negative climate effects was eye opening. It helpful to hear what others in my group felt they could do and weigh that against what I think/thought I could do.”*

**Table 2.3: Extent to which the workshop enhanced self- and collective-efficacy**

Outcome Area	Item		Not at all	Somewhat	A great deal	n
Self-Efficacy	<i>Your confidence that you can work effectively on adaptation in your area</i>	Total	4%	61%	35%	325
		Range <sup>a</sup>	0-14%	38%-100%	0-56%	
Collective-Efficacy	<i>Your confidence that the people working on adaptation in your area can achieve success</i>	Total	4%	63%	33%	325
		Range <sup>a</sup>	0-25%	42%-86%	14%-58%	

<sup>a</sup> Indicates the range in the percentage of respondents from individual workshops who selected each answer option.

### Action outcomes



Participants' open-ended descriptions of actions stemming from the workshop fell into three broad categories: *intermediate products* (actions and outputs that arose primarily during the workshop process, such as analyses, brainstorming, or preliminary planning); projects, plans, and initiatives (such as incorporating climate adaptation into formal planning documents, changes to practice, research and monitoring initiatives, new undertakings, or greater involvement in ongoing adaptive processes); and outcomes related to knowledge distribution (such as additional adaptation workshops, publications, or sharing informational resources). Sample responses for each of these outcomes are presented in Table 2.4.

**Table 2.4. Action outcomes**

	<b>Outcome</b>	<b>Example quotes from survey</b>	<b>n</b>
<b>Intermediate products</b>	Assessment and strategies plans developed during the workshop	<i>Taking the time (we never have enough) to really sit down and think about and figure out how to include climate adaptation practices in my work was the largest outcome</i>	32
	Incorporation of climate adaptation into formal planning documents	<i>Included specific suggestions and ideas from the Climate Adaptation workshop in our species management plans.</i>	33
<b>Projects, planning &amp; initiatives</b>	Changes to practice	<i>We identified locations... that could provide climate change refugia for target species. We are able to target monitoring at those locations to see how conditions and species change. We are also able to deter high visitation from those areas.</i>	7
	Individual involvement in ongoing climate projects	<i>Some attendees were more actively involved in the Resilience Project afterwards than they were before the workshop.</i>	4
	Development of adaptation tools for use by workshop participants and others	<i>During one of the many fruitful discussions during the workshop, the need for a menu of adaptation options for non-forested wetlands was identified. My group adopted this as a project and after several years of dedicated work just recently published this menu, which is being used at current adaptation workshops. ... and ... have also formed a fabulous partnership co-leading adaptation workshop around Wisconsin, developing other helpful adaptation resources, and promoting demonstration sites.</i>	4
	Research and monitoring initiatives	<i>One result is a follow up research project on climate change refugia for parks across the... region.</i>	3
	Proposals for grants and research	<i>I was able to use the results of the workshop to develop a solid study proposal for [a grant solicitation].</i>	1
	Infrastructure projects	<i>Several projects in the town have been addressed and completed... These projects include replacement of two deteriorated storm drain culvert boxes and repairs to storm drainpipe... Town Council also approved funding to purchase a DR Equipment Commercial Vacuum for the purpose of cleaning ditches within the town.</i>	1

<b>Knowledge distribution</b>	Sharing information beyond the workshop, additional meetings or workshops.	<i>The workshop prompted important discussions in our region. It resulted in more information circulating to the public regarding resilience.</i>	8
	Publications (peer-reviewed and white papers)	<i>There will be a publication coming out of the workshop, which will add to our best available scientific information.</i>	5

In closed-ended responses (Table 2.5), respondents were somewhat circumspect when asked about the degree to which the workshop they attended stimulated adaptation actions: 41% of respondents were unsure of the workshop’s impact. More than half (53%) of respondents felt the workshop had a minor or moderate impact. Only 5% of respondents indicated that the workshop made a major contribution to adaptation action in the area.

**Table 2.5. Extent to which the workshop helped stimulate adaptation actions in the area**

	<b>I am unsure of the workshop’s impact</b>	<b>Not at all</b>	<b>A minor amount</b>	<b>A moderate amount</b>	<b>A major amount</b>	<b>n</b>
Total	41%	2%	23%	30%	5%	304
Range <sup>a</sup>	0-75%	0-12%	11-50%	0-60%	0-11%	

<sup>a</sup> Indicates the range in the percentage of respondents from individual workshops who selected each answer option.

### **Effective elements of adaptation workshops**

Participants’ perceptions of workshop elements that positively influenced outcomes can be broadly categorized as relating to opportunities for varied interactions with a diverse group of participants; useful materials and opportunities to practice using them; the roles of high-quality facilitators; and a focus on real-world, local applications linked to ongoing responsibilities or projects. Table 2.6 presents qualitative coding results of participants’ write-in responses detailing specific aspects of these elements. Participants’ responses to closed-ended questions about workshop attributes are detailed in Table 2.7. Results from these open- and closed-ended questions largely aligned.

Participants valued workshops where attendees brought a range of backgrounds, roles, and areas of expertise. They also valued seeing both new and familiar faces at workshops. In response to closed-ended questions, 45% of respondents indicated that pre-existing relationships between workshop attendees had a major positive influence on workshop outcomes, and an additional 47% indicated that these relationships had a minor positive influence (Table 2.7). Relationships that were formed or strengthened during the workshop also contributed to workshop outcomes: 43% of respondents indicated a major positive influence, and an additional 45% reported a minor positive influence.

Participants valued variety in the kinds of opportunities they had to engage in adaptation workshops, including breakout groups, expert presentations, open discussion, report-outs of breakout activities, and time for networking and collaboration. They especially valued opportunities to try out tools, data, and other materials shared during the workshop. For example, one participant reported that they valued *“Going through the Adaptation Workbook and being able to take the workbook back and have that resource available when making climate adaptation plans within our individual agencies or entities.”* These materials were particularly useful when they were linked to participants’ work responsibilities, as one participant noted: *“being able to apply the information directly to OUR work was highly effective.”* Participants also noted that tools served as a focal point for interactions: *“[the workbook] inspired dialogue, critical thinking and hard conversations about project design and implementation and also walked us through using a structured process for incorporating climate resiliency into our project design and implementation.”*

**Table 2.6. Participant perceptions of effective elements of climate adaptation workshops**

<b>Element area</b>	<b>Element</b>	<b>n</b>
<b>Diverse interactions</b>	<b>Breakout groups:</b> Small-group discussion and activities	76

	<b>Expert presentations:</b> Panels and lectures from subject-matter experts	44
	<b>Networking:</b> Opportunities for networking and collaboration	38
	<b>Discussions:</b> Discussions among participants (in plenary or unspecified)	27
	<b>Report-outs:</b> Presentations to plenary on breakout processes and findings	16
<b>Focus on real world, local applications linked to ongoing responsibilities or projects.</b>	<b>“Real world” focus:</b> Examples and case studies (success stories and failures); focus on participants’ own projects	52
	<b>Applicable research &amp; evidence:</b> Climate projections and research scaled to relevant geographic area or workshop focus	29
	<b>Adaptation strategies:</b> Specific approaches for taking action	12
	<b>Scenario plans:</b> Focus on exploring a range of possible futures	12
<b>Diverse participants</b>	<b>Multiple perspectives:</b> Participants with a range of backgrounds, expertise, experience, and roles	51
<b>Useful materials and opportunities to practice</b>	<b>Tools, menus &amp; other resources:</b> Workbooks, websites, and other material shared during the workshop	19
	<b>Practice using resources:</b> Opportunities to try using material shared during workshop	14
<b>Roles of quality facilitators</b>	<b>Creating a clear structure:</b> Clear organization, agenda, and objectives	10
	<b>Advancing the workshop:</b> Keeping people on track, taking notes, logistics	8
	<b>Framing &amp; knowledge:</b> Directing workshop orientation and sharing facilitator expertise	6
	<b>Enabling social processes:</b> Balancing power dynamics, promoting participation	4

**Table 2.7. Extent to which workshop elements had a positive influence on workshop outcomes**

Element		No meaningful positive influence	A minor positive influence	A major positive influence	n
The quality of the facilitator	Total	3%	21%	77%	261
	Range <sup>a</sup>	0-25%	0-43%	50-100%	
Pre-existing relationships between workshop attendees	Total	8%	47%	45%	260
	Range <sup>a</sup>	0-40%	0-86%	14-83%	
Realistic strategies developed during the workshop	Total	7%	49%	44%	259
	Range <sup>a</sup>	0-29%	0-100%	0-83%	
Leadership by specific individuals after the workshop	Total	21%	49%	30%	254
	Range <sup>a</sup>	0-38%	17-100%	0-67%	
Commitments that people made during the workshop	Total	25%	57%	18%	257
	Range <sup>a</sup>	0-50%	17-100%	0-50%	

<sup>a</sup> Indicates the range in the percentage of respondents from individual workshops who selected each answer option.

Participants also highlighted the value of high-quality facilitation in adaptation workshops and identified a range of supportive roles facilitators can perform. In closed-ended responses, 77% of respondents reported that the quality of the facilitator had a major positive influence on their workshop’s outcomes (Table 2.7). In open-ended responses, participants indicated the ways facilitators contribute to adaptation workshops. Skillful facilitators create a clear organizational structure for the workshop by developing realistic agendas and objectives; advance the workshop by keeping people on track, taking notes, and attending to logistics; share their own knowledge and expertise and frame the workshop’s overall orientation; and enable social processes by balancing power dynamics and promoting participation. For example, one participant noted that the facilitators “...brought people together to communicate effectively. No matter how much you know or have to offer, if a meeting of minds is not facilitated properly, you will not make any progress.” Another wrote that “expert moderation was an important factor in framing the discussion and development of local resilience criteria.”

Finally, participants valued workshop content oriented around real world applications linked to their ongoing work, responsibilities, and projects. This included a focus on concrete examples, locally applicable research, success stories, specific strategies tailored to their context, and scenario planning that focused on exploring a range of possible futures. For example, one participant lauded workshop segments “where participants came with real world issues and we discussed how to plan and address them, [and] presenters who discussed projects that they had completed.”

Three respondents—each from a different workshop—reported that the workshops they attended did not produce meaningful outcomes. They identified two reasons they felt the workshops failed: Participants lacked expertise necessary for meaningful contributions, and the structure of the workshop was poorly aligned with the goals of the gathering.

## Discussion

### *Adaptation workshop outcomes*

Our results suggest that workshop participants find value in the events they attended and that workshops can play a meaningful role in climate change adaptation. Participants identified a range of meaningful workshop outcomes, including learning, relationship, efficacy-related, and action outcomes. Learning that took place during workshops included the development of shared understandings among participants, as well as individual procedural, declarative, and perspective-shifting learning. Relationships were formed and strengthened during adaptation workshops, with some participants reporting the creation of new groups and collaborations. Participants also indicated that the workshops they attended enhanced their feelings of self- and collective-efficacy. These findings align with previous literature that identified workshop outcomes related to learning (e.g., de Vente et al., 2016), relationships (e.g., Phadke et al., 2015), and efficacy (e.g., Olabisi, 2022).

Study participants attributed a range of action outcomes to the workshops they attended. They reported that workshops contributed in meaningful ways to planning processes, spurred additional knowledge seeking and sharing, and—less consistently—led to concrete adaptive actions. The most common action outcomes were intermediate products developed during the workshop process itself, such as the creation of vulnerability assessments or adaptation strategies. Another frequently reported outcome was the incorporation of adaptation strategies into formal planning documents. Other action outcomes, such as infrastructure projects, longer-term changes to practice, and research and monitoring initiatives, were reported less frequently. These tended to be relatively low-cost endeavors that were within the power of individuals or small groups to undertake, such as replacing storm culvert boxes or deterring natural-area visitors from entering designated climate refugia. Beyond their primary adaptive functions, these “small wins,” could also contribute to a sense of efficacy and accomplishment, build capacity for further action, and develop constituencies for future efforts (Termeer *et al.*, 2013; Termeer & Dewulf, 2019). Larger initiatives, which often require substantial planning, permitting, and funding, may reach fruition over longer time-horizons than our inquiry allowed.

Although most survey respondents were willing to attribute specific outcomes to the workshops they attended, 41% were unsure of their workshop’s impact. This uncertainty may be because workshops take place within broader contexts of other ongoing, long-term activities and planning efforts, which can complicate the attribution of specific outcomes to an individual workshop (Tuler *et al.*, 2020). Alternatively, participants may have thought that subsequent projects and initiatives could have occurred irrespective of whether the workshop they attended took place. Regardless, the range of outcomes attributed to workshops—and the fact that only 2% of respondents reported that the workshop they attended did not advance adaptation in the area—suggest that participants generally believed workshops can promote meaningful outcomes.

### ***Valued workshop elements***

Participants highlighted workshop elements that they felt most powerfully catalyzed outcomes, including the ability to engage with a diverse group of participants, opportunities to practice deploying locally-relevant data and tools, and well-facilitated processes. Respondents valued workshops that afforded opportunities to learn with and from their peers in breakout groups and discussions. Workshop outcomes were also reportedly enhanced by the participation of individuals whose experience and expertise were appropriate for the workshop context. The presence of familiar faces at workshops as well as opportunities to develop new relationships were both reported to improve to workshop outcomes. These findings align with prior research on team management (Parise & Rolag, 2010) and professional networks (Bodin *et al.*, 2019), which suggests that preexisting connections can help enhance the formation of new relationships among indirectly linked individuals and contribute to group performance.

Participants valued workshop content focused on real-world impacts, climate data scaled to a relevant geographic scope, and the use of project-based approaches and tools to develop realistic strategies linked to ongoing work responsibilities. Prior research suggests that adaptation planning tools—defined here as

replicable, structured, formal methods to advance participant understanding—can help groups collectively define problems, generate possible solutions, and prioritize among them (Plate et al., 2020). In addition, a tight focus on local projections, impacts, and solutions can enhance workshop outcomes (Bormann et al., 2019; Plate et al., 2020; Schmitt et al., 2021; Tuler et al., 2020). In combination, with other valued elements, such as expert presentations and group discussion, these workshop features could encourage the formation of shared understandings. For example, participants reported that using an adaptation workbook in a small group to walk through designing a project helped spur critical thinking and dialogue. By making the process of climate adaptation more “*tangible*,” as one participant put it, these workshop elements could also help enhance feelings of individual and collective efficacy. Participants also reported using the tools post-workshop as communication and instructional aids with their home organizations and external stakeholders. This may help explain why knowledge-sharing emerged as an important action outcome of adaptation workshops. Having experienced tools spurring effective dialogue during a workshop, participants may have felt emboldened to use them in similar ways afterward.

Workshop facilitation clearly matters. Harvey and colleagues suggest that facilitators’ primary role is “supporting people to change their practice,” and that facilitators’ functions lie along a spectrum, from “doing for” others to “enabling” others (2002, p. 585). “Doing for” others entails performing functions such as managing projects or providing technical assistance, whereas “enabling” relates to efforts to “explore and release the inherent potential of individuals” and groups (Harvey, 2002, p. 581). Many facilitators perform both roles, and adaptation workshop participants valued approaches related to both “doing for” and enabling” facilitation. Participants reported that facilitators performed “enabling” functions, such as helping to frame discussions, advancing social processes, and expediting participant goal formation and learning. Facilitators were also valued for performing “doing for” functions, such as ensuring that limited time was used effectively and that insights, ideas, and next steps were captured and carried forward. Facilitators’ efforts outside the workshop itself, such as shaping the agenda in collaboration with local partners and curating the tools and data with which participants would engage during the workshop, also undergird many of the other valued workshop elements. These findings align with prior research suggesting that facilitation can contribute to learning, conflict resolution, and enhanced trust, among other adaptation outcomes (de Vente et al., 2016).

### ***Adaptation workshops as venues for norm formation & reference group expansion***

Participants in the climate adaptation workshops in this study reported that they valued gaining broader exposure to additional disciplinary and cultural vantages as well as deepening relationships across those boundaries. This preference for collaboration and the prevalence of perspective-shifting and collective learning among workshop participants may be indicative of reference group expansion and norm formation in workshops. Norms are socially prescribed standards for behavior, and they are associated with many climate-related behaviors (Nolan, 2021). Reference group theory helps explain the process by which climate adaptation workshops could foster norms around climate adaptation and, in turn, promote collective action. Reference groups are the groups with whom individuals share cultural and normative commitments (Merton, 1968). Individuals use reference groups to help shape their values and attitudes about situations, and, as such, they are powerful drivers of beliefs and behaviors. Reference groups may be familiar individuals, such as family or co-workers, or more distant referents, such as politicians or thought leaders. Individuals can shift their reference groups over time, and events such as adaptation workshops could serve as venues where reference groups are updated and expanded. As participants experience shifts in their focus and understanding vis-à-vis climate adaptation and perceive the development of shared understandings among other attendees, they may also expand their reference group. In turn, this broadened reference group could contribute to the formation and reformation of norms around adaptation, buttress efficacy beliefs, and open new pathways toward adaptation solutions (Doherty & Webler, 2016; Stern and Coleman, 2015).

### ***Study Limitations***

Several limitations should inform interpretation of this study. These include a relatively small sample of workshops (n = 33) and modest response rates (averaging 57% of participants in each workshop), making it possible that self-selection bias may have impacted the results. People are more likely to respond to surveys when they are interested in the subject matter (Groves *et al.*, 2004; Fan & Zheng, 2010). Thus, those who had positive experiences in a workshop or felt that the workshop contributed to meaningful outcomes may have been more likely to dedicate the time necessary to complete a survey about their experience. We expect this may have resulted in a positive bias for workshop evaluations and outcomes. We have little information about nonrespondents, but our analysis of workshop participants' professional affiliations suggests that attendees affiliated with local government responded to the survey to a higher degree than those affiliated with universities. Thus, our sample may overrepresent the perspectives of local government employees.

Because we rely on survey data for these analyses, we don't know how often a particular workshop attribute or characteristic was present during a particular convening. Therefore, when respondents report what they think made the biggest difference, we may be missing things that might be critically important, but simply didn't take place in these 33 workshops.

Two attributes of the timing of this survey complicate interpretation. First, we administered the survey during the COVID-19 pandemic, which likely impacted our results (e.g., actions delayed or derailed by COVID priorities or complications, networks altered by pandemic-related restrictions and job shuffling). Second, the range in time elapsed between when each workshop ended and when our data collection began pose an additional challenge. In instances where workshops occurred up to three years before we administered the survey, respondents might have struggled to recall the specific workshop and to articulate linkages between the workshop and outcomes. Conversely, when we administered surveys within a year of a workshop's conclusion, longer-term workshop outcomes may not yet have manifested. Thus, this study provides a snapshot into the possible outcomes of climate adaptation workshops and some of the elements that participants feel best catalyze those outcomes. It does not provide a representative picture of the general effectiveness of such workshops overall. To address some of these limitations and gain additional insights, future research could also attempt to untangle which aspects of adaptation workshops most contribute to improved outcomes by identifying commonalities and differences among workshop-level contexts, elements, and outcomes.

### **Conclusion**

As the need for climate adaptation grows, place-based workshops may play an important role. Effective workshops convene key actors with diverse perspectives and provide tools, examples, and data calibrated to the needs of the participants. They can advance learning for adaptation, strengthen networks and broaden reference groups, enhance feelings of efficacy, and contribute to a range of action outcomes. As climate impacts become increasingly widespread, and the national conversation around climate change and the adaptation field continues to mature, climate adaptation workshops could serve as nexuses for the dissemination of norms and knowledge around climate adaptation and as springboards for enduring positive change.

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## Chapter 3

### **Climate adaptation as a team process: The role of place-based climate adaptation workshops in catalyzing collective action**

#### **Abstract**

Place-based climate adaptation workshops are an increasingly common approach to advance collective efforts to prepare for, and cope with, the effects of climate change. We conducted a comparative case study, using surveys, interviews, and archival review across 30 workshops that took place in the United States between 2017 and 2020 to identify which workshop characteristics were most often associated with subsequent adaptation-related planning and action. Workshops that featured local champions who advanced workshop efforts and benefited from sustained post-workshop support from backbone support organizations or workshop organizers yielded the strongest post-workshop climate actions. Co-design of workshop processes and products by organizers and helped galvanize action by deepening relationships, strengthening collective efficacy, and fostering the creation of shared vision and understanding among workshop participants. Our findings outline a potential framework for implementing impactful adaptation workshops and offer insights for incorporating complex science into collective initiatives.

#### **Introduction**

The impacts of climate change are present, pervasive, and predicted to persist and progress (Pörtner et al., 2022). In response, individuals and groups are engaging in climate adaptation, or “the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities” (Pörtner et al., 2022, p. 5). One approach being used to advance climate adaptation is place-based climate adaptation workshops, which we define as *convenings or series of convenings designed to help multiple stakeholders develop strategies for adapting to climate change in a specific place* (Stern et al., 2023). These workshops can yield a range of planning and action outcomes that may contribute to adaptation in an area (Butler et al., 2015; O’Brien et al., in review; Tuler et al., 2020). Planning outcomes include developing novel strategies for adaptation, creating adaptation plans, or incorporating adaptation into related planning documents. Action outcomes include tangible activities resulting from the workshop, such as changes to professional practices, implementing specific projects, or coordinating activities within a group. These actions, in turn, can reduce a place’s vulnerability to climate risks, increase system resilience, or enhance a community’s adaptive capacity (Cinner et al., 2018; de França et al., 2009; Osbahr et al., 2010).

To advance understanding of the ways workshops can contribute to adaptation processes and why some workshops yield stronger outcomes than others, we sought to answer the following research question:

***What characteristics of place-based climate adaptation workshops are associated with higher degrees of planning and action?***

We draw upon the concept of team processes to explore the characteristics of adaptation workshops associated with planning and action (Marks et al., 2001). Team process theory suggests that groups draw upon a range of inputs that inform the collective processes they undergo, which in turn contribute to emergent states and outcomes. Our approach sorts the cases in our sample by the nature of the planning and action outcomes identified by participants and explores differences in the inputs, processes, and emergent states associated with higher- and lower-performing workshops.

#### **Literature Review**

### **Adaptation workshops as team processes**

Marks and colleagues (2001) developed a framework of team processes, which suggests that teams move through cyclical stages of teamwork, and that within each cycle, team outcomes result from a combination of inputs, processes, and emergent states. In the team process framework, inputs encompass team attributes and contextual elements that shape team function (Maltarich et al., 2016). Team attributes include factors such as personality types and tasks, whereas contextual elements include factors like the resources available to the team. Team processes are the interactions among team members as they undertake their work, such as communication, collaboration, and task division (Maltarich et al., 2016). Emergent states are attributes of team dynamics that arise from, and contribute to, team inputs and processes. Emergent states can encompass cognitive, affective, and motivational attributes (Rapp et al., 2021). Cognitive emergent states include shared understandings and goals. Affective emergent states include relational attributes such as trust and interpersonal relationships. Motivational emergent states can include feelings of collective efficacy and ownership (Bandura, 2000).

The outcomes of effective place-based climate adaptation can be viewed as resulting from team processes, as they benefit from coordinated efforts across plans, sectors, and actors (Berke et al., 2019; Meerow & Woodruff, 2020). In these cases, the team is comprised of the individuals collaborating on climate adaptation, regardless of their organizational home or sector. Although climate adaptation processes may involve groups that are only loosely affiliated, and who may not identify themselves as teammates, we feel the team process framework offers an appropriate structure to understand place-based group climate adaptation efforts. We describe aspects of workshop inputs and processes identified in prior literature as factors related to emergent state and outcomes of climate adaptation workshop.

### **Workshop inputs**

Empirical research suggests a range of inputs may influence outcomes of local adaptation efforts, including the existing network of individuals and groups engaged in climate adaptation, the presence of local climate champions, experiences of extreme weather events thought to be linked to climate change, policy mandates, and the political context of an area (e.g. Adger, 2003; Demski et al., 2017; Egan et al., 2017; Hanleybrown et al., 2012). Robust networks can serve as avenues for information exchange, resource mobilization, conflict negotiation, and consensus building (Juhola and Westeroff, 2011; Moser et al., 2008). Conversely, actions undertaken in contexts where network members are confined to silos may result in solutions that maintain the status quo, fail to seize opportunities for systemic change, or lead to unintended consequences and maladaptation (Voulvoulis et al., 2022).

The individual actors within those networks also contribute to outcomes. Local champions are individuals who are committed to helping a group achieve a shared goal, and they can be especially important for advancing outcomes (Hanleybrown et al., 2012). Local champions can serve a variety of roles and functions within a collective process. In a climate change adaptation context, they can promote the use of specific decision-support tools within organizations; serve as a “conduit” between researchers and practitioners for disseminating climate information and strategies; and develop, advocate for, and implement innovative ideas (Hodgkinson, Hobday, & Pinkard, 2014, p. 1675; Holmes & Butler, 2021). For example, in a case study of two municipalities in the South Africa’s Western Cape, Pasquini and colleagues (2015) identified environmental champions within political leadership as key catalysts for climate change adaptation at the level of local governments. In an assessment of coastal adaptation efforts in Nova Scotia, Canada, Righter and Chang (2023) found mixed support for the importance of champions in advancing adaptation actions, suggesting that their role may vary by the context in which adaptation is taking place. In the context of place-based adaptation workshops, local champions could help external

facilitators navigate local norms, communicate the goals of an initiative to the local community, mobilize attendees, and maintain momentum after a workshop (Nkoana, Verbruggen, & Hugé, 2018).

In addition to the involvement of local champions, workshops may benefit from the input of participants from a range of disciplinary backgrounds and areas of expertise (Stern et al., 2023). Recruiting and sustaining the involvement of attendees with the power to make decisions or implement projects, those directly impacted by potential actions, and representatives from a wide range of professional and disciplinary sectors is thought to help groups create a more accurate understanding of the climate impacts on the system of interest and to forestall some maladaptation, or actions that lead to increased vulnerability to climate change (Bertana et al., 2022; Stern et al., 2023).

Other contextual factors may also help focus or divert the efforts of individuals and networks on climate change adaptation. Experiencing extreme events—such as flooding, wildfires, or straight-line wind events—can trigger adaptation planning, by opening policy windows for action, increasing the salience of climate change, and elevating a community’s perception of climate risks (Berrang-Ford et al., 2011; Demski et al., 2017). The presence of higher-level policy mandates can also spur adaptive planning, although the quality of local responses to those mandates may vary widely from perfunctory box-checking to more meaningful undertakings (Boudet et al., 2020; Butler et al., 2021; Shi et al., 2015). Finally, the prevailing political context in an area may influence adaptation efforts: considerable evidence suggests that Democrats are significantly more likely than Republicans to agree that human caused climate change is real, and that disparity can, in turn, influence how communities prioritize their collective efforts (Carmichael et al., 2017; Egan et al., 2017).

### **Workshop processes**

The format and structure of adaptation workshops may influence workshop outcomes (Coleman & Stern, 2018; Roche, Pidd & Freeman, 2009; Tuler et al., 2020). Credible, expert facilitators can enhance deliberation, promote trust, frame challenges in a constructive manner, keep participants on task, and help groups integrate scientific understanding with other priorities and ways of knowing (Chamber et al., 2021; Coleman et al., 2018; Devente et al., 2016; Turner et al., 2016). Processes that focus on addressing specific, manageable problems and which allow participants to engage in small groups with other motivated participants have also been associated with positive outcomes (Roche, Pidd & Freeman, 2009). Tuler and colleagues (2020) assessed the adaptation, policy, and capacity-building outcomes from 14 iterations of an engagement process designed to support local vulnerability assessments and adaptation planning. They found that process elements including coordination between workshop processes and ongoing activities, sufficient time for meaningful deliberation, and facilitator support for creative thinking contributed to meaningful outcomes. Additional interventions or incentives to act post-workshop, such as follow-up phone calls or feedback on performance, can also support adaptation by helping participants bridge the gap between workshop activities and their ongoing responsibilities (McWilliam, 2007; Stern et al., 2023).

Ongoing coordination led by backbone support organizations can be a key part of efforts to achieve large-scale collaborative impact (Kaina & Kramer, 2011). Backbone support organizations are entities with dedicated staff and coordination skills to help keep member organizations and agencies on track over time. They can serve a range of roles in collaborative efforts such as climate adaptation, including helping to establish a common vision for the group, enabling dialogue among partners, prioritizing data collection and establishing shared measures, building public support, advancing policy, and gaining access to funding (Turner et al., 2012). As part of broader efforts to advance collective action, backbone support organizations have been found to be effective in a range of contexts, including healthcare, non-native



species management, and climate change initiatives (Braun et al., 2016; Chambers et al., 2021; Ledley et al., 2014; Truett-Theodorson et al., 2015).

As researchers, scientists and others have increasingly recognized the importance of collaborative decision-making and power sharing for achieving meaningful climate action, co-design of climate science engagement has gained greater prominence (Fleming et al., 2023). Co-design, a process in which participants are actively engaged in the development and deployment of an initiative, may empower stakeholders, improve the quality of planning decisions, and increase the relevance of climate science to a range of problem areas (Butler et al., 2020; Collins & Ison, 2009; Neset et al., 2021). In an assessment of 32 sustainability-related initiatives from around the globe, Chambers and colleagues (2021) found that initiatives that were collaboratively designed and practiced—and which continued over longer durations—were linked to improved outcomes.

Taken together, these findings suggest that workshop processes that are designed with and for participants, account for the local context, include steps to link workshop products with subsequent action, and feature effective facilitation that enhances the learning and interpersonal aspects of workshops can together help advance meaningful climate adaptation efforts.

### **Emergent states**

As team processes play out during and after a climate adaptation workshop, cognitive, affective, and motivational emergent states may arise (Marks et al., 2001). Here, we consider social learning, aspects of social capital, and collective efficacy as cognitive, affective, and motivational emergent states, respectively.

#### ***Cognitive: Social Learning***

Social learning encompasses processes through which groups collectively learn and share knowledge, thereby enabling collective action (Cundill & Rodela, 2012). In a systematic review, Suškevičs and colleagues (2017) found that social learning is linked to improved natural resource management outcomes. They found that this cognitive emergent state can be enhanced by fostering interactions between distinct organizations that operate at multiple scales (such as local, regional, and national) and by leading participants through activities designed to build new skills. Similarly, a recent Delphi study of climate adaptation workshop facilitators suggests that climate adaptation workshops may advance social learning by convening a diverse group of relevant actors and enhancing their sense of community and mutual understanding (Stern et al., 2023).

#### ***Affective: Enhanced social capital***

Social capital describes “relations of trust, reciprocity, and exchange; the evolution of common rules; and the role of networks” (Adger, 2003, p. 389). Here, we focus on the affective elements of social capital, such as feelings, attitudes, and emotions toward others. Strengthened social capital is linked to a range of positive outcomes, such as improved collaborative governance and greater knowledge generation and diffusion within networks (Burch et al., 2014; Bodin & Crona, 2009; Crona & Bodin, 2006). Trust can play a particularly important role in shaping the outcomes of collaborative processes, including landscape-scale forest restoration efforts (Stern and Coleman, 2015), transboundary collaboration in fisheries (Song et al., 2019); sustainable development initiatives (Chambers et al. 2023); and local-level adaptation planning (Kettle & Dow, 2016).

#### ***Motivational: Collective Efficacy***

Collective efficacy describes “people's shared beliefs in their collective power to produce desired results” (Bandura, 2000, p. 75). It is associated with the degree of group investment in a collective endeavor and their sustained commitment in the face of setbacks. In a climate change adaptation context, higher degrees

of perceived collective efficacy have been associated with greater collective action, such as activities to conserve water resources or preparations for extreme weather events (Azad et al., 2022; Thaker et al., 2016).

### **Outcomes**

Evaluating meaningful climate adaptation is a challenge, due to the context-specific, iterative nature of climate adaptation efforts (Moser & Boykoff, 2013; Vogel et al., 2014). Moser & Ekstrom (2010) developed a framework for categorizing climate change adaptation processes across three temporal phases: understanding, planning, and management. Adaptation workshop outcomes can be situated within each phase of Moser and Ekstrom's framework. Although the reality of climate adaptation is often far less orderly than a tidy linear progression, these stages of adaptation provide a useful means of categorizing some common processes and challenges of climate change adaptation.

The understanding phase involves aspects of problem detection, awareness raising, information gathering, and steps to frame and reframe the problem (Moser & Ekstrom, 2010). For example, in a recent assessment of government efforts to address sea level rise in coastal counties in Florida, Hines and colleagues (2022) found uneven progress in counties' efforts to move through the understanding phase. They found that 40 percent of counties did not recognize the need to respond to climate change and sea level rise-based risks in planning documents, and that 60 percent lacked defined policies for conducting climate vulnerability assessments.

Planning involves developing, assessing, and selecting adaptation options. These aspects of planning can be an important step in collaborative processes, helping a group establish direction, alignment, and commitment around adaptation goals (Drath et al., 2008). Formal planning efforts gained greater prominence in the United States beginning in the 1980s, and since the early 2010s, planning related to climate change adaptation and mitigation has become an increasingly important planning area for communities (Berke and Conroy, 2000; Campbell, 2016). These planning efforts may be undertaken voluntarily, or in response to mandates, such as state-level requirements that compel communities to incorporate climate adaptation into comprehensive plans (Butler et al., 2021).

The European Environment Agency identified three types of adaptive action that communities may implement during the managing phase of climate adaptation processes: grey, green, and soft (EEA, 2013). Grey actions reduce vulnerability through technical and engineered solutions, such as beach nourishment or constructing levees. Green activities draw upon ecosystem services to advance adaptation, such as restoring wetlands to buffer flooding. Soft actions seek to alter human behavior and governance approaches, through efforts such as educational outreach or changing policy. Activities such as monitoring outcomes and evaluating the efficacy of the action, can be applied across grey, green, and soft actions (Moser and Ekstrom, 2010).

Moving from planning to implementation can challenge communities seeking to achieve their climate adaptation goals, as planning outputs do not necessarily entail action outcomes (Runhaar et al., 2018). In assessments of adaptation and mitigation efforts around the world, scholars have found widespread evidence of a gap between the actions prescribed in policies and plans and concrete steps actually undertaken (Mahlkow & Donner, 2017; Millard-Ball, 2012; Runhaar et al., 2018). This gap may be due to difficulties overcoming organizational routines, the different identities of the people planning actions and those charged with carrying them out, lack of funding, staffing constraints, and other barriers (Saha & Paterson, 2008; Uittenbroek, 2016). Our research seeks to identify adaptation workshops that most effectively help communities span this gap and to identify the inputs, processes, and emergent states that enable meaningful climate adaptation.

## Methods

We applied a mixed-method comparative-case case study design to address this question. Comparative case studies are an appropriate research method because this work seeks to answer questions about contemporary happenings without demanding tight control of behavioral events (Yin, 2013). Following Eisenhardt (1989), our approach was an iterative exercise of gathering and analyzing data and enfolding additional concepts and frameworks by checking, fitting, and disconfirming propositions in the literature as new themes emerged.

We employed three data collection methods: interviews with workshop facilitators and local conveners; the collection and review of documents such as agendas, reports, and publications; and surveys of workshop participants. Drawing on multiple data sources can enhance a study's validity and reliability by allowing for triangulation of different perspectives and affording a more complete understanding of the data (Glesne and Peshkin, 1992; Yin, 2013). Unlike research that generalizes to populations through statistical means, case studies rely on “analytic generalization,” that is, generalizing to theory (Yin, 2009, p. 43). We aimed to build theory based on our empirical findings of the sampled cases about what workshop characteristics may lead to different outcomes related to climate adaptation. To do so, we used Marks and colleagues' (2001) team process framework to identify what inputs and processes seemed to lead to positive emergent states that subsequently influenced meaningful outcomes for participants.

### *Case selection*

We included workshops that took place in the United States and involved at least ten participants from a range of stakeholder groups and which lasted at least half a day. We opted to exclude workshops whose geographic scope encompassed entire states or larger regions, as these tend to be more general trainings, rather than focused on adaptation within a specific location. This limited our sample to specific geographies within which cohesive and tangible adaptation activities could reasonably take place. We included workshops that were conducted from 2017 to March 2020—a range that we felt allowed enough time for meaningful action to potentially result from a workshop, but not so much time that participants might fail to recall the event's specifics.

We identified potential cases through three avenues. First, we asked a panel of 22 expert adaptation-workshop facilitators, who were participating in a related Delphi Study (Stern et al., 2023), to identify all recent adaptation workshops of which they were aware. Second, we sent out a call for workshops on listservs and other platforms frequented by workshop facilitators, such as the American Society of Adaptation Professionals (ASAP) and the Climate Adaptation Knowledge Exchange (CAKE). Finally, we used snowball sampling by asking the facilitators of adaptation workshops in our initial sample to help identify other possible workshops to include. We identified a total of 62 potential workshops that appeared to meet our criteria, and we proceeded with data collection on 33 workshops. For the remaining 29 workshops, we were unable to contact the organizers, or they declined to participate.

### *Data collection and analysis*

Data collection took place between July 2020 and March 2021. For more recent workshops, we waited until at least 6 months had elapsed since the event to begin data collection. For each case, we began data collection with semi-structured interviews with the facilitator(s) of the workshop. In the interview, we solicited information about the genesis of the workshop and the context in which it took place, the participants, how the workshop unfolded, and what had happened since. We worked with facilitators to

obtain contact information for workshop participants. We then emailed participants an invitation to participate in an online Qualtrics survey. This survey gathered information on participants' goals, goal achievement, workshop outcomes, workshop components, constraints, and open-ended recollections of the most and least valuable components of those workshops. We sent a follow-up email to nonrespondents after one week, and a final reminder email after two weeks.

Next, we interviewed the local convener(s) for each workshop. Local conveners are facilitators' counterparts who are based in the workshop location. They often help facilitators plan and execute adaptation workshops by identifying and recruiting participants and helping facilitators understand the local context. In instances where no local convener was available, we instead interviewed workshop participants whom facilitators indicated could speak meaningfully to what has occurred since the workshop. Interviews with local conveners covered topics similar to those explored in our interviews with facilitators. We asked conveners to help interpret our preliminary summary findings from the surveys of workshop participants as a form of member checking (Doyle 2007). All research protocols involving human subjects were approved by the Virginia Tech Institutional Review Board.

We also collected artifacts associated with each workshop, such as invitations, agendas, websites, reports, evaluations, and meeting notes. We solicited these materials from facilitators and local conveners, and we conducted web searches to identify additional material. We used these artifacts to augment our understanding of the duration, structure, and purpose of each workshop; to guide specific interview questions; to corroborate workshop outputs and outcomes; and to further understand contextual elements contributing to the workshop.

All interviews were transcribed by the lead author. The transcripts were then coded by the lead author through an iterative process of identifying and refining themes. These themes were a mixture of emergent elements and pre-existing aspects identified in prior literature—including the team process framework, climate champions, cycles of value creation, aspects of the collective impact framework, and the attributes of communities of practice (Bailey, 2017; Marks et al., 2001; Miles et al., 2018). They were augmented with additional codes on subsequent passes through the data. Codes were discussed and vetted with co-authors during the coding process. We calculated descriptive statistics for quantitative survey data and thematically coded responses to write-in questions. We drew upon the interviews, artifacts, and survey data to draft memos for each case (Bailey, 2007). These memos described the community context in which the workshop took place, the genesis and structure of each workshop, participant and facilitator perceptions of the elements that contributed to positive outcomes, mistakes and missteps, emergent states that arose from the workshop, the events and actions that took place after its conclusion, and analytic notes that connected and interpreted these elements.

## ***Workshop outcomes***

### *Identifying effective workshops*

We drew upon interview and survey data to identify workshop outcomes. To capture organizers' perspectives of outcomes, we drew upon interviews with facilitators and local conveners to identify evidence of planning and action outcomes. If either the facilitator or local convener reported a planning or action outcome they definitively attributed to the workshop during our interviews, we coded that outcome as present. If neither interview source reported an outcome, we considered it absent.

We also drew upon the following open-ended question from the survey to identify workshop participants' perspectives on outcomes: "Please describe any meaningful outcomes that you feel happened specifically as a result of the workshop(s) that might not have happened if it had not taken place." We coded all responses through an iterative process of open and axial coding (Bailey, 2017), settling on the broad

codes of planning and action outcomes described in Table 3.1. Codes were scaled to the workshop level to enable an exploration of workshop-level characteristics and outcomes. We considered evidence for an outcome present if any respondent from a workshop reported an outcome in that category. For example, if zero respondents indicated planning outcomes, but two respondents attributed adaptation actions to the workshop, we considered that workshop to have generated action outcomes but not planning outcomes.

We then sought to distinguish the highest- and lowest-performing cases in our sample. To do so, we sorted all cases into three categories: workshops with the strongest evidence for impact, workshops with mixed evidence for impact, and workshops with weak evidence for impact. In our assessment of workshop impact, we prioritized evidence for adaptation actions underway or completed over planning outcomes to account for the planning-implementation gap in enacting climate adaptation efforts. However, we recognize that planning is, itself, often viewed as an important workshop outcome by participants and organizers, and it is often a precursor to meaningful action. We also note that workshop participants and facilitators have distinct perspectives on the events and their outcomes, and they each provide unique data that can help triangulate workshop outcomes.

We then categorized workshop outcomes based on the following criteria: We considered a workshop higher-impact if both participants and organizers reported action outcomes that they attributed to the workshop. We considered workshops to have mixed impact if only one respondent type (participants or organizers) reported action outcomes or both groups reported planning but not action outcomes. We consider workshops lower-impact if neither participants nor organizers reported action outcomes and at most one group reported planning outcomes. The absence of evidence of action outcomes does not necessarily mean that workshops were lower impact. However, by triangulating across multiple data sources, we feel confident that for workshops where neither participants nor organizers identified meaningful action outcomes, there existed genuine differences in outcomes from those workshops we classified as higher-impact. Table 3.1 summarizes how planning and action outcomes were conceptualized.

**Table 3.1. Workshop outcome categories**

<b>Outcome</b>	<b>Definition</b>	<b>Example</b>
Planning	Includes planning processes underway and the integration of climate adaptation into formal and nonformal planning documents.	<i>We developed a plan to address climate change impacts for a Federally Threatened species... in the Recovery Implementation Strategy document we were working on.</i>
Action	Actions reported by participants as resulting from the workshop beyond planning, such as grant funding accessed, changes to ongoing practices, concrete projects undertaken, tools developed, and monitoring efforts.	<i>Several projects have been completed... such as repairs to old, deteriorated culvert boxes and drainage pipes.</i>

To identify the inputs, processes, and emergent states associated with effective workshops, we selected the cases with the strongest evidence for meaningful outcomes and compared their attributes with the cases with the weakest evidence for outcomes. Because we rely upon self-reported information from a variety of sources, and because our assessment of outcomes doesn't provide for definitive cutpoints between cases' outcomes, we were unable to unambiguously rank individual workshops. Rather, we considered the clearest distinctions to be between the highest- and lowest-performing workshops and felt that comparing between these two groups could reveal meaningful differences between processes yielding more- or less-substantial outcomes. To make these comparisons, we dropped workshops with mixed

evidence for impact and sought patterns among the attributes of these highest- and lowest-impact workshops using matrices and other displays (Miles et al., 2018). We identified and sought to explain contrasting results and to explore rival explanations for workshop outcomes (Yin, 2009).

#### *Workshop inputs and processes*

Data on workshop inputs and processes came from interviews, surveys, and workshop documents. In interviews with workshop organizers, we asked about the community context at the time of the workshop, the network of stakeholders involved in the workshop and how they were selected, how the workshop agenda was structured, and the organizers impressions of how the workshop unfolded. We asked organizers to share workshop agendas, reports, and other documents and to identify any deviations from the official agenda. Relevant survey items included open- and closed-ended questions about participants' goals for the workshop and their assessment of how workshop processes contributed to outcomes.

We compiled comprehensive reports on each case that catalogued the inputs and processes associated with each workshop. We compared across workshops, seeking areas of commonality and differences. As we did so, we sought evidence for themes from the literature as well as emergent themes arising from our data. These included factors such as the presence of backbone support organizations, climate champions, and preexisting network qualities, as well as workshop attributes, such as the duration of the convening; the extent of pre- and post-workshop engagement by facilitators; the nature of workshop deliverables; and the use of tools, presentations, breakout groups, and other approaches during workshops.

Lastly, we drew upon survey data that asked workshop participants to describe the workshop elements that most advanced workshop outcomes as well as things they would change about the workshop they attended. We coded and tallied participant responses and selected those workshops elements consistent with workshop processes. We then identified the positive workshop processes that were reported more often by participants in higher-performing workshops and the negative workshop processes identified more often by participants in lower-performing workshops.

#### *Workshop emergent states*

We drew upon two sources to identify emergent states. First, we discussed emergent states in interviews with facilitators and local conveners. We asked about what the workshop achieved and why, and at times the interviewee described outcomes that we considered emergent states. We also reviewed survey responses for additional data to identify areas of agreement and disagreement. We drew upon two open-ended questions: "Please describe any meaningful outcomes that you feel happened specifically as a result of the workshop(s) that might not have happened if it had not taken place" and: "Looking back, what would have made the workshop(s) better? What changes, if any, would you make?" Responses to this latter question sometimes indicated specific emergent states that failed to result from the workshop.

Following Marks and colleagues (2001), we categorized these data as cognitive, affective, and motivational emergent states at the group level. We considered a workshop to exhibit an emergent state only if we found evidence that it existed beyond a single individual. For example, survey respondents from all workshops reported learning from the gatherings they attended. However, to be considered evidence for a cognitive emergent state, we sought an indication that participants perceived changes at a collective level, such as survey respondents reporting the development of a shared understanding of climate adaptation strategies within a group.

## **Results**

### **Overview of included workshops**

A total of 431 workshop participants from 33 workshops responded to our survey, yielding a global

response rate of 57%. Response rates for individual workshops were variable. Although there is no standard minimum adequate survey response rate, 50% is generally considered a reasonable threshold for representing a group (Babbie, 1973; Draugalis, Coons, & Plaza, 2008). In 21 of the 33 workshops, our response rates were at or above 50%. We found that the workshops in our sample with lower response rates tended to be among the lower-performing processes. Because we drew upon additional data sources, including interviews and workshop documents to triangulate our findings, we felt that excluding all workshops with response rates below 50% risked eliminating opportunities for insights into less-satisfactory processes. We therefore considered a response rate of more than 30% acceptable. We dropped three cases with response rates below that threshold from our analysis, leaving 30 cases and 404 total survey responses.

Of the 30 workshops in the study, seven took place in California, two each in Colorado, Florida, Maryland, New Mexico, and Wisconsin, and the remaining workshops were held in Arizona, Georgia, Idaho, Maine, Michigan, Nebraska, New York, North Carolina, South Carolina, South Dakota, Texas, and Virginia. To ensure confidentiality, we do not link our data to specific workshops or locations.

### **Workshop outcomes**

Seven cases met our criteria for high-impact workshops. Seventeen workshops exhibited mixed impacts. Six workshops met our criteria for lower-impact workshops. Table 3.2 summarizes the evidence for planning and action outcomes for each workshop.

**Table 3.2. Workshop overview and summary of evidence for action and planning outcomes.**

Workshop ID code	Year	Focus <sup>1</sup>	Survey responses	Evidence for actions <sup>2</sup>	Evidence for planning <sup>3</sup>	Actions reported	Class of actions			
							Grey	Green	Soft	Monitoring
<b>Higher-impact workshops</b>										
1	2017	U	10/18	P, O	P, O	Job training program, flood abatement activities	X		X	
2	2017	NR	32/43	P, O	P	Sub-watershed scale adaptation efforts funded/implemented, development of an adaptation tool		X	X	
3	2019	NR	8/10	P, O	P, O	Monitoring, climate smart tree plantings, augmenting air conditioning in facilities	X	X		X
4	2018	NR	7/23	P, O	--	Monitoring, adaptation-informed ecological restoration, additional research efforts		X		X
5	2018	O	10/33	P, O	P, O	Replacement of storm drain culverts, repairs to drainpipes, stormwater system maintenance equipment purchased	X			
6	2019	U	10/24	P, O	P, O	Grey/green park stormwater improvements	X	X		
<b>Mixed-impact workshops</b>										
7	2019	O	12/21	P	--	Land management actions to increase water retention on landscape		X		
8	2018	NR	17/23	P	P	Adaptation-informed ecological restoration (shift in tree species planted)		X		
9	2018	NR	16/25	O	P, O	Adaptation-informed savannah habitat restoration		X		
10	2020	O	34/55	P	P, O	Outreach			X	
11	2019	NR	18/31	O	O	Adaptation-informed shifts to grazing and fire management		X		
12	2018	NR	13/17	P	--	Wildlife adaptation study proposal submitted				
13	2019	NR	16/27	O	P	Adaptation informed habitat restoration/preservation efforts		X		



14	2017	NR	9/21	P	--	Stream temperature monitoring				X
15	2017	NR	7/18	O	--	Outreach, adaptation-informed vegetation management		X	X	
16	2020	O	20/31	--	P, O					
17	2019	NR	17/25	--	P, O					
18	2018	NR	8/14	--	P, O					
19	2020	NR	22/28	--	P, O					
20	2020	O	11/22	--	P, O					
21	2019	NR	7/12	--	P, O					
22	2017	NR	8/18	--	P, O					
23	2018	O	11/35	--	P, O					
24	2018	NR	5/10	--	P, O					
<b>Lower-impact workshops</b>										
25	2019	U	4/7	--	O					
26	2019	O	18/23	--	P					
27	2017	NR	16/22	--	O					
28	2019	O	6/19	--	O					
29	2017	NR	5/16	--	--					
30	2017	NR	4/7	--	--					

1. “U” indicates urban-focused workshops, “NR” indicates workshops focused on natural resources. “O” indicates workshops with other/mixed focal areas.

2. & 3. “P” indicates that an outcome was identified in surveys by workshop participants. “O” indicates an outcome was identified in interviews by workshop organizers. “--” indicates neither group identified an outcome.

The specific kinds of planning and action outcomes reported by participants and facilitators varied within and across workshops. These actions included changes to existing practices (such as planting tree species thought to be more resilient to projected climate impacts), implementing new programs, and outreach efforts, including sharing information internally and externally beyond the workshop. Reported planning outcomes included efforts to incorporate climate adaptation into ongoing planning efforts, expanding the role of climate adaptation within planning processes, and the production of stand-alone climate adaptation plans. All higher-impact workshops except one (Case 4) also exhibited evidence of planning actions. In Case 4, the reported actions were suggestive of behaviors that would require planning, and survey respondents indicated that planning had taken place since the workshop, but neither interview participants nor survey respondents directly indicated that planning activities had specifically resulted from the workshop. They did, however, attribute actions to the occurrence of the workshop.

In the mixed-impact workshops, we found partial evidence for action outcomes or stronger evidence for planning outcomes. Because we were unable to triangulate evidence for action outcomes in these instances, we do not consider them higher-impact workshops. Nevertheless, in nine of these cases participants or organizers indicated that meaningful adaptation actions resulted from the workshops, suggesting that these cases may have more in common with higher- than lower-impact workshops. Three of the workshops where we found no evidence for actions but both participants and organizers reported planning outcomes took place in 2020. Because these cases were among the most recent workshops in our sample, it is possible that we would have found meaningful adaptation outcomes had the community had more time between the conclusion of the workshop and our data collection.

### **Inputs and process attributes of higher- and lower-impact workshops**

Many of the workshops in our sample exhibited common input and process elements, such as pre-workshop calls with local conveners, presentations by facilitators or other speakers, sharing climate projections during the workshop, and the use of breakout groups. Despite these commonalities across most workshops, we identified several attributes that distinguish higher-impact workshops from less effective processes. Higher-impact workshops featured local champions and sustained post workshop support from backbone support organizations or external facilitators, suggesting that local champions and a source of sustained support (whether internal or external to the adaptation network) are necessary for impactful workshops. All but one higher-performing case featured workshops were co-designed with participants, whereas none of the lower-performing workshops were co-designed, suggesting that co-design is helpful, but perhaps not always necessary, for achieving impact. Table 3.3 describes workshop attributes that we identified as distinguishing higher-impact from lower-impact workshops and the data sources and analyses we used to identify those attributes. Our assessment of these attributes for each higher- and lower-impact case are summarized in Table 3.4.

**Table 3.3. Attributes associated with higher-impact workshops.**

Attribute	Description	Data source	Scoring criteria
Local champion	The ongoing meaningful engagement of at least one local individual committed to organizing, convening, and ensuring post-workshop success of the adaptation workshop. In cases where an existing champion left a network before a workshop yields outcomes, we considered that case to lack a champion.	Interviews	Yes: One or more local champions identified. No: No local champion identified, champion(s) constrained by turnover, or facilitators report disengaged local convener/no active champion.
Process co-design	Facilitators' efforts to engage a broad swath of stakeholders and workshop attendees in designing, creating, or implementing the workshop agenda, tools, or outputs. For example, seeking input or co-developing workshop tools, or working with participants to gather data about projected impacts and vulnerabilities would constitute co-design. Assembling workshop proceedings or findings into a report would not constitute co- design.	Interviews & artifacts	Yes: Clear evidence that workshop organizers engaged in co- design. No: No evidence that workshop organizers engaged in co-design.
Backbone Support Organization	The presence and meaningful engagement of a backbone organization during the workshop that carries efforts forward post-workshop. We consider backbone organizations those that commit to carrying forward the work of advancing collective action for climate change adaptation post-workshop by committing staff that facilitate dialogue, build public support, advance policy, mobilize funding and/or establish shared measurement.	Interviews	Yes: Backbone organization meaningful engaged during and after adaptation workshop. No: No evidence of a backbone organization.
Sustained support	The degree of support from workshop facilitators provided post-workshop.	Interviews & artifacts	Low: No evidence of post-workshop engagement by workshop organizers. Moderate: limited engagement, such as assembling and sharing a workshop summary or report. High: Organizing future meetings, workshop

			processes structured as regular, recurring convenings, or offering post-workshop services, assistance, or follow-up calls. A minimum of three engagements.
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**Table 3.4: Salient attributes of higher- and lower-performing workshops**

	Case ID number	Local champion	Process co-design	Sustained support		Time post-workshop (months)
				External sustained support	Backbone support organization	
Higher-impact workshops	1	Yes	Yes	Low	Yes	24+
	2	Yes	Yes	High	No	24+
	3	Yes	Yes	High	No	12-17
	4	Yes	Yes	Moderate	Yes	24+
	5	Yes	No	High	No	24+
	6	Yes	Yes	High	No	18-23
Lower-impact workshops	25	No	No	Moderate	Yes	12-17
	26	Yes	No	Low	No	6-11
	27	Yes	No	Moderate	No	24+
	28	No	No	Moderate	No	24+
	29	Yes	No	Moderate	No	6-11
	30	No	No	Moderate	No	24+

**Inputs: Local champions**

Each of the higher-impact workshops featured local champions, who helped organize the workshop, recruit participants, and carry forward workshop outputs. For example, the workshop in Case 3 was part of a larger process dedicated to the development of a planning document for a federal protected area. The local convener was recognized as a local champion by workshop facilitators, who noted the critical role he played in ensuring that actions identified in the plan moved forward. Here’s how the champion described his own role in the process:

A lot of it was driven just by me being really passionate about it, I think. Not to toot my own horn, but I really wanted to take action. I don't want this to be a document that we spend a bunch of time on, and then it sits on the shelf, and nobody ever does anything with it, because that is what we do with a lot of stuff. We're great at documenting declines, writing reports, and then never doing anything. Whereas for me, I was like, "OK, we have all this knowledge, we know what the effects are going to be, now what do we go do on the landscape?" And I tried pretty hard to get that weaved into the [planning document]. And before I left, too, we started work-planning based off [it]. What is the next year going to look like? What tasks are we going to try to accomplish? So, we sat down, and we did that.

After the workshop, the protected area continued adaptation efforts related to reintroducing native species and acquired funding to plant 100,000 tree seedlings in climate-appropriate locations. Fiscal planning documents allocated time and resources to monitor and evaluated prior innovative management approaches as adaptation strategies.

Three of the lower-impact workshops featured local champions, suggesting that these champions may be necessary but not sufficient for advancing workshop outcomes. However, in Cases 26 and 28, less than 11

months had elapsed between the workshop and data collection. In all other regards, time since the workshop seemed to have little effect on outcomes.

The remaining lower-impact workshops lacked a local champion. In Case 25, the local convener was not engaged in climate adaptation work and was unable to engage meaningfully in advancing climate adaptation after the workshop. In Case 28, there was a leadership change shortly after the workshop, and the new leader was less interested in advancing the climate adaptation effort begun by their predecessor. The workshop facilitator felt that this absence of a champion contributed to the failure of the project. In Case 30, the local convener worked for a federal agency and was assigned a different portfolio of work after organizing the workshop due to a change in administration.

### ***Process: Co-design***

All but one of the higher-impact workshops engaged participants in a meaningful process of co-design. While most cases involved facilitators conducting planning calls or exchanging email correspondences with local conveners to identify stakeholder groups to invite and to select focal resources to prioritize during the workshop, higher-impact workshops included additional engagement mechanisms that informed workshop design, such as surveying participants about their needs and experiences, conducting a preliminary scorecard resilience assessment, asking participants to complete the opening steps of a workbook, or hosting pre-workshop webinars. They also engaged workshop participants in co-producing workshop tools. For example, Case 6 was structured as a series of repeated engagements with a group over a course of months to develop a GIS-based resilience tool. Between gatherings, the organizers would take input from the participants, develop the next stage of the tool, and share the results with attendees during subsequent gatherings.

Similarly, Case 4 engaged workshop participants in a process of co-design. This workshop was designed to prioritize actions in and around a federal protected area. It was structured as a two-part process, including (1) an initial meeting to kick off a research project designed to link climate science more effectively to natural resource management and to solicit input on key focal species and managers' needs, followed by (2) a meeting that shared preliminary results and an interactive, web-based mapping tool based upon the input from the first workshop. As the facilitator noted, "People are more likely to use something if they helped build it. A major part is just having them feel that ownership." One participant praised the workshop for supporting the "collaborative identification of priorities, data sets, and management applications... The facilitated collaborative approach was critical." The workshop and its outputs have since informed restoration, management, and monitoring efforts in the area.

In contrast, Case 9 offers an example of a process that suffered from not being co-produced with participants. Case 9 centered on a federal protected area grappling with projected sea-level rise amid growing urbanization in the surrounding area. Workshop organizers conducted a two-part workshop featuring scenario-planning and Strengths-Weaknesses-Opportunities-Threats analysis (SWOT) exercises in 2017 (Chermack et al., 2002; Helms & Nixon, 2010). After the workshop, organizers provided participants with a report and additional analyses. They also worked with the representatives from a nearby federal protected area to produce a story map that adapted their research to the protected area's context. However, workshop organizers and participants did not report any additional planning and action outcomes.

The facilitator noted that the scenario-planning approach did not align with the needs of the participants, who wanted answers instead of explorations of possible futures. As the local convener observed:

It was a lot of rehashing... We already know this stuff. We already know what the threats are. We already know what the challenges are to mitigating for those threats... So, we did this this exercise with the sticky notes, and you put it up there and put it in the right quadrant as to is it high impact and blah, blah, blah, you know? And in talking to my colleagues, they were like: "We already know this. Why are we doing this?" And so, in the survey, it asked questions like, did it change your way of thinking? No. Did it change the way things are done? No. Have you referred back to it? No. And I wasn't trying to be ugly or negative. It was just another exercise.

Workshop participants seemed to feel that the workshop process was externally-imposed, instead of arising from the needs of area residents. The local convener observed:

I really don't know, still, what they were hoping to accomplish. Were they wanting to change agency thinking? What was their goal?... Maybe the [facilitators] got what they thought was the takeaway from whatever we provided, but we, as participants, were like, 'Are you happy? Are you satisfied? Are we supposed to do something now?'

Despite the organizing team's efforts to identify an appropriate community for their workshop through an "engagement tour," our findings suggest that the process was a poor fit for the perceived needs of the community.

Other lower-performing workshops also seemed to suffer from a mismatch between workshop processes and community needs and expectations. In Case 25, participants felt the workshop was too short for the group to grasp what they felt were complex documents and steps. As one participant noted, "The workshop would have been made better by having a clearer sense of who was in the room and their familiarity with climate change beforehand... [it] would have helped build the agenda for the group and made it more appealing to folks to attend." Participants from Case 25 also indicated that the workshop design did not meet their needs: "Our region was peripheral to this project - that was reflected in how many meetings we had and the intensity at which we were engaged. Our inclusion in this project felt like an afterthought. I feel that we may have been a checkbox to the contractor."

Conversely, the sole higher-performing workshop that did not exhibit co-design (Case 5) still seemed to meet the participants' needs. Although the workshop was not designed with community input, workshop organizers conducted an extensive pre-workshop resilience assessment of the participating communities. This assessment evaluated communities in five dimensions: leadership and collaboration, risk assessments and emergency management, infrastructure, planning, and community engagement and wellbeing. Organizers and participants described how this assessment offered a structured starting place for conversations within the workshop, which may have helped the workshop align with participants' needs.

### **Process: Sustained support & backbone support organizations**

Two cases (Cases 1 and 4) exhibited benefited directly from the presence of a backbone support organization. The workshop in Case 1 was structured as a vulnerability assessment and strategy development process within a larger collaborative initiative designed to coordinate more than 30 organizations from a range of sectors to address issues related to racial equity, health, and the environment. Workshop organizers provided little support after the workshop beyond preparing a summary report from the workshop. However, the backbone support organization was able to help transfer leadership of the collaborative group's climate adaptation work from the backbone support organization to a different member organization. According to the local convener, this shift in leadership was, itself, an important outcome of the workshop because it empowered a community-based organization to take charge of the adaptation work. Since assuming leadership of the adaptation work, that

organization has conducted a cultural and climate assessment, initiated a workforce training program for green infrastructure, and engaged in arts and other place-making projects related to climate adaptation.

Case 25 was the only lower-impact workshop featuring a backbone support organization. However, in this case, climate adaptation was not an area of expertise for the organization. The local convener of the workshop, who worked for the backbone support organization, bemoaned the absence of a coordinating organization that was focused primarily on adaptation: “Even with our organization serving as the bridge, it can be overwhelming to incorporate climate adaptation without a local, closely partnered organization to steer the ship.”

Cases 2, 3, 5, and 6 lacked clear evidence of a backbone support organization, but all seemed to benefit from the sustained involvement of workshop organizers. In Case 5, the process began with a scorecard assessment of “low-hanging fruit” for enhancing the resilience of communities in a largely rural area along the East Coast. Representatives from each locale in the area then gathered for a workshop in which they developed a short-term checklist of adaptive actions for their communities. Post-workshop, the external organizing team held monthly meetings with participants to help support communities as they implemented the items on the checklist. This support included activities such as enlisting students to do GIS mapping and helping develop emergency communications plans. This sustained support seemed instrumental in forging lasting relationships among people in the area, elevating adaptation as a priority for the region, and enabling meaningful adaptation actions. One workshop participant explained,

At the time of workshop start, resiliency seemed an issue shouted from rooftops and of anecdotal examples. Over the past couple of years, much has changed with the assistance of [the workshop team] ... As the state of the art improved, [they] helped keep the members informed. In update of the comprehensive plan, [the workshop team] provided information, suggestions, and references which were very useful.

However, even for the communities in higher-impact Case 5, the transition after a year of support was not entirely seamless. Participants and local conveners reported feeling lost and somewhat aimless without the ongoing efforts of the workshop organizers. As one participant noted:

The problems are so complicated, right? We started out with [this process], and then all of a sudden it kind of petered away. It was kind of turned over to the county, and the county kind of took up, but the meeting between townships went away... [Now] it’s starting to move again, but there was that lull.

Greater post-workshop engagement was the change most often suggested by participants in open-ended responses to a question about what would have improved the workshop they attended. For example, a participant from Case 22 noted, “It would be useful if there was a way to receive consultation after a workshop to help our organization utilize the tools that were introduced - or at least help us figure out how to best integrate the tools into our existing practices along with targets for integration...”

Unfortunately, workshops tend to be funded as a one-time event versus an ongoing experience and process that becomes relevant at an organizational level where it will maximize outcomes/benefits.”

Survey respondents were generally indifferent about whether this support came from workshop organizers or other avenues such as more local backbone support organizations coordinating efforts in the area. One respondent noted: “There needs to be a commitment by leaders of various agencies, governments, and organizations to continue with meetings and work on implementing what has been taught. There needs to be someone to help with scaffolding, facilitating meetings, and organization - until the group congeals.”



### Emergent States

Higher-impact workshops were associated with the development of positive cognitive, affective, and motivational emergent states to a greater degree than lower-impact workshops. Table 3.5 describes the emergent states identified or noted as absent across workshop. Table 3.6 indicates the emergent states associated with each higher- and lower-impact workshop.

**Table 3.5. Emergent states (or their absence) and emblematic quotes.**

Category	Emergent state	Emblematic quote (source case)
Cognitive	Shared vision	<i>It brought together various stakeholders with different priorities and created a unified vision for the future. (10)</i>
	Shared understanding	<i>We also have a shared understanding and language to collaborate with other organizations in the region to protect climate change refugia. (4)</i>
Affective	Enhanced relationships	<i>Connections were built with new partners, relationships with already known orgs were strengthened (2)</i>
	Strengthened social capital	<i>The workshop also played an important role by providing an opportunity for a diverse group of stakeholders to further build a working level of trust and synergy across organizations (and between individuals) ... (1)</i>
Motivational	Enhanced collective efficacy	<i>One of the exercises about what we could do in our current role to improve/strengthen combating negative climate effects was eye opening. It helpful to hear what others in my group felt they could do and weigh that against what I think/thought I could do. (7)</i>
	Enhanced sense of ownership	<i>Each team coming up with their own project... provided real world examples and allowed for ownership in the exercises. (4)</i>
	Lack of collective efficacy	<i>I desperately wanted more scientific expertise in the room. The breakout groups that I participated in were mostly composed of people with great interest in the topic, but who did not consider themselves experts. (27)</i>
	Lack of ownership	<i>I was done with it, and I never returned to it. And having a conversation with at least two other individuals, I was like what do you think? They were like, ' Well, [the organizers] wanted to do this, and they wanted to use [us] as an example. (29)</i>

**Table 3.6. Presence/absence of emergent states for higher- and lower-impact workshops.**

	Case	Emergent states		
		Cognitive	Affective	Motivational
Higher-impact workshops	1	Shared vision, shared understanding	Enhanced relationships, strengthened social capital	Enhanced collective efficacy
	2	Shared understanding	Enhanced relationships	Enhanced collective efficacy
	3	Shared vision, shared understanding	Enhanced relationships	--
	4	Shared understanding	Enhanced relationships	Enhanced sense of

				ownership
	5	Shared understanding	Enhanced relationships	--
	6	Shared understanding	Enhanced relationships	--
Lower-impact workshops	25	Shared understanding	--	--
	26	Shared understanding	Enhanced relationships	--
	27	Shared vision	--	Lack of ownership, lack of collective efficacy
	28	--	Enhanced relationships	Lack of ownership, lack of collective efficacy
	29	Shared understanding	--	--
	30	--	Enhanced relationships	--

In some instances, we found evidence that the cognitive, affective, and motivation emergent states that arose during the workshops impacted subsequent actions. For example, in Case 3, organizers described institutional silos that had impeded collaboration before the workshop. The workshop strengthened relationships across those barriers, resulting in greater communication and coordination between departments post-workshop. Conversely, workshop participants from Case 29 attributed the lack of action post-workshop, in part, to the failure of the workshop to generate collective efficacy: “It has really in my opinion, gone downhill. Every time I talk to the [protected area] manager, she's like, ‘Well, we lose about X amount of acres every year. And what are you going to do?’ There's nothing really what we can do about it, and there's no action item that came out of [the workshop] to save it. And maybe that's what's so sad I mean, we could talk about this to death, but there are some things that are just out of our control.”

### Effective workshop elements

Survey responses offered additional insights into the specific attributes of higher-impact workshops that participants singled out as effective more often than participants who attended lower-impact workshops. These workshop elements generally fell within three broad categories: (1) diverse opportunities for interactions during and after a workshop; (2) a focus on local applications; and (3) facilitators who established a clear workshop process and communicated effectively with participants. The elements most often invoked by participants in higher-impact workshops are detailed in Table 3.7. Five additional elements were each reported by a single survey respondent from the higher-impact workshops. These additional elements were: a process for grappling with uncertainty, field visits, workshop attendees that included community members and colleagues, workshops held in a comfortable venue, and the ability to maintain connections with other attendees post workshop.

**Table 3.7. Effective elements associated with higher-impact workshops.**

Element area	Effective element	Count of higher-impact workshop participants identifying effective elements
<b>Diverse interactions</b>	Collaboration & networking opportunities	10
	Interactive workshop approach	5
	Workgroup presentations to plenary (Report outs)	3
	Panel discussions and technical presentations	3
	Post workshop interactions with facilitators & larger group check-ins, coordinated group efforts	3
<b>Focus on</b>	"Real world" focus	9

<b>real world, local applications</b>	Multiple systems approach	4
	Shared strategies & case studies	3
	Workbooks, menus and other decision support tools	6
<b>Quality facilitators</b>	Clear workshop process, effective communication	6

Case 2 exhibited many of the effective elements, especially offering opportunities for collaboration and networking and focusing on real-world applications. The workshop was designed to provide natural resource managers and conservation professionals a dedicated space to think about climate adaptation in a hands-on way, by building adaptation plans that could be integrated into current or future projects. The workshop took place over two days, with the first day open to the public and focused on information sharing, with opportunities for networking over coffee and during breaks and lunch. The second day was limited to invited participants, and it was primarily dedicated to working through an adaptation workbook in small groups to develop adaptation plans for projects proposed in advance by participants. One survey respondent highlighted the value of “coming together... with new and old partners to network around climate change opportunities. Knowledge of new adaptation strategies, repackaging or rethinking "conventional" resource management strategies into climate-related strategies.” Another participant also noted effective elements related to networking and a real-world focus:

Coming away with tools (e.g., adaptation references, workbooks, and menus), as well as new relationships with folks who have expertise in climate change and adaptation, and with local folks who are also managing resources and trying to figure out how this all works. With these relationships, we've expanded our list of folks to contact who we can bounce ideas off of. It was a very positive experience in that regard.

Participants from Case 3 singled out the workshop facilitators as an important factor driving their success. One survey respondent noted, “The facilitators effectively brought people together to communicate effectively. No matter how much you know or have to offer, if a meeting of minds is not facilitated properly, you will not make any progress.” Another respondent elaborated on how they did so, praising the way they “presented a framework that ensured resources were not missed or forgotten. They encouraged discussion that drew out ideas yet kept the momentum moving toward the final goal.”

Conversely, participants in lower-impact workshops singled out ineffective elements of adaptation workshop processes. Survey respondents from lower-impact workshops reported that the convening they attended would have benefitted from greater attention to aspects of participants related to diversity, equity, and inclusion (n=3), as well greater inclusion of participants with specific subject-matter expertise and decision-making power (n=2). In terms of logistics, participants reported a desire for longer workshops (n=5) and more extensive facilitator engagement pre- and post-workshop (n=5). Other criticisms included a desire for a deeper focus on practical projects; additional historical data; and more icebreakers, inspiring presentations, and specific commitments elicited from workshop participants (each reported by a single respondent).

## **Discussion**

### ***Team processes and adaptation workshops***

To our knowledge, this is the first study that has examined climate adaptation workshops as team

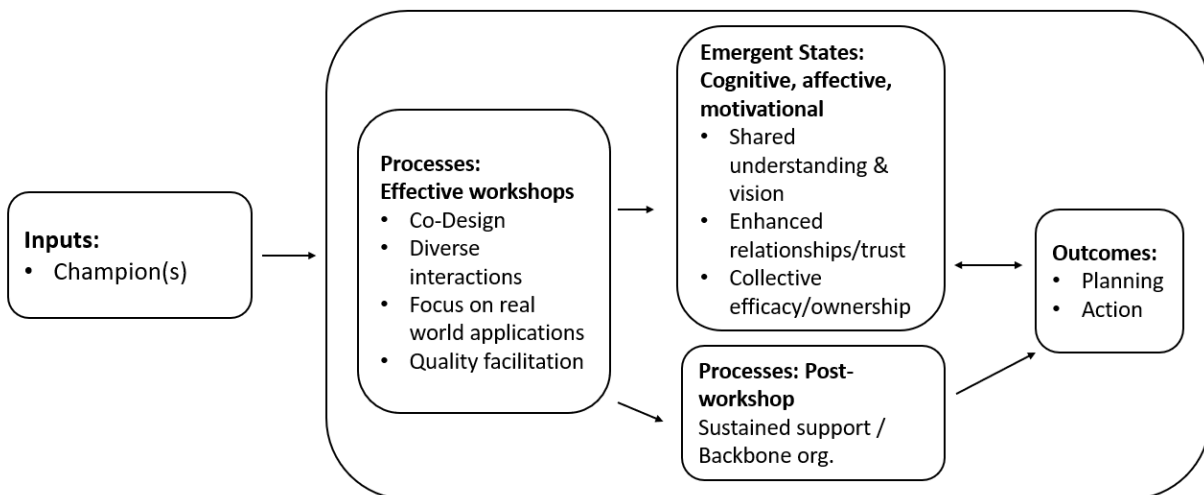
processes. Our findings generally align with the theoretical elements of the Team Process Model and suggest that the framework can be applied to local networks involved in place-based climate adaptation workshops. However, the Team Process Model views team performance as following trajectories that unfold within iterative and overlapping cycles of inputs, processes, emergent states, and outputs (Marks 2001). Because our study relied on a retrospective assessment of the workshops in our sample and treated workshops as a single process cycle, it is necessarily a simplification of these complex and iterative interactions. Nevertheless, we feel that the model is a fruitful tool for examining climate adaptation workshops and yielded insights about how these processes function.

**Key findings**

Our findings suggest that higher-impact adaptation workshops are distinguished from lower-impact workshops by several key inputs, processes, and emergent states. All higher-impact workshops featured champions who shepherded the workshop process along. They all benefitted from support from a backbone support organization or sustained involvement from workshop facilitators. Most, but not all, higher-impact workshops also engaged participants in a process of co-design.

We identified a range of effective practices highlighted more often by participants in higher-impact workshops, including opportunities for diverse interactions, a focus on real-world local applications, and effective facilitation. These inputs and process elements, in turn, contributed to the development of positive cognitive, affective, and motivational emergent states within the group, such as shared understandings, deepened relationships, and strengthened feelings of collective efficacy. These emergent states helped workshop participants ease the transition between the workshop process and subsequent efforts to advance meaningful planning and adaptation activities. Theoretically, achieving planning and action goals may then reinforce the emergent states that arose during the workshop in a positive feedback loop (Parks et al., 2013). A conceptual diagram of the relationships among the workshop inputs, processes, emergent states, and outcomes that distinguished higher- from lower-impact workshops is depicted in Figure 3.1. We elaborate on these key findings below, beginning with outcomes and working backwards to inputs.

**Figure 3.1. Inputs, processes, emergent states, and outcomes identified by organizers and participants that distinguished higher-impact workshops from lower-impact workshops.**



### ***Emergent states and outcomes***

In complex, dynamic efforts such as climate adaptation, successfully bridging the gap between planning and action often requires ongoing interaction among relevant stakeholders and reevaluating and adjusting plans (Margerum, 2011). Thus, group efforts are more likely to be successful if they garner the support and enthusiasm of stakeholders, incorporate a broad range of perspectives, and generate shared understandings among those responsible for implementation (Margerum, 2011, Burby, 2003). Our findings suggest that workshops may help lay a positive groundwork for ongoing interactions among workshop participants in part by generating positive emergent states. This association between positive cognitive, affective, and motivational emergent states and positive team outcomes is supported by prior research on the outcomes of collaborative efforts (Drath et al., 2017; Rapp et al., 2021; Suškevičs, 2017).

### ***Team processes: Sustained support***

Sustained support in the form of prolonged post-workshop engagement from workshop organizers or the involvement of a backbone support organization helped workshop participants navigate the transition from the workshop to subsequent adaptive efforts and reinforced the positive emergent states generated during the workshop. These findings align with prior research about the value of collaborative partnerships that endure over long periods of time and devote resources to monitoring the process and outcomes (Chambers et al., 2021; Kania & Kramer, 2011). Our findings suggest that external workshop facilitators could temporarily help fulfil the role of a backbone support organization in instances where a community lacks a preexisting entity in that role and where workshop organizers have the resources to stay meaningfully engaged in the community. However, given the long-term nature of climate adaptation and the transaction costs associated with long-term collaborative efforts, time-limited support may be of somewhat limited utility absent the likely availability of additional resources. Post-workshop support from facilitating organizations may be more effective if organizers are clear in advance about the duration and nature of the support participants can expect after a workshop and if organizers help the community establish a self-sustaining partnership supporting the flow of information and decisions (Gardner et al., 2009; Margerum & Robinson, 2015; Stern et al., 2023). Future research could investigate the advantages and limitations of facilitating organizations fulfilling the role of backbone support organizations and the duration of post-workshop engagement necessary for groups to become self-sustaining.

### ***Team processes: Effective workshop elements***

The workshop processes deemed most effective by participants in higher-impact workshops were largely consistent with those thought to foster social learning (Stern et al., 2023; Suškevičs, 2017). These include opportunities for diverse kinds of interactions among a broad group of stakeholders; a focus on real world, local applications; opportunities to practice performing vulnerability assessments and generating adaptation strategies; and facilitation that aided the process before, during, and after the workshop by generating clear goals and objectives, easing social processes, and providing a bridge to post-workshop action. Other research has highlighted the key role of facilitated processes for communication and knowledge-exchange in supporting learning in contexts of participatory environmental governance (Newig et al., 2019). Opportunities to engage with a broad group of relevant stakeholders, and to do so in a variety of formats including breakout sessions, icebreakers, and informal interactions, may also contribute to affective emergent states by affording opportunities for participants strengthen social capital and build trust (Stern et al., 2021).

### ***Team Processes: Co-design***

Co-design emerged as a factor that distinguished all but one higher-impact workshop from those with lower impact. In Case 4, for example, by co-developing the climate refugia tool, workshop organizers ensured that the final product would be compatible with managers' needs and that they would feel

ownership over the product. In Case 6, by iteratively developing a GIS planning tool with workshop participants, organizers helped ensure that the tool would meet users' needs. None of the lower-impact workshops in our sample were co-designed, and, in many instances, we found evidence that these processes struggled to meet attendees' needs. For example, participants had little or no input into the tool used in Case 25, and the workshop left participants confused, frustrated, and skeptical. Other climate adaptation initiatives have encountered similar stumbling-blocks. For example, in an assessment of five climate service projects, Fleming and colleagues (2023) found that when efforts failed to meet users' needs it was due to insufficient time and resources allocated to the project, insufficient engagement with key stakeholders, and a mismatch between funder and stakeholder needs.

Co-design has been linked to a range of positive outcomes such as policy uptake and institution building in other studies as well (Chambers et al., 2021; Neset et al., 2021). Our research suggests that effective co-design may help ensure that workshops better match the needs of workshop participants, which, in turn, could contribute to the emergence of positive emergent states, such as feelings of collective efficacy and ownership over the process.

### ***Inputs: Local champions***

The presence and meaningful involvement of local champions was the sole input that distinguished all higher-impact workshops in our sample. The functions these champions performed in the cases in our study largely aligned with the roles identified in previous studies (Hanleybrown et al., 2012; Nkoana, Verbruggen, & Hugé, 2018). In our sample, champions helped organize workshops, recruited participants, and provided momentum and enthusiasm to implement work plans.

Prior studies have also highlighted the importance of other inputs in driving adaptation workshop outcomes, such as communities experiencing extreme weather events, the presence of policy mandates, and the prevailing political context (Berrang-Ford et al., 2011; Boudet et al., 2020; Butler et al., 2021; Carmichael et al., 2017; Demski et al., 2017; Shi et al., 2015). None of these factors separated higher- from lower-performing workshops in our sample. This suggests that while these and other inputs may shape outcomes, they may not be fully determinative of outcomes. In addition, because we relied primarily on interviews with participants and organizers to understand each workshop's inputs, we may not have fully captured all meaningful inputs. For example, the influence of a single champion may have stood out to interviewees more than the strength of the existing network, even if the latter was a powerful driver of the workshop's outcome.

### **Limitations**

Our analysis relies primarily on self-reported data from workshop participants, facilitators, and conveners. Thus, we lack definitive evidence for the extent to which reported adaptation actions were implemented, and the degree to which those actions may have reduced vulnerability or enhanced adaptive capacity. While the number of cases in this study allowed for comparisons across a broad array of contexts, the relatively large number of cases and limited resources precluded additional forms of in-depth data collection and analysis, such as interviews with additional workshop participants, follow-up interviews with conveners, and "ground-truthing" of reported adaptation actions. Future research could seek to elucidate the connections among perceptions of adaptive actions and objective measures of community resilience.

Our methods solicited input in a single post-hoc snapshot from organizers and participants about what they felt to be salient at the time we collected data. Our failure to detect other workshop process elements does not mean they were not present nor relevant. Furthermore, our approach relied on identifying team process elements that differed between higher- and lower-impact workshops. Many process elements,

such as the duration of the workshops and the use of workbooks and other decision support tools did not vary considerably across the sample. We were thus unable to determine the value of these specific elements.

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## Chapter 4

### **Learning for collaborative action: Learning domains and processes in place-based climate adaptation workshops**

#### **Abstract**

Efforts to address the complex challenges facing communities today benefit from learning within collaborative groups. Place-based climate adaptation workshops, which are designed to help multiple stakeholders incorporate climate projections into site-specific adaptation strategies, are one space where collaborative learning can occur. We studied how learning occurred in eight climate adaptation workshops held in communities in the United States between 2021 and 2023. We examined declarative, procedural, and relational learning and the processes through which tacit and explicit knowledge interacted in each workshop. We found evidence for learning across all three learning domains and evidence of enhanced motivation and feelings of efficacy among workshop participants. Participants reported instances of conversions between tacit and explicit knowledge and linked learning to a broad range of workshop elements. We found no meaningful differences in respondents' self-assessed learning between online (n = 6) and in-person (n = 2) workshops, nor between individual workshops. These findings suggest that a range of workshop formats can support meaningful learning. We discuss the theoretical and practical implications of these findings for understanding and fostering learning in the context of collaborative climate adaptation.

#### **Introduction**

Learning has long been identified as an important element for communities coping with the wicked complexity of contemporary environmental management (Plummer et al., 2017; Rittel and Webber; Suškevičs et al., 2018, 1973). Learning can drive changes to resource management approaches, to policies and institutions, and ultimately to environmental conditions (e.g. Armitage et al 2012; Borrini-Feyerabend 2006; Bromley, 1991; Koontz and Thomas, 2006; Paavola 2007; Plummer and Armitage, 2007). Consequently, scholars of natural resource management have increasingly directed their attention to the process by which scientific and other forms of knowledge are collaboratively created, shared, and acted upon, especially in complex and wicked contexts (Gerlak et al., 2019; Vinke-de Kruijf & Pahl-Wostl, 2016). However, learning can be challenging to define and measure and our understanding of the factors that shape learning remains underdeveloped (Armitage et al., 2008; Crona & Parker, 2012; Suškevičs et al., 2019).

One wicked problem where learning may help accelerate positive change is the challenge of preparing for and dealing with the effects of anthropogenic climate change (IPCC 2022; Vinke-de Kruijf, & Pahl-Wostl, 2016). This effort is known as climate change adaptation, or “the process of adjustment to actual or expected climate and its effects in order to moderate harm or take advantage of beneficial opportunities” (van Valkengoed and Steg, 2019, p. 158). Effective climate adaptation relies upon accessing and using insights from a range of knowledge systems, including scientific and traditional ecological knowledge (Moller et al., 2004). However, despite the proliferation of potentially useful climate information over the past several decades, there remains a gap between the information available and its uptake by potential users (Lemos et al., 2012).

On a local level, groups have increasingly turned to educational and capacity-building events such as place-based climate adaptation workshops to foster learning and advance climate adaptation (Biagini et al., 2014). Here, we define place-based climate adaptation workshops as *convenings or series of convenings designed to help multiple stakeholders develop strategies for adapting to climate change in a specific place* (Stern et al., 2023). These workshops commonly involve sharing climate science data with

participants, collectively analyzing the vulnerability of focal systems, and developing and prioritizing potential solutions.

This paper hypothesizes and tests a framework to characterize learning in collaborative contexts. We examine how our framework interacts with processes of knowledge creation in the context of climate change adaptation workshops, and we explore the practical and theoretical implications of this approach to learning.

## **Perspectives on Learning**

Learning may be thought of as both an outcome and a process (Gerlak et al., 2019). As an outcome, learning can refer to newly acquired knowledge or changes to beliefs in individuals and groups (Leach et al. 2014). As a process, learning may refer to how information is acquired, interpreted, reconfigured, vetted, and shared among stakeholders (Heikkila and Gerlak, 2013). We describe a typology of learning domains that categorizes meaningful learning outcomes for climate adaptation and related processes. We then describe Nonaka's theory of Organizational Knowledge Creation, which details how knowledge may be developed, combined, and disseminated within a collective group. We explore these elements in the context of place-based climate adaptation workshops.

### ***Learning Outcomes***

We conceptualize learning outcomes as occurring within declarative, procedural, and relational domains. Declarative learning is learning related to understanding of concepts, facts, and other information and the ways those elements relate (Baird et al 2014; Cooke et al., 2000; Krathwohl, 2002). Procedural learning involves understanding and gaining capacity for processes, procedures, and techniques (Cooke et al., 2000; Krathwohl, 2002). These categories are roughly analogous to distinctions between “know-what” knowledge and “know-how” knowledge, or Bloom's factual/conceptual and procedural dimensions of knowledge (Anderson & Bloom, 2001; Garud, 1997). Relational learning involves gaining understanding of the mindsets and priorities of other actors within a network and of the broader social network's structure and dynamics (Suškevičs; 2018).

This framework draws upon previous efforts to articulate forms of learning relevant to climate adaptation and other related contexts (e.g. Baird et al 2013; Huitema et al., 2010). Learning outcomes in each domain could help foster the conditions that contribute to successful collective action by enhancing the collaborative capacity of the group engaged in climate adaptation. Collaborative capacity is the combined abilities of groups to effectively solve problems over the long term (Ryan and Urgenson, 2019). Declarative learning could enhance collaborative capacity by developing to a shared body of knowledge among workshop participants (Emerson and Nabatchi, 2015). Procedural learning could bolster the skills, expertise, and procedural arrangements by which groups effectively collaborate, and overcoming process barriers, such as unfamiliarity with the process of climate adaptation or a lack of the skills required to undertake adaptation (Emerson and Nabatchi, 2015; Wondolleck, and Yaffee, 2000). Lastly, relational learning could help address barriers to collaboration stemming from attitudes and perceptions, such as mistrust, negative intergroup attitude, and mismatches between organizational norms and culture, by deepening a groups' understanding of its members priorities and interests (Pahl-Wostl et al., 2007; Vinke-de Kruijf et al., 2014; Wondolleck, and Yaffee, 2000).

### ***Learning processes: Nonaka's Theory of Organizational Knowledge Creation***

Learning unfolds at multiple levels in collective contexts (i.e., within individuals, within groups, and within networks). These levels are bridged by “dynamic social processes of producing and sharing knowledge” (Heikkila & Gerlak, 2013, p. 486). Nonaka's Organizational Knowledge Creation Theory offers a framework to explain the process by which learning occurs across scales in collaborative contexts.

Nonaka’s theory suggests that knowledge exists along a spectrum from tacit to explicit (Nonaka, Toyama, & Konno, 2000; Polanyi, 2009). Tacit knowledge is embodied, enacted, and encoded in routines, procedures, values, and emotions. It is difficult to communicate directly to others and is more often indirectly observed, veiled in story, or developed through shared experience. Explicit knowledge can be more easily explained and communicated to others, as it can be communicated via symbols and is readily processed, stored, and transmitted in conversations, data, formulas, manuals, maps, and other vehicles. Because tacit and explicit knowledge differ, the format of the knowledge lends itself to different functions in a group. For example making tacit knowledge explicit can help groups articulate knowledge held by individuals and formulate general principles from primary experiences. Explicit knowledge can be more readily shared across a collective and then collaboratively acted upon (Nonaka, Toyama, & Konno, 2000). Conversely, as explicit knowledge becomes tacit, it becomes embedded in routines, habits, and embodied action.

Nonaka identifies four stages that comprise a cycle of “knowledge conversions” by which tacit and explicit knowledge forms are transformed, transferred, or combined within organizations: socialization, externalization, combination, and internalization (Table 4.1). *Socialization* is the process of transferring tacit knowledge between individuals or from an individual to a group, often through shared experiences or storytelling. *Externalization* is the process of transforming tacit knowledge to explicit knowledge through acts such as drawing lessons and conclusions from stories or linking anecdotes to broader trends. *Combination* involves bringing together sets of explicit knowledge by comparing, contrasting, and synthesizing information. Lastly, *Internalization* is the process of transforming explicit knowledge into tacit knowledge through training and the integration of knowledge into practice, routines, and processes. Nonaka’s theory holds that movement along the cycle can move knowledge from one end to the other of the tacit-explicit spectrum and enable the movement of knowledge between individuals and groups (Tokayama and Konno, 2000).

Movement along the stages of the SECI (Socialization, Externalization, Combination, Internalization) cycle could help equip groups with a shared corpus of useful knowledge for tackling complex problems. *Socialization* can spread tacit knowledge within a group, potentially helping align worldviews, strengthening trust among group members, and establishing shared routines and experiences. In *externalization*, individuals’ tacit knowledge is transformed to explicit knowledge, which enables insights to be more readily interrogated and shared among group members. During *combination*, groups engaged in climate adaptation could examine explicit knowledge sets, such as climate projections for their region, and integrate them with newly externalized knowledge about factors such as group dynamics, workflows, and local regulations, for example. Finally, as groups engage in the work of planning and implementing climate adaptations, the explicit insights established during combination could become embedded in altered worldviews, trusting relationships, and altered workflows in the process of *internalization*. Attending to these knowledge conversions offers a potential mechanism by which workshop facilitators and others could help groups overcome the climate information usability gap and make knowledge more readily articulated, vetted, shared, and rendered actionable (Stern et al., 2020).

**Table 4.1. Knowledge conversions in the SECI cycle (Nonaka, Toyama, & Konno, 2000)**

		Combine/Convert To:	
		Tacit	Explicit
Combine/ Convert From:	Tacit	<i>Socialization:</i> The transfer of tacit knowledge, often through shared experience or story.	<i>Externalization:</i> The process of converting tacit knowledge to explicit knowledge
	Explicit	<i>Internalization:</i> The process of transforming explicit knowledge into tacit knowledge.	<i>Combination:</i> The process of melding sets of explicit knowledge

From a practical standpoint, movement along the SECI cycle could be enhanced or constrained by the attributes of the learning processes that take place during adaptation workshops, as some formats and activities may lend themselves more readily to specific knowledge conversions (Nonaka et al., 2000) . For example, *internalization* may be less likely to occur during a plenary presentation, which often involves a one-way sharing of information from a single speaker to a group, because the format does not readily lend itself to practicing or acting upon information. Conversely *combination* may be more likely to occur during plenary as speakers share data or other information that audience members could integrate with their existing knowledge. Table 4.2 describes attributes of climate adaptation processes we hypothesize may engender specific steps within the SECI cycle.

Both virtual and in-person learning spaces can accommodate movement along the SECI cycle, although they may be more- or less-well suited to a specific stage. For example, virtual conferences may lack networking opportunities such as coffee breaks and happy hours that could allow for informal exchange of tacit knowledge (*socialization*: Bosslet et al., 2020; Rich et al., 2020). Conversely, technological innovations for virtual gathering such as “chat” features, polling, document sharing, or one-on-one breakouts could enable novel forms of interactions that facilitate *combination* (Lawton et al., 2020; Harabor et al., 2020; ACMPT Force, 2022). Because virtual convenings tend to be less costly than in-person gatherings, they may be more accessible to nondominant populations such as those with disabilities or health challenges, those requiring childcare, and other groups that may be less able to attend in-person gatherings (De Picker, 2020; Lawton, 2020; Lortie et al., 2019). Making gatherings more accessible to nondominant groups could add breadth to the range of tacit knowledge that is shared and made explicit in the processes of *socialization* and *externalization*.

**Table 4.2: Process attributes potentially linked to the SECI cycle.**

<b>Knowledge conversion process</b>	<b>Activities</b>	<b>Source</b>
<b>Socialization</b> <i>The transfer of tacit knowledge, often through shared experience or story.</i>	-Sharing stories, experiences, expertise, and skills	Biedenweg & Monroe, 2013; Hahn et al., 2006; Stern et al., 2020
<b>Externalization</b> <i>The process of converting tacit knowledge to explicit knowledge</i>	-Demonstrations of deductive and inductive logic -Use of metaphor in dialogue that helps to illuminate lessons from stories -Linking anecdotes and local experiences to broader trends -Interpreting stories to draw conclusions	Choi & Lee, 2002; Stern et al., 2020
<b>Combination</b> <i>The process of melding sets of explicit knowledge</i>	-Comparing multiple sets of data or information -Planning strategies based on literature and data -Creating manuals and plans -Gathering technical information -Questioning, comparing, offering feedback on data or other explicit knowledge sets	Choi & Lee, 2002; Stern et al., 2020
<b>Internalization</b> <i>The process of transforming explicit knowledge into individual tacit knowledge.</i>	-Trainings to put new knowledge into practice -Integrating knowledge into work -Changes in practice, routines, or processes	Cundill, 2010; Stern et al., 2020



**Learning outcome domains and the SECI cycle**

Declarative, procedural, and relational learning outcomes each exist along a spectrum from tacit to explicit (Table 4.3). We suggest that learning outcomes in each domain may arise through movement along the SECI cycle. By fostering learning in all three domains and attending to the explicit and tacit dimensions of knowledge, effective adaptation workshops could potentially enhance collaborative capacity and help overcome the climate information usability gap. Workshop organizers could develop workshop agendas in a manner designed to make knowledge more accessible and sharable within a group, and thereby empower them to take informed and coordinated action.

This work extends Nonaka’s theory by exploring its applicability in a collaborative, multi-stakeholder setting that is different in some ways from the kinds of organizations that were envisioned when the theory was developed. Past research has explored the role of the SECI cycle in a range of organizations, such as those engaged in manufacturing, trade, transportation, service, finance, disaster risk reduction, and aerospace engineering (Becerra-Fernandez & Sabherwal, 2001; Chou & He, 2004; Nonaka et al., 1994; Oktari et al., 2022). We are unaware of research that has empirically examined Nonaka’s theory within a local collaborative climate adaptation context, nor that links the SECI cycle to learning domains. Because effective collaborative climate adaptation requires long-term cross-sector coalitions (Kaina & Kramer, 2011), and given the range of sectors, disciplines, and levels ideally engaged in climate adaptation, we suggest that a focus on learning may enrich Nonaka’s theory when applied in collaborative, multi-stakeholder settings.

**Table 4.3. Tacit and explicit dimensions of declarative, procedural, and relational learning outcome domains**

		Learning Outcome Domain		
		Declarative (Know-what)	Procedural (Know-how)	Relational (Know-who)
<b>Dimension</b>	<b>Explicit</b>	Facts, figures, concepts	Articulated and shareable processes and protocols	Knowledge of network structure and dynamics, operationalized through —conversations, network maps, organizational charts, and other artifacts
	<b>Tacit</b>	Worldview, mental models, hunches, intuition, implicit rules of thumb	Skills, habits, routines, physical/sensory experiences	Trust, affinity, distrust, unspoken group norms

Adaptation workshops are informal science learning environments in which deepened scientific and other forms of knowledge could begin to be transformed into individual and collective action (National Research Council, 2009). As such, they offer a context in which learning processes can be examined and assessed. This research examines the prevalence of learning in each domain and the evidence for SECI-cycle knowledge conversions during climate adaptation workshops. Insights from this area of inquiry could provide lessons for overcoming the climate information usability gap and improving future adaptation workshops and deepen our understanding of how learning may help communities grapple with contemporary wicked problems. We address the following research questions:

- 1) **What kinds of learning result from climate adaptation workshops?**
- 2) **What learning processes are associated with adaptation workshops?**
- 3) **What workshop elements are associated with learning?**

**Methods**

This manuscript draws upon data gathered about eight place-based climate adaptation workshops that took place between January 2021 and April 2023 and which were part of a larger study focusing on these and other research questions. Data collection took place before, during and after each workshop. Before each workshop, we conducted interviews with the local convener(s)—individuals who helped organize the workshop—to gain a deeper understanding of the community context and their goals for the workshop. All workshop participants also completed an online survey that also served as a registration form for the workshop using QuestionPro or Qualtrics survey software. At the end of each workshop, participants completed a second survey about their experience. While all workshops were originally planned to take place in person, the COVID-19 pandemic shifted six of them to online experiences. This survey was administered online if the workshop was held virtually ( $n = 6$ ) and on paper if the workshop took place in person ( $n = 2$ ). All research protocols involving human subjects were approved by the REMOVED FOR BLIND REVIEW Institutional Review Board.

### **Assessment of learning outcomes**

To evaluate the domains in which learning took place during the workshops, we drew upon closed and open-ended survey items. Participants responded to an identical battery of survey items in the pre-and post-workshop survey to evaluate their own levels of knowledge. We developed these items to correspond with declarative, procedural, and relational adaptation knowledge (Table 4.4). Response categories were composed of a seven-point Likert-type scale with response options *Strong disagree*, *Disagree*, *Somewhat Disagree*, *Neither agree nor disagree*, *Somewhat agree*, *Agree*, and *Strong agree*. When we refer to knowledge, we are referring to participants' responses to these survey items. We consider differences in scores from pre- to post workshop to be evidence of self-assessed learning.

We conducted confirmatory factor analyses (CFA) and reliability analyses using R to examine relationships among items and underlying latent factors. CFA tests hypothesized measurement models and identifies model revisions to improve fit with the data (Bandalos, 2018). We tested a range of models, including a one-dimensional model to explicitly test the null hypothesis that the forms of knowledge in our typology were indistinguishable. We next tested three-dimensional models to evaluate our originally hypothesized three-domain model. We also tested a two-dimensional model that combined procedural and relational knowledge. In each case, we followed Andersen and Gerbing's (1988) approach to model testing by evaluating the loadings of indicators within each independent measurement model and sequentially removing indicators with latent-variable loadings below 0.5. We examined indicators of model fit including the Robust Comparative Fit Index (CFI), Standardized Root Mean Square Residual (SRMR) the Robust Root Mean Square Error of Approximation (RMSEA), the Akaike information criterion (AIC), and the Bayesian information criterion (BIC) to identify the best-fitting model (Brown 2015; Byrne, 2013). Values for the CFI should be greater than .9, for the SRMR should be less than .09, and for the RMSEA should be below .06 for acceptable models (Bandalos, 2018; Hu & Bentler, 1999). For AIC and BIC, smaller values are indicative of better fitting models (Burnham & Anderson, 2004). After identifying the best-fitting measurement model, we created composite indices for each learning dimension by weighting each item equally and averaging all items within the index. We also calculated Cronbach's alpha scores for all resulting indices. Cronbach's alpha measures an index's internal consistency on a scale ranging from 0 to 1, with higher scores representing greater internal consistency. Scores above .7 are considered acceptable for index development (DeVellis, 2003).

We performed a range of tests to examine each research question. We performed paired sample t-tests to examine the impact of participating in an adaptation workshop on respondents' self-assessed knowledge by comparing mean knowledge scores before and after participation in the workshop. We also examined differences between individual workshops, between those that happened in-person vs. those online, and between those that happened before and after minor adjustments were made to the workshop design (see below for more detail) using independent samples t-tests and ANOVA to compare self-assessed learning

across workshops. We calculated Cohen’s *d* for each of the statistically significant results. Cohen’s *d* assesses the effect size of statistically significant associations. A score of 0.2 is considered small, 0.5 is considered medium, and 0.8 or higher is considered a large effect size (Cohen, 1988). We calculated Cohen’s *d* for each of the statistically significant results.

**Table 4.4. Survey items associated with Declarative, Procedural and Relational knowledge.**

<b>Domain</b>	<b>Survey item (7-pt scale: Strongly disagree to Strongly Agree)</b>
Declarative	I understand the causes of climate change
	I understand the impact of climate change in my region
	I feel I have a good understanding of the concept of climate adaptation
Procedural	I know how to plan for meaningful climate adaptation in my region
	I know how to implement climate adaptation strategies
	I know how to identify which climate adaptation strategies are likely to be most successful.
Relational	I understand the relationships among the people and groups working on climate adaptation in my location.
	I understand the priorities of others engaged in climate adaptation work in my region
	I see how my work can fit with the work of others in climate adaptation efforts in my region

### **SECI cycles and workshop components’ contributions to learning**

We contend that the knowledge conversions of the SECI cycle may manifest as “ah-ha” moments, or instances of sudden realization, insight, or comprehension that contribute to long-term learning (Pilcher, 2015; Topolinski and Reber 2010). We analyzed participants’ self-reported “ah-ha” moments to establish linkages among the kinds of insights reported by workshop participants, the stages of the SECI cycle, and the workshop context in which they occurred. We drew upon the following open-ended question in the post-workshop survey: “Did you have any “ah-ha” or “light-bulb” moments during the workshop? If so, please describe them and explain how the workshop contributed.” The lead author coded write-in responses through an iterative sequence of identifying themes then refining and adding additional codes in subsequent coding efforts to accommodate additional concepts and insights (Bailey, 2017; Miles et al., 2018). We classified “ah-ha” moments as declarative, procedural, and relational learning, as well as within other emergent codes. We further classified respondents’ “ah-ha” moments within the SECI cycle with one additional nuance. Because *internalization* is gradual process that likely extends beyond the timeframe of the workshop, we could only code “ah-ha” moments for anticipation, planning, or preparing to act in a manner consistent with internalization, rather than the act itself. We labeled these instances *potential internalization*. Finally, we categorized respondents’ explanations of how the workshop contributed to their insight according to elements of the workshop agenda and other emergent codes. Codes and examples were discussed with the second author to enhance validity. Following Eisenhardt (1989), we compared the emergent themes with existing literature and enfolded additional concepts to refine our constructs and boost generalizability. See supplementary materials for our codebook. We then cross tabulated learning domains and stages of the SECI cycle to examine associations between them. We also cross tabulated each with the workshop elements identified by participants as contributing to their key insights to examine trends in which components of the workshop most contributed to each learning domain and process.

### **Case selection and workshop format**

We sent out a call for applications to communities to host a climate adaptation workshop through a variety of professional networks, including the Climate Adaptation Knowledge Exchange (CAKE) and the American Society of Adaptation Professionals (ASAP). We received more than 90 applications. We

then selected communities based upon three factors. First, we sought communities wherein local planning processes were underway or in preparation because literature suggests that incorporating climate adaptation into ongoing efforts can help advance sustainable change (e.g. Runhaar et al., 2018). Of eligible communities, we then sought places that varied along two dimensions: the presence or absence of climate adaptation planning mandates and the occurrence of extreme weather events during the previous five years that the local partners linked to climate change.

By selecting communities according to the presence or absence of mandates and extreme events, we sought to include cases that varied systematically along dimensions that prior research suggests can influence learning within collective adaptation processes. Disasters such as climate change-related extreme weather events may help trigger learning because of the “availability heuristic,” which holds that individuals are more likely to attend to issues with which they have firsthand experience (Kahneman, 2011). Similarly, mandates requiring that communities engage in planning related to climate adaptation can be indicative of the extent to which climate change adaptation is prioritized within a community and serve as a proxy for the prevailing political climate of an area. Political affiliation and other collective identities can influence attitudes, beliefs, and behavior related to climate change (Carmichael et al., 2017; Egan et al., 2017; Mackay et al., 2021). One way this may influence learning in climate adaptation workshops is through identity threat, which can occur when an experience is perceived as potentially endangering “the value, meanings or enactment of an identity” (Petriglieri 2011:641). In areas where talking about climate change may cause identity threats, workshop participants may be more likely to engage in motivated reasoning, in which people tend to automatically evaluate information by how well it aligns with the views of groups with which they identify (Kahan, 2013; Stets & Serpe, 2013). Workshops were also selected to ensure diversity in geographical spread across the U.S. and for each site’s urban/rural character. See Table 4.5 for an overview of all selected cases.

Once a community was selected, we worked with the applicant or other local conveners to organize the workshop. This process included selecting workshop dates and a venue (if in-person), identifying, and inviting participants, and selecting focal topics for deeper exploration during the workshop. Workshop organizers and host communities had planned for each workshop to take place in person. Disruptions from the COVID-19 pandemic caused six of the eight workshops to be held virtually, using the Zoom videoconferencing platform. The workshops in Butte-Silver Bow, Montana, and Salisbury, Maryland, took place in person because transmission rates at the time of the workshop were at a level deemed acceptable by organizers and the host community.

**Table 4.5: Host community overview and workshop format**

		<b>Mandate</b>	
		<b>No adaptation mandate</b>	<b>Adaptation mandate</b>
<b>Climate event</b>	<b>No climate event</b>	<b>Place:</b> Kalamazoo, MI <b>Climate Event:</b> None <b>Density:</b> Urban <b>Workshop format:</b> Virtual	<b>Place:</b> Salisbury MD <b>Climate Event:</b> None <b>Density:</b> Urban <b>Workshop format:</b> In-person
		<b>Place:</b> Butte-Silver Bow, MT <b>Climate Event:</b> None <b>Density:</b> Rural <b>Workshop format:</b> In-person	<b>Place:</b> Canton and Potsdam, NY <b>Climate Event:</b> None <b>Density:</b> Urban <b>Workshop format:</b> Virtual
	<b>Climate event</b>	<b>Place:</b> Johnson County, IA <b>Climate Event:</b> Freshwater flooding <b>Density:</b> Rural <b>Workshop format:</b> Virtual	<b>Place:</b> Santa Rosa, CA <b>Climate Event:</b> Fire <b>Density:</b> Urban <b>Workshop format:</b> Virtual
		<b>Place:</b> Chattanooga, TN	<b>Place:</b> Indian River County, FL

	<b>Climate Event:</b> tornado, drought, wildfire <b>Density:</b> Urban <b>Workshop format:</b> Virtual	<b>Climate Event:</b> Hurricane and Erosion <b>Density:</b> Rural <b>Workshop format:</b> Virtual
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**Workshop overview**

Both in-person and virtual versions of the workshop covered essentially the same material, and the basic structure of the event remained largely consistent between workshops. In-person workshops took place over two consecutive days, whereas virtual workshops took place over three half-day sessions spread over one or two weeks.

The arc of each workshop followed the steps described in the Rapid Vulnerability and Adaptation Tool (RVAT), a workbook designed to usher users through four consecutive steps: project scoping, vulnerability assessment, adaptation strategy development, and adaptation implementation planning (EcoAdapt, 2021). During in-person workshops, the first day focused on discussing local climate impacts, project scoping and assessing vulnerability, and the second day focused on developing adaptation strategies. For virtual workshops, the first session focused on understanding climate impacts and project scoping, the second on assessing vulnerability, and the third on developing adaptation strategies. All workshops followed the same basic format. After welcoming remarks, facilitators lead participants through an icebreaker about whether participants thought of themselves as optimists, pessimists, or pragmatists, both in their daily lives and in terms of how they think about climate change. In virtual workshops, participants then spent five minutes in breakout groups with two other workshop participants for small-group introductions. During in-person workshops, facilitators asked participants to line up according to the extent of their experience with climate change adaptation (from those new to the work to more seasoned adaptation practitioners), and then led a discussion with participants from both ends of the spectrum.

Facilitators gave an overview of the workshop agenda and presented on the steps involved in adaptation planning. Participants then worked individually to complete the opening steps of the Climate Change Adaptation Certification Tool (CCAC), a workbook designed to assess the climate readiness of specific projects and policies. The CCAC process helps users to identify climate change risk factors, evaluate climate impact on their project, and determine whether to approve the project. After completing the first step of the CCAC, participants were asked to finish the CCAC as a homework assignment outside workshop hours.

During plenary presentations, facilitators next introduced climate change impacts and vulnerability assessments, including a summary of projected changes to climate (such as temperature, precipitation, and seasonality) and impacts for the region, where to find data, and how to use it. The workshop then shifted to breakout groups, wherein each group worked through the first steps of the RVAT. Breakout group themes and members were determined in advance in collaboration with local organizers to address topics of interest to the community. Each workshop’s breakout groups are described in Table 4.6. In breakout, facilitators led each group through a process of identifying and prioritizing pre-existing conditions—or current stressors already impacting their community—as well as climate stressors. Each breakout group then conducted a vulnerability assessment by exploring the intersection of each priority pre-existing condition and climate stressor to identify probable impacts of greatest concern for their focal area. For each impact of greatest concern, the group then assessed the likelihood and consequence of the impact occurring, the resulting risk, and the community’s adaptive capacity to cope with the impact to develop a holistic assessment of the community’s vulnerability to each impact. Participants returned to plenary to share their findings with the group, and facilitators presented an introduction to adaptation strategies.



to specific climate-related impacts. After the workshop in Kalamazoo, organizers expanded a presentation on vulnerability assessments to include a stronger focus on equity.

**Table 4.6. Climate change adaptation workshop details.**

<b>Workshop</b>	<b>Date</b>	<b>Format</b>	<b>Breakout topics</b>	<b>Number of participants</b>
<b>Santa Rosa</b>	January 19, 21, & 27, 2021	Virtual	Land Use & Economic Vitality Housing & Environmental Justice Transportation & Noise and Safety Public Services & Open Space	33
<b>Johnson County</b>	March 23 & 30, & April 6, 2021	Virtual	Land Use Health and Safety Transit Facilities and Public Services	28
<b>Indian River County</b>	October 26, & 28, & November 3, 2021	Virtual	Utilities Transportation Conservation Lands and Parks	16
<b>Kalamazoo</b>	February 8, 10, & 14, 2022	Virtual	Connected Communities Habitat Conservation and Biodiversity Food Security and Agriculture	27
<b>Butte Silver-Bow</b>	June 8-9, 2022	In-person	Public Health Water Resources Contaminated Sites Protection and Redevelopment	26
<b>Chattanooga</b>	October 3, 4, & 6, 2022	Virtual	Housing Transportation Natural Resources	27
<b>Canton/Potsdam</b>	March 7, 9 & 14, 2023	Virtual	Housing Utilities Agriculture and Food Security	19
<b>Salisbury</b>	April 24-25, 2023	In-person	Transit/housing Open Spaces	13

## **Results**

A total of 248 people registered for the eight adaptation workshops, and 189 attended at least a portion of the workshop for which they had registered. We collected both pre-and post-workshop surveys from a total of 151 participants. Due to a survey formatting error, we were unable to use quantitative post-workshop knowledge scores for participants from one workshop (Chattanooga). While those data have been excluded from quantitative analyses, we do include the open-ended responses from Chattanooga participants in our analysis of “ah-ha” moments. This leaves an effective sample size of 138 for quantitative analyses and 151 for qualitative analyses.

### ***Index development: Learning domains***

Our CFA analyses compared one- and three-factor models to test the fit of our hypothesized model. Independent measurement models of the three-dimensional model suggested dropping two items due to low factor loadings (< .5): “I feel I have a good understanding of the concept of climate adaptation”

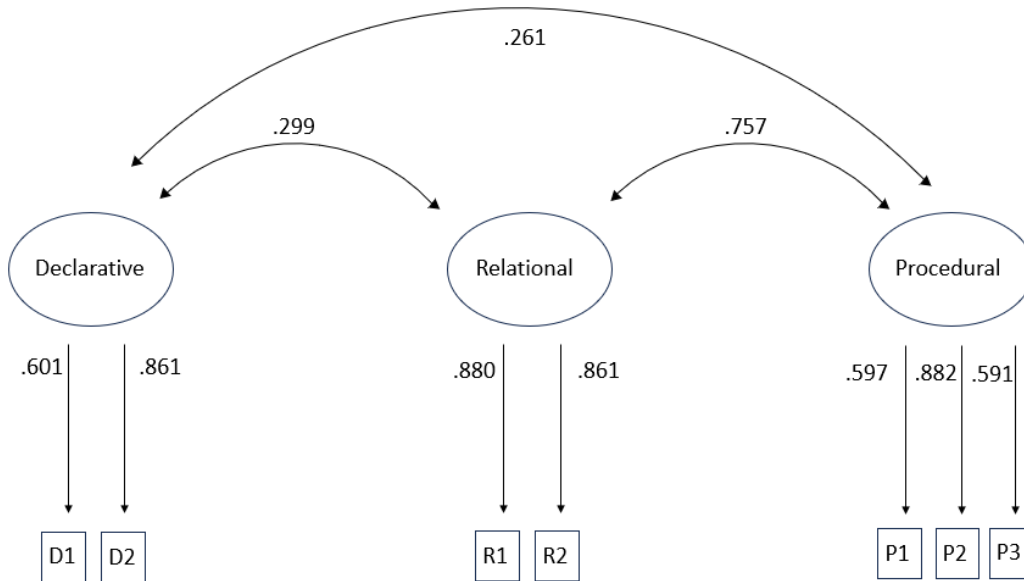
(declarative) and “I see how my work can fit with the work of others in climate adaptation efforts in my region” (relational).

Because we found relatively high covariance between procedural and relational knowledge. We also developed a two-dimensional model that combined procedural and relational knowledge, but the fit indices indicated that the three-dimensional model was the best fit, suggests that they better reflect distinct concepts as originally hypothesized (Table 4.7; Figure 4.2). The resulting Cronbach’s alpha scores for the declarative (.839), procedural (.879), and relational (.915) knowledge indices were each deemed acceptable.

**Table 4.7. Results from CFA model building and adjustments for learning domains.**

Model Development	Df	Chi-Square	CFI	RMSEA	SRMR	AIC	BIC
<b>One-dimensional model</b>	27	72.120	0.814	0.117	0.100	3208.091	3258.563
<b>2-D model w/out covariance</b>	15	30.385	0.912	0.091	0.110	2504.568	2541.126
<b>2-D model with covariance between factors</b>	13	25.148	0.931	0.087	0.055	2500.472	2542.655
<b>3-D model w/out covariance</b>	17	96.830	0.545	0.195	0.380	2587.319	2618.253
<b>3-D model with covariance between factors</b>	11	5.016	1.000	0.000	0.026	2480.253	2528.060

**Figure 4.2. Best fitting model.**



**Workshop Learning**

We observed statistically significant gains in declarative, procedural, and relational knowledge (Table 4.8). Gains in procedural and relational knowledge exhibited a large effect size, whereas the change in declarative knowledge exhibited a small effect size, likely due to a ceiling effect resulting from high self-reported levels of declarative knowledge prior to the workshops. We found no significant differences



between workshops in the learning scores for declarative, procedural, or relational knowledge; between workshops that took place during the first versus the second half of the study (after revisions to the workshop design); or between online and in-person workshops ( $p > 0.05$ ).

**Table 4.8. Paired sample t-test and effect sizes for self-assessed declarative, procedural, and relational knowledge indices.**

Item	Pre-mean	Post-mean	SD	T-stat	DF	P-value	Cohen's d
Declarative knowledge	6.02	6.16	0.68	2.37	123	0.02	0.21
Procedural knowledge	4.29	5.41	1.11	11.18	123	<.01	1.00
Relational knowledge	4.14	5.45	1.31	10.57	125	<.01	0.94

***“Ah-ha” moments and learning outcome domains***

One-hundred and four respondents (69% of those who completed post-workshop surveys) indicated that they experienced an “ah-ha” moment as a result of the workshop they attended. Many of these insights were classifiable as declarative, procedural, or relational knowledge, but insights in other domains emerged as well (Table 4.9). The most common “ah-ha” moments were related to procedural learning (47), followed by relational (25) and declarative (24) learning. Respondents also reported “ah-ha” moments linked to affective states, or insights around feelings, attitudes, and emotions (Marks et al., 2010). Through an iterative process of refining codes and consulting the literature to accommodate emergent themes (Eisenhardt, 1989), we categorized these affective “ah-ha” moments as insights into efficacy (11) and motivation for climate adaptation (12). Nine respondents reported general “ah-ha” moments but did not provide sufficient detail to categorize their insight (Table 4.9).

**Table 4.9. “Ah-ha” moments reported by adaptation workshop participants.**

Category	“Ah-ha” moment	Count	Emblematic quotes from workshop participant survey responses
Learning domain	Procedural	47	<i>A systemic way of looking at the risks and vulnerabilities as well as solutions and opportunities</i>
	Relational	26	<i>Ah-ha moment was when we realized that all of the key leaders in sustainability were in the room but none of us really knew what the City's goals were around certain things like % increase of tree canopy, how many acres of green space, emissions reductions, etc. Seems like something that would be important for all of us to know this so that we can be working towards shared goals.</i>
	Declarative	24	<i>Getting the infographic of the changes by 2050 and 2100 was very grounding</i>
Affective domain	Efficacy	11	<i>I was not optimistic about [our ability to adapt] but now I am.</i>
	Motivation	12	<i>The future projections of weather changes made me want to move faster to implementation.</i>  <i>I gained insight into the importance of factoring in expected climate changes into planning of adaptive measures.</i>
Other	General	9	<i>The work groups had numerous moments where great ideas were shared</i>

### ***“Ah-ha” moments and workshop elements***

Respondents described the context in which an “ah-ha” moment they experienced occurred (Table 4.10). These “ah-ha” most commonly took place during plenary activities (n=12) or breakout work (n=10). Of those who identified insights occurring during breakout sessions, five highlighted the RVAT process, and three indicated that their insight occurred during breakout sessions more generally. Two respondents pinpointed specific element of the breakout work: efforts around developing and prioritizing strategies. Other participants (n=3) attributed their insights to the interdisciplinary nature of the process overall, hearing the perspectives of other participants, and observations made outside workshop sessions. Five respondents indicated that more than one workshop element generated key insights. Declarative, procedural, and relational “ah-ha” moments took place in both plenary and breakout sessions. Most declarative insights occurred in plenary, whereas most procedural insights took place in breakout groups. Relational insights were evenly divided between plenary and breakout. The plenary element that triggered relational insights for participants was the series of network maps that workshop organizers shared with participants and which they were invited to modify and adapt. Reported affective “ah-ha” moments related to motivation for climate adaptation were entirely triggered in plenary. No participants linked efficacy-related “ah-ha” moments to specific workshop elements. Some participants described when their “ah-ha” moment occurred during the workshop but did not identify the nature of the insight. These general “ah-ha” moments occurred during Breakouts (3) icebreakers (1) and outside the workshop (1).

**Table 4.10. Context in which "ah-ha" moments occurred.**

Workshop Context (number of associated "ah-ha moments)		Emblematic quotes from workshop participant survey responses (Learning domain of quote)	Learning domains			
			Declarative	Procedural	Relational	Motivational
Plenary	<b>Projections (4)</b>	<i>Definitely hearing about the real scientific numbers for warming, which were dramatically higher than the conservative watered-down numbers you see on the news. (Declarative)</i>	4			2
	<b>Network maps (2)</b>	<i>The network visualization really showed how a lot of different entities were connected when addressing complex issues. (Relational)</i>		1	2	
	<b>CCAC tool (2)</b>	<i>I had this gut dropping feeling that I need to show the... CCAC tool to as many people in leadership positions as possible. (Motivational)</i>	1			1
	<b>Ice breakers (2)</b>	<i>During one of the ice-breaker chats we realized we need to get our sustainability committees working together more, and I met the Climate Smart Communities Regional Coordinator who can help us make that happen. (Procedural; Relational)</i>		1		
	<b>Report outs (1)</b>	<i>Hearing the other breakout presentations and seeing large amt of overlap. So much in common! (Relational)</i>	1			
	<b>Presentations (1)</b>	<i>How affected all sectors of community will be b/c of climate change--CCAC &amp; presentations (Declarative)</i>	1			
Breakout work	<b>RVAT process (5)</b>	<i>The climate adaptation tool process was an aha moment. Easy way to think about future impact. (Procedural)</i>		4		
	<b>Breakout: General (3)</b>	<i>I realized during the agriculture breakout session just how many resources ARE already available. As a farmer myself, I made a list of different places to look for grants, support, etc. One of our goals was to broadcast these resources more readily. (Procedural)</i>	2		1	
	<b>Developing strategies (1)</b>	<i>Maybe I strayed a bit from the topic at hand, but discussing strategies helped me brainstorm ideas for how to integrate concepts into work I'm doing now. "People hate native plants that look like weeds." Maybe a native coloring book for local kids to learn about them &amp; to find them in the real world. (Procedural)</i>		1	1	
	<b>Prioritizing strategies (1)</b>	<i>Just watching the creative/thoughtful juices flow by end of day I--follow-up on day II --&gt; solutions ranking (General)</i>				
Other	<b>Interdisciplinarity of workshop (1)</b>	<i>I was thinking about natural solutions for climate impacts to [our community], it made me think about how our work in conservation and ecological restoration could help mitigate flooding along the... River with the right resources. It was essentially the interdisciplinary approach of</i>	1			

		<i>this program that provided the context. (Procedural)</i>				
	<b>Other participants sharing (1)</b>	<i>It was good to hear others share the perspective that housing density is important to climate adaption. (Relational)</i>		<i>1</i>		
	<b>Outside the workshop (1)</b>	<i>As I was walking around my neighborhood, I had new ideas come up. (General)</i>				

***“Ah-ha” moments, learning domains, and the SECI cycle***

Some “ah-ha” moments were codable as instances of combination (n=19), potential internalization (n=15), and externalization (n=8). For example, one participant described an insight related to combining two elements of explicit knowledge (combination): “The process challenged me to think specifically about the element of long-term change brought on by climate and how that change might influence the work we do.” Another participant spoke about how the explicit knowledge they acquired in the workshop could be transformed into tacit knowledge embedded in their workflow (potential internalization): “One of the ‘ah-ha’ moments for me was thinking through how my office at the state level could apply this information directly. We don’t control a lot of physical assets, but we do offer grant funding that results in physical assets. So I did have a bit of a lightbulb moment that attaching some additional requirements to grants could be a good option for furthering adoption of climate smart design/development.” A third participant described a process of converting tacit knowledge into a shared explicit understanding (externalization) as their intuitions about the nature of their shared goals were made clear: “We realized that all of the key leaders in sustainability were in the room but none of us really knew what the City’s goals were around certain things like % increase of tree canopy, how many acres of green space, emissions reductions, etc.”

We were able to code 43 “ah-ha” moments in terms of both learning domains and stages of the SECI cycle (Table 4.11). Instances of externalization were primarily related to relational learning and instances of potential internalization with procedural learning. Examples of combination were more evenly distributed across learning domains. Three responses were linked to affective “ah-ha” moments and stages of the SECI cycle. Two motivational insights were linked to moments of externalization, and one efficacy insight was linked to potential internalization.

**Table 4.11. Distribution of participants’ “ah-ha” moments within the SECI cycle as a function of learning outcome domain.**

SECI stage	Learning Domain				
		Declarative	Procedural	Relational	Total
<b>Externalization</b>	<i>N</i>	2	2	7	11
	%	29%	9%	50%	26%
<b>Combination</b>	<i>N</i>	5	7	4	16
	%	71%	32%	29%	37%
<b>Potential Internalization</b>	<i>N</i>	0	13	3	16
	%	0%	59%	21%	37%
<b>Total</b>	<i>N</i>	7	22	14	43

Thirteen “ah-ha” moments were classifiable in terms of their SECI cycle stage and associated workshop context (Table 4.12). Four “ah-ha” moments related to combination were associated with projections that were shared during the workshop. The remaining instances of “ah-ha” moments were broadly distributed across workshop elements and SECI stages.

**Table 4.12. Workshop elements associated with “ah-ha” moments classifiable within the SECI cycle.**

Workshop element	SECI Stage			Total
	Externalization	Combination	Internalization	
<b>Network maps</b>	1	--	--	1
<b>Breakouts</b>	1	1	--	2
<b>Projections</b>	--	4	--	4

<b>Interdisciplinarity of the workshop</b>	1	--	--	1
<b>Developing strategies</b>	--	--	1	1
<b>CCAC tool</b>	--	1	--	1
<b>Presentations</b>	1	--	--	1
<b>Ice breakers</b>	--	--	1	1
<b>Report outs</b>	--	1	--	1
<b>Total</b>	4	7	2	13

## Discussion

This study sought to identify how learning happens in climate adaptation workshops. Our analyses support our hypothesis that declarative, procedural, and relational learning comprise distinct learning outcome domains for participants in climate adaptation workshops, and we found that participants across all workshops in our sample reported statistically significant learning gains in each domain. Our qualitative findings provided further evidence that workshop participants experienced key “ah-ha” moments across these learning domains, as well changes in respondents’ perceived efficacy and motivation. Key insights experienced by workshop participants aligned with some stages of the SECI cycle. We identified “ah-ha” moments associated with externalization, combination, and potential internalization, but not socialization. Of the responses that were both classifiable within the SECI cycle and linked to learning domains, most were associated with procedural learning, but we also found evidence of knowledge conversions across declarative and relational learning domains.

Participants linked their learning to a range of workshop elements. Reported declarative and motivational insights were primarily associated with workshop elements that occurred in plenary, whereas procedural insights more often occurred in breakout sessions. Relational “ah-ha” moments were divided between plenary (associated with network maps) and breakout sessions. The most common pairing of SECI stages and workshop elements were instances of combination associated with sharing climate projections in plenary. The remaining “ah-ha” moments associated with SECI stages were broadly distributed across workshop elements. We explore the theoretical and practical implications of these findings below.

### Declarative, procedural, and relational learning

Our findings of distinct declarative, procedural, and relational learning domains align with prior research which has sought to disaggregate forms of learning relevant for climate adaptation and related contexts (e.g. Baird et al 2013; Huitema et al., 2010). Although participants reported learning across all domains, the relatively high covariance between procedural and relational knowledge in our confirmatory factor analysis may indicate a closer relationship between these two forms of learning than between either domain and declarative learning. This suggests that for adaptation professionals, an understanding of the adaptation network and of the steps, approaches, and processes for enacting adaptation were more strongly associated with one another than with an understanding of relevant facts and concepts. However, the smaller gains we identified in declarative knowledge may be partially due to a ceiling effect (Cramer and Howett, 2004), because participants arrived at the workshop reporting relatively high levels of declarative knowledge. A retrospective assessment, in which participants are asked immediately after the workshop to reflect upon the extent of their learning in each domain, might have yielded a more sensitive measure.

### Knowledge conversions and learning domains

Participants reported experiences related to externalization, combination, and internalization across declarative, procedural, and relational domains. This suggests that adaptation workshops can serve as venues for sharing and transforming tacit and explicit knowledge across learning domains. Movement

along the SECI cycle from tacit to explicit serves to make knowledge shareable, and therefore more actionable, across a collective (Stern et al., 2020). The occurrence of externalization and combination during the adaptation workshops in our sample suggest that these processes can help groups create a shared body of actionable knowledge across learning domains by transforming individual, tacit knowledge into shared explicit knowledge. These stores of actionable knowledge could, in turn, enable groups to take more meaningful, informed, and effective action (Mach, et al., 2020). We have as of yet been unable to track these impacts long-term, due to the lag between knowledge generation and the impact of that knowledge. This lag is a persistent challenge for those seeking to gauge the success of efforts to generate actionable knowledge (Jagannathan et al., 2023). However, the presence of potential internalization knowledge conversions in our sample suggests that participants anticipated their ability to draw upon shared explicit knowledge and convert it to tacit knowledge in the future.

The prevalence of procedural knowledge conversions relative to conversions in other domains may be due to at least three factors. First, the workshop process designed by the facilitating organization in our study is closely linked to an adaptation workbook and structured to help communities plan for implementation. Workshops designed with a stronger focus on climate science, for example, might have generated more declarative knowledge conversions. Second, because participants arrived at workshops with higher levels of declarative knowledge, they may have experienced fewer conversions in that domain. Lastly, procedural knowledge conversions may have stood out to participants as more useful or better aligned with their needs and expectations than conversions in other domains, and therefore been reported as significant “ah-ha” moments at a higher rate, even if participants experienced insights equally across domains.

Uncertainty about how to respond to climate change can be a significant barrier to adaptive action (Berhout et al., 2006; Siders and Pierce, 2021). This uncertainty could leave individuals and groups grappling with a lack of efficacy. Efficacy beliefs are linked to behavior across a range of environmental domains (e.g. Geiger, Swim and Fraser, 2017; Schutte and Bhullar, 2017). Procedural learning in adaptation workshops could empower individuals to take actions in part by enhancing their feelings of efficacy. This link between procedural learning and efficacy beliefs, and the challenges stemming from uncertainty about how to respond to climate change, could explain why procedural knowledge conversions were more prevalent among workshop participants’ “ah-ha” moments.

Several factors may have contributed to the absence of socialization from our sample and the limited number of internalization-type “ah-ha” moments. Socialization and internalization stages of the SECI cycle may not have registered as key insights for participants because they involve sharing or forming tacit knowledge, which is, by nature, less readily articulated. Reporting on tacit knowledge in a survey would require respondents to effectively engage in a process of externalization in order to share their experience. The research team observed clear examples of the sharing of tacit knowledge between parties during in-person workshops, suggesting that observational techniques coupled with qualitative reflection might have been better able to identify socialization than questionnaires about “ah-ha” experiences. Survey biases may have also played a role in limiting socialization-type responses. For example, social desirability bias can lead survey respondents to answer in ways that they think will reflect favorably on them in terms of prevailing cultural norms (Krumpal, 2013). Participants may have felt that insights gleaned while chatting with one’s neighbor during a bathroom break were less worthy of reporting than those that arose during a formal presentation. Socialization may be under-represented in our sample due to the prevalence of online workshops in our sample. In-person workshops may lend themselves to socialization more readily than online processes, and only two workshops in our sample were in-person. Lastly, because internalization is usually a longer-term process, participants may have experienced “ah-ha” moments related to this stage of the SECI cycle.



Alternatively, participants may simply value explicit knowledge more. Other research reflects a distinction between the perceived impact of conversions yielding explicit knowledge and those yielding tacit knowledge. Becerra-Fernandez and Sabherwal (2001) found that knowledge conversions resulting in explicit knowledge (combination and externalization) impacted perceived knowledge satisfaction for study participants, whereas those stages yielding tacit knowledge (socialization and internalization) did not. Because converting knowledge to explicit formats can help render it actionable for a group, externalization and combination may have felt more impactful for workshop participants engaged in collective climate action. Future research could seek to identify linkages among learning in declarative, procedural, and relational domains; knowledge conversions; and collective action.

### **Learning and workshop design**

Learning outcomes in each domain were observed across diverse components of the workshops. The distribution of learning across workshop elements supports prior findings suggesting that diverse formats and opportunities for interchange between participants are important for fostering learning across learning domains (Stern et al., 2023). Although we found that learning in all domains could take place across workshop components, more instances of declarative learning occurred in plenary, whereas more instances of procedural learning occurred in breakouts, suggesting that certain workshop elements may lend themselves more readily to learning within specific domains.

We did not identify statistically significant differences in self-reported learning between online and in-person workshops, suggesting that meaningful declarative, procedural, and relational learning can take place despite the differences between formats. Workshop organizers adjusted the agenda when preparing for online workshops in an effort to foster the kinds of informal interpersonal interactions that arise naturally during in-person events. We found evidence that these changes contributed to learning in online workshops. For example, one participant reported a key insight arising from the small-group introductions that took place at the beginning of each online workshop session. The interactions in those small-group discussions may have helped compensate for the absence of encounters that would have taken place during breaks and in the interstices of in-person workshops. However, the absence of meaningful differences between in-person and online workshops may instead be indicative of shortcomings in our measurements. Without retrospective or systematic, qualitative observational data, we may have missed opportunities to measure socialization effectively.

### **Implications for practice**

From a practical standpoint, our findings of distinct learning domains suggest that facilitators and other practitioners could design workshops around declarative, procedural, and relational learning. They could strive to ensure broader learning outcomes by developing workshop agendas that purposefully touch upon each learning domain or purposefully target workshops to encourage learning within select domains depending on the needs of the community. One potentially innovative strategy for accomplishing this could be by overlaying the learning domains on the stages of the SECI cycle. By helping groups articulate and share knowledge in each domain, facilitators could equip groups with a broader suite of actionable knowledge. Potential learning outcomes and activities that could support knowledge conversions across domains of learning outcomes are described in the supplementary materials. External facilitators could further tailor their efforts to participants' needs by seeking to identify the preexisting levels of shared knowledge within each domain through surveys or interviews with prospective workshop participants and local organizers and then weighting workshop activities to favor movement along the SECI cycle in domains where the group is in greater need of support.

In contexts like climate change adaptation efforts, there can exist a presumption that explicit, scientific knowledge forms should drive decisions (Antonello and Howkins, 2020). An approach to climate adaptation workshops that attends to the full range of learning domains and dimensions could counter that presumption, help generate actionable knowledge, and align workshops with the kinds of learning that

participants value. Our findings indicate that procedural knowledge is a primary area in which participants experience key insights. Shifting workshops to focus more on procedural learning and less on declarative scientific knowledge could help more participants achieve these valued insights. Participants also experienced key insights linked to stages in the SECI cycle involving explicit knowledge. Helping participants transform tacit knowledge to explicit knowledge through externalization before engaging in the more familiar process of combination could help bridge the knowing-doing gap as by supporting groups as they articulate, examine, and synthesize shared knowledge (Hulme, 2014; Stern et al., 2020). For example, if the members of a group come together and articulate their tacit understanding of the patterns of their respective workflows, then compare those trends to new ideas about how to implement climate adaptation, they could potentially develop more effective procedures for taking action than if they had not articulated and shared their knowledge.

Broadening the aperture of valued learning domains and dimensions could also benefit collective adaptation efforts in other ways. Although our participants did not report socialization-related insights, the kinds of interactions thought to contribute to socialization can benefit groups by deepening trust and strengthening relationships (Stern et al., 2020). Similarly, although internalization is an individual process that primarily occurs after adaptation workshops, by considering the internalization stage of the SECI cycle in workshop design, facilitators could support groups seeking to act upon the shared knowledge they have created. This aligns with findings of other research that demonstrates the importance of long-term support for groups working on place-based climate adaptation (O'Brien, in prep; Stern et al., 2023). Lastly, structuring workshops in a manner attentive to all learning domains and dimensions could help foster more equitable relationships in which non-dominant knowledge holders are better able to introduce and share their knowledge (Mach et al., 2020).

### **Conclusion**

This study offers a coarse first attempt at providing evidence for a typology of collaborative learning and examining how the typology aligns with the stages of the SECI cycle in climate change adaptation processes. Our work has both theoretical and practical implications for research and practice. In terms of theory, this work provides support for a tripartite learning typology and demonstrates that place-based climate adaptation workshops yield meaningful knowledge conversions for participants. We also link moments of key insight to a range of workshop elements and find that online and in-person workshops can yield comparable self-assessed learning outcomes. From a practical standpoint, overlaying our learning typology with the SECI cycle provides a scaffolding upon which workshop organizers could develop adaptation workshop agendas and structure collaborative practices. Our findings suggest that procedural learning and SECI cycles related to externalization, combination, and potential internalization can yield key insights for participants.

Although our work begins to illuminate the contours of learning domains relevant for climate adaptation and supports the SECI cycle as a mechanism for fueling knowledge conversions across domains, future research could expand upon or challenge our findings. Scholars could seek to link workshop learning to subsequent adaptive actions, and to further explore the relationships among declarative, procedural, and relational knowledge and feelings of efficacy and motivation. We hope practitioners and scholars continue to explore, critique, and deploy the concepts elaborated upon herein.

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## Supplementary materials

**Supplementary Table 4.1. Codebook**

Parent code	Child code 1	Description
Learning		Evidence of a process “that results in a relatively enduring change in a person or persons, and consequently how that person or persons will perceive the world and reciprocally respond to its affordances physically, psychologically, and socially” (Alexander et al., 2009).
	Declarative	New understandings of facts, concepts, and the ways they interact
	Procedural	New understandings of processes, procedures, and techniques for action
	Relational	Understanding others’ mindsets and priorities Understanding network structure and dynamics
	Efficacy	Changes to feeling of self-or collective-efficacy related to adaptation
	Motivation	Changes to feelings of drive or enthusiasm for adaptation
	General	Reported ah-ha moment that cannot be classified within the learning typology
SECI cycle		Evidence of the combination or transformation of knowledge types (Nonaka et al., 2000)
	Socialization	Evidence of the transfer of tacit knowledge between individuals
	Externalization	Evidence of the conversion of tacit to explicit knowledge
	Combination	Evidence of melding sets of explicit knowledge.
	Potential Internalization	Evidence of the transformation of explicit knowledge to tacit knowledge in individuals or evidence that respondents are considering ways that explicit knowledge could be embedded in tacit knowledge in the future.
Workshop element	Projections	Climate projections shared during the workshop in presentations and as handouts
	Network maps	Social network maps shared as posters or interactive website
	CCAC tool	A worksheet designed to assess the robustness of projects to climate projections
	Ice breakers	Small- and large-group activities designed to foster interaction and connections among participants.
	Report outs	Sharing of information and results of activities from breakout groups with all participants
	Presentations	Presentations by workshop facilitators

	RVAT process	A rapid vulnerability and adaptation tool completed during the workshop
	Breakout (general)	Small-group work within thematic areas
	Developing strategies	Brainstorming options for adaptive actions
	Prioritizing strategies	Selecting priority strategies for implementation
	Interdisciplinarity of workshop	The blend of sectors and perspectives represented by workshop participants
	Other participants sharing	Hearing from workshop participants during the workshop
	Outside the workshop	Insights linked to the workshop, but which took place outside the hours of the event.

**Supplementary Table 4.2 SECI stages and learning domains in a climate adaptation context.**

*This table describes hypothesized connections between stages of the SECI cycle and declarative, procedural, and relational learning outcomes in climate adaptation workshops. For each stage, we detail actions that could promote knowledge conversions in each learning domain and note workshop activities that could help foster those conversions.*

	<b>Learning outcome domain</b>		
<b>SECI stage</b>	<b>Declarative</b>	<b>Procedural</b>	<b>Relational</b>
<b>Socialization</b>	Sharing experiences with climate impacts	Sharing about routines, processes, habits related to climate adaptation	Sharing about, and interacting, with past, current, and potential collaborators
	<b>Potential activities:</b> Site visits, coffee breaks, icebreakers, structured opportunities for storytelling, demonstrations		
<b>Externalization</b>	Articulating trends and principles (E.g., In my experience, summers are getting hotter. These pieces of evidence suggest that these species are failing.)	Articulating mechanisms and logic behind actions, codifying processes' expected inputs, steps, and outcomes.	Articulating the nature of existing relationships and cataloguing stakeholders' priorities, positions, & interests.
	<b>Potential activities:</b> Participatory modeling, cognitive mapping, structured dialogue, network mapping, group reflection		
<b>Combination</b>	Evaluating, comparing, and combining multiple data sources.	Evaluating, comparing, and developing new and existing approaches, procedures, and routines.	Evaluating network strengths, weaknesses, and opportunities; Aligning interests.
	<b>Potential activities:</b> Structured decision making, facilitated dialogue, work planning, collaborative monitoring		
<b>Internalization</b>	Adjusting worldviews & mental models.	Mastering skills, adopting & integrating routines	Putting new connections to work.
	<b>Potential activities:</b> Serious gaming, practice, on-the-job trainings, ongoing collaborations, establishing new processes & routines		

## **Chapter 5**

### **Introduction**

It is late July of 2023, and I write these words having just returned from a walk around my neighborhood here in Blacksburg, Virginia. Wanting a break from working on revisions, I closed my computer and stepped outside. I walked past the shuttered houses of my wealthy neighbors, past a group of schoolchildren out on some ambiguous journey, past the crows chanting their guttural incantations to the sky. And everywhere I turned, a pall lay upon the land. A thick haze filled the air and drained the world of color. Smoke, the headlines told me. Smoke blown down to Virginia from wildfires in Canada. For weeks now, this fluttering curtain of particulate matter has moved here and there across the planet and smothered millions under some of the least healthy air anywhere on the Globe. Concealing first New York, and then Chicago; darkening Spain, then dimming Appalachia. As I walked, it struck me that I was—we all were—filling our lungs with tiny fragments of Canada’s ruined ecosystems. Forests scorched and sundered and flung aloft into the haywire atmosphere only to take root at last within the damp chambers of our alveoli. What species of trees were we breathing? Which creatures’ vanished habitat?

I came home, opened my laptop, and resumed writing.

It has been, at times, hard to reconcile the enormity of the crisis we are facing with the minutia of my research. What difference can one student hope to make? Can the slow, incremental work of science help us find our way out of this smoky, sinking, sweltering labyrinth?

On good days, I think it can. And every day—good or bad—I am filled with admiration for the countless planners, bureaucrats, citizens, and businesspeople who are working toward solutions and whose generosity, creativity, and pragmatism are the moral core of this work.

Stepping back and squinting at each chapter of this dissertation, some themes emerge through the haze. Here I highlight these glimmering nuggets in the hopes that they are useful, and I share a few personal reflections about key lessons I have learned over the past four years.

### **Cross-cutting themes**

This dissertation investigates learning within place-based climate adaptation workshops. It seeks to understand what aspects of workshops and the contexts in which they occur facilitate learning, to identify the kinds of learning that take place in adaptation workshops and unravel how those processes occur, and to tease out what difference learning can make. Chapter two examined 33 place-based adaptation workshops to understand participant perceptions of workshop outcomes and the elements that drove those outcomes. We found that participants learned, strengthened their sense of efficacy, and deepened their relationships with other workshop attendees. They identified specific climate actions that resulted from the workshops they attended, including successfully implementing adaptation projects. Chapter 3 sought to place those outcomes within a broader context in order to more deeply understand the inputs and workshop processes that distinguished higher- from lower-performing workshops. In Chapter three, we found that higher-impact workshops had local champions who advanced workshop efforts. Higher-impact workshops were also aided by sustained post-workshop support from backbone support organizations or workshop organizers. Co-design of workshop processes and products by organizers and participants was helpful for advancing workshop outcomes, but not always necessary for achieving higher impact. Together, these features contributed to meaningful planning and action outcomes by deepening relationships, strengthening collective efficacy, and

creating a shared vision and understanding among workshop participants. In chapter four, we focused our gaze on learning, and sought to understand how learning occurred in eight recent adaptation workshops. We found that participants learned within declarative, procedural, and relational learning domains and evidence of enhanced motivation and feelings of efficacy among workshop participants. Participants identified shifts between tacit and explicit knowledge, and they linked their learning experiences to a broad range of workshop elements. We did not identify meaningful differences between in-person and online workshops, nor between individual workshops in our sample. Taken together, these findings highlight the importance of leveraging relationships to foster action, the key role of both individual and groups in advancing adaptation, and the complex ways that knowledge is created and shared among individuals and groups.

### **Leveraging relationships to foster action**

In every chapter of this dissertation, building and deepening relationships emerged as a key function of climate adaptation workshops. In particular, participants found value in fostering connections across sectorial silos and between levels, such as between those working on similar issues at a local and regional scale. These connections seemed to spark a deeper understanding of the interconnectedness of climate adaptation work, and at times led participants to embark on new adaptation initiatives.

These findings point toward the role of social capital in climate change adaptation. Social capital describes “relations of trust, reciprocity, and exchange; the evolution of common rules; and the role of networks” (Adger, 2003, p. 389). Strengthened relationships and greater social capital can enhance a group’s capacity to collaborate, as they more effectively share resources and knowledge, build procedural institutional arrangements that help manage interactions over time, and buffer against threats to collaboration (Emerson & Natabachi, 2015; Ryan & Urgenson, 2019; Stern & Coleman, 2015). Other studies have also highlighted the role of adaptation workshops in developing social capital by fostering cross-jurisdictional and multidisciplinary dialogue (e.g. Cross et al, 2013).

### **Individuals and collective groups matter**

Our findings highlight the important and complementary roles that individuals and groups play in climate adaptation workshops. Chapter 3 surfaced the role of local champions in creating impactful adaptation workshops. These individuals helped recruit participants, served as intermediaries between organizers and attendees, and sustained enthusiasm and momentum post-workshop. But individual champions alone were not sufficient to advance meaningful climate adaptation. Sustained support from facilitators and backbone support organizations helped solidify and coordinate collective action in higher-performing workshops. We also found evidence that the collective emergent states that arose during workshops were influential in shaping workshops outcomes. Feelings of collective efficacy, strengthened social capital, and social learning were all linked to higher-impact workshops.

These findings suggest that adaptation workshop organizers should attend to both individual and group dynamics as they plan and implement adaptation workshops. Identifying local champions and empowering them to galvanize action could help ensure workshops are more impactful. One way that local champions could bridge the gap between individuals and collectives is by fulfilling the role of boundary spanner. Boundary spanners connect and facilitate exchange between two or more groups (Williams, 2002). Given the importance of cross-disciplinary and cross-level interactions identified above, local champions who intentionally connect disparate groups could fulfil a vital role in advancing climate adaptation.

Workshop organizers should also seek to foster positive team processes within adaptation workshops and to ensure that positive emergent states are sustained and reinforced post-workshop. Co-designing adaptation workshops with participants is one approach that could achieve these aims. However, co-design is not without costs. Meaningful co-design, like meaningful climate adaptation, cannot be a cookie-cutter process. It can be a slow and relational process, and workshop organizers and funders should be prepared to invest deeply in communities before, during, and after adaptation workshops if they hope to reliably enable positive team processes.

### **Learning for doing**

Learning played a central role in each chapter of this dissertation. In Chapter 2, participants described key workshop outcomes related to declarative, procedural, and perspective-shifting learning. They identified learning as taking place at both individual and collective levels. In Chapter 3, we found that cognitive emergent states including social learning tended to be associated with more-impactful adaptation workshops. In Chapter four, we identified learning within distinct declarative, procedural and relational domains. We established that participants experienced knowledge conversions between tacit and explicit knowledge and that these conversions registered as important learning moments for participants. Taken together, these findings highlight the critical and complex role of learning in adaptation workshops.

Given the depth and breadth of learning that participants link to adaptation, important learning likely takes place in domains and modalities that may be overlooked in traditional models of science communication wherein scientists serve up knowledge on a loading dock for uptake by practitioners and decision-makers (Cash et al, 2006). Our findings align with literature that suggests that more effective processes attend to many forms of knowledge (e.g., Reid et al., 2020; Baird et al, 2014) and the ways that knowledge moves from individuals to groups and transforms within individuals (Polanyi, 1958; Nonaka, 1994). Designing workshops to center the formation and exchange of tacit and explicit knowledge within declarative, procedural, and relational domains could help facilitators avoid the pitfalls of the loading-dock approach. A checklist approach, where facilitators aim to facilitate learning within each learning domain's tacit and explicit dimensions, could result in radically restructured adaptation workshops, and, perhaps, strengthened connections to meaningful adaptation outcomes.

### **Personal reflections**

Before starting this program, I was working as the farm manager for a small organic orchard in central Missouri. I sat on a tractor; I pulled weeds; I built fences and tinkered with machinery. I listened to a *lot* of podcasts.

While I valued the immediacy of my work and the challenges of running a diversified farm, I was not wholly satisfied. I wanted to better understand the human causes of the changes I was reading about in the news and seeing all around me. I wanted to equip myself with better tools for answering questions and creating solutions. I can see now that at the time, I didn't even really have the vocabulary to describe what I wanted to understand, and my ideas about how to answer the kinds of complex questions that interested me were hopelessly naïve. I am still pretty naïve, and I am still pretty hopeless, but at least now I have a better feel for the contours of my own ignorance.

Three cheers for the known unknowns (Pawson et al, 2011).

Engaging in the coursework, research, and writing that will culminate in the completion of this dissertation has led me to insights and lessons beyond those captured in my research on learning and climate adaptation—lessons about myself as a scholar, about the enterprise of academia, about the slow journey of building knowledge. I have learned a lot about how other people think and learn, and I have learned a great deal about myself.

Here, I will sketch a selection of these lessons as I see them from the vantage of the present and reflect on the changes these four years have wrought.

### **Planning and fallacies**

In his astoundingly insightful little book “Thinking Fast and Slow,” Dan Kahneman (2011) introduces and illustrates the planning fallacy by telling a story about some academics undertaking a project, which inevitably takes far longer to realize than they anticipate. It takes so long, in fact, that the enterprise crumbles to nothingness. I remember reading this passage while enrolled in Danny’s social psychology course and thinking *Wow, good to know! Now I can just inflate my timelines and dodge the planning fallacy!*

Dear reader, I am here to tell you that dog won’t hunt. In my experience, just as nature abhors a vacuum, the implacable planning fallacy will scoff at your puny Gantt charts and fill your calendar to overflowing, no matter what precautions you take. The best you can hope for is to be less wrong in your estimates.

But unless I am mistaken, it is still better to be less wrong. To that end, one of the most valuable aspects of this program has been the opportunity to gain skills and experience related to managing long-term undertakings while juggling multiple overlapping projects. Plunging back into academia within a new discipline and stepping into an NSF research project that was already well underway challenged me to manage my time more effectively over the short- and long-term. It is something I am still learning.

A friend of mine swears by this alliterative mantra: “Proper preparation prevents poor performance.” While I quibble with aspects of this dictum, I have come to see its worth over the course of my degree. Time and again, I have returned to my proposal and found, if not answers, at least some guidance in its contents. Creating a thoughtful, rigorous, well-vetted roadmap for an initiative is invaluable. Equally invaluable is a recognition that circumstances change. It is helpful to be flexible enough to change gears when, for example, an unexpected global pandemic decides to liven things up.

### **Collaboration and leadership**

I wrote in some detail in the acknowledgments about the scores of colleagues, mentors, and generous strangers who made this work possible. In the process of doing our research and in the lessons that research has offered, the power of collaboration emerges as a central theme. But collaboration can be cumbersome and costly, and I have come to appreciate the key role of leadership within collaborative contexts.

I am a devotee of Drath and colleagues’ (2008) ontology of leadership: Direction, Alignment, and Commitment (DAC... which you might say makes me a DAColyte). DAC turns traditional leadership on its head and suggests that one can lead from anywhere by seeking ways to ensure that a collaborative group shares direction toward shared goals, is aligned around the process of achieving those goals, and committed to putting the group’s interests ahead of their own. Granted, it may be easier to lead from a position of power, but Drath and colleagues suggest that a distributed model is well-designed for advancing action in collaborative and peer-like spaces.

My experiences both in and out of leadership roles in formal and informal groups over the past four years attest to the value of attending to the elements of DAC to limit the transaction costs of collaboration and help groups achieve their goals. Fostering direction, alignment, and commitment is easy to say, but can be challenging to do. In my experience, leadership in collaborative contexts often means creating structures that enable groups to establish direction and maintain alignment and commitment. How does one do this? Well, it could be by volunteering to facilitate initial meetings and clearly articulating shared goals that arise during the conversation... and then scheduling the next meeting and making sure people show up. It could be by establishing agreed-upon deadlines... and reminding people that they said they would finish a task. It could be by creating a space where people with a shared interest can regularly interact... and working to ensure that those interactions are inclusive and generative.

Keeping an eye on DAC can be a lot of work, but the collaborative undertakings I have been a part of on the margins of my doctoral program have been truly rewarding and allowed me to accomplish far more than I could alone. Publishing with my dear friend Zack Miller and other colleagues (O'Brien et al., 2023), developing teaching modules about the role of values in science, creating opportunities for exchange and professional development in the Interfaces of Global Change program, and securing funding for a reforestation initiative on Virginia Tech's campus stand out to me as collaborative undertakings that were powered by a shared sense of direction, alignment, and commitment among those involved.

### **Onward**

By the time I defend this dissertation, I will already be fully immersed in my next role, one focused on helping sustainability professionals understand global challenges and engage as global citizens—in part by helping them comprehend and employ social science theory. I hope to draw upon the insights I have gained from my own research and studies to support learners as they confront the myriad challenges around building a more sustainable future.

I look forward to continuing the work we have been undertaking for the past four years. We have much more to learn about the eight adaptation workshops featured in Chapter 3 and the ways that the workshops contribute (or not) to galvanizing adaptation in each community. There are important lessons ahead that, once distilled, could be useful for adaptation professionals and communities engaging in climate change adaptation. I am especially interested in continuing to engage with Nonaka's work and further understanding how the SECI cycle interacts with declarative, procedural, and relational learning. Nonaka's theory can seem complex, and overlaying learning domains atop it may serve only to triple the complexity, but I believe that there's practical value in doing so. A challenge I will face moving forward is finding ways to explain and operationalize these insights in a way that is accessible and useful.

I also hope to continue developing the research skills I have acquired over the past four years and deploying them in other domains. I have been fortunate to be a part of the Interfaces of Global Change's Restoration Ecology Workgroup, and I look forward to continuing engaging in the human dimensions of ecological restoration. I am also excited to learn more about learning in online sustainability masters' programs and using my research and evaluation skills to make them more effective.

I will be returning to my hometown of Columbia, Missouri at the end of the summer. I am saddened to be leaving the community of scholars I have come to know here at Virginia Tech and the rich and complex landscape of Appalachia. I hope to maintain and strengthen those connections at a distance, and to sink roots and build community back in Missouri. Onward, then, with humility and gratitude.



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## Appendix

IRB materials:



**Division of Scholarly Integrity and  
Research Compliance**  
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## MEMORANDUM

**DATE:** February 16, 2023  
**TO:** Marc J Stern, Jennifer Joyce Brousseau, Caleb O'Brien  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572)  
**PROTOCOL TITLE:** Collaborative Research: What drives learning and action in place-based adaptation workshops  
**IRB NUMBER:** 18-603

Thank you for your submission. The Virginia Tech Human Research Protection Program (HRPP), has received and reviewed your Progress Report.

Your next Progress Report will be due on Feb 25, 2024. You will receive automated reminders through the IRB Protocol Management online system.

If your study is complete before then and is eligible to be reported as Closed, please proceed to close the study by accessing the appropriate link in Virginia Tech's IRB Protocol Management online system. If you have any questions or require any additional information, please contact the protocol coordinator that has been assigned to the protocol. If a coordinator has not been assigned, please contact irb@vt.edu for assistance.

*Invent the Future*

## MEMORANDUM

**DATE:** February 14, 2022  
**TO:** Marc J Stern, Caleb O'Brien, Jennifer Joyce Brousseau  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572)  
**PROTOCOL TITLE:** Climate adaptation workshop study  
**IRB NUMBER:** **20-985**

Effective February 14, 2022, the Virginia Tech Human Research Protection Program (HRPP) determined that this protocol meets the criteria for exemption from IRB review under 45 CFR 46.104 (d) category(ies) 2(ii).

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit an amendment to the HRPP for a determination.

This exempt determination does not apply to any collaborating institution(s). The Virginia Tech HRPP and IRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<https://secure.research.vt.edu/external/irb/responsibilities.htm>

(Please review responsibilities before beginning your research. )

## PROTOCOL INFORMATION:

Determined As: **Exempt, under 45 CFR 46.104(d) category(ies) 2(ii)**  
Protocol Determination Date: **December 15, 2020**

## ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol, and which of the listed proposals, if any, have been compared to this protocol, if required.

**SPECIAL INSTRUCTIONS:**

This amendment, submitted February 2, 2022, updates the research protocol document by updating sections 8.2 and 9.4; and updates the consent form by providing two sentences about asking participants' consent at the start of the workshop to share recordings of the plenary sessions with participants after the workshop, and including another line to clarify this regarding the confidentiality of the recordings.

\*\*\*Please note: The HRPP office has stopped stamping documents for Exempt protocols. It is your responsibility to maintain these documents and make current versions available on request.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?
12/14/2020	PRIGNXW5	National Science Foundation (Title: Collaborative Research: What drives learning and action in place-based climate adaptation workshops?)	Not required (Exempt approval)

\* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this protocol is to cover any other grant proposals, please contact the HRPP office (irb@vt.edu) immediately.