THESIS

I SEE WHAT YOU MEAN:

VISUAL AND PARTICIPATORY CLIMATE CHANGE COMMUNICATION

Submitted by

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ABSTRACT

I SEE WHAT YOU MEAN:

VISUAL AND PARTICIPATORY METHODS OF CLIMATE CHANGE COMMUNICATION

Empowering people to think critically and engage with climate change is a challenging goal: forcing science and facts on people is not enough to change values that support more sustainable behaviors (Kubeck, 2011; Maibach, Roser-Renouf, & Leiserowitz, 2009). This thesis approaches understanding how non-expert audiences are interested in learning about climate change with a new perspective: by listening to these audiences researchers can develop climate change outreach strategies that resonate with the constructs that each audience identifies with (Fosnot, 1996; Kubeck, 2011).

Science communication methods that explore alternative avenues of creative engagement such as art may improve effectiveness (Leiserowitz, 2003; Nicholson-Cole, 2005). Connecting with people personally through simple yet clear images is one method that shows promise in the field of climate change communication (Roam, 2009). Translating complex climate science to digestible chunks of words and illustrations showing relationships between ideas (i.e. graphic recording), is one method to engage in climate change. Another method that incorporates art and experiential learning includes participatory approaches such as citizen science. By exploring in nature, citizen scientists build efficacy and connections to a given place. For example, using artistic repeat photography as data to compare historic vistas with those seen today can engage audiences in helping and track changes.

National parks and wildlife refuges are places that people across the United States revere and view as trusted places to learn and explore. These places can provide powerful experiences through hands-on programs that incorporate artistic means of communicating complex science. By facilitating opportunities for visitors to explore and help collect scientific data through repeat photography, their observations and connections with these remarkable places may lead to a more open and accepting conversation about climate change.

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INTRODUCTION

Sparkling azure water laps against the glistening white-blue ice of glaciers grinding their way through soaring peaks cloaked in misty clouds. Lush vegetation carpets the mountainsides before dissolving into the "rock and ice" that influenced the preservation of many places like this. Exclamations of awe or excitement are heard; memories and emotional connections emerge forging a bond between these lands and their visitors as they see the wildlife, flora, rivers and vistas that make these places fascinating and special enough to draw people from across the country and around the world: our nation's national parks and wildlife refuges.

Although these places remain protected to preserve their resources and beauty for us and for future generations, the effects of global climate change are surfacing in our parks as bleached coral reefs, migration of flora and fauna, changes in water levels and snowpack, and inability to observe historic vistas, among others (NPS, 2010). These impacts often seem far removed from the daily lives of most people in the United States and are based on complex science that is difficult for a non-expert audience to understand. The lack of action to reduce humans' contribution to climate change demonstrated by the United States and other countries shows that the traditional communication methods we have used to communicate this process are inadequate to inspire and educate non-experts (A. Leiserowitz, Smith, & Marlon, 2010; McCright & Dunlap, 2011; Nisbet, Markowitz, & & Kotcher, 2012; Somerville & Hassol, 2011). I propose that a new approach to communicating to and engaging non-technical audiences with climate change is needed: scientists and communications specialists need to *listen* to our audiences to better understand how they are interested in learning about climate change. In this thesis I provide insight into the effectiveness of participatory and artistic communication methods and tools to

more effectively communicate about climate change through two complementary manuscripts that support the use of artistic, participatory communication into the climate change conversation.

National parks and wildlife refuges provide a unique opportunity to observe how global changes are affecting natural landscapes of our country. Even more importantly, through trusted frontline interpreters and scientists, parks and refuges have potential to be leaders in innovative education and engagement strategies regarding climate change.

"Will human beings, by adding carbon dioxide and other heat-trapping gases to the atmosphere, significantly affect climate? The answer, debated for decades, is now known to be yes," (Somerville & Hassol, 2011, p. 48). The occurrence of climate change is no longer questioned in the scientific world, nor is the attribution of at least some of that change to human behavior (IPCC, 2007; Maibach, Roser-Renouf, & Leiserowitz, 2009; Oreskes, 2004; Somerville & Hassol, 2011). There is consensus among scientists around the globe that human activities have elevated the levels of carbon dioxide and other greenhouse gases beyond a natural occurrence cycle. However studies show that between the years of 2008 and 2010 a growing number of citizens and policy-makers in many countries, including the United States, reject the science (Akerlof et al., 2010; Leiserowitz, Maibach, Roser-Renouf, & Hmielowski, 2012; Leiserowitz, Smith, & Marlon, 2010; Maibach et al., 2009; Somerville & Hassol, 2011). Innovative communication methods must be developed that not only help people understand climate science, but engage them with natural places they care about that have the potential to be affected by a changing climate (Budescu, Broomell, & Por, 2009; Moser, 2010; Schweizer, Thompson, Teel, & Bruyere, 2009; Somerville & Hassol, 2011).

The difficulty of understanding complex climate science, the daunting nature of a global environmental problem, as well as perceived difficulty to adopting "climate friendly" behaviors creates multiple layers of communication challenges (Akerlof et al., 2010; Kubeck, 2011; A. Leiserowitz, Maibach, Roser-Renouf, & Hmielowski, 2012b; Somerville & Hassol, 2011). Despite these difficulties, there are numerous efforts to inform the populous about human impacts on the planet and how to mitigate climate change for society's safety and for the sake of future generations. The Place-Based Climate Change Education Partnership (CCEP) is one of 14 grants funded by the National Science Foundation (NSF) focused on improving communication and education about climate change. The Place-Based CCEP, which focuses on climate change at America's national parks and national wildlife refuges, had the following objectives:

1. To learn what ecosystem and management changes America's national parks and wildlife refuges have observed related to climate change;
2. To inventory current climate change communication, education and outreach efforts;
3. To identify perceived barriers and opportunities to engage park and wildlife refuge visitors in climate change communication;
4. Develop a long-term climate change education strategy for parks and wildlife refuges.

Using insights from existing climate change communication literature and the results of the project's research objectives, the team developed an education strategy to facilitate a diverse audience's connection with the impacts of climate change on treasured landscapes. Specifically, the strategy is aimed at actively engaging a range of visitors across region, age, gender, education and race in understanding how climate change is changing America's national parks and wildlife refuges.

The CCEP team conducted research in five pilot sites in the United States: Northern Colorado, South Florida, Washington, D.C., Southern Alaska and the Puget Sound region. These sites were identified by agency partners in the National Park Service (NPS) and US Fish and Wildlife Service (USFWS) as "priority regions" in regards to climate change impacts. In addition to on-site focus groups (n=16), extensive surveys (n=4,181) and interviews (n=349), the CCEP team hosted a one-day World Café-style workshop for agency managers, staff, partners and local decision-makers in each region. The workshops focused on addressing relevant questions through multiple and simultaneous small group conversations with key stakeholders. The full process used during workshops is described in Chapter 2.

This thesis offers lessons learned from the use of graphic recording to communicate complex science in the Place-Based CCEP's climate change workshops and the development of a web-based repeat photography citizen science program for national parks in Southwest Alaska, a project created through the Place-Based CCEP. These case studies provide guidance for others in search of participatory and visually-based climate change education tools.

Understanding Climate Change Communication

Climate change will create many new challenges for humans around the globe. Its potential effects on our lives and how we perceive it have been emerging research topics in recent years. For example, while climate change presents health risks including heat-related problems, increased spread of infectious diseases, and higher exposure to cancer risks, the majority of people in the United States see climate change as a risk mainly to people in developing countries (Akerlof et al., 2010). The Yale Project on Climate Change Communication (YPCC) and George Mason University's Center for Climate Change Communication (4C) conducted several research studies in the United States about the public's

knowledge and attitudes about climate change. In one study, Global Warming's Six Americas, Maibach et al. (2009) categorized people into six segments based on survey responses. The six segments included: alarmed, concerned, cautious, disengaged, doubtful and dismissive.

In subsequent studies the Yale researchers have seen fluctuations in the salience and strength of the six segments. Most recently they observed an increase in the cautious and doubtful segments regarding climate change (A. Leiserowitz et al., 2012a). In a study about Americans' knowledge of climate change, Leiserowitz et al. (2010) found that over one-half of the participants thought climate change was happening but did not understand why. The Yale researchers concluded that without sufficient scientific literacy regarding climate change it is difficult for people to develop informed opinions about climate change policy. These findings mirror those found more than a decade ago in a national and international survey by Bord et al. (1998) in which there was general support for the environment, yet people were not informed on causes, effects, nor as concerned about climate change as other social issues.

Why do we in the United States opt to ignore or downplay the urgency of climate change and even at times favor policy that makes mitigation of climate change difficult? Human beings are complex, thus our reasoning and decision-making have been popular research topics, particularly pertaining to climate change. Somerville and Hassol (2011) summarized their insights as to why people, especially in the US, deny or ignore climate change instead of embracing adaptation options. First, they argue that strength of the economy tends to predict the general level of acceptance of human-caused climate change. In uncertain economic periods, science seems less appealing to the public, perhaps based on a fear that more policy will stifle economic development in already challenging times. Second, a well-funded and organized misinformation campaign has been detrimental to generating support of climate change

mitigation. Hiring the best and brightest in public relations and marketing to create clear, repeatable messages has served climate deniers well by creating confusion among non-experts regarding climate science (Somerville & Hassol, 2011).

In addition, a small minority of climate scientists disagree with the central findings of the field that are widely accepted (Somerville & Hassol, 2011), which has generated further confusion and hesitancy to accept climate change as scientific fact. These differing conclusions are not only normal in the scientific world, but are integral to good science and should be thoroughly considered. However they should be interpreted within the full context of climate change science; more than 84% of peer-reviewed scientific research concluded that climate change is occurring at an unnatural level (skepticalscience.org).

Somerville and Hassol's third explanation is that people trust those they perceive to be similar to them culturally and though shared values. This explanation is supported by other research such as (Michaud, 2007; Somerville & Hassol, 2011; Tenbrunsel, Wade-Benzoni, Bazerman, & Messick, 1997). When science comes from an unknown or less familiar source, people are less likely to care or accept it, leading to widespread scientific illiteracy (Somerville & Hassol, 2011).

Fourth, weather and natural disasters have been historically understood and perceived as being out of control of humans. Even today we refer to weather disasters as *acts of God* in our insurance policies and historical texts. This attitude may make it difficult for some people to accept that humans can have an influence on global systems, such as weather and climate.

Fifth, the way climate change is portrayed through media outlets also plays a role in our general understanding about and perceptions of climate change. For example, a standard ethic in

news reporting in the United States is to present all sides of a story. When a majority of news stories about climate change include sections that question its occurrence, the journalist or reporter is simply following the norm within their profession to provide a comprehensive account. This leads to a perception that climate change is controversial or uncertain (Boykoff & Boykoff, 2004).

Additionally, Somerville and Hassol suggest that scientists' lack of communication about their findings to a non-expert audience has sabotaged their ability to convince large portions of the population that human-caused climate change is real.

Mitigation of climate change will require the contributions of not only policy-makers around the globe, but likely billions of the planet's inhabitants as well. Consequently, the need for public understanding about climate change is critical and imminent, and highlights the need for scientists to become more skilled in communication. The science tells us that meeting policy goals requires urgent action across the globe, however because of limited public understanding it is also urgent for scientists to more effectively communicate their research (Somerville & Hassol, 2011). It is imperative as we move forward to show people that climate change is not simply an environmental issue, it is a social issue, one of economy and security for our generation and those to come. Effective climate change communication techniques must be employed if we wish to preserve our planet as it is today. Understanding how people make decisions and what encourages behavior change are key areas to effective engagement (Drake, Thompson, & Melena, 2012)

Climate change communication.

Global climate change can be an overwhelming, if not a confusing or intimidating topic for people to think about, and it is often difficult to discuss climate change at the scale that is necessary for global social change (Moser, 2010). One of the largest barriers to effectively communicating about climate change is that the changes human beings will see are not easily predicted and may occur over longer periods of time. Uncertainty leads to doubt and mistrust among people who do not understand what is happening to the planet or why (Budescu et al., 2009; Fischhoff, 2011). It is difficult to attribute isolated events to climate change because it is so interconnected with other changes such as seasonal events and natural cycles in our larger, planetary system (IPCC, 2007; Moser, 2010; NPS, 2010). Marguiles and Sibbet (2009) reported that visual mapping of ideas being discussed can help people better understand the complexity of societal change and visualize ideas for the future.

The challenge of effectively communicating about climate change is deepened by traditionally-trained scientists' lack of public communication savvy and skills; scientists are not known to be adept at explaining their work to a lay audience (Leiserowitz et al., 2012b; Miller & Fahy, 2009; Mooney, 2010; Rudel, 2011). Mooney (2010) illustrated this sentiment: "Perhaps what is needed instead is a public that is more familiar, comfortable with, and trusting of scientists; that is more regularly engaged by the scientific community on potentially controversial subjects; and moreover, that is engaged …" (p. 3). Leiserowitz et al (2012b) found that despite communication challenges, a large majority of Americans continue to trust climate scientists (74%) as well as weather reporters (62%) and park rangers follow closely as the third most trustworthy source of climate change information.

Researchers have investigated several ways to make climate change communication more effective to a broad audience, such as the visitors to America's public lands (e.g., national parks, wildlife refuges, and national forests). Schweizer, Thompson, Teel and Bruyere (2009) developed nine key messages and ten key principles for communicating about climate change on public lands. The principles include:

1. Use themes of adaptation and human impact on the land
2. Make the message relevant to the audience's lives and personal experiences
3. Emphasize that each person can make a difference
4. Tailor each message for each type of audience (e.g., visitors, staff or partners)
5. Use a credible messenger to deliver the message
6. Connect to the audience's core values
7. Make the message empowering
8. Use examples that are specific to the local context and place

These are essential aspects of effective climate change communication on public lands. However, getting the managers, scientists and staff at national parks and wildlife refuges to coordinate their public messages about climate change is inherently difficult because of the wide range of expertise, knowledge and ability. In building place-based capacity for effective climate change communication efforts need to be taken to link scientific understanding of impacts as well as knowledge of the audience.

Following the principles of climate change communication from Schweizer et al. (2009), the Place-Based CCEP team is working with the trustworthy messengers at national parks and wildlife refuges to develop climate change education and communication activities for America's public lands. This approach emphasized the place-based impacts of climate change

and the resulting management decisions at each site. Using parks and refuges to set the context of the message provides an innovative opportunity to build upon the audience's connection to place; people are inextricably tied to the places they are familiar with, identify with and with which they have fond memories (Eisenhauer, Krannich, & Blahna, 2000; Hess, Malilay, & Parkinson, 2008; Portier & Tart, 2010; Stedman, 2002; Tuan, 1974).

Inviting non-experts into the dialogue about climate change remains one of the most important yet challenging aspects of science communication. In addition to building upon the audience's connection to place, another method to engage a broader audience in conversations about climate change is through art (Moser, 2010; Randerson, 2007). According to Trumbo (1999), visual interpretations of data are an effective way to engage people with science learning. Descartes said "Imagination or visualization, and in particular the use of diagrams, has a crucial part to play in scientific investigation," (Descartes *as cited by* Trumbo, 1999 p. 409). In traditional science, visualization has played a part in explaining research or phenomena, but has not been utilized to its full potential in education and communication of findings.

Not only is data visualization effective for communicating abstract scientific concepts, graphics have also been shown to portray information clearly for better problem-solving and designing (Trumbo, 1999; Tufte, 2006a). Many foundational figures in science used graphics in their breakthroughs: "Einstein used imagery as a way to conduct his 'thought experiments'" (Mattimore 1994 *as cited by* Trumbo, 1999 p. 413).

Studies on effective methods of communicating climate change have also revealed practices the media use as well as peoples' unexpected responses to these campaigns. O'Neill & Nicholson-Cole (2009) explain how the media's use of sensational language may actually elicit ambivalent behavior toward climate change. The results showed that although people chose

fearful images such as natural disasters to portray climate change in a media campaign, they personally stated those images would not be effective in convincing them to change their behavior to be more sustainable. Instead, pictures of riding a bike, gardening, composting and turning off the lights when not in use resonated with the majority of the individuals (O'Neill & Nicholson-Cole, 2009). This study illustrates the complexity of humans' perceptions of climate change.

Visual communication methods offer an opportunity to make the science and challenges of climate change into something that is easy to understand and interesting, if not *fun*, to look at and think about. These characteristics are, as the research cited above indicates, ways to make climate change relevant and interesting to the staff and visitors at America's parks and refuges.

Summary of Chapters

The first manuscript, entitled *Graphic Recording: Using Vivid Visuals to Communicate Climate Change,* explores the cutting edge of research on the use of graphic recording – using hand-drawn images and text to create a large-scale map of a conversation or presentation – to communicate about climate science. Graphic recording has largely been utilized in the private sector to illuminate organizational challenges, encourage creative and divergent thinking to create solutions, facilitate collaborative work and learning, or more effectively and quickly explain an idea to a group. Supported by well-documented theoretical concepts such as systems theory (Bertalanffy, 1950), the theory of multiple intelligences (Gardner, 1983), and dual-coding theory (Paivio, 1971), graphic recording has the potential to transform the way climate change science is communicated, particularly during small workshop settings.

Surveys (n=184) and semi-structured interviews (n=29) were conducted at workshops around the United States and in Japan to understand if capturing the presentations through graphic recording was perceived as beneficial to workshop participants. Presentations consisted of local climate science and impacts, as well as the results of research on visitors' perceptions of climate change in parks and refuges. Presentations were graphically recorded in real-time while workshop participants were able to observe. Graphics were then displayed for the remainder of the day and distributed to participants digitally after the workshop had concluded. After coding for themes in responses, I summarize the most useful aspects of graphic recording to enhance science communication as follows:

1. Graphics made information from presentations easier to understand;
2. The graphics served as a memory aide;
3. The graphics helped participants make connections between ideas and events;
4. The graphics inspired creativity among workshop participants;
5. Graphics appealed to multiple learning styles;
6. Graphic recording made the presentations and workshop more engaging;
7. The graphics are visually appealing;
8. The graphics improved group participation;
9. The graphic recording process showed systems and relationships among ideas.

These findings support my first research question: Does graphic recording, as a visual communication tool at facilitated meetings, enhance the understanding of complex climate science among members of a non-expert audience? The results of the analyses also offer insight into my second research question: If effective at conveying complex climate science, in what

ways is graphic recording most helpful for members of a non-expert audience? The interviews show that memory is self-reportedly enhanced, participants seem to be more engaged and empowered to think creatively, and complex information was easier to understand.

The second manuscript, titled *Facilitating the Development and Evaluation of a Citizen Science Website: A Case Study of Repeat Photography and Climate Change in Southwest Alaska's National Parks*, chronicles the process of developing a web-based citizen science repeat photography program for national parks in Southwest Alaska. This collaborative agreement between Colorado State University and the Southwest Alaska Network (SWAN) began in 2011 during the Place-Based CCEP's site visit to Alaska. The parks in Southwest Alaska were developing an accessible database of historic photos for visitors to browse, contribute and observe changes in the landscape through photographs of the past and present. The methods used were based on findings from the Place-Based CCEP's visitor interviews which showed that people indicated they were highly interested in learning about climate change through photographs, citizen science programs, and technology. Because these findings were consistent across the country, the SWAN database afforded me an opportunity to develop a program which held great promise in realizing these findings as a case study to answer the following research questions:

RQ 1: How will a web-based repeat photography citizen science site achieve a shift in the climate change conversation?

RQ 2: What are the key elements of collaborative development for such a site? Which aspects of the development require facilitation and special attention for other groups hoping to replicate the process for their organizations?

The core team emerged as three National Park Service employees in Alaska and three researchers at Colorado State University who stayed in communication through monthly calls to share progress and ideas. The project, which is still in progress at the time of this writing, has evolved nicely and the team has learned a great deal while developing the repeat photography website. Based on interest from other groups around the country, it is beneficial to analyze the team's successes and failures as a case study for others interested in creating a similar website or program so they may build on previous work. Semi-structured interviews (n=5) were conducted with the core team asking about best practices and areas that could have been improved as a team and compared with field notes taken by the project facilitator. The findings from these interviews are summarized below and represent lessons learned for best practice:

Finding 1: An in-person meeting including all core team members of the project is highly recommended to develop clear goals, assigning roles and leadership positions, identify a target audience, create and adhere to a timeline, and build relationships.

Finding 2: A central document easily accessible to all group members outlining the desired features, actions that have been accomplished, ideas the group tried but moved away from, and a marketing plan should be used. This document could also contain tasks for which people have taken responsibility for to foster accountability.

Finding 3: Regular group communication enables members to share ideas and opinions, build relationships, and stay current on work that is being done throughout the group on the project. Ideally the group would meet face to face on a regular basis, but if this is not possible well-facilitated group calls that encourage open dialogue and deliberation are also effective.

Finding 4: Build a site using code that is agile and able to be easily adapted to iterative rounds of feedback. Additionally, make sure design ideas and features have been clearly thought-out and visualized through wireframes before investing much time and energy into the actual code.

Finding 5: Weave the reflection and evaluation process into the entire duration of the project. Conducting informal interviews during the development process and after phases of the project have been completed could reveal many of the incongruences between group members (i.e. goals, audience, expectations). Knowing these discrepancies existed earlier in the project would have allowed for conversations to clarify leadership and project objectives for better use of the group's time and a more satisfactory end product.

By testing, reflecting on and iteratively developing new, creative climate change communication strategies, I hope to inspire action, engagement and collaboration for present and future effective communication about climate change.

GRAPHIC RECORDING: USING VIVID VISUALS TO COMMUNICATE CLIMATE CHANGE

Climate change is potentially one of the greatest problems that humans will ever face. The consensus of the scientific community is overwhelming: climate change is happening and humans are increasing greenhouse gas emissions which is exacerbating the problem (Anderegg, Prall, Harold, & Schneider, 2010; IPCC, 2007; Sheppard, 2005). However a large portion of people in the United States are still unsure of the causes, certainty and effects of climate change (A. Leiserowitz et al., 2010; Maibach et al., 2009; Moser, 2010; Sheppard, 2005). Scientists report being frustrated that they are unable to effectively communicate with the American public and increasingly climatic change literature is replete with discussions of the challenges of communicating the complexity of climate change (Moser, 2010).

The purpose of this manuscript is to evaluate the potential of graphic recording as a visual communication technique in translating information about complex processes, such as climate change science in small, workshop settings. Graphic recording is a meeting facilitation tool in which a "graphic recorder" draws a map or mural of presentations and group discussions. The graphic recorder uses images and text to depict key ideas and information, in real time. The Place-Based CCEP team initially used graphic recording during the climate science presentations at workshops, and quickly realized the impact the maps and murals had on the audience and expanded the use of graphic recording throughout the day's workshop event.

To date, the body of empirical literature on graphic recording is small and largely based on qualitative observations. This empirical study investigates and ultimately confirms previous anecdotal evidence about the benefits of graphic recording. The case I present provides additional quantitative and qualitative data to address the following research questions:

RQ 1: Does graphic recording, as a visual communication tool at facilitated meetings, enhance the understanding of complex climate science among members of a non-expert audience?

RQ 2: If effective at conveying complex climate science, in what ways is graphic recording most helpful for members of a non-expert audience?

This study begins with an overview of challenges to effectively communicating climate change and suggested strategies to alleviate such barriers. The following section introduces some of the theoretical influences that inform the practice of graphic recording. I then describe the methods and results of this study as well as implications of using graphic recording to communicate science. Finally, I identify gaps in the literature and how this research, and further research, is necessary to better understand the potential of graphic recording as a visual communication tool.

Literature Review

In the past five years the literature on climate change communication has expanded exponentially, and thus different communication methods have been tested and studied. Much of this research has focused on peoples' knowledge, attitudes and perceptions of climate change, their willingness to support sustainable behaviors and how to effectively communicate actions for mitigating human's impact on the planet.

Graphic Recording

Graphic recording is a form of visual communication which can be used in meetings or during presentations. While people are presenting to the group or when a conversation or

brainstorming session is taking place, a graphic recorder or graphic facilitator uses hand-drawn words and text, colors and pictures to summarize and organize a group's thoughts and ideas (Agerbeck, 2012; Kelly, 2005; Roam, 2009; Sibbet, 2008). Deeper solutions and thinking about the larger system enhance the memory of the workshop or meeting attendees (Brown, Isaacs, Community, Senge, & Wheatley, 2005; Kelly, 2005; Marguiles & Sibbet, 2007a; Sibbet, 2008). Using markers and chalks on large pieces of paper taped to the walls – typically eight feet by four feet – a graphic recorder captures the group's ideas visually, in real time as conversations are unfolding. Figure 1 is an example of a graphic recording from the Place-Based CCEP workshop in Washington, D.C. Graphic recording is particularly suited for the World Café process, which focuses on small group conversations around a series of specific and directed questions (Brown et al., 2005). Each graphic recording is different based on the recorder, the situation and the goals of the process. For example, some graphic recordings simply capture the key ideas of a presentation (see Figure 1).

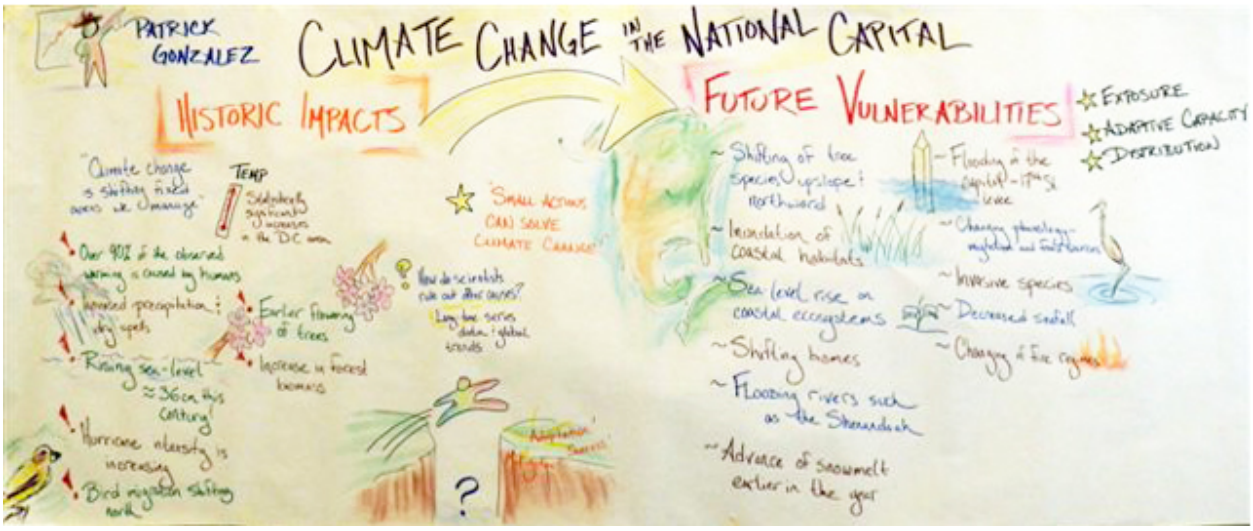

Figure 1. Graphic of summary of the science showing how climate change is affecting the Washington, D.C. region by Karina Mullen.

Other graphic recordings serve as a map to where the group wants to go – how to take many parts of a system they are working within and move forward to overcome a challenge or achieve a goal. These graphics can then be used as a summary to share the essence of the talk with people not present during its creation or serve as a visual reminder of action steps generated from meetings. Each of these types of graphics is created with a particular purpose or desired outcome. These include focusing the group, showing the flow of the groups' thoughts, comparing or combining ideas, growing understanding of systems, animating meaning and seeing unity. These formats are not mutually exclusive and can be used within each other to better visualize ideas. For example, using a mural-style graphic in a planning meeting can be very helpful, particularly if lists or diagrams are incorporated into the drawing.

Graphic recording has been applied in a multitude of situations from board meetings for businesses and non-profit organizations to large audience presentations such as Ted Talks. It has potential to be applied in many educational and planning sessions and can be utilized in climate change engagement by presenting information in a way that helps people understand a larger picture, clarifies complex ideas and invites group participation (Brown et al., 2005; Marguiles & Sibbet, 2007a; Sibbet, 2008). According to Moser (2010), future directions of climate change communication include "new technologies and modes" such as art and communication focused on dialogic processes. Graphic recording presents a mode in which these aspects can be utilized for deeper understanding and engagement in climate change.

Theoretical Concepts

The theories behind graphic recording are complex and numerous. I have chosen to focus on three foundational theories guiding the practices' evolution: systems theory (Bertalanffy, 1950), the theory of multiple intelligences (Gardner, 1983) and dual-coding theory (Paivio,

1971). After a brief introduction of each theoretical concept, I specifically link key aspects of the theory to the practice of graphic recording. Findings from key researchers in the field of visual communication are noted as they related to graphic recording and communication.

Systems theory.

Systems theory was introduced by Ludwig von Bertalanffy in 1950. In his paper *An Outline of General System Theory,* he detailed how the route of science has relied on breaking down natural phenomena into "elementary units", which are examined separately in minutiae, to explain causal relationships (p. 134). Bertalanffy (1950) proposed that instead of creating an understanding of a scientific concept by examining each part independently, a larger-picture perspective should be taken by scientists. Building upon the *Gestalt* concept of the whole being greater than the sum of its parts, Bertalanffy (1950) observed similar patterns of behavior occurring in different fields of science, from biology to chemistry, and imparted upon his audience the concept of systems theory. Defining a system as "a complex of interacting elements… [that] stand in a certain relation," Bertalanffy (1950) outlined several characteristics we can see in systems ranging from ecological to organizational (p. 143).

The concept of systems is a foundational aspect of graphic recording. According to the literature, graphic recording during meetings has the potential to visually show groups how ideas are inter-related because they can literally see the entire network of ideas on the wall (Agerbeck, 2012; Brown et al., 2005; Kelly, 2005; Marguiles & Sibbet, 2007a; Sibbet, 2008). Instead of seeing concepts listed singly on PowerPoint slides in a disjointed manner or simply listening to a conversation, by using a graphic recording in conversations people are able to see all the ideas together and draw relationships or better remember the information presented (Agerbeck, 2012; Beissner, 1993). "The principles of *Gestalt* perceptual psychology have been applied to visual

representation and explain the tendency of individuals to visually group elements into cohesive wholes," (Koffka, 1935 *as cited by* Trumbo, 1999, p. 414). To communicate about climate science, which can be inherently difficult to grasp, literally seeing how components of a social or ecological system (or both) interact and influence each other can greatly enhance understanding.

The systems concept of equifinality is also inherently connected with the practice of graphic recording. Bertalanffy (1950) described the achievement of equifinality as multimodal: "the final state may be reached from different initial conditions and in different ways," (p. 157). By writing and drawing all the different ideas from a group on a piece of paper everyone can see, people can observe that there are different solutions and paths to take to achieve goals or ways of looking at scientific information. By incorporating a systemic approach to meetings, "the elucidation of problems which, in the usual schematisms and pigeonholes of the specialized fields, are not envisaged," can be clearly seen and new approaches to solving them can be applied (Bertalanffy, 1950, p. 163). By seeing that there is not simply one answer to adapting to climate change, visionaries can co-create innovative strategies to live in a changing world and disseminate the important information captured by the graphic to inspire the development of specific messages that they will use to reach a broader audience .

Sibbet (2010) has observed fundamental aspects of systems theory in his noteworthy experience as a graphic recorder. Being able to see the "big picture" and how things are connected is one of the benefits graphic recording provides to a group. For instance, using the mandala format in a graphic of a meeting shows "how parts unify into a whole," (p. 122). Additionally, using visual processes such as causal loop diagramming, which illustrates feedback loops in systems, can be helpful to show a group how ideas they are discussing influence each other in a whole (Sibbet, 2010). Again, these principles of seeing systems of all sizes and how

they influence each other is an important aspect of good climate change communication, which can be exemplified and enhanced by graphic recording.

Theory of multiple intelligences.

"Some individuals think more visually than others" (Friedhoff & Benzon, 1991 *as cited by* Trumbo, 1999, p. 414). Howard Gardner (1983) observed this phenomenon, and many others, in the way that children and adults interact, choose to learn and excel in learning. Aside from mathematical-logical and linguistic intelligences, Gardner (1983, 1992) asserted that bodily-kinesthetic, spatial, musical, interpersonal, intrapersonal and naturalistic abilities are also intelligences that should be seriously considered in education systems and understanding one another. By "intelligence", Gardner (1987) meant "an ability to solve a problem or to fashion a product which is valued in one or more cultural settings," (p. 25). These skills are used to solve problems or make valuable things and are esteemed in a cultural setting, which ultimately makes them intelligences (Gardner, 1987).

Graphic recording is a process that has the potential to create opportunities for people with diverse and different learning styles to communicate and collaborate about complex issues (Marguiles & Sibbet, 2007a; Sibbet, 2010). By displaying information on one large sheet where everything can be seen at one time in a different format than just pages of lists or a PowerPoint that flashes small chunks of information to the audience rapidly and often disjointedly (E. R. Tufte, 2006a; E. Tufte, 2009), spatial learners can access, remember the information, and see how the ideas presented relate to one another more easily. By posting the graphics around the room for meeting participants to look at, they are introduced to an opportunity to engage with others who are also examining the posters, which can help verbal and interpersonal learners process the information more readily (Gardner, 1983). In a culture where individuals are

constantly interacting with technology having a tactile, human mechanism for depicting information engages audiences more readily than using impersonal electronic methods (E. Tufte, 2009).

These advantages can be particularly helpful in climate change communication, which has traditionally relied on rigorous scientific studies and facts to share information. As the literature shows, hard science does not change values, but understanding how an individual's actions influence changes in a place that is special to them can (Adger et al., 2009; Hess et al., 2008; Schweizer et al., 2009). Using graphic recording to show how changes are already affecting natural landscapes around the world and how people in places far away are influencing those changes has the potential to be an effective communication tool. Additionally, creating an atmosphere where divergent thinking is encouraged could lead to innovative solutions to climate change mitigation behaviors and communication strategies.

Dual-coding theory.

Dual-coding theory was developed by Allan Paivio (1971) as one way to describe how the brain processes information. The name comes from the idea that the two main avenues humans use to represent information are through visual imagery and language. (Mazoyer, Tzourio-Mazoyer, Mazard, Denis, & Mellet, 2002). The theory postulates that these two types of representation are not separate from one another, but in fact combine to help human beings better understand and process information (Paivio, 1971). Graphic recording is a tangible example of how dual-coding in the brain can be triggered in order for a person to learn and remember more effectively. Because graphic recording is using words and images simultaneously to display ideas, according to dual-coding theory and multimodal semiotics the information portrayed will be more easily stored and accessed (Unsworth & Cléirigh, 2009). Two pioneers of visual

recordings reference the value of the dual-coding approach graphic recording embodies: "Making ideas visible, using both words and images, means that we are making our very process of thinking visible," (Marguiles & Valenza, 2010, p. 8).

Cognitive load theory is closely related to dual-coding theory. Illustrating that people can only store a finite amount of information at one time, cognitive load theory is an important principle to consider when teaching or presenting to a group (Sweller, 2011). The theory "suggests that working memory has a maximum capacity of information it can process. If that load is exceeded, learning does not take place," (IARE and AEL, 2003, p. 5). By using pictures, which the brain can more quickly and easily interpret or use to access memories about information, in concert with describing words, graphic recording can help reduce cognitive load and therefore free more mental resources to learn new material (IARE and AEL, 2003).

Mayer and Moreno (2003) describe nine ways to reduce cognitive load in learning. They state that "meaningful learning involves cognitive processing including building connections between pictorial and verbal representations," (Mayer & Moreno, 2003, p. 43). Several of the suggestions they made to improve learning and retention of information are reflected in graphic recording. For example, they recommend aligning words near parts of pictures they correspond with and presenting spoken words while simultaneously depicting the message graphically (Mayer & Moreno, 2003). If information is presented proximally and at the same time, Mayer and Moreno conclude that students' cognitive load will be reduced, freeing them to "devote more cognitive capacity to essential processing," (Mayer & Moreno, 2003, p. 49). Horn (1998) also advocates for using a dual-coding approach to facilitate deeper thinking: "Such externalization [visualization of information] gives the mind more stable, albeit interim, data with which to work" (p. 213).

Additionally, their research yielded better results on a problem-solving test from students that learned from "integrated presentations" (pictures and words together) than those who did not (Mayer & Moreno, 2003). "[Research to reduce cognitive load] has contributed to theoretical advances in cognitive science – a well-supported theory of how people learn from words and pictures," (Mayer & Moreno, 2003). This shows that using a technique like graphic recording to facilitate understanding of complex ideas such as climate change eases the load of the brain and makes divergent thinking and solutions more accessible to the mind.

"Understanding what we see is important. Equally important is being able to produce images to explain what we mean," (Woolsey, Kim, & Curtis, 2004, p. 13). Graphic recording is a perfect example of successfully embodying this principle to enhance communication in groups and among individuals. Climate change is a global challenge and to find a solution it will take a coordinated effort among many groups of people. Horn (1998) calls upon visual language and communication to:

> […] cooperatively construct an information mural that displays the multiplicity of aspects of the issue on the table encourages a group of problem solvers to stay focused (literally) on the issue as a whole, rather than on those subsets of a particular problem that each individual will tend to emphasize, (p. 205).

Graphic recording is a tool to communicate climate change through art and written words that has potential to transform communication strategies. By integrating an array of ideas in a coherent manner to show the *big picture*, graphic recording shows, literally, new ways to approach climate change communication.

Visual communication.

In addition to these theories that illustrate why graphic recording has potential to simply summarize complex science, work by Wysocki and Lynch (2007), Unsworth and Cléirigh (2009), Tufte (2006b)and others (Kostelnick & Roberts, 1998; Kress & Van Leeuwen, 2001) provide further depth into the benefits of using both images and text in communication.

Graphic recording follows what Wysocki and Lynch (2007) refer to as the "*logos* in the arrangement of elements" (p. 86) to distill information presented into an easily digestible graphic. Climate science is heavy, systemic, and often filled with jargon. Graphics include only the key ideas presented through a *visual hierarchy* that uses color and size to indicate importance and connections between ideas in a format that is easy for the eye to track (Kostelnick & Roberts, 1998; E. R. Tufte, 2006a; Wysocki & Lynch, 2007). Suddenly the charts, indescribably large numbers, and processes that raced across the screen in a PowerPoint are crystallized and paired down to be read and understood, even by non-expert audiences (Wysocki & Lynch, 2007). Graphics use carefully selected *typeface*, positioning of images and text, and colors to direct a viewer's eye through the information to help them process and draw connections between ideas that may have been otherwise overlooked.

In the *Routledge Handbook of Multimodal Analysis* (2009) Unsworth and Cléirigh detail the relationship between images and text as multimodal semiotics to enhance communication. Parallel to the work by Mayer and Moreno (Mayer & Moreno, 2003), Unsworth and Cléirigh (2009) describe the *functional specialization* of text and images to describe scientific textbooks. Their findings show that the use of verbal text often lends itself to linear concepts while images can better describe spatial relationships, and, when used together, these communication

mechanisms have greater potential to engage and illustrate complex concepts (Unsworth & Cléirigh, 2009).

Edward Tufte (2006a) is a leader in the field of data visualization and effective communication using images and text. He states "Science and art have in common intense seeing, the wide-eyed observing that generates empirical information," (Tufte, 2006, p. 9). Tufte (2006a) places great importance on mapping information to show inherent connections between ideas or things and should incorporate images and text. In his third chapter, many fundamental aspects of graphic recording such as causal arrows and color choice are shown as far back as 1936 (Tufte, 2006). Other tools touted by popular graphic recorders of today such as denoting importance of a concept through size can be traced back to the 1600s through Tufte's work (2006). Through copious examples of illustrations, photographs and diagrams, Tufte (2006a) weaves a historical narrative of information graphics that describes in detail many foundational aspects of graphic recording.

Methodology

Both quantitative and qualitative data are beneficial and give depth to this study; using a suite of mixed methodology and analysis can expand the scope of research and offset the weaknesses of either approach alone (Driscoll, Appiah-yeboah, Salib, & Rupert, 2007; Hesse-Biber, 2010). Thus, using both approaches has the potential to reach a broader audience and collect more valid data. This method is known as triangulation; using a combination of quantitative and qualitative research methods to show validity of data collected (Lindlof & Taylor, 2002). Climate change is an environmental issue in which humans are inextricably linked. Because of the nature of climate change some researchers encourage mixed methods. "…[T]hese designs could aid ecological and environmental anthropologists in their efforts to

overcome lack of public engagement in, or denial of, linkages between human activities and their physical environments," (Schmidt, 2005 as cited by Driscoll et al, 2007, p. 19).

This study supports anecdotal reports on the benefits and effectiveness of graphic recording. The research questions guiding this study are:

RQ 1: Does graphic recording, as a visual communication tool at facilitated meetings, enhance the understanding of complex climate science among members of a non-expert audience?

RQ 2: If effective at conveying complex climate science, in what ways is graphic recording most helpful for members of a non-expert audience?

Participants were recruited by members of the Place-Based CCEP team to voluntarily complete the electronic workshop evaluation on an iPad. Using the iSurvey App, participants answered primarily quantitative questions about their experience in the workshop, three of which pertained to the graphic recording. Results are summarized in Tables 1 and 2.

A total of 184 anonymous respondents answered these questions. 133 surveys were collected during CCEP World Café workshops, 13 during a United Nations Environmental Program (UNEP) World Café meeting graphic facilitated by the author, and 45 from an undergraduate course discussing the role of art in environmental communication. The responses were collected in identical workshop procedures excluding the university and Japan data; in the university setting participants voluntarily answered questions during a class period when they observed graphic recording during a PowerPoint presentation, in Japan participants were asked

these questions after a World Café which focused on international environmental governance instead of directly discussing climate change communication. Although these were different situations and locations, I believe the quantitative data provided by respondents can still be used to draw general conclusions about the effectiveness of graphic recording to communicate complex information.

The World Café

Data were collected during three climate change World Café workshops hosted in Washington D.C., Cooper Landing Alaska, and Seattle Washington. Additionally, quantitative data were collected during a World Café workshop for the United Nations Environmental Program in Hakone, Japan, and during an undergraduate environmental communication course at a large western US university. Quantitative data were collected using a workshop evaluation (n = 184) and qualitative data were gathered through informal interviews (n = 29) with workshop participants. Because of the anonymity of participants, it is unknown whether the same person responded to both methods of data collection.

The World Café is a process that enables a group "to create generative networks of conversation focused on the questions that are critical to the real work of their community" (Brown et al., 2005, p. 181) and has been used by "thousands of people on six continents" (Brown et al., 2005, p. 181; Holman, Devane, & Cady, 2007). Because this project focuses on global climate change and each site visit is in a different part of the country, it involves a large group of people from different cultural backgrounds, making the World Café applicable as it is proven to work well in many cultures. According to *The Change Handbook* (2007), this process "evokes the collective intelligence of any group," (p. 181).

The World Café method is conversation-based. Pleasant lighting, comfortable chairs, many small, circular tables and access to refreshments are aspects that define the Café atmosphere. Each table is covered by a bright tablecloth and paper, which participants can use to draw and write ideas. For the Place-Based CCEP, workshop participants consisted of park and refuge managers, scientists, interpreters, local partners and non-profit organizations, teachers from local schools, and other key stakeholders identified by the parks and refuges in each region. Workshop participants were recruited through invitations sent several months in advance to superintendents and managers of, on average, two parks and two refuges in each region, although only one park and one refuge participated in the Alaska Café, and three parks and two refuges participated in the Puget Sound Café. Participants were mostly Caucasian and middle-aged despite efforts to engage a broad age range at each Café. Workshop sizes ranged from approximately 50-100 participants in each location.

A host plays the role of a traditional facilitator. Hosts explain the format of rounds of conversation where important questions as identified by group leaders are discussed. In this project, the questions were about how to effectively communicate about climate change at national parks and national wildlife refuges including: Who is your priority audience? What do you want them to do about climate change? What climate change stories are most important to tell at this park/refuge? What innovative ways can staff at the park/refuge engage their audiences with climate change science? After each round of conversation, participants move to other tables to share ideas and talk with new people about a new question or delve deeper into the previous question asked.

Before participants move from one table to another, ideas are harvested as members of each table share key ideas from their table's conversation. As ideas were shared during this

research, they were graphic recorded for participants to see throughout the workshop leading to discussions among participants examining the different ways to communicate about climate change.

Using graphic recording in concert with the facilitation of the Café host can help participants understand complex ideas and form visual connections that they might otherwise miss (Agerbeck, 2012; Marguiles & Sibbet, 2007a; Sibbet, 2010). Additionally, the use of pictures by the graphic recorder can aid participants that may have a more visual learning style to understand and summarize all the ideas put forth by the group, reflecting the "whole" generated and mirroring the group's content and process (Agerbeck, 2012; Gardner, 1987; Kelly, 2005). Figure 2 is an example of a graphic recording from the Alaska workshop.

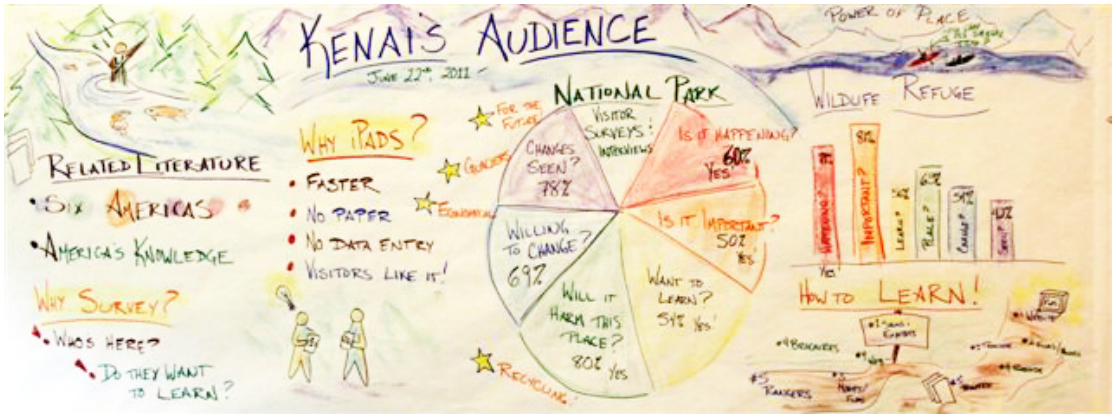

Figure 2. Graphic recording of survey results in the Kenai Peninsula, Alaska by Karina Mullen.

Quantitative and Qualitative Data Collection

The quantitative data informed an understanding about participants' reaction to viewing graphic recording during presentations and discussions. Data were collected via a workshop evaluation on both paper and electronic surveys, which were entered by hand and uploaded directly to the Statistical Package for the Social Sciences (SPSS 19). The evaluation questionnaire asked three questions on a five-point Likert scale (1= "strongly disagree" and 5 =

"strongly agree"): 1) The graphic recording helped me understand the material better; 2) The information portrayed in the graphic recording enhanced my experience today; 3) I enjoyed the graphic recording.

A frequency analysis was run on the data collected to show overall perceptions of graphic recording, as well as individually within each workshop. Next, the three graphic recording variables were combined into one, *graphic recording perceptions*. A reliability analysis was run on this combined variable to determine the quality of the variables.

The qualitative data collection was semi-structured and initially emergent which led me to probe further focusing on my research questions in a more systematic manner (Rubin & Rubin, 2012). During the workshops many people expressed interest in learning more about graphic recording. At the end of each workshop, I interviewed participants about their thoughts and experiences with graphic recording. As participants asked questions and commented about the graphics, I conducted informal interviews, digitally recorded, to capture the participants' opinions about the graphic recording.

Interview questions were based on the participant's interests; however a general outline was followed to gather in-depth responses that complimented the evaluation questions (Lindlof & Taylor, 2002; Rubin & Rubin, 2012). Typical questions included: 1) Do you like the graphic recording? Why or why not? 2) Did you learn something because of the graphic you would not have understood otherwise? 3) How did the graphics impact your experience today? These questions led to themes in how the graphic recording portrayed information and evaluating its utility in enhancing the participants' experience.

I analyzed interview transcripts through open coding and categorizing of emergent themes (Patterson & Williams, 2002). Transcripts were interpreted and I made a summary of key

generalizations about the effectiveness of the graphic recording experience pertaining to climate science. This hermeneutical approach allowed me to seek relationships among interviews and across sites in order to summarize patterns and draw holistic conclusions (Lindlof & Taylor, 2002; Patterson & Williams, 2002). Using qualitative hermeneutical inquiry is not limited by the positivist perspective that there is a universal truth to be sought, rather that each human experience is different and seeks to understand how that influences individuals' interpretations of their lived experiences (Lindlof & Taylor, 2002).

The reliability of the findings is based on cross-referencing the responses from informal interviews and the effectiveness scale questions. Results reveal similarities among workshop participants across sites. Additionally, results can be compared with previous literature using anecdotal conclusions about the effectiveness of graphic recording (Agerbeck, 2012; Congleton, 2011; Kelly, 2005; Marguiles & Sibbet, 2007a, 2007b; Marguiles & Valenza, 2010; Roam, 2009; Sibbet, 2008).

Results

These results are preliminary evidence that graphic recording facilitated the majority (69%) of participants understanding of the material presented. Additionally, a majority of participants (79%) agreed that the information portrayed by the graphic recording enhanced their experience and over 85% of participants reported that they enjoyed the graphic recording component of the workshops.

When variables were combined into one, Graphic Recording Perceptions, the Cronbach's alpha = .95 (very reliable). Additionally, each variable was highly correlated to the others ranging from .821 to .888 (Table 1).

Table 1. Reliability analysis of graphic recording variables.

Scale Items	Cronbach's alpha	Item total correlation	M	SD
Graphic Recording Perceptions	.95			
The graphic recording helped me understand the material better.		.847	3.99	.911
The information portrayed in the graphic recording enhanced my experience today.		.888	4.11	.887
I enjoyed the graphic recording.		.821	4.39	.828

Note: Using a five-point scale of 1=Strongly disagree to 5 = Strongly agree. N = 184.
SD = Standard deviation
M = mean

Table 2. Graphic recording perceptions by location

Location	n	M	SD
Washington D.C.	34	3.96	.811
Alaska	34	4.18	.892
Puget Sound	61	4.20	.744
Japan	13	4.64	.400
Colorado	45	4.01	.875
Totals	184	4.16	.803

Note: Using a five-point scale of 1=Strongly disagree to 5=Strongly agree.
SD=Standard deviation
M=mean

Table 3. Means and standard deviations of responses by location.

	Washington D.C.			Alaska			Japan			Washington			Colorado			Totals
Quest.	n	M	SD	n	M	SD	n	M	SD	n	M	SD	n	M	SD	M
1	34	3.94	.919	34	4.00	.921	13	4.62	.506	61	3.94	.903	45	3.44	.990	4.01
2		3.88	.946		4.18	.936		4.54	.519		4.11	.819		4.09	.661	4.13
3		4.09	.793		4.35	.950		4.77	.439		4.48	.766		4.51	.973	4.38

Note: Using a five-point scale of 1=Strongly disagree to 5=Strongly agree. N=184.

1 The graphic recording helped me understand the material better.
2 The information portrayed in the graphic recording enhanced my experience today.
3 I enjoyed the graphic recording.
SD=Standard deviation
M=mean

I conducted 29 qualitative interviews with workshop participants, who volunteered to be interviewed after the workshop. Participants were selected through convenience and spontaneous sampling (Curtis, Gesler, Smith, & Washburn, 2000; Peek & Fothergill, 2009); as people were looking at the graphics or talking with the graphic recorder (me), they were asked if they would be willing to discuss their thoughts on graphic recording. If so, they were asked if they would be comfortable if the conversation was digitally recorded. Every workshop participant who was asked to be interviewed agreed and occasionally others around them chimed into the conversation to share their opinion unsolicited. The interview participants may or may not have also answered the quantitative evaluation survey questions which were anonymous and could not be linked to specific individuals. Additionally, interviewees were not asked any

personal information and were assured they would be anonymous and their individual interviews would not be shared with anyone other than the interviewer.

It is important to note the possible biases from this qualitative research. The interviews were conducted by the lead author of this paper, who was also the graphic recorder for the workshops. It is entirely plausible that the data does not represent a complete picture of the opinions of the workshop participants about graphic recording as people are not likely to discuss negative opinions about something the interviewer created and obviously condones. Additionally, people who were not as engaged by the graphic recording are unlikely to be looking at it or to approach the graphic recorder to learn more about it. This is how the majority of interviewees were recruited for the research, which leaves a less-than-ideal hole in the picture of the workshop participants' perspectives. However, based on the quantitative data collected from a majority of workshop participants, it is likely that the interview transcripts represent many of the benefits and shortcomings of graphic recording.

There are also benefits to me playing the role of both researcher and graphic recorder. In this situation, having a depth of knowledge in climate change science, communication and graphic recording allows me to ask relevant and informed questions about how participants interpreted the climate science depicted in the graphics. Understanding the regional climate science was an advantage that enabled me to capture the complex ideas with images that resonated with the audience and likely helped them better interpret the information presented. Additionally, I could answer questions about graphic recording with more detail and depth than a non-expert would be able to.

Interview transcripts were analyzed through open and axial coding to determine patterns in the interviews about participants' thoughts on the graphics (Lindlof & Taylor, 2002; Strauss &

Corbin, 1990). Using an open coding and analysis process, I read the transcripts three times: first for key ideas and themes, second for repeating ideas, and third to search for ideas that were missed in the first two readings. Codes were then categorized into larger themes, such as memory aid, engagement, making connections, better understanding, appealing to different learning styles and enjoyment. Based on these categories conclusions were drawn about when and how graphic recording was helpful to workshop participants.

The participants' perceived benefits of graphic recording ranged from memory aide to aesthetic beauty. Categories created by the author through open coding and interpretive analysis include the following themes:

1. Graphics made information from presentations easier to understand;
2. The graphics served as a memory aide;
3. The graphics helped participants make connections between ideas and events;
4. The graphics inspired creativity among workshop participants;
5. Graphics appealed to multiple learning styles;
6. Graphic recording made the presentations and workshop more engaging;
7. The graphics are visually appealing;
8. The graphics improved group participation;
9. The graphic recording process showed the systems and relationships among ideas.

The coding categories and examples of direct quotes from the interview transcripts are outlined in Table 4.

Table 4. Coding Categories for the Qualitative Data: Major Coding Themes and Examples of Direct quotes from interviewees in Washington, D.C., Alaska and Washington.

Coding Category	Examples of Participant Responses
Memory Aide	• I like the synthesis. I like how is this stealing the heart of the conversation and recording it. • I would say the most effective piece of this is that you re-visit the presentation…it just doubles the impact. • For me, I could take notes but it would never have the understanding that this provides.
Improved Group Participation	• So I think it's probably something that people tune into but sub-consciously… • They got to see the sequence of images statically displayed as well as presented. So they could really explore the information kind of at their own pace.
Making Connections	• It's amazing to me how when you participate in one that's captured really well you're leaving some ideas in their mind; you're leaving it so they can see some of the overarching stuff. It makes such a difference in terms of taking it back and applying it. • And I like how you're capturing the reactions and not just the conversation. You're really capturing the sparks of moments in which you can feel the audience connecting. • But I like that you, you start to clump them together with internal or local communities, then you take like, birders, suddenly it doesn't seem like such a random comment, you know? It's really linked in.
Multiple Intelligences	• [My] older [son] is dyslexic … he's very bright but your spatial, the way you're laying things out spatially gave me some insight in terms of how he's thinking, how he's processing. He isn't verbal this way and isn't a confident speller so those parts might be intimidating…but to release…you're doing something that's really releasing the thinking. • And had I been taught that way, to do this, like in middle school, like when I started really resenting information, because I actually used to put my pencil down and not take notes

	because I couldn't pay attention… • And I think for kids it just makes it so you don't have to organize your thoughts the same way everyone else does. You can do something different and it still will make sense to other people too.
Happening Simultaneously with Presentations	• It's kind of cool that you're doing it simultaneously. Initially I was kind of distracted from what was going on then I realized, oh, I can go look at that later and it helps give a little more depth and consistency to that. • Like you were working very quickly and encompassing all these heavy ideas into this very…paring it down to the bare bones of the presentation.
Engaging	• But just drawing the bar graphs and pie charts it just gives it, it's just a more dynamic way of presenting the information I think. • It seemed like I was watching time-lapse photography. • I think it just added a really amazing dimension, a real visual, fun, expressive way of looking at the information instead of just notes, text, so visually you get some impact, it's interesting, it's fun.
Visually Appealing	• And it's visually attractive, it's nice to look at. But it also helps to refresh my memory. • I mean it paints an amazing picture to me, and I love it!
Inspires Creativity	• I think it makes me think more creatively in general. Watching someone else be creative makes me want to do the same thing so. • But by the end of it we were coming up with ideas and we had sort of honed in on an idea and I sort of circled it and then everything else we were saying that was all kind of interconnecting and linking in… without thinking about it was writing it in a more circular way and drawing the arrows back in which I think was helpful…and I thought that was cool because I never do that.
Shows Systems & Relationships	• I feel like it tells a story if anything…like it puts, for me it takes the data and puts it more into ways that, where we see our communities…

	• You know I've voted before plenty of times with dots and it's usually on flip charts with the list. But you actually created a whole flow. And that flow was really fascinating to look at and there was a couple times where the flow went back and somehow you managed to get that.
Graphics Are Not Best for Some People	• Because looking at it, it could seem disjointed, it doesn't to me but someone on the outside walking in … how can I make this really accessible for people who didn't come to this workshop. • These mind map things are not the way that I think but I think it's wonderful. • It's distracting probably because it's fascinating

There were also participants who were not as engaged by the graphic recording, showing that using this approach in concert with other, more linear methods may be an optimal way to communicate complex science with a non-expert audience.

Discussion

The data collected shows that graphic recording is an effective tool for climate change communication. Prior research has shown anecdotally that graphic recording helps groups better remember information, helps show a larger picture of the issue being discussed and builds efficacy and engagement among groups creating a vision or strategic plan (Agerbeck, 2012; Brown et al., 2005; Roam, 2009; Sibbet, 2008, 2010; Trumbo, 1999). The data collected shows that the majority of people exposed to graphic recording felt it improved their overall experience in the meeting (85%), and almost three quarters of the participants found it helped them understand complex topics more easily (69%). Additionally, when the three variables used in the survey were combined into one (Graphic Recording Perceptions), a reliability test show instrument reliability (α =.95) (See Table 1). These high percentages show that a broad audience

in four states (Alaska, Colorado, Washington D.C. and Washington State) and two countries (the United States and Japan) found graphic recording to be an insightful tool.

The interview analysis reveals that participants felt the graphics helped them with several key components of understanding climate change. These include:

1. Remembering information from the entire day;
2. Feeling more engaged and involved in the process;
3. Understanding and making connections in larger systems;
4. Showing the movement of the group's ideas in a visually appealing and inspiring way.

These findings support existing literature on graphic recording (Agerbeck, 2012; Brown et al., 2005; Congleton, 2011; Gardner, 1987; Kelly, 2005; Marguiles & Sibbet, 2007a; Roam, 2009; Sibbet, 2008, 2010). Previous publications report similar anecdotal results about the benefits of graphic recording, though no studies have focused on climate change communication.

Using mixed methods, particularly qualitative methods, leads to biases within the research. As previously stated, there are always biases to account for when conducting qualitative research. In this study, as the artist creating the graphic recordings, I believe that it is a useful and beneficial way to display technical and complex information. This bias could be interpreted in the analysis of our interview questions. Each question asked was slightly different given the nature of informal and emergent interviews. It is possible that as I interviewed people I asked questions in a way that I thought would elicit the answer I wanted to hear, even though I made a conscious effort to ask non-biased, non-leading questions. Additionally, people may have felt like they needed to tell me they enjoyed the graphic recording because I was the artist and they did not want to offend me. Being involved intimately in this research also had potential advantages as someone who is knowledgeable about climate science and graphic recording and

who was involved in this project over a long period of time. I was likely able to pick up nuances from our interactions and remember how people were talking about certain aspects of the graphics that influenced my analysis and gave me more insight than simply reading transcripts or listening to recordings of the interviews.

There are several other limitations to this research that must be acknowledged. The quantitative questions were asked using an iPad, which may have resulted in some participants feeling less comfortable with the technology and therefore not wanting to respond to the optional evaluation. Additionally, those not familiar with using an iPad survey may have entered inaccurate data by touching the screen accidentally. The size of the group sampled is another limitation to this research. The researcher was unable to gather enough responses for a statistically significant representation of the population. Additional research with a wider-reaching survey could validate the preliminary responses found in this study.

Qualitative limitations to the study include interviews only being conducted for three workshops while survey questions were asked at four workshops and in the environmental communication course. Participants were entirely adult and almost every interview was conducted with a Caucasian native-English speaker, which also limits the study.

Additional research is needed not only to increase the sample size to be statistically significant, but also to observe the effects of graphic recording on long-term memory of the information presented. Ideally, a longitudinal study comparing participants observing graphic recording during a workshop and those without a graphic recorder for their ability to recall information presented both short- and long-term would be conducted.

Conclusion

Though much as been done to better understand learning styles and how to use visuals in communication, gaps still remain in the research. These areas include, but are not limited to, research on adult learning styles and the evaluation of the graphic recording process as an effective learning tool. There is a great deal of research working with children to better understand learning and information retention; however, few formal papers have been documented with adult learning through visuals and text together (Congleton, 2011; Gardner, 1983; Sibbet, 2010). This study works almost exclusively with an adult population to better understand how graphic recording facilitates learning and understanding of complex scientific material, as well as other benefits previously unknown.

Although research on visual communication is broad, there has been no formal evaluation of using a tool such as graphic recording. Anecdotal evidence shows several benefits to using graphics in meetings and workshops (Agerbeck, 2012; Kelly, 2005; Marguiles & Sibbet, 2007a; Sibbet, 2008). However no systematic research has been conducted to see which aspects of graphic recording are found most often to be helpful and if these results are valid. A systematic investigation focused on validity of results as well as patterns from conversations with a diverse set of participants may reveal a more credible and holistic evaluation of the benefits of using graphic recording.

Future Research

Because this is a relatively new form of visual communication, further research opportunities abound. A larger sample size for quantitative data collection and asking more survey questions that complement the qualitative interviews, such as “The graphic recording helped me remember information throughout the day,” or “I feel like my ideas were heard by the

group through the graphic recording," would make future studies stronger. Qualitatively, having a person who is perceived as unassociated with the graphic recording implementing the interviews may lead to less biased responses by participants not wishing to offend the graphic recorder with honest replies. Working with other cultures to see if the same principles held true would be beneficial in reiterating the success of the World Café being used in multicultural contexts. More examinations of graphic recording internationally could be examined to see if it is accepted in other cultures and also compared with results from the study conducted almost entirely in the United States – only 13 responses were collected in Japan – to see if the same benefits are reported cross-culturally. This area of study would be particularly applicable to climate change communication as tools are needed that reach broad audiences in an effective way. Graphic recording shows promise as one of these innovative tools.

Climate change is an environmental issue that has the potential to affect human beings around the globe for generations to come (IPCC, 2007; Karl & Trenberth, 2003; Maibach et al., 2009; Moser, 2010). Innovative visual communication tools and strategies are needed to convey the depth of this challenge and show people what they can do to contribute to the solution (Davis, Thompson, & Schweizer, 2012; Schweizer et al., 2009). This study illustrates how graphic recording can be used to literally show these things to messengers and the public by making ideas easier to understand, remember and showing how individuals are involved in the larger system. With the potential to visualize big picture perspectives and clarify complex scientific concepts, graphic recording is a tool emerging in the world of communication that should be well-understood and utilized where it can be most beneficial such as multifaceted, systemic problems like global climate change.

FACILITATING THE DEVELOPMENT AND EVALUATION OF A CITIZEN SCIENCE WEBSITE: A CASE STUDY OF REPEAT PHOTOGRAPHY AND CLIMATE CHANGE IN SOUTHWEST ALASKA'S NATIONAL PARKS

Introduction

This paper is a qualitative analysis of the process used to create and evaluate a repeat photography citizen science website as a climate change communication tool. The website project was developed to enhance climate change education in the national parks of Southwest Alaska. The objective of this chapter is to explain the process and facilitation of developing the website and suggest practical guidance for the development of similar, future projects. This chapter reports an in-depth qualitative evaluation of the entire project process and concludes with key insights from the core team and project facilitator. By evaluating the process through qualitative measures, I hope to encourage others to learn from, emulate and improve our team's efforts.

Inspiration for the Project

This research was initiated through the Place-Based Climate Change Education Partnership (CCEP) which was created in 2010 through funding from the National Science Foundation (NSF). The transdisciplinary, collaborative Partnership brought together researchers from Colorado State University (CSU) and practitioners from the National Park Service (NPS), the US Fish and Wildlife Service (FWS), and the National Parks Conservation Association (NPCA) to develop strategies to better communicate with and engage visitors in climate change communication efforts. Between February 2011 and January 2012 the research team conducted a

series of site visits, which included substantial data collection (4,181 visitor surveys, 349 interviews and 14 staff focus groups) and strategic communication planning workshops in five pilot locations around the country: Northern Colorado; South Florida; Washington, D.C.; Southern Alaska; and the Puget Sound region in Washington State.

The semi-structured visitor interviews in particular provided insights that informed the development of the repeat photography website as a climate change engagement tool for park visitors (Rubin & Rubin, 2012). Interviewees were asked a number of questions developed prior to the interviews about climate change such as "What is the ideal method for you to learn about climate change in this place?" (See Appendix A for full interview questions). Through open coding and categorization several themes emerged to indicate visitors' ideal methods of learning about local landscape changes occurring (Lindlof & Taylor, 2002; Rubin & Rubin, 2012). Across age, gender and perspective on climate change, visitors expressed a high level of interest in programs that revolved around place-based, citizen science approaches to learning, the use of images and photographs to illustrate change, and technology. The following key findings describe each concept in more detail:

Key finding 1: discovery. Repeatedly, the qualitative research team heard that people did not want climate change education forced upon them, rather they wanted to discover and learn through activities or materials that gave facts and stories and let them delve deeper if they wished. Visitors to parks and refuges were often on vacation and were often looking for a relaxing, pleasant experience; the idea of feeling guilty for driving or depressed about the loss of special flora and fauna on vacation was not appealing to many interviewees.

Key finding 2: repeat photography. Visitors often expressed interest in seeing visuals of how the landscape has changed through time: “It could be interesting at some of these landscape overlooks to see in time-lapse kind of photos…” (Interviewee #4, personal communication, July 9, 2011). They also repeatedly displayed interest in activities that were active, hands-on and family friendly, which often included mention of visuals to accompany information.

Key finding 3: place. Another trend that emerged from the data addressed how visitors were interested in learning about climate change in the places they love. It was clear that these places were special to a majority of the visitors: “Why am I conscientious about my actions? This place,” (Interviewee #3, personal communication, July 6, 2011). This is consistent with previous research which shows that people are more likely to change their behaviors to mitigate climate change impacts if they have a connection with the place (A. Leiserowitz et al., 2010; Maibach et al., 2009; Somerville & Hassol, 2011).

Key finding 4: technology. Finally, the use of technology to learn about climate change and the park was a common trend in interviews and surveys. Based on survey data, most of which was collected via the new technology of iPads (see Davis, Thompson, & Schweizer, 2012), the most preferred way for visitors to learn was through websites and similar online resources. Although interviews revealed slightly different priorities, visitors still often answered the question of how they would like to learn about change in that park or refuge with answers like an app or online through the park website.

Based on what I learned from previous research, building a web-based repeat photography site can provide an opportunity to approach the climate change conversation in a

different way. Additionally, the creation of such a forum, with multiple agencies, key players and designers will require some facilitation. Thus, my research questions for this case study are:

RQ 1: How will a web-based repeat photography citizen science site achieve a shift in the climate change conversation?

RQ 2: What are the key elements of collaborative development for such a site? Which aspects of the development require facilitation and special attention so other groups hoping to replicate the process for their organizations can learn from this research?

By opening the conversation about climate change through exploratory programs that are not forcing facts upon visitors but instead presenting climate change impacts through personal discovery, the climate conversation can be approached in a different way which is likely to be more palatable for a greater number of park visitors.

Agile Development & Reflection

The research team at CSU built a citizen science website based on best practices cited in the literature, including features for different user groups, mechanisms for communication about data collection and use, and simple, clear features for a broad range of users (Beck et al., 2011; Newman et al., 2010; Newman, Graham, Crall, & Laituri, 2011).

Websites provide an excellent platform for citizen engagement programs by making many of the traditional citizen science challenges more manageable. Issues such as efficient program management, citizen buy-in, quality assurance tools, volunteer recruitment, and marketing and communication mechanisms are all eased through the development and use of a good web platform (Newman et al., 2010). Thus it is important to take into consideration the

diversity of participants who may access the site when developing a program that may be accessed and contributed to as easily as possible.

Empowering participation of citizen scientists to share information they collect is one way to create deeper buy-in through the development of an increased awareness of the research being addressed (Couvet, Jiguet, Julliard, Levrel, & Teyssedre, 2008; Cronje, Rohlinger, Crall, & Newman, 2011). However for these kinds of programs to be effective, scientists must also share research results and provide updates to the volunteers helping collect the data so they can follow how their efforts made a broader impact (Newman et al., 2010). Additionally, to have an effective program that can truly inform decision makers, standardized monitoring protocols must be employed to ensure consistency and reliability among the data, regardless of the scale of the project (Newman et al., 2010; Ottinger, 2009).

Newman et al. (2010) conducted extensive research on creating effective citizen science websites. Through participant observations, interviews and quantitative measures, they distilled their findings into key factors for consideration. These findings were critical during our team's web development period. First the web development team sought to develop simple, clear website features to encourage initial exploration, and then build into more complex interfaces as participants become familiar with the website. Next the web developers wanted to provide web features for multiple user groups. In this website features were created for NPS Inventory and Monitoring scientists browsing for metadata, but also an appealing format for non-expert adults and children to explore, learn, add and view photos. Third, web developers created and adhered to protocols that ensure data quality. A succinct description of good repeat photography methods is available on the website and NPS employees have the power to ensure photos are appropriate and relevant before being posted.

It was important to include features to facilitate easy communication between project managers, members, and volunteer coordinators. Ensuring participants understand their role, what they are doing and how the data is being used is essential to success. A description of the project and what we need from visitors is part of the "about" section of the repeat photo site. Additionally, a feedback survey and a contact form are readily accessible from each page. Finally, good citizen science websites provide certifications and digital awards for accomplishments and contributions foster motivation and participation (Longan, 2007). Engagement of Park visitors of all ages needs to be fun, particularly for children and families. I am planning to implement a "digital photo badge" reward system in a future iteration of this website. In their study, Devictor et al. (2010) distilled their learning into five similar key factors of success: simplicity of features for users; good structure for communication and protocols; feedback from users and scientists to inform one another; communication between scientists, users, and facilitators; and sustainability of the site so it can be utilized in long-term monitoring efforts.

These findings reflect a new trend in web development known as agile development. Creating an interface that is able to change quickly to respond to user feedback and works well with small teams such as organizations developing citizen science programs are key aspects of agile development (Beck et al., 2011; Devedzic & Milenkovic, 2011). The research team strived to respond quickly to changing needs from members of the development team and users as well as focusing on collaboration rather than working solely from an initial contract (Beck et al., 2011).

The repeat photography website was developed following an iterative, agile software design approach (Biggs, Breen, Slotow, Freitag, & Hockings, 2011). The software development

cycle included the following phases: (1) investigation and feasibility analysis; (2) requirements specification; iterative cycles of: (3) design, (4) development, and (5) testing; and (6) system maintenance. The system requirements (step 2) were determined through a series of stakeholder conversations conducted through teleconference and WebEx calls and continuous feedback from NPS staff from disciplines including research, science, natural resource management, administration, interpretation, education, and outreach.

To understand the development process it is useful to note the technical aspects of the code developed. The web application was developed using a variety of both open source and commercial software and hardware applications. These applications include the PHP open source scripting language along with several open source libraries including JavaScript, JQuery, and JQUI. Web application page presentation was accomplished using PHP, JavaScript, JQuery, CSS, and HTML. Several open authentication (OAuth) Application Programming Interfaces (e.g., APIs) were used for integration with several popular social media outlets, including Facebook and Google Maps. The system database uses the Microsoft SQL Server 2008 enterprise level relational database management system and the web application is served on a Microsoft Windows 2007 Server web server running Internet Information Server (IIS) version 6.0.

The system leveraged several code libraries developed for the International Biological Information System (previously the Global Organism Detection and Monitoring System (iSee)(Graham, Newman, Jarnevich, Shory, & Stohlgren, 2007) and followed user interface design paradigms used by the CitSci.org multi-scale citizen science website (Newman et al., 2011). A test web server was used for testing and NPS feedback and new code releases were

rolled out to the test server for review monthly. Figure 3 is a screenshot of the website homepage.

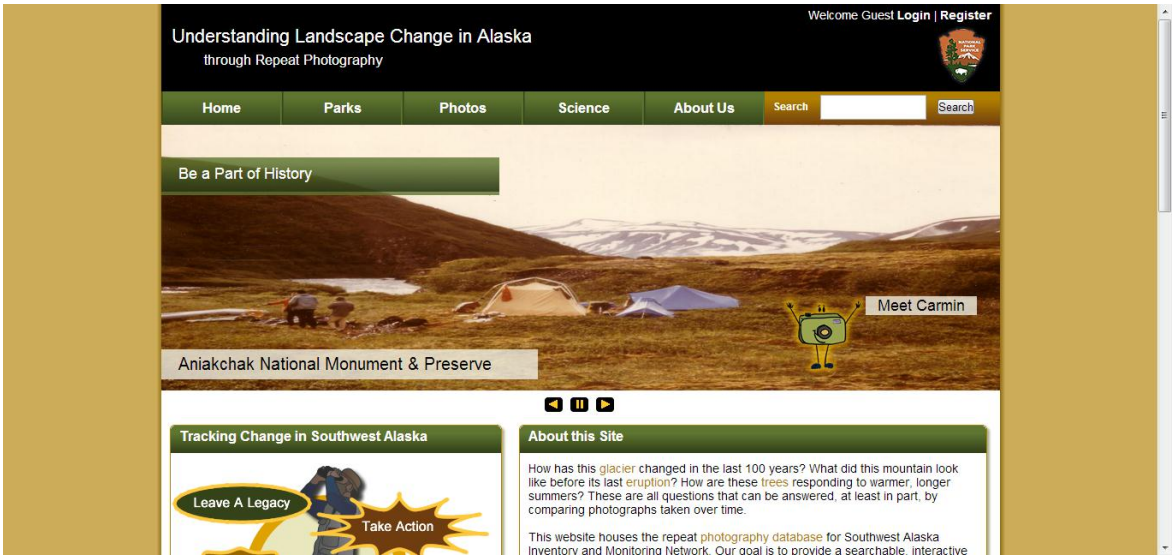

Figure 3: Landscape Change website homepage: <www.ibis.colostate.edu/ccep>.

Facilitation and Process

The group was convened through a collaborative agreement between CSU and NPS. The core team consisted of ecologists, interpreters, web developers and science communicators. With a diverse group collaborating over a large distance to develop the website, an array of facilitation strategies were employed to communicate, gather input, provide feedback and disseminate information.

The team used email and monthly calls as the primary means of group communication. These calls were planned through email conversations and focused largely on sharing website development, gathering reactions to the website's progress, and immediate next steps to take which revolved around the website appearance and features. In addition, the core team members in each location (Colorado and Alaska) often met in person to discuss the project. Email was used for individual communication as well as planning regular group calls. These

communication mechanisms worked well for this group and are recommended for this type of process, as well as additional communication approaches outlined in the results and discussion.

The Repeat Photography Website Vision

This section of the manuscript describes the vision for the repeat photography website project when fully developed. The purpose of the website is multifaceted; it was designed to serve the following purposes:

1. Provide a platform for users to browse a photo database of the SWAN national parks;
2. Offer users the ability to upload their own repeat photographs of historic images;
3. Allow users to comment on photos to note changes or lack thereof;
4. Provide resources for users to learn more about the Inventory and Monitoring projects in SWAN parks, additional information about climate change, and lists of other citizen science projects in different areas and nationally across the United States.

The website is designed to inform and engage three distinct user groups: virtual visitors, citizen scientists and researchers and scientists.

Group A: virtual visitors. The first user group includes those who do not physically travel to and visit the parks in Southwest Alaska. I anticipate these users primarily browsing the photographs to see changes in the landscapes and learning about climate science and other research projects in the parks. They are likely not contributing any photographs to the website but are able to observe landscape changes through the images provided by the Park Service and other web users. They can comment on photos, learn about research in the parks focusing on climate science as well as other research, and learn how they can get involved in citizen science projects near their own homes.

Group B: citizen scientists. A second group of users are those who visit the parks and contribute their personal photos to an on-line database. This group can also download coordinates and follow directions to specific repeat photo locations found on the website, take a photograph that repeats a historic photo location, upload their photo and associated metadata (i.e., coordinates, date, changes observed, photographer, other notes), and make comments and observations about landscape change in the region based on their visit and the photos taken over many years compiled in the database.

Group C: researchers and scientists. A third group of website users are scientists interested in using the photographs for tracking change across these landscapes. These scientists are able to take and upload repeat photographs and use the pictures and data collected by citizen scientists to inform research, draw new conclusions or observe new phenomena in locations they are unable to track as regularly and thoroughly can be possible with a large cadre of citizen scientists.

Evaluation Processes

To better understand the successful and challenging aspects of facilitating a transdisciplinary project such as this, it is important to evaluate the process (Abma & Widdershoven, 2011; Patton, M.Q., 1999; Patton, M.Q., 2001). To ensure a holistic and reflexive perspective about the process of developing the website, qualitative methods were primarily employed. Informal interviews with members of the research team and personal reflections from the project facilitator provided internal feedback and evaluation on the project development process. Using qualitative questions and interviews paints a more complete picture informing the authors more accurately (Rubin & Rubin, 2012).

Over a year of planning, collaboration, development, implementation, and iterative refinement of the website have resulted in reflective evaluation of the project. According to Altheide and Johnson (2011) and others (Champ, 2008; Denzin & Lincoln, 2000), the social world is not literal, but based on interpretation and symbolic sense-making. Using ethnographic reflection and semi-structured interviews on the process reveals how the team worked together, the strengths, weaknesses and future opportunities for this project.

This transdisciplinary project team included experts in climate science, biological monitoring, environmental communication and computer science. As such, it addressed problems that were defined by the users, was complex, and acknowledged the importance of including perspectives and values of many stakeholders (Roux, Stirzaker, Breen, Lefroy, & Cresswell, 2010). A project of this nature requires a substantial amount of cooperation and management effort to be successful (Roux et al., 2010). Given these characteristics, utilizing qualitative observations facilitates a well-rounded understanding of the process and allows for full analysis from differing yet equally important perspectives (Lindlof & Taylor, 2002; Rubin & Rubin, 2012). Using interviews as an evaluation method also allows individuals involved to reflect and adapt to a complex and changing system (Biggs et al., 2011). A validity-as-reflexive-accounting (VARA) view was employed to approach and ensure validity of the qualitative analyses by including the interaction of the researchers with the topic and the reflection process (Altheide & Johnson, 2011).

I conducted emergent and semi-structured qualitative interviews with members of the core team of three Alaska NPS employees and two CSU employees to learn about their perspectives regarding the final website design and group collaboration process. The interviews were conducted by phone and in person by the project facilitator (also the author). Questions

addressed interviewees' perceived strengths and weaknesses of the project, as well as the future potential of the project such as "What do you think we did well during the development of this process?" (See Appendix B for full interview questions). Interview content was then analyzed, and compared with observations of the project facilitator to reveal patterns about how the project was successful and where there was room to improve (Champ, 2008; Denzin & Lincoln, 2000; Roux et al., 2010).

Given my close and direct involvement in the project, I believe it important to share my personal biases and to acknowledge that these and my own interactions with other core team members affected the responses from interviewees (Abma & Widdershoven, 2011; Champ, 2008; Denzin & Lincoln, 2000). As someone with a leadership role in the project, it is likely that responses from the interviewees were influenced by this role. Additionally, I had my own personal goals for this website from its inception and may be interpreting the interviews in a subjective manner based on my desires for the website. However being closely involved in the project also gave me advantages as a researcher by having already built rapport with the interviewees. Having knowledge about the process and the entirety of the project also aided my interviews as I knew what specific questions would be most appropriate.

Results

I follow the results from the interviews with a discussion of the lessons learned while creating a citizen engagement website to communicate about climate change. The findings are meant to serve as guiding recommendations for future research and development of facilitating similar processes.

The development of this project provides important learning opportunities for collaborative groups. The project team was not currently aware of other fully-developed repeat photography citizen science websites in the National Park Service; however, the team recognized the need for this kind of tool is growing based on conclusions drawn from the visitor interviews as well as being approached by several other groups working on similar projects in other regions. Over a year of calls, collaboration and development has led to several valuable insights as to what can make this kind of project successful and what challenges other groups creating this kind of website might face. This section of the paper describes reflections from the project facilitator and the responses to the interviews conducted with each core team member.

Synthesis of Reflection and Interviews

The following are reflections from the project facilitator followed by interview responses that brought up new acumens. Results are summarized in Table 5 and 6.

In person meeting. Working from two disparate locations proved to be one of the most challenging aspects of this project. Many of the most poignant difficulties of the project stemmed from not meeting face-to-face at the outset of the project when the concept needed definition and clarification. Having at the least one initial meeting together could have alleviated many of the future challenges and was the primary recommendation to other groups participating in similar work (Roux et al., 2010).

First, the team had a difficult time defining the overall goals of the website during group phone calls. Through the interviews a wide array of goals from each core team member were described including creating a more accessible photo database, engaging more visitors in the monitoring, and engaging web users in climate change education. This would not have been

difficult for the team to work with or narrow down had they been shared openly from the onset of the project. However, because they were never openly brought forth until the end of the first phase of work, the lack of congruency between purposes for the site made it difficult to create a satisfactory final product.

A face-to-face meeting also would have provided an opportunity for the team to define clear roles for each member. The decision-making process often occurred over conference phone calls. Without explicit designation of primary leadership within the Park Service partners and the level of influence CSU had made final decisions difficult. This often led to circular discussion until a satisfactory compromise was reached.

A target audience was not defined at the beginning of the project, creating more difficulty and inefficiencies during the website development process. For example, during a phone call one person emphasized that this website would be for scientists and therefore should highlight the metadata associated with each photograph. It was clear other team members disagreed and instead thought the audience was a less technical visitor population that would be distracted and frustrated by metadata; they needed more interactive and visually appealing features. The team came to a consensus compromising to allow scientists access to more data without inundating web users with such metadata immediately.

Finally, an in-person meeting would have provided an opportunity to answer questions such as a clear timeline and more personal relationships to foster better communication from a distance.

Enthusiasm and collaboration. The enthusiasm and energy of the core team was integral to its success. With two groups of people in separate geographic locations, keeping

momentum and a positive outlook on the project can be challenging, but the team persevered through long-distance communication. Although group communication was limited to phone and internet, the team successfully developed a complex website in a short period of time with little funding.

As a whole, the group represented many diverse perspectives; and this lends itself to healthy constructive criticism and ultimately, improvements to the site occurred more quickly than might have otherwise happened. Facilitation of an open space during calls in which all voices were heard resulted in candid and useful feedback and development. Having both scientists, developers, and interpreters as part of the core group meant we were able to incorporate data and details in an engaging way for a broad audience as recommended in the literature (Newman et al., 2010).

Place-specific plan. Taking the location of the project into consideration is extremely important to its success. In this case, the team quickly realized that using technology would be an integral part of the project, but it needed to be utilized in a way that best served the visitors in Alaska as well as web-based users. Initially the CSU team wanted to develop an app and a QR scan code for mobile devices which could be used to find interpretive signs or posts associated with this project. It was quickly learned that most of the photo locations in Southwest Alaska the team intended to document do not have internet or cell phone service, inhibiting the use of that kind of technology. In addition, due to a probability of destruction from wildlife or other natural phenomena, NPS was reluctant to build infrastructure (e.g., signs) for this project.

Instead, the team developed downloadable and printable directions visitors can follow using a GPS, provided on the website and at visitor centers. This method allows visitors to

download the directions to their phones or print them out if they prefer. When they gain internet access later after their visit, they can upload photos to the website, make comments and contribute data on the site.

Use wireframes effectively. Building a website from scratch resulted in a completely customized site designed to be exactly what the team needed and wanted. It also meant time-consuming development which could have been streamlined through the use of wireframes and careful decision-making. Wireframes are mock-up designs of the website layout using intended placement, color, and fonts to show the group how the site or page is envisioned, yet is not functional. This enables web developers to quickly explain their ideas without spending valuable time creating a website that the rest of the group will disagree with. For example, the web development team created a browse photos page with each photo pair including metadata displayed based on the query from the user. Based on feedback from the following call, they programmed a dissolve mechanism which faded between historic and recent photos. A third round of feedback and discussion elicited the created of a slider tool so the user could drag the mouse across the historic photo to reveal the recent photo to examine changes. The group finally decided to display the images side-by-side with a dissolve option. These changes were extremely time-consuming and technically advanced. To use time more effectively, it would have been better to create more wireframes and gain a consensus of the final vision before development. To use web development time effectively I recommend beginning with at the least a sketch of the website design in mind instead of developing code prematurely.

Agile development. Another challenge of this project was utilizing agile software development methods while working with a large government agency. The web development team wanted to create an organizational system that could be built on a CSU server then

transferred to an NPS server. It was also important to be able to make edits and design changes to the site easily as feedback is received from users. This proved to be difficult while complying with NPS website standards as well as waiting for approval, data, and communication from the NPS side of the project.

Synthesis of Interviews

Interviews with the core team members revealed that many of the findings above were congruent with individual team members' conclusions about the project. This section summarizes additional insights on the successes and areas for improvement during the website development process from interviews that were not previously noted in the project facilitator's reflections.

Regular communication. Monthly or bi-weekly calls proved to be one of the most integral parts of the success of the project. The physical distance between the two groups in the core team meant that maintaining contact through regular group phone meetings helped the group build better relationships, share ideas and update one another on progress. One interviewee said that scheduling calls "even when it seemed like we had nothing to talk about we ended up having tons to talk about."

Clear goals and steps to achieve them. Having a guiding document which clearly outlines completed tasks what the group wanted to achieve, ideas that had been tried and rejected, and that designates responsibility for different tasks. Each group member had a clear definition of goals for the project; however most of these remained unarticulated to the entire group making it difficult to follow a cohesive plan. Although after each call action steps were circulated in meeting notes, there was no comprehensive record of the group's progress for

everyone to access which led to redundant conversations or difficulty recalling what the group had already tried. Creating this type of summary would also bring expectations of group members to the surface so everyone knew exactly what was expected of them and when the job would be considered complete. A document that can be accessed by multiple people in many locations such as a Google Doc or Dropbox folder is recommended to keep everyone informed on the progress and gaps in the project.

Pre- and post-call notes. During group calls there was often a list of changes that had been made to the website which needed feedback. The web development team had a list of changes to discuss, but did not disseminate this widely among core team members. Providing a short summary of changes made during the period between calls and then sent to the group prior to the calls would enable each person to have time to peruse the site and test the changes. Having time to process the website changes would also allow members on the call to provide prepared feedback instead of being overwhelmed with information shared rapidly during the calls.

A clear message. This theme stems from a lack of clear goals from the group. Without a key message to a target audience the goals, features and priorities of the website were often nebulous or ill-defined to the entire group.

Marketing plan. I recommend having a plan for promoting, sharing and disseminating the website when it is completed. This plan should be discussed from the inception of the project so necessary steps can be taken to contact the right people, develop materials to promote the website and have a clear timeline as to when these actions should happen. The success of this kind of website depends on bringing it to users' attention so they can access and utilize it. Without a plan of dissemination, the website's purpose is questionable.

Dynamic group. The success of this project stemmed largely from the drive, talent and hard work of the group members, for example it was “The creativity and comfort with ambiguity among the group as the website developed and changed” that inspired ongoing collaboration. Good interpersonal relationships were developed despite the lack of face-to-face meetings, which made calls enjoyable and productive. The team also used the wide array of expertise in the core team effectively to delegate tasks to those with strengths in that specific area.

Web development. This project was successful in large part because of the talent of the technical developers. With a wide range of skills and determination, the web designers were a key component to making the website a reality. The CSU web development team spent a large amount of time thinking about the needs of the Park Service for this project. During the design process, their desires and how it would be used were taken into account and influenced the development of the site.

A second recommendation would be to have technical web designers in all geographic locations involved in the project. In this case if we had an NPS web developer to collaborate with the CSU team would have made communication and development much easier.

In-person meeting. Finally, the need for a face-to-face meeting during the initial stages of this project was brought up in four of five interviews as being a key to the success of a project like this. Having a meeting where the group could get to know one another, see faces, and physically discuss and say out goals, target audiences, and steps for the project would likely have made the process much easier. Ideally, an in-person meeting at the beginning of the project should be followed by a mid-project gathering as well as at the end of the project development

period to ensure clear communication and execution of goals. The findings from field notes and interviews are summarized with relevant examples in Tables 5 and 6.

Table 5. Categorization of field notes and interview responses to the open-ended question, What do you think our team did well during the development process?

Inductive Categories	**Key Coding Words**	**Examples of Field Notes & Participant Responses**
Dynamic Group	• Creativity • Expertise • Challenge • Create	The creativity and comfort with ambiguity as the website developed and changed It's a really hard thing to create something from scratch that's new and innovative
Regular and Open Communication	• Talk • Calls • Ideas • Communication	"Even when it seemed like we had nothing to talk about we ended up having tons to talk about!" "Having monthly on average communication calls was extremely effective."
Enthusiasm and Collaboration	• Attitude • Commitment • Working well • Collaboration	"…the attitude has helped keep a high level of productiveness…" "…being able to stay on track and stay committed while making so many changes…"
Agile Development	• Technology • Iterative • Code • Open-source	"I really think we did spend some time thinking about the needs of the agency and what they were trying to accomplish…" "We made great use of existing technology and leveraging open source technology…"
Place-Specific Plan	• Location • Place • Region • Alaska	"Taking the location of the project into consideration is important to its success." "The team quickly realized that using technology would be an integral part of the project, but it needed to be utilized in a way that best served the visitors in Alaska as well as web-based users."

Table 6. Categorization of field notes and interview responses to the open-ended question, Where do you think our team could have improved to make development process better?

Inductive Categories	**Key Coding Words**	**Examples of Field Notes & Participant Responses**
In-Person Meeting	• Meeting • In-person • Face-to-face	"I would have loved to see us all gather as a team at the beginning to define requirement specifications…" "An in-person meeting at the onset of the project to define and clarify leadership, goals and timelines, as well as build relationships."
Clear Goals and Message	• Goals • Clear • Requirements • Message	"…it took us a little while to match up each person's individual goals and the overall goals of the project…" "What are the key goals, key messages, key target audiences to get the project focused…"
Well-Defined Leadership	• Leadership • Lead • Roles • Expectations	"…who is taking the lead on various parts and who is making the call on these things…" "…lay out expectations, what each person is going to do so that everybody knows…"
Marketing Plan	• Marketing • Communication • Release strategy • Market	"I would have insisted that we come up with a plan for promoting and using this website prior to its development." "…to ensure that the release strategy, which didn't exist, really was happening…"
Documented Timeline	• List • Clear timeline • Action items • Document	"We may not have defined a timeline and schedule early enough…" "We don't have a way to keep track of all the suggestions that have been made, here's what's been completed, and here's the changes we want to make…"
Pre- and Post-Call Notes	• Call • Notes • Summary • List	"…before we meet/call having a short summary of what stage, where we are, so people could have a chance to look at the site, look at the changes before getting on the line…"

Through these interviews and the subsequent coding, trends emerged that can guide future research and development in this field. All the participants agreed that future research and development in this field should include the characteristics summarized in Table 7.

Although there were no specific issues where interviewees expressed contrasting opinions, the key recommendations listed above embody the most common commendations for other similar projects.

Discussion: Recommendations and Lessons Learned

This website has potential to be a highly useful resource for interpreters and other park staff across Alaska. Through the web development process I learned an exceptional amount about what works well when creating a web-based citizen science program. Sharing these "lessons learned" with other groups provides an opportunity to reflect on the team's work and enable others to build upon what we have started. Although many insights to the process were illuminated through the interviews, I have distilled the key learning points from this process into the following recommendations (summarized in Table 7):

Recommendation 1. An in-person meeting including all core team members at the beginning of the project is highly recommended to develop clear goals, assigning roles and leadership positions, identify a target audience, create and adhere to a timeline, and to build relationships.

Recommendation 2. A central document easily accessible to all group members outlining the desired features, actions that have been accomplished, ideas the group tried but moved away from, and a marketing plan. This document can also contain tasks people have taken responsibility to foster accountability.

Recommendation 4. Regular group communication enables members to share ideas and opinions, build relationships, and stay current on work that is being done throughout the group on the project. Ideally the group would meet face to face on a regular basis, but if this is not

possible well-facilitated group calls that encourage open dialogue and deliberation are also effective.

Recommendation 5. Build a site using agile code and able to be easily adapted to iterative rounds of feedback. Additionally, make sure design ideas and features have been clearly thought-out and visualized through wireframes before investing much time and energy into the actual code.

Recommendation 6. A final recommendation is to weave the reflection and evaluation process into the entire duration of the project. Even though open communication among the group was fostered, unspoken assumptions proved to be inhibiting factors in this project. Conducting informal interviews during the development process as well as after phases of the project have been completed could reveal many of the incongruences between group members (i.e. goals, audience, expectations) (Biggs et al., 2011; Roux et al., 2010). Knowing these discrepancies existed earlier in the project would have allowed for conversations to clarify leadership and project objectives for better use of the group's time and a more satisfactory end product.

Table 7. Summary of five key recommendations for future multidisciplinary citizen science website development.

1. An initial in-person group meeting to determine goals, features, roles, timeline and leadership.
2. A clear message with a defined audience.
3. A well-developed marketing plan to promote the website when it is complete.
4. Regular, open group communication with a shared document to track progress.
5. Evaluation measures taken and analyzed throughout the duration of the process to reveal any discrepancies among group members' perceptions of the project.
6. Weave evaluation and reflection opportunities into the duration of the project to incorporate insights from group members to improve the process iteratively.

Limitations and Looking Forward

Limitations

This study gives a detailed qualitative analysis of the process of developing a transdisciplinary repeat photography website. It provides a window to learn from the successes and lessons learned for future development of this type of website yet it is not all-encompassing and includes limitations.

As previously stated, interviews and reflection of the process occurred only once: at the end of the website development period. The information obtained from the interviews proved to be invaluable in defining several of the key challenges we encountered during this project. Had I conducted these informal interviews earlier in the development period in addition to a final

reflection at the end, it is likely many of these discrepancies in goals and communication would have surfaced and we could have created solutions much earlier in the project.

Qualitative analysis could create limitations by not acknowledging biases, only reporting reflections that support the arguments being made or interpreting interview responses to back up the research. Although I am a human and can never be purely unbiased, I feel I openly shared my potential biases and how they could affect the results of this research. I also feel that based on the recognition of these biases I maintained as objective a perspective as possible when analyzing responses and comparing them with reflections.

Future Research Opportunities

I am currently conducting a mixed methods approach to evaluating web user experience with the website and the statistically significant insights will be available in future publications. Surveys are available to website users that include both quantitative questions and open-ended qualitative questions to gain insight from website users on the usability, content, educational potential and perceptions about climate change (Newman et al., 2010; Pearson & Pearson, 2008; Zimmerman & Paschal, 2009). Users' satisfaction with the website, ease of use, efficiency, preferences, attitudes and behaviors will be measured (Newman et al., 2010; Pearson & Pearson, 2008).

Agile development requires continuous assessment and iterative refinement of a website and the team is currently refining and improving website features. Priorities include expanding the role of the site mascot Carmen the Camera to engage web users through more dynamic interaction, creating an "Ask a Scientist" feature where citizen contributors can have questions answered by Park Service scientists, developing "e-badges" to recognize users who are

contributing photos and data are top priorities as the project moves forward and making the connection to social media sites for visitors to easily share their photos and comments. The parks in Southwest Alaska have already developed a remarkable web presence through effective use of social media and it would behoove the repeat photography site to integrate and leverage this work.

Integrating the site with the impressive interpretation resources of the Park Service is another opportunity for future growth of this project. Creating ranger-led "photo walks" to more accessible locations has the potential to reach a broad range of visitors and engage them in the discussion of climate change and inventory and monitoring in Alaska's National Parks.

As this project grows, the question of including other parks and protected areas arises. The team and I would like to engage other parks, particularly those in Alaska, in this project however it is unclear whether it would be best to move forward with single, unified site or facilitate the development of regional repeat photography sites for parks around the country.

A comprehensive evaluation of the project from a web user perspective should be undertaken after the website is fully released with proper marketing and visitor engagement. Important questions to consider are users' preferences and ease of navigation around the site, the amount of information given, and perceptions of climate change. Other research outlets could be exploring if this project helped move repeat photography and citizen science closer together or if the experiences shared by this group enabled other groups to more easily implement their projects based on recommendations from this paper.

This project has provided each member of the team an opportunity to learn, grow and collaborate on a transdisciplinary project that will engage national park visitors and web users in

reflection on landscape change, climate change and our nation's natural resources. The opportunities for future research, development and evaluation in this field are numerous and deserve attention of future research. I hope that by sharing my experiences this project can advance the field of web-based citizen science and repeat photography engagement projects.

CONCLUSION

Climate science is often impersonal, complex and difficult to relate to non-expert audiences' day-to-day lives, yet climate change is a global phenomenon that affects each person on our planet. The research described within this thesis paints a new picture of climate change communication through listening to the audiences researchers wish to communicate to. Hearing these non-expert audiences' preferences has led to research utilizing art-centric tools that intrigue audiences and reach beyond the common mantra of "more science results in behavior change." Scientific research into the causes and effects of anthropogenic climate change are integral as we move forward in a world where the mark of a changing climate will permeate both our cities and protected areas. However scientists and communicators should seek out creative and innovative means to engage their audiences with climate change such as graphic recording, repeat photography and citizen science.

Our national parks and wildlife refuges are ideal locations to engage non-technical audiences with climate change; their scientists are trusted by the public and are conducting cutting-edge research into the effects of climate change in these places that people feel connected with. Graphic recording translates complex climate science into a meaningful mural of information that can be digested visually to see and share processes from a holistic and systemic

perspective. Using images and text to synthesize and capture different aspects of local climate science makes it easier for non-technical audiences to see, understand and remember, as well as making the often dry, depressing information more fun and interesting to look at, inspiring innovation and change. Graphic recordings provide a congregation space in which viewers can discuss what they see enabling verbal and interpersonal learners to process the information and more fully understand it instead of simply watching it flash across a screen disjointedly during a presentation.

Through the surveys and semi-structured interviews conducted at workshops we gained understanding that capturing the presentations through graphic recording was perceived as beneficial to the majority of workshop participants. Presentations on local climate science as well as the results of the Place-Based CCEP's research on visitors' perceptions of climate change in parks and refuges were graphic recorded for workshop participants to observe. Graphics were then displayed for the remainder of the day and distributed to participants digitally after the workshop had concluded. After coding for themes in responses, I have summarized the most useful aspects of graphic recording to enhance science communication into the following findings:

1. Graphics made information from presentations easier to understand;
2. The graphics served as a memory aide;
3. The graphics helped participants make connections between ideas and events;
4. The graphics inspired creativity among workshop participants;
5. Graphics appealed to multiple learning styles;
6. Graphic recording made the presentations and workshop more engaging;
7. The graphics are visually appealing;

8. The graphics improved group participation;
9. The graphic recording process showed the systems and relationships among ideas.

These findings support my first research question: Does graphic recording, as a visual communication tool at facilitated meetings, enhance the understanding of complex climate science among members of a non-expert audience? The results of the analyses also offer insight into my second research question: If effective at conveying complex climate science, in what ways is graphic recording most helpful for members of a non-expert audience? The interviews show that memory is self-reportedly enhanced, participants seem to be more engaged and empowered to think creatively, and complex information was easier to understand.

Graphic recording is a relatively unstudied tool based on principles of communication human beings have been using for thousands of years. From the beginning as cave paintings depicting complex stories graphic recording has evolved through the ages to become the sophisticated blend of listening authentically and synthesizing complex information in meetings and presentations. The study of information graphics and how to convey messages through intentional placement of words in relation to images that capture emotions and summarize multifaceted ideas succinctly has been developing over the past decades however a comprehensive study of how graphic recording can be utilized to communicate complex science has been missing until now. This thesis provides a stepping stone on which the field can launch in many new directions to more fully understand how and when graphic recording can be best utilized to share and understand information. By knowing these things, parks and refuges can more easily see their climate systems, effects and mitigation possibilities, and translate them to easily digestible chunks to share with visitors across ages and languages.

Using photographs also provides a platform for parks and refuges to communicate complex information quickly and in a concise manner. Pairing repeat photographs with citizen science creates an opportunity for park and refuge visitors to explore their natural areas, form a more personal connection with the place and personally see the changes occurring in the landscape. Enabling them to contribute to research through historic and recent photographs paves the way for meaningful, place-based learning about climate change. By connecting with a place people have seen and appreciate, they are more likely to be interested in learning about how it may change because of the shifting climate. Interdisciplinary collaboration is challenging yet necessary to gather feedback from visitors to create climate change education tools that take into consideration how they want to learn. Reflecting on the development of this kind of project provides a foundation upon which other groups can build their own engagement tools more easily. Additionally, the results of this research indicate several key factors to successful interdisciplinary partnerships which can be used beyond the field of climate change communication.

Our core team emerged as three National Park Service employees in Alaska and three researchers at Colorado State University who stayed in communication through monthly calls to share progress and ideas. The project, which is still in progress at the time of this writing, has progressed well and we have also learned a great deal while developing this website. Based on interest from other groups around the country, we decided it would be beneficial to analyze our successes and failures to communicate with others interested in creating a website or program like this so they may build on our work. Semi-structured interviews were conducted with the core team asking about best practices and areas we could have improved on as a team and

compared with my field notes as the project facilitator. The findings from these interviews have been distilled into the following lessons learned for best practice:

Finding 1: An in-person meeting including all core team members of the project is highly recommended to develop clear goals, assigning roles and leadership positions, identify a target audience, create and adhere to a timeline, and to build relationships.

Finding 2: A central document easily accessible to all group members outlining the desired features, actions that have been accomplished, ideas the group tried but moved away from, and a marketing plan. This document can also contain tasks people have taken responsibility to foster accountability.

Finding 3: Regular group communication enables members to share ideas and opinions, build relationships, and stay current on work that is being done throughout the group on the project. Ideally the group would meet face to face on a regular basis, but if this is not possible well-facilitated group calls that encourage open dialogue and deliberation are also effective.

Finding 4: Build a site using code that is agile and able to be easily adapted to iterative rounds of feedback. Additionally, make sure design ideas and features have been clearly thought-out and visualized through wireframes before investing much time and energy into the actual code.

Finding 5: Weave the reflection and evaluation process into the entire duration of the project. Conducting informal interviews during the development process as well as after phases of the project have been completed could reveal many of the incongruences between group members (i.e. goals, audience, expectations). Knowing these discrepancies existed earlier in the

project would have allowed for conversations to clarify leadership and project objectives for better use of the group's time and a more satisfactory end product.

Through the research described in this thesis, I hope to inspire the creativity in both communication and science experts to create more unique, participatory climate change education tools. Using elements like graphic recording to depict complex science, repeat photography to show changes in the landscape, citizen science to engage and create a personal bond to non-experts with protected areas, and infusing technology in these methods promises to be effective and engaging in the future of climate change communication.

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APPENDICES

Appendix A: Place-based Climate Change Education Partnership Visitor Interview Questions

1. How many times have you been to Kenai Fjords National Park?
2. Have you seen anything in the refuge that you'd say is happening because of climate change?
3. What does climate change mean to you?
4. How would you describe climate change to a friend?
5. Have you received any information from the refuge about changes they're seeing?
6. Would you like to?
7. How would you like to learn?
8. Have you heard of citizen science?
9. Would you be interested in participating in a program where you collect scientific data to contribute to the refuge's data of changes over time?
10. Do you personally do anything to reduce your impacts on the earth?
11. What motivates you to take these actions?

Appendix B: Core Team Interview Questions

1. What are your initial impressions on the project?
2. What do you think we did really well?
3. Where could we have done something differently to make it better?
4. What were your goals coming into this project?
5. Do you think they were completed?
6. Would you have done anything differently through the development of this website?
7. What potential future improvements/work around the site do you see?
8. Other thoughts on the ideal project?