TRAINING THE NEXT GENERATION OF CLIMATE SCIENCE INTEGRATORS: LESSONS FROM THE LANDSCAPE CONSERVATION COOPERATIVES

By

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Abstract

Science that can be readily applied to policy or decision-making is a critical component of adapting to the climate emergency. Boundary spanning facilitates the creation of credible, relevant, and legitimate science for use in policy and decision making. Individuals who are adept at navigating the interface between science and decision making (referred to as "boundary spanners") are crucial in developing science that fits the needs of managers. Though the attributes and skills needed to be an effective boundary spanner are well-defined, individuals are not often trained for these roles.

This study incorporates two sets of interviews conducted with employees and affiliates of the Landscape Conservation Cooperatives (LCCs), a boundary spanning organization that was administered by the U.S. Fish and Wildlife Service between 2010 and 2017.

Participants across the LCC Network were asked which training they considered to be most effective in their role as a boundary spanner, what changes resulted from that training, and if they had been trained in co-production of knowledge or boundary spanning. Participants from the five Alaskan LCCs who attended a science communication workshop in 2015 were asked about their job tasks, science communication barriers, and goals within their LCC.

Participants cited a number of different trainings that they considered to be effective. Trainings involving decision theory and peer-to-peer learning opportunities were referenced slightly more frequently than other trainings. Changes to the strategic plan and overall direction of the organization was the most often cited training outcome. Capacity (funding, time, or skills) was the most frequently cited barrier to science communication among the Alaskan LCCs.

Small boundary-spanning organizations may benefit from increasing capacity by hiring individuals who already possess necessary skills, or by focusing on science translation rather than generating new science. Boundary spanners should be encouraged to access peer-to-peer learning environments and training in decision making.

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Chapter 1. Introduction

The defining challenge of the 21st century will be how to maximize resilience and adaptation in the face of the ongoing climate emergency. The Landscape Conservation Cooperatives, a federal program initiated in 2010, emphasized co-production of knowledge and landscape-scale conservation. Co-produced science is gaining traction as a way to involve decision makers and managers in the process of producing science to ensure that it fits their needs (Norstrom et al. 2020). Boundary spanning organizations are one approach to developing co-produced science (Meadow et al. 2015). They operate at the boundary of science and policy and ensure the flow of information and needs between the two (Bednarek et al. 2018). Landscape-scale conservation is a trans-boundary conservation approach that operates at a geographic and temporal scale much larger than traditional conservation approaches (Donaldson et al. 2016). Landscape-scale conservation offers the opportunity to consider land use tradeoffs in order to maximize, for example, food security and biodiversity, within an ecoregion (Cordingley et al. 2016).

A critical component of boundary spanning is the knowledge, attributes, and skills of individual boundary spanners (Safford et al. 2017). Boundary spanners are expected to have a suite of cognitive, emotional, and social skills, including being able to work in an interdisciplinary setting (Meyer et al. 2015; van Meerkerk & Edelenbos 2019; Welch-Devine et al. 2014), understand the decision making contexts of stakeholders (Brugger et al. 2016; Djenontin & Meadow 2018; Porter & Dessai 2017), and foster trust between stakeholders (Bednarek et al. 2018; Djenontin & Meadow 2018). Despite being recognized as critical to the success of the organization, boundary spanning roles are often not recognized or appropriately compensated (Goodrich 2020). Additionally, individuals in boundary spanning roles are often not offered appropriate training to enhance their skills (Brugger et al. 2016).

The Landscape Conservation Cooperatives each had a core staff of two people (Haubold & Wathen 2017). The knowledge, skills, and attributes of these employees likely had a significant influence on their respective LCCs. For this reason, the LCCs are an appropriate environment in which to explore the training of individual boundary spanners.

1.1 Purpose of Study and Research Questions

This study investigates training of employees and affiliates of the Landscape Conservation Cooperatives. The specific research questions addressed in this study are:

1. What can the 2015 science communication workshop that was held in Fairbanks, Alaska teach us about science communication training needs of the LCCs?
2. What type of training do national-level LCC employees receive, and which trainings do they consider to be most effective in their work?

1.2 General Study Methods

This is a qualitative study that includes two sets of interviews with employees and affiliates of the LCCs. Approval for this research was granted by the Institutional Review Board (IRB) on October 30th, 2020 (Appendix A. Institutional Review Board Exemption No. 1) and an amendment was approved on August 12, 2021 to include the set of interviews conducted in 2015 (Appendix B. Institutional Review Board Exemption No. 2). One set of interviews was conducted at a science communication workshop that took place in Fairbanks, Alaska, in 2015. Participants in this set of interviews worked for or with the Alaskan LCCs. The other set of interviews was conducted between 2020 and 2021 with people from LCCs across the Network. The codebook was created through an iterative grounded theory approach, with additional coding structures adapted from Wall et al. (2016), van Meerkerk & Edelenbos (2019), and Brugger et al. (2016). Two different people coded samples of text to test intercoder reliability and determine the validity of the codebook. The final coding and analysis was completed by one researcher in NVivo 10.

1.3 Study Limitations

The LCCs were administered by the U.S. Fish and Wildlife Service (USFWS) under the Science Applications program. Because of this, most of the LCC employees were (and continue to be) employed by the USFWS. A significant limitation of this research is that the USFWS denied my requests to interview their current employees. This reduced my pool of potential participants from the 2015 workshop section from eleven to seven. At the national level, this decreased the number of potential participants by approximately half. Four completed interviews with national-level participants had to be discarded.

Another consideration of study quality is the time between the training event and the interview. The Science Communication Workshop in Fairbanks took place in 2015, while the follow-up interviews with these participants took place in 2021. Similarly, the LCCs were disbanded in 2017, and interviews with national-level participants took place in 2020 and 2021. This length of time may affect the level of specificity and accuracy presented by participants in describing training efficacy and outcomes.

The codebook used for analysis was validated by calculating the rate of inter-coder agreement using the kappa-cohen coefficient. This was done by having two people code selections of interviews separately, then using NVivo 10 to calculate the coefficient. One of the coders was an individual who agreed to help code on a voluntary basis. This process was constrained by the limited amount of time that was available. Ultimately, the volunteer spent approximately sixteen hours assisting with this project. Additional time investment outside of that was deemed excessive, and there are a few sub-codes that were only coded by one person.

1.4 Landscape Conservation Cooperatives

The Landscape Conservation Cooperative (LCC) Network was a federal program initiated under the Obama administration to address climate change and other conservation challenges at the landscape-scale. The LCCs were officially created on September 14, 2009, when Department of the Interior (DOI) Secretary Ken Salazar signed Executive Order 3289 (Department of the Interior, 2010). A network of twenty-two partnerships that spanned the entire United States, sovereign tribal lands, parts of Canada and Mexico, Puerto Rico, the U.S. Virgin Islands, and U.S.-affiliated Pacific Islands (U.S. Fish and Wildlife Service, 2012). After the Trump administration took office in 2017, the budget for the LCCs was "zeroed out," and they were no longer financially supported by the federal government (Dunlevy 2019). The total lifespan of the federally-funded LCC Network was approximately seven years.

1.4.1 Governance Structure of the LCCs

Primary administrative responsibility for the LCCs fell under the U.S. Fish and Wildlife Service (USFWS), with limited involvement from the U.S. Bureau of Reclamation (USBR), National Park Service (NPS), and the Bureau of Land Management (BLM) (Haubold & Wathen 2017). The Haubold and Wathen (2017) paper also indicates that congress approved $20 million

to assist with the initial rollout of the LCCs, with around $24 million appropriated each year for the LCCs thereafter. They go on to say that each LCC received different amounts of money (between $400,000 and $1 million annually), which was intended to be used primarily for hiring staff and conducting science projects. Additional money was also provided by steering committee organizations (U.S. Fish and Wildlife Service, 2012).

The vision of the LCC Network was "landscapes capable of sustaining natural and cultural resources for current and future generations." (Landscape Conservation Cooperatives Network, 2014). The responsibilities delegated to the Network at the national level were outlined in a factsheet produced by the USFWS as follows:

> *The role of the national LCC network is to: provide a forum for national and international conservation planning; to integrate the efforts of the 22 LCCs; and to facilitate efforts across and among individual LCCs.* (U.S. Fish and Wildlife Service, 2012, p. 1)

Although this national network-level governance existed, many governance choices were left up to the individual LCCs. This resulted in a patchwork of approaches, with some LCCs choosing to develop strategic plans, science plans, and/or business plans, while others did not have strategic plans at all. The USFWS defined the responsibilities of the individual LCCs as follows:

> *The role of an individual LCC is to: leverage funding, staff, and resources; to develop common goals; to develop tools and strategies to inform landscape-scale planning and management decisions; to link science to management; and to facilitate information exchange among partners.* (U.S. Fish and Wildlife Service, 2012, p. 1)

Each LCC had a minimum of two staff members: a coordinator and a science coordinator (Haubold & Wathen 2017). Some LCCs chose to hire additional staff (sometimes funded by outside organizations), for example, GIS specialists, communications coordinators, cultural resource specialists, or data managers. Each LCC also had a volunteer steering committee that consisted of representatives from federal, state, tribal, international, and non-governmental organizations.

The initial roll-out of the LCCs was met with mixed enthusiasm, with LCCs in some regions (such as the East Coast) quickly assembling steering committees and developing strategic plans, while LCCs in other regions faced skepticism from stakeholders who viewed the LCCs as another federal program that required them to stretch already thin budgets (National Academy of Sciences, 2016). Some states, for example, were expected to participate in multiple LCCs without additional support, leading representatives to pick and choose which LCCs to participate in while abandoning others (National Academy of Sciences, 2016). This initial roll-out led to developmental differences between LCCs across the network that lasted until they were defunded.

1.4.2 Geography of the LCC Network

The boundaries of each LCC were created by a team of scientists from the USFWS and U.S. Geological Survey (U.S. Fish and Wildlife Service, 2012). They did this by looking at avian, terrestrial, and aquatic species assemblages and migration routes and dividing areas into "ecoregions," areas that have similar plant and animal assemblages (U.S. Fish and Wildlife Service, 2012). Ultimately, all 22 LCCs were operating by the end of 2012, covering the geography of the entire United States, sovereign tribal lands, Puerto Rico, the U.S. Virgin Islands, and the U.S.-affiliated Pacific Islands (U.S. Fish and Wildlife Service, 2012). Large sections of Mexico and Canada also fell under the geographic boundaries of the LCCs. Figure 1.1 depicts the geography of the LCC Network.

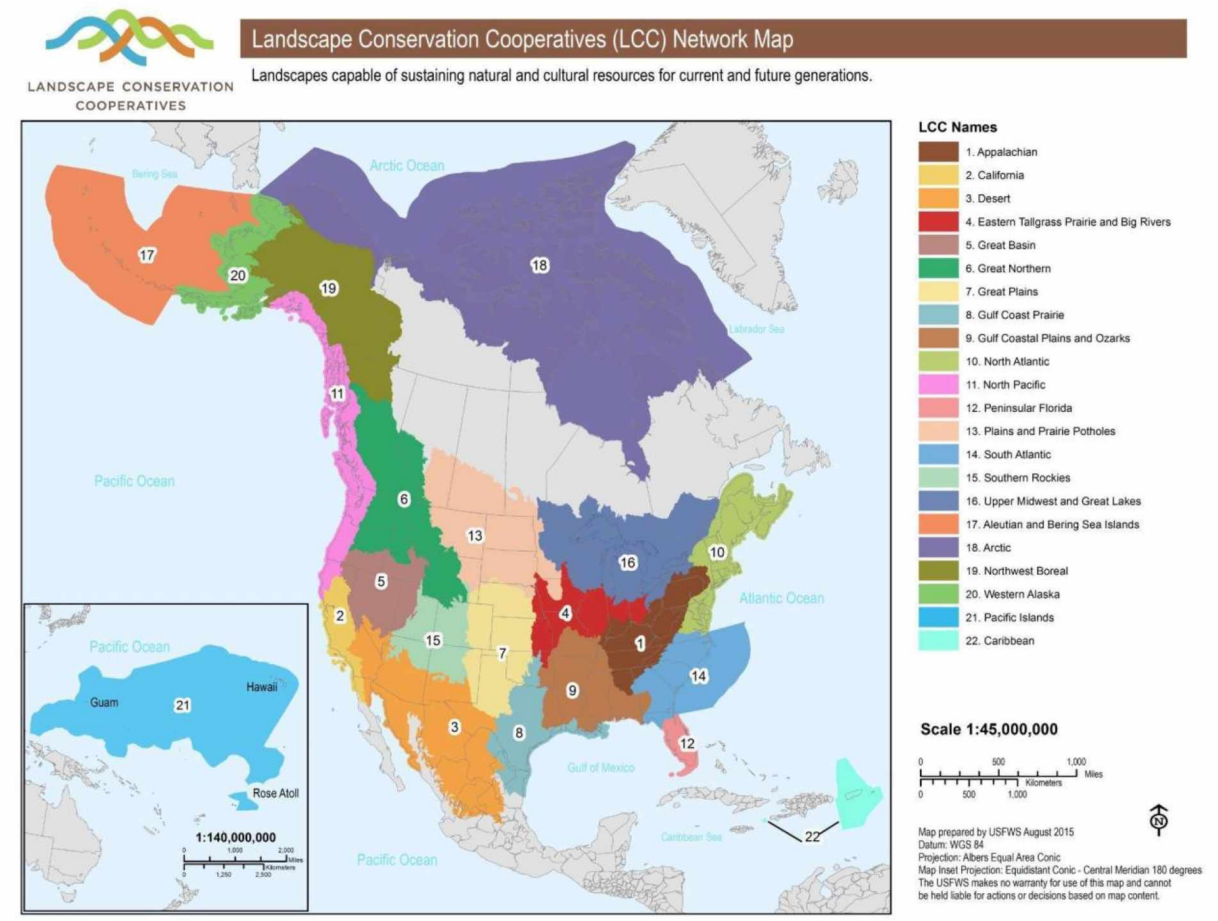

Figure 1: ***Map of the geographic boundaries of the LCC Network (Landscape Conservation Cooperative Network 2015).***

1.4.3 Projects Supported by the LCC Network

The scale and scope of projects tackled by the LCCs varied enormously. Examples of projects supported by the Alaskan LCCs include the Beaver Restoration Guidebook, developed by the North Pacific LCC to help managers improve beaver habitats (Castro et al. 2015); the Arctic LCC developed the infrastructure for the Terrestrial Arctic Observation Network (TEON) which contributed to long-term observational data about watershed changes in Arctic Alaska (Crosby 2013); the expansion of Canada's Boreal Ecosystem Analysis for Conservation Networks (BEACON) into Alaska was supported by the Northwest Boreal LCC (Schmiegelow & Lisgo 2017); Western Alaska LCC initiated the placement of ocean sensors along the coast of Western Alaska, facilitating better weather monitoring and alerting residents to storm surges (Western Alaska Landscape Conservation Cooperative 2016); and the Aleutian and Bering Sea

Islands LCC was able to change vessel routes to avoid ecologically vulnerable areas in the Aleutians (Adapt Alaska, 2021b).

Examples of projects supported by the LCC network include the California Climate Commons, a compendium of climate change information and adaptation tools for the state of California developed by the California LCC (The Climate Commons, n.d.); a floodplain inundation frequency data layer developed by the Gulf Coastal Plains and Ozarks LCC that improved understanding of flood frequency and regions (Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative, 2017); the Upper Midwest and Great Lakes LCC developed several decision support tools to improve coastal wetland protection and support the Great Lakes Restoration Initiative (Upper Midwest and Great Lakes Landscape Conservation Cooperative, 2017); and the Pacific Islands Climate Change Cooperative developed a forest bird vulnerability assessment to enhance efforts to preserve habitat of native Hawai'ian bird species (Peterson, 2015).

In addition to pursuing their own initiatives, LCCs often collaborated on larger-scale issues. One example of a project managed by multiple LCCs was the Gulf Hypoxia Initiative. This was a collaborative effort involving seven LCCs to reduce downstream effects of agriculture on the Gulf of Mexico (Landscape Conservation Cooperative Network, n.d.). Alaskan LCCs were part of a larger collaboration that founded Adapt Alaska, a central resource for information on climate change adaptation tools for Alaskan contexts (Adapt Alaska 2021a).

1.4.4 Trainings Available to LCC Employees

Employees of the U.S. Fish and Wildlife Service often attend trainings at the National Conservation Training Center (NCTC), located in West Virginia. The NCTC offers training in a structured classroom environment on a number of topics, including conservation policy, statistics and modeling, and leadership and supervision (U.S. Fish and Wildlife Service 2020). Employees of the USFWS are not charged tuition when they attend a training at the NCTC (U.S. Fish and Wildlife Service 2021). Figure 1.2 depicts the types of trainings offered by the NCTC.

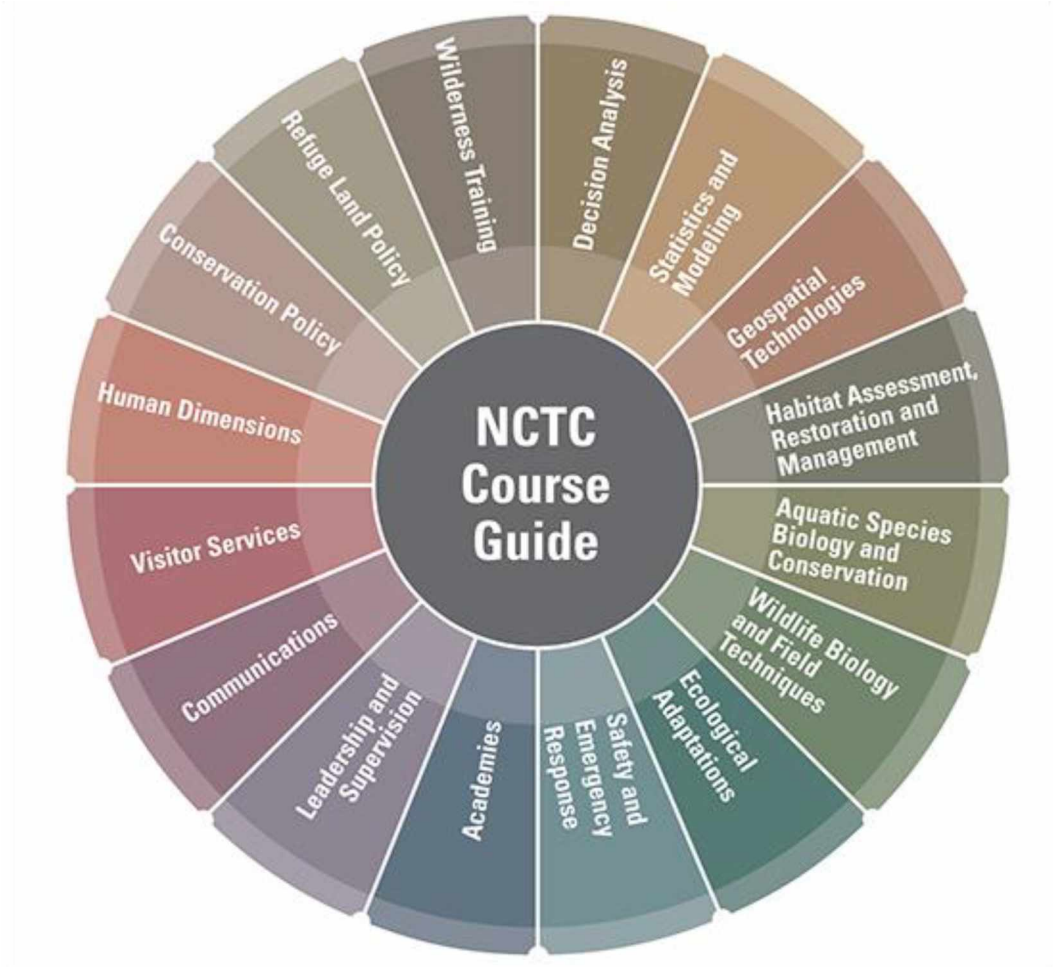

Figure 2: ***Types of training offered by the U.S. Fish and Wildlife Service at the National Conservation Training Center (U.S. Fish and Wildlife Service 2021a).***

1.5.5 Demise of the LCC Network

Despite congressional appropriation of funds, the Trump administration declined to continue financial support for the LCCs in 2017 (Haubold & Wathen 2017). After being defunded, the Alaskan LCCs tended to fare better than the other LCCs in the Network. Three of the five original LCCs (Aleutian and Bering Sea Islands, Northwest Boreal, and Western Alaska) are part of the Northern Latitudes Partnerships, and maintain their original LCC boundaries (Northern Latitudes Partnerships 2021). These partnerships are funded primarily by NGOs, including the Volgenau Foundation, the Alaska Conservation Foundation, and the U.S. Fish and Wildlife Service (Northern Latitudes Partnerships 2021).

Chapter 2. Literature Review

2.1 Landscape-Scale Conservation

Landscape-scale conservation considers the inherent connectivity of the environment, and approaches conservation at larger geographic and temporal scales than traditional core-corridor-buffer conservation models (Donaldson et al. 2017). A "landscape," also commonly called an "ecoregion," is "a large area that contains a relatively distinct assemblage of plants and animals" (Trombulak & Baldwin 2010, p. 7). and "provide a geographic framework for making decisions based on ecosystem processes rather than political boundaries" (Trombulak & Baldwin 2010, p. 7).

One of the main benefits of conservation planning at the landscape level is the ability to assess and make ecosystem service trade-offs at a larger scale (Cordingley et al. 2016;). The integration of stakeholders into landscape-scale management is critical, however, the problem of wrangling dozens of stakeholder groups over large jurisdictional boundaries remains a serious challenge (Campellone et al. 2018; Doyle-Capitman et al. 2018).

Developing boundaries around ecoregions is not an exact science, and conservation organizations take different approaches. The World Wildlife Fund, U.S. Forest Service, and Landscape Conservation Cooperatives, for example, all have different approaches for classifying ecoregions (Trombulak & Baldwin, 2010).

2.2 Co-Production of Knowledge and Boundary Spanning

The Landscape Conservation Cooperative Network operated as network of boundary organizations. Boundary organizations serve to address the divide between knowledge and action systems, most relevantly the gap between science and policy or management institutions (Guston 2001) in order to produce usable science (Meadow et al. 2015). Boundary organizations are frequently used to address "wicked problems" (Bednarek et al. 2018). Boundary organizations facilitate the exchange of knowledge across these different realms (stakeholders, scientists, policy makers, managers, etc.), and maintain the legitimacy, salience, and credibility of information across the boundary (Cash et al. 2005). In order to facilitate this exchange, boundary organizations engage in four primary activities across boundaries: convening, translation,

collaboration, and mediation (Cash et al. 2006). Ideally, this process creates science that is more immediately useful to end-users than the traditional research process (Meadow et al. 2015).

Safford et al. (2017) describes four primary characteristics of successful boundary spanning organizations (p. 561):

1. *Commitment to a well-planned system for boundary spanning activities;*
2. *Development of useful products by the boundary-spanning unit and its partners;*
3. *The existence of an accountability framework that includes both science providers and users;*
4. *The traits of individual boundary spanners.*

Boundary organizations must also be accountable to the realms they are serving, and maintain saliency, credibility, and legitimacy in all of them (Cash et al. 2005). This means maintaining the integrity of the boundary between (for example) science and management, and not being pulled too far in the direction of one or the other, which can be difficult to avoid for some individual boundary spanners (Safford et al. 2017).

2.3 Training Boundary Spanning Individuals

In order to address highly complex sustainability and conservation problems, there is a demand for individuals who are not only proficient in a single scientific discipline, but who also have a suite of other personal and professional characteristics. For example, these people are expected to be able to translate science into policy, facilitate relationships between stakeholders, and be friendly and approachable (Brugger et al. 2016; Djenontin & Meadow 2018; Welch-Devine et al. 2016). These people are sometimes referred to as "renaissance scientists," (McBride et al. 2011), "agile scientists" (Welch-Devine et al. 2014), and "climate science integrators" (Brugger et al. 2016). In this paper, they will be referred to as "boundary spanning individuals" or "boundary spanners."

The existence of boundary spanners within an organization devoted to conservation is considered crucial to the success of the organization (Bednarek et al. 2018). Some positive outcomes associated with the actions of boundary spanning individuals outlined in Bednarek et al. (2018) include the increased efficiency and uptake of scientific information, the enactment of policy that is more durable by creating a "knowledge infrastructure," the increased legitimacy of science among end users, and the ability to identify and quickly act on "policy windows." Van

Meerkerk and Edelenbos (2019) note that while it is essential for boundary spanners to understand the content in their field, they do not need to be experts. Bednarek et al. (2018) suggest that scientists may not even be especially suited for the role.

The classic example of a boundary spanning individual working in the natural resources field is the extension agent. Extension workers assist agricultural producers with integrating scientific information into their decision making. These decisions are made in complex and uncertain environments, and, especially in the context of climate change, can be highly political. Diehl et al. (2015) found that extension workers noted the importance of co-producing knowledge with agricultural workers in order to increase the perceived legitimacy of the information, as well as increase the applicability of the information.

2.3.1 What skills are necessary for employees of the LCCs?

The knowledge, skills, and competencies required to be an effective boundary spanning individual are extensive. A brief overview of competencies noted in the literature can be found in Table 2.1. Van Meerkerk and Edelenbos (2019) helpfully delineated boundary spanning competencies into three realms: emotional, social, and cognitive. These are rough guidelines that can have significant overlap; however, they are useful distinctions when considering training approaches.

Examples of emotional skills required for boundary spanning activities include patience and humility (Brugger et al. 2016). The same paper gives examples of social skills for boundary spanners, including being a good listener and facilitating long-term relationships between stakeholders. Cognitive skills, the realm most adequately addressed by graduate school and professional training opportunities, includes the ability to gather and exchange information (van Meerkerk & Edelenbos 2019).

Table 1: ***Knowledge, skills, and/or attributes of successful boundary-spanning individuals from selected sources.***

Attribute	Citation
Able to gather and exchange information	Bednarek et al. (2018); Meerkerk & Edelenbos (2019)
Able to work in an interdisciplinary setting	Meyer et al. (2015); Meerkerk & Edelenbos (2019); Welch-Devine et al. (2014)
Appreciate the complexity of conservation issues	Welch-Devine et al. (2014)
Be a good listener	Brugger et al. (2016)
Be friendly and approachable	Djenontin & Meadow (2018)
Co-produce decision support tools and research	Goodrich et al. (2020)
Communicate science to multiple audiences	Brugger et al. (2016) Djenontin & Meadow (2018)
Facilitate long-term relationships between stakeholders	Brugger et al. (2016)
Facilitate mediation and cooperation	Djenontin & Meadow (2018)
Foster trust between stakeholders	Bednarek et al. (2018); Djenontin & Meadow (2018)
Grounded in a particular discipline	Meyer et al. (2015) Welch-Devine et al. (2014)
Have humility, curiosity, and patience	Brugger et al. (2016)
Maintain credibility with stakeholder groups	Brugger et al. (2016)
Move between theory and practice	Welch-Devine et al. (2014)
Respect others	Brugger et al. (2016)
Translate science into policy	Welch-Devine et al. (2014)
Understand decision-making contexts of stakeholders	Brugger et al. (2016); Djenontin & Meadow (2018); Porter & Dessai (2017)

2.3.2 What skills can be trained?

Effective training of employees is an ongoing, iterative process that can have positive effects on organizations when done correctly (Salas et al. 2012). Many attributes of competent

boundary spanners are commonly considered to be innate characteristics of an individual, rather than qualities that can be trained (for example, humility, curiosity, respect for others, etc.). But, is this true? Van Meerkerk and Edelenbos (2019) outline a few key trainings available in the under-emphasized social and emotional attributes of boundary spanners, in addition to trainings for the more conventionally recognized cognitive skills.

Overall, van Meerkerk and Edelenbos (2019) consider interdisciplinary training as the most important cognitive training that boundary spanning individuals can have. The National Science Foundation's Integrative Graduate Education and Research Traineeship (IGERT) program is one of the most well-known efforts to expand interdisciplinary research in academia (Brugger et al. 2016; Borrego & Cutler 2013). Social trainings are also fairly common and well-understood, even if they are less formally recognized than cognitive trainings. Examples of social trainings include meeting facilitation, conflict resolution, and negotiation techniques (van Meerkerk & Edelenbos 2019).

While the development of emotional competencies remains the least-understood in terms of training, there are a few strategies that can be used to enhance emotional skills (van Meerkerk & Edelenbos 2019). There is significant evidence to suggest that empathy can be trained (Teding van Berkhout & Malouff 2016). One of the better documented trainings for developing empathy is engaging in role-playing activities pertaining to real-life or simulated conservation scenarios (van Meerkerk & Edelenbos 2019).

2.3.3 What types of trainings are available?

Brugger et al. (2016) outlined a variety of effective training methods that exist for individual boundary-spanners. This section focuses on the types of training available within academic circles, professional training and workshops, informal "on-the-job" trainings, and skills acquired as a result of personal background.

There are a few programs that incorporate boundary spanning and co-production of knowledge training at the graduate and post-graduate level. The National Science Foundation's Integrative Graduate Education and Research Traineeship (IGERT) program, already mentioned, is one example. The University of Maine conducted a Sustainability Science Initiative (funded

by the National Science Foundation) that, among other things, trained graduate students to do work that spans the boundary between knowledge and action (Meyer et al. 2016).

Some of the formal trainings outlined by Brugger et al. (2016) include training in social science research methods, science communication, and science integration. Communications training is especially emphasized because its efficacy is well-established (Meerkerk & Edelenbos 2019). The types of formal trainings offered by the U.S. Fish and Wildlife Service for employees will be discussed in-depth below.

Brugger et al. (2016) interviewed people involved with NOAA's Regional Integrated and Sciences Assessment (RISA) program, and the DOI's Climate Science Centers (CSCs), two programs which are similar to the LCCs. Respondents said that most of the work they do related to boundary-spanning was learned on-the-job (Brugger et al. 2016). Experience working overseas or in a cross-cultural setting was found to enhance the effectiveness of an individual boundary spanner (Au & Fukuda 2016).

An individual's personal background also influences their work as a boundary spanner. Brugger et al. (2016) found that individuals that grew up in farming communities had more credibility with agricultural groups. An assessment done by Brown (2017) investigating the Australian government's failure to adequately address the needs of Indigenous people suggested that instead of spending time and money training non-Indigenous Australians to effectively engage with Indigenous Australians, they could simply hire more Indigenous Australians.

Chapter 3. Methods

3.1 Design and Data Collection

3.1.1 Participants

This study includes data from two different sets of participants, with some overlap between the groups. The first set of participants are individuals who attended a science communications workshop in Fairbanks, Alaska, in 2015. There are 11 study participants in total, out of 15 people who attended the science communications training. Participants were employees from each of the five Alaskan LCCs, as well as one person who worked for the Fish and Wildlife Service in conjunction with the LCCs, and another person who worked for the Alaska Climate Science Center.

The second group of participants is comprised of 14 individuals who worked at any LCC nationwide, and represent 11 out of the 22 LCCs in the Network. These individuals were recruited via email and agreed to participate in this study. All participants worked at an LCC for at least two years between 2010 and 2021. Twelve participants were employed as coordinators or science coordinators, while two participants had another job title. Because many of the LCCs had as few as two employees, specific LCCs and job titles will not be included in this description to maintain confidentiality. This study excluded individuals who were employed by the U.S. Fish and Wildlife Service at the time of the interview.

3.1.2 Data Collection

This study includes data from two different sets of interviews. The first set includes eleven interviews that were conducted in 2015 prior to a science communication workshop held in Fairbanks, Alaska. Participants represented all five of the Alaskan LCCs, and one additional participant worked with an affiliated organization, the Alaska Climate Science Center. The interview included questions about the participants' job description, their thoughts on science communication, successes and challenges within their LCC, and their goals for the workshop. See full interview protocol in Appendix C. Interview Protocol: Science Communications Workshop. Interview length ranged from approximately a half hour to an hour, and were recorded and later transcribed.

The second set of interviews were conducted between November 2020 and July 2021. Originally, the interviews were designed to answer several research questions about evaluation in the LCCs, training of LCC employees, and lessons learned from the LCC Network. The interview length was cut from seventeen questions to six questions to place more of an emphasis on training questions and reduce the time burden on participants. See full interview protocol in Appendix D. Interview Protocol: Most Effective Trainings.

There are fourteen interviews from the second interview set in total, representing eleven different LCCs. Interviews included questions about what training the participant considers to be effective in their LCC work, and if they had training in co-production of knowledge or boundary spanning. If participants attended the 2015 communications training in Fairbanks, they were asked about the impact of that training on their LCC. The interviews were conducted over zoom and interview length ranged between approximately twenty minutes to an hour. Interviews were recorded and later transcribed.

3.2 Data Analysis

3.2.1 Development of Codebook

The codebook was developed using a combination of grounded theory and codes developed from literature on training boundary spanners and evaluating co-production of knowledge. The sources that were used to develop the codebook were Brugger et al. (2016), van Meerkerk and Edelenbos (2019), and Wall et al. (2016).

The Wall et al. (2016) paper includes a table that delineates evaluation metrics for co-produced science projects. This table was used to categorize goals, barriers, and challenges described by participants in the 2015 interview set. While the LCCs themselves are not a science "project," the metrics generally align with challenges and barriers described by participants and allows for broader contextualization of the results. These coding categories were used in the analysis of research question number one.

The Brugger et al. (2016) paper was used to develop codes to contextualize where participant's most effective training occurred. These four codes included a professional context (i.e. workshops), an academic context (i.e. graduate school), an "on-the-job" context (i.e. informal learning acquired at work), and a personal history context (i.e. anything about the

participant's background they considered to be training-relevant, including lifetime career learning). These coding categories were used in the analysis of research question number two.

Van Meerkerk and Edelenbos (2019) focuses on types of training for boundary spanners and creates three separate categories for these trainings: cognitive, emotional, and social. Examples of skills derived from these training categories include content expertise (cognitive), conflict management (social), and empathy (emotional). These coding categories were used in the analysis of research question number two. Codes that were not developed from existing theoretical frameworks were the result of an iterative coding process (Saldaña 2013) done by one researcher.

3.2.2 Establishing the Validity of the Codebook

All codes were developed by one researcher. Interviews were divided into three different sections. Section 1 included questions 2 through 8 from the 2015 interview data set, section 2 included questions 6 through 12 and question 15 from the 2015 interview data set, and section 3 included all questions from the 2020/2021 interview data set. To determine which texts would be coded by both coders for comparison, I used a random number generator and selected three interviews from each section. Coding was done in NVivo 10 and Google Docs.

To test inter-rater reliability, the Kappa-Cohen coefficient was used. Any Kappa value over 0.60 was considered to be acceptable and no further refinement of the code was needed (McHugh 2012). Anything that fell under that value was addressed through eliminating the codes from the codebook, discussion between the coders, or changing the definition in the codebook to be clearer. NVivo 10 was used to calculate the Kappa value.

The first round of coding was done separately by each coder, then entered into NVivo 10. After that, coder #1 recoded text, taking into consideration the amount of text coverage, and if they thought that coder #2 had a better coding approach in certain instances. Finally, coder #1 sent any remaining discrepancies to coder #2 to see if an agreement could be reached.

Section 1 included questions 2 through 8 from the 2015 interview set. Section 1 did not have any disagreements, so no further coding was done in that section. Table 2 displays the Kappa values for the first coding section.

Table 2: *Kappa values for the first coding section*

Code	Kappa Value
How would you describe your job responsibilities?	
Bridging science and management	0.92
Communications	0.61
Relationships	0.67
Science management	0.85
Strategic planning	0.63
Do you consider science communication, translation, or application to be part of your job?	
Yes, part of my job	1
No, not my job	1
What percentage of your time do you spend with those activities?	
50-74%	1
75-100%	1
Overall Kappa Value Average	**0.85**

Section 2 included questions nine through twelve and question fifteen from the 2015 interview set. There were some disagreements that were below the threshold of acceptability in this section. Final Kappa values for section two are displayed in Table 3. Section 3 represents all questions from the new interview set. There were some disagreements that were below the threshold of acceptability in this section. The final Kappa values for section 3 are displayed in Table 4.

Table 3: *Kappa values for the second coding section*

Code	1st Round Kappa Value	2nd Round Kappa Value
What are your LCCs goals for communicating science so that it is useful for resource management and decision making?		
Input	0.78	0.97
Output	0.33	0.66
Outcome	0.33	0.66
Impact	0.55	0.82
Do you face barriers in reaching your goals for science communication?		
Input	0.31	0.71
Process	0.87	0.98
Output	0.66	0.77
Impact	0.66	0.53
Why is this science workshop needed?		
Communicate to diverse audiences	0.81	1
Develop communications strategy	0.66	0.94
Increase communication capacity	0.33	0.33
Insert LCCs into decision making	0.99	0.93
What are your goals for this communications workshop?		
Create better science products	0.66	1
Develop a communications strategy	0.88	1
Direct or improve communications capacity	0.66	0.94
Emphasize communications in LCC	0.79	0.79
Improve stakeholder involvement	0.47	0.66
Overall Kappa Value Average	**0.63**	**0.81**

Table 4: ***Kappa values for the third coding section.***

Code	1st Round Kappa Value	2nd Round Kappa Value
Have you ever had training in co-production of knowledge or boundary spanning?		
Training in boundary spanning; informal	0.85	0.94
Training in boundary spanning; informal; on-the-job	0.33	0.77
Training in boundary spanning; informal; read literature	0.85	0.94
Training in co-production; informal	0.33	1
Training in co-production; informal; on-the-job	0.66	1
What is the most effective training you've had?		
Crucial conversations	1	1
Informal career learning	0.33	0.32
Informally built relationships through work	0.65	0.61
Structured decision making	0.66	0.66
Training context		
"On-the-job"	0.32	0.33
Personal Background	0.66	0.66
Training theme		
Cognitive	0.66	0.66
Social	0.08	0.33
Training Process		
Building relationships	0.66	0.6
Cross-cultural	0.66	0.66
Immersive	1	0.66
Peer-to-peer learning	0.33	0.66
Training Outcome		
Communications	0.66	0.66

Table 4. continued		
Decision making	0.66	1
Framework or strategic plan	0.8	0.67
No outcome or unknown	0.66	0.9
Partnerships	0.57	0.46
Average Kappa Value	**0.57**	**0.7**

3.2.3 Resolving Coding Discrepancies

There were two Kappa values below the acceptable threshold in section 2. One of these was the "increase communications capacity" code under the "Why is this workshop needed?" question. This resulted from codes that were overlooked in the text by one coder. Both coders ultimately agreed on the same codes for these sections.

The other low Kappa value in this section stems from a disagreement over whether a sentence indicates an impact barrier or input barrier: "Ok, so what I've seen is when information is sort of dis-linked from problem contexts, there's not clarity on who the audience is." The two coders ultimately agreed that this was more of an input barrier than an impact barrier, as it aligns well with the indicator I.6 in the Wall et al. (2016) paper, "target agency representative perceives a path to use/application of the research findings."

There are four codes in section 3 that have Kappa values that are below the acceptable threshold. Some of these discrepancies resulted in changes to the codebook. This included discarding codes that categorized trainings as being "social, emotional, or cognitive" based on the van Meerkerk and Edelenbos (2019) paper, as it appeared there was not enough information to categorize the trainings in that way.

One interview in Section 3 named three different trainings as being their most effective training. One coder selected all the trainings, while the other one selected only one training. This resulted in the low Kappa values for the codes "informal career learning" and "on-the-job." The decision was made to include all of these trainings as their most effective training.

The discrepancy over the code in section 3 "partnerships" was resolved by determining one coder had used a process code where they meant to use an outcome code.

3.3.4 Other Changes to the Codebook

Sub-codes were added to the Wall et al. 2016 categories (input, output, impact, etc.) for additional clarification and meaning. Sub-codes for capacity (funding, skills, time) were also developed. Neither set of sub-codes went through the inter-coder agreement process due to time constraints. These sub-codes were coded by only one researcher.

Two codes under the "why is this workshop needed?" question were combined into one code after the inter-coder agreement process. These were the codes "communicate to diverse audiences" and "communicate science to the general public." These were combined to create a code "communicate to a broader audience."

The question "what are your goals for this science communication workshop" had a few codes combined after the inter-coder agreement process. The code "create better science products" was reconsidered and combined into the "increase communications capacity" code. The code "emphasize communications in the LCCs" was absorbed by the "develop a communications strategy" code.

There were two interviews in which the "most important training" was unclear. These interviews identified the same training sequence, so the decision was made to incorporate all of the trainings that they named. The interviews are displayed side-by-side in Chapter 4 in Table 19.

The final coding was done by one person using NVivo 10.

Chapter 4. Results

4.1 Research Question #1

Participants were asked how they would describe their job responsibilities in two questions, "how would you describe your job responsibilities?" and "are there any other terms or phrases you would use to describe your job?" There were no significant differences between how Coordinators and Science Coordinators described their job responsibilities. Table 5 displays participant responses to these questions by code category.

Table 5: ***Descriptions of participants' day-to-day job duties***

Code	Participants	Example Quote
Administrative	A1, A2, B1, B2, D1	"I have oversight responsibility over this office...and so I supervise staff, I oversee the budget..."
Bridging Science and Management	A2, B2, C2, D1, E1, F1	"I put together research partnerships to address high priority information needs that multiple managers and stakeholders have in the [LCC region]."
Communications	A1, A2, B2, E2, F2	"I do most of the work with twitter...monitoring the LCC twitter account, sending out information..."
Relationships	C1, D1, F2	"My job responsibilities include engaging, managing, and maintaining diverse conservation partnerships in [LCC region]."
Science Management	A1, B2, C2, E2, F1	"...science program development [is] another huge part of my time."
Strategic Planning	B1, B2, D1, E1, E2, F2	"My job is to coordinate the partnership, provide leadership, and help the steering committee provide policy direction for the LCC."

Participants were asked whether they consider science communication, translation, or application to be a part of their job. All participants indicated that they consider at least one of these to be a part of their job. They were then asked to estimate what percentage of time they spend on these activities while at work. Figure 3 shows the amount of time in percentage that participants estimated that they spend on science communication, translation, or application during work hours.

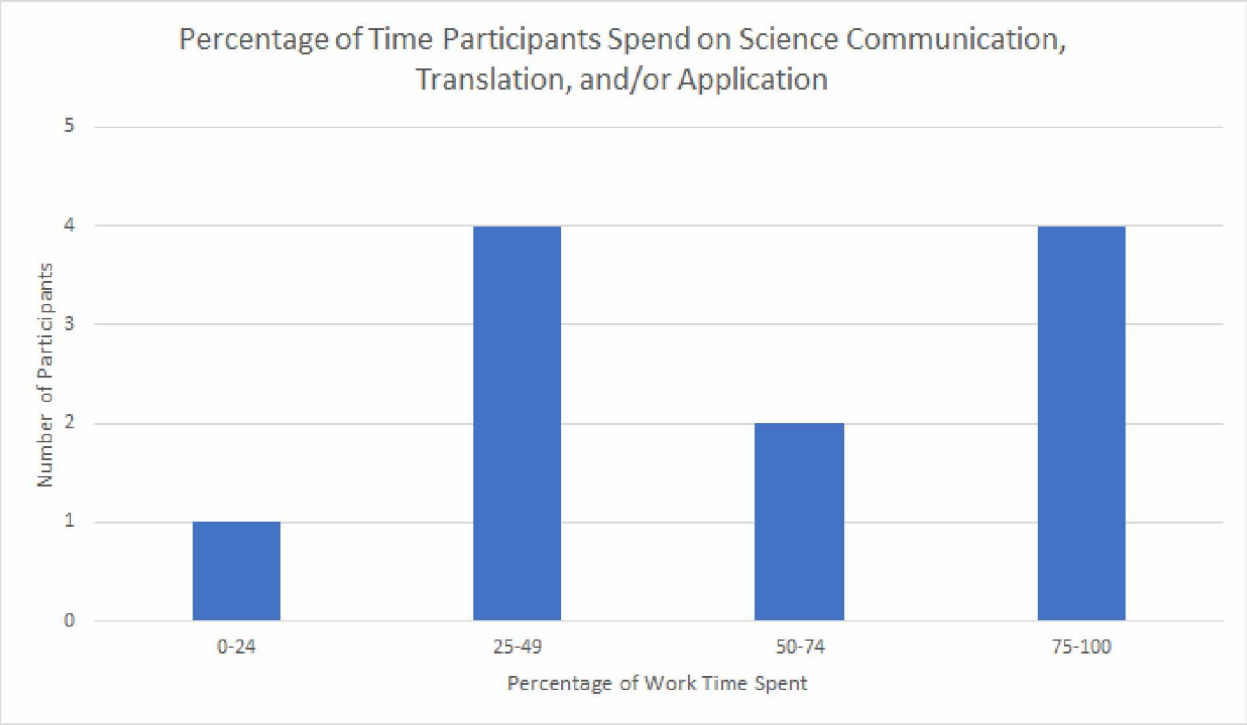

Figure 3*: Self-reported percentage of time that participants spend on science communication, translation, and/or application while at work.*

Participants were asked to describe the status of communicating science for decision making in their LCC. Table 6 displays a selection of responses to this question. These descriptions were coded as "description" of their status by one coder.

Table 6: ***Description of organization's status for communicating science in resource management and decision making***

Participant	Description
A1	"I think we're trying, and I think we're doing a pretty good job."
A2	"I would say we're very early in our development."
B1	"I think it's fair...I think we struggle on the communication side of things."
B2	"Currently, I would say it's a little dysfunctional. Maybe a lot dysfunctional."
C1	"I'd say it's hit and miss."
C2	"I think it's sort of in its infancy."
D1	"I would say we're working hard to do a better job."
E1	"I think we're way behind."
E2	"It's pretty limited so far. It needs improvement."
F1	"I see a lot of room for improvement."
F2	"I know there's increasingly good feelings."

Participants were asked "what are your LCC's goals for communicating science so that it is useful for resource management and decision making?" Responses were coded according to the Wall et al. (2016) table, and further divided into sub-codes. The most commonly cited goal was creating accessible science, followed by having a stakeholder engagement strategy, developing science tools, increasing understanding of climate change, and applying the science they create. Table 7 displays the types of goals cited by participants.

Table 7: ***Participants' goals for communicating science for resource management and decision making in their organization***

Code	Participants Citing this Goal
Input: Stakeholder Engagement Strategy	A1, C1, F1
Input: Identify Science Needs	E2, F2
Process: Mediation	A2
Process: Participatory Engagement	A2, C1
Process: Multi-directional Communications	C1, F2
Output: Science Tools	C1, D1, F2
Output: Accessible Science	B1, D1, E1, E2, F2
Outcome: Demonstrate Value of LCC	A2, D1
Outcome: Credibility	C1
Impact: Applied Science	A2, C2, F1
Impact: Understanding of Climate Change	C1, D1, E2
No Goals	B2

Participants were asked about barriers they face in communicating science for resource management and decision making. Table 8 displays the responses to this question by coding category. The LCC's capacity to communicate science is the most frequently cited barrier by a significant margin.

Table 8: ***Barriers to communicating science for resource ad decision making in participants' organization***

Barrier Code and Sub-Code	Participants Citing this Barrier
Input: Capacity of LCC	A2, B1, B2, C1, D1, E1, E2, F1, F2
Input: Capacity of Partners	D1, F2
Input: Scientists Disinterested in Application	E1
Input: Identifying Science Needs	A1, E1
Process: Stakeholder Disinterest	A2
Process: Cultural Differences	B1
Process: Mediation Challenges	B1
Output: Information Accessibility	D1
Output: Information Overload	B2, F1
Outcome: Lack of Credibility	F1

The meaning of "capacity" as a barrier was further broken into three different types: funding; employee skills; and employee time. Figure 4 displays what participants are talking about when they discuss barriers. Table 4.5 gives examples of what constitutes each type of barrier, and what participants are citing these barriers.

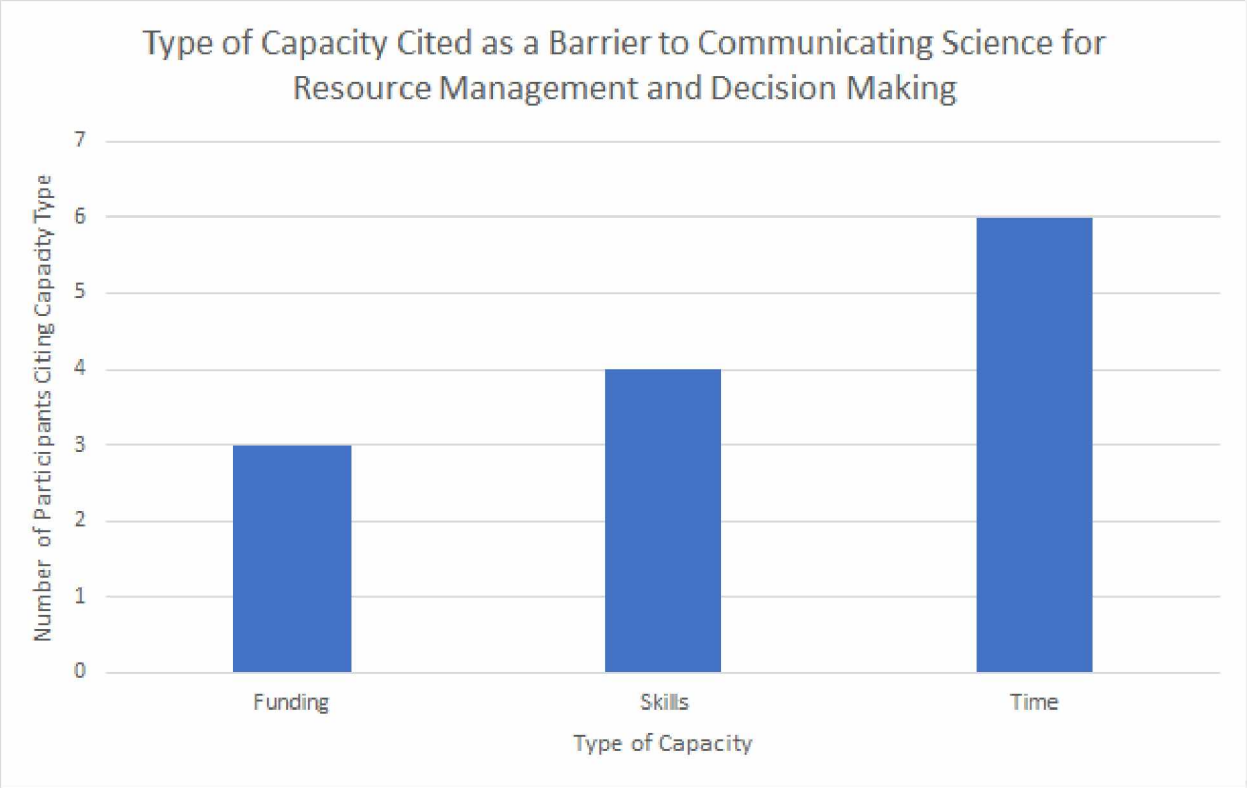

Figure 4*: Types of capacity barriers to communicating science for resource management and decision making identified by participants.*

Table 9: ***Quotes exemplifying the types of capacity barriers that exist in communicating science for resource management and decision making.***

Capacity Type	**Participants**	**Example Quote**
Funding	A2, C1, D1	"...due to our budget crisis, I can't hire a science coordinator right now. So I'm actually doing the job of coordinator and science coordinator."
Skills	A2, B1, E2, F2	"...yes they want to communicate and get that out, but they don't necessarily have the time or expertise to find the most effective way of communicating that."
Time	B2, C1, D1, E2, F1, F2	"Just not being able to devote enough time because this stuff really is time consuming. To do that work is really time consuming."

Participants were asked why this science communication workshop is needed. Table 10 displays some selected remarks from participants indicating that they think the LCCs are not especially good at communicating science.

Table 10: ***Negative responses to the question "why is this science communication workshop needed?"***

Participant	Why is this science communication workshop needed?
A1	"Because we don't know what we're doing...I think we're really terrible at it, in fact."
B2	"...science communication is a neglected part of what I should be doing."
C1	"Cause we're really bad at it."
E2	"Because we need to do a better job."
F2	"The blatant version is because we're terrible communicators, and we know that we are, but we don't know when we are."

Other responses to the question "why is this science communication workshop needed?" Are displayed in Table 11. "Increase communications capacity" is the most frequently cited reason.

Table 11: ***Exemplary responses to the question "why is this science communication workshop needed?"***

Code	Participants	Example Quote
Communicate to a broader audience	A2, B1, C1, E1, F2	"It's important to inform the next generation of scientists...and make sure that the voting public is more informed about science."
Develop a communications strategy	A1, C1	"It's vitally important for us to communicate more effectively...this workshop will hopefully help us develop more effective in-reach strategies."
Document value of LCCs	B1, C1, D1	"Somehow document that there are management decisions now that are being made that are better, smarter, more efficient than had LCCs not done this kind of work."
Increase communications capacity	A1, A2, B1, B2, C1, C2, E1, E2, F2	"...I think it's mostly a lack of capacity, but even if we had capacity I'm not sure if we'd know exactly what to do with it."
Insert LCCs into decision making processes	B1, C2, D1, F1	"I think it's needed because I think the LCCs have really struggled to insert themselves into decision-making processes in an effective way."

Participants were asked what their goals were for the science communication workshop specifically. Two participants did not have any goals for the workshop. The most frequently cited goal was "increase communications capacity." Table 12 displays the responses to this question.

Table 12: ***Participant's goals for the science communication workshop.***

Code	Participants	Example Quote
Develop a Communications Strategy	E2, F2	"I think at the minimum goal, is that if we have this nice little sentence or paragraph even in our ten-year strategic plan that says we're developing a communications strategy, and I would like to come out of the workshop with at least a rough outline or a much better sense of what that should look like and the components."
Document Value of LCCs	B1	"...for our program to be more effective at communicating the value of the work that we do throughout our organization."
Increase Communications Capacity	A1, B1, B2, C1, C2	"I think my goals coming out of that workshop....[are] how best to use our limited capacity in terms of science communication."
Improve Network Coordination	A1, B2, F1	"...I also want all the other people I work with to get better at it because frankly, we all stink."
Improve Stakeholder Involvement	A2, B2, C2	"It's sort of like this voyage of discovery [that] I think those ultimate recipients need to be joining us on, so I think it'd be great if the LCCs try to do more of these projects...that we're thinking about communication throughout."
No Goals	D1, E1	"I don't really have any. I'll participate and learn."

Follow-up interviews were done with four people who had attended the 2015 science communication workshop. They were asked if the workshop resulted in any changes to their LCC, and if so, what the changes were. One participant indicated that the workshop did not result in any changes (participant E1). Participant A2 said that their LCC hired an additional staff member in a communications role. Participants C1 and E2 gave similar responses, that the workshop confirmed the path they were already on. Table 13 shows participant's opinion on whether this training resulted in changes to their LCC, and what the changes were.

Table 13: ***Participant's perceptions of changes resulting from the 2015 science communication workshop in Fairbanks, Alaska.***

Participant	Changes Resulting from the 2015 Workshop
A2	"Yeah, we basically hired a half-time communications position following that training. We basically recognized that we needed that capacity, and that's probably the biggest move that we took."
C1	"I think it gave us a bit more context and tools to do what we were already trying to do. It didn't change it, but it probably strengthened it."
E1	"I don't think so."
E2	"I spent part of [the training] in comparison against what we had done, either confirming some decisions that we had arrived at, I realize we could have gotten there a lot faster if we talked to somebody."

4.2 Research Question #2

When asked what training they found most effective, five participants indicated that they had not received much training in their role at the LCC (see Table 14). Despite this, all of these participants went on to name trainings they considered to be effective.

Table 14: ***Participant responses indicating a lack of training***

Participant	Quote
A1	"There kind of wasn't a lot of training, just to be totally frank."
H1	"I never had a formal training...I never received any kind of training except through my peers and supervisors."
I1	"I am going to start answering your question by saying I had very little training as an LCC [employee]."
J1	"...personally, I've never had any training in partnerships at all."
K1	"That's a strange question, actually, because there wasn't really set training for the LCC staff."

Five participants had not had any type of training in boundary spanning or co-production of knowledge. Of the participants that were trained in co-production of knowledge, three participants were formally trained. All of these participants were from Alaskan LCCs. Two of

the Alaskan participants attended a workshop at the Alaska Marine Science Symposium, and one attended a workshop through the Alaska Ocean Observing System. Six participants had informal training in co-production of knowledge. Of these six participants, four had "on-the-job" training, one had read literature on the topic, and one had done both. Only one participant had training in boundary spanning. This participant had "on-the-job" training, read literature about the subject, and had published papers about boundary spanning. Figure 5 displays the types of training received by participants in co-production of knowledge or boundary spanning.

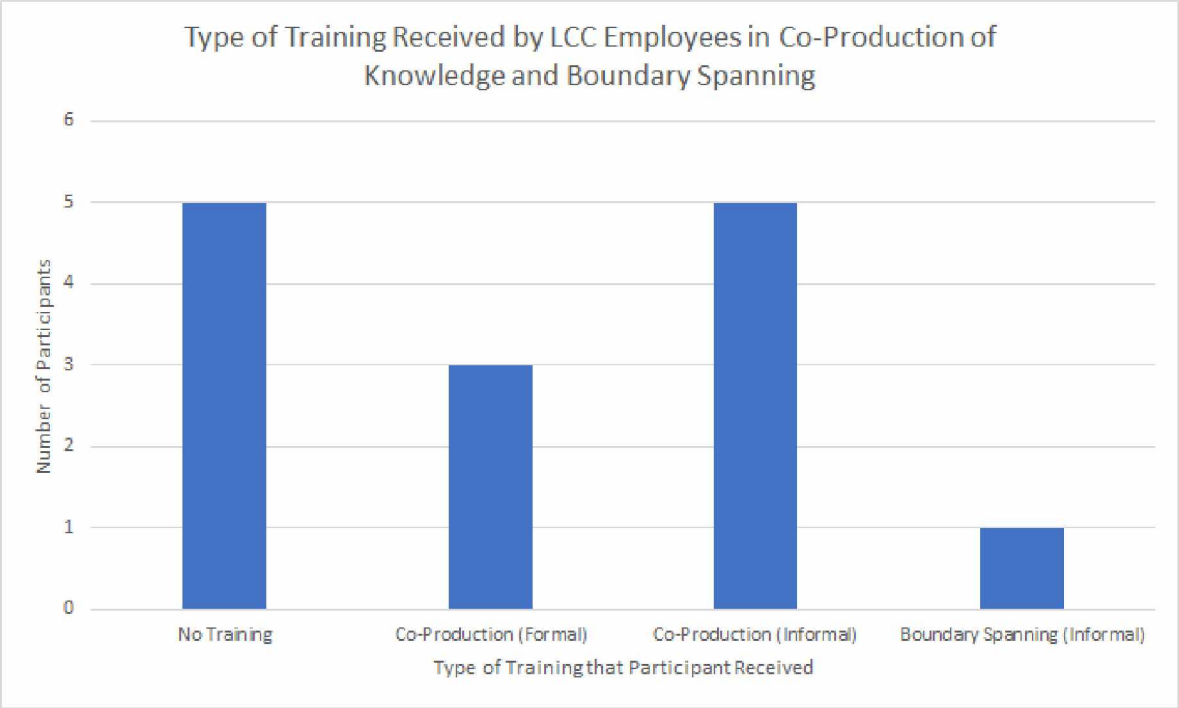

Figure 5*: Type of training in co-production of knowledge and boundary spanning received by participants.*

Participants were asked what training they found most effective related to their work at the LCC, and what made it effective. The most effective type of training was related to decision making, either structured decision making or decision theory. Table 15 and 16 display the most effective trainings, divided into formal and informal trainings.

Table 15: ***List of most effective formal trainings cited by participants***

Training	Participants
Alaska Native Relations	F1
Climate Smart Training	C1, G1
Climate Vulnerability Training	D2, G1
Crucial Conversations	F2
Indigenous Racial Equity Dialogues	A1
Meeting Facilitation	E1
Program Management	D1
Structured Decision Making	D2, I1, K1, K2

Table 16: ***List of most effective informal trainings cited by participants***

Training	Participants
Accumulated career learning	I1, K1
Nationwide meetings with other LCC employees	B1, I1, K1
On-the-job training	H1, J1

None of the four participants included in this study who attended the 2015 science communications workshop in Fairbanks, Alaska cited this as being the most effective training they attended. Additionally, no participant referenced a training specifically devoted to co-production of knowledge or boundary spanning as being the most important training they attended.

The majority (eleven out of fourteen) of participants said that their "most effective" trainings occurred in a professional context, i.e. attending a workshop or class through employment. Two trainings occurred "on-the-job" and both of these were coded as "informal relationship building." Eight occurred while they were employed by the LCC, two said the trainings were from previous positions.

Participants were asked what made the trainings effective. Eight participants described some aspect of the process as a reason that the training was so effective. The same trainings tended to have similar process reasons that made it effective, for example the two participants

who cited the Climate Smart training as being most effective both indicated that the opportunity to become a trainer after finishing the course was one reason they considered it to be an effective training.

Table 17: ***Process and outcome attributes of training considered to be most effective***

Training	Process	Outcome
Accumulated Career Learning	N/A	Mediation skills, Interdisciplinarity
Alaska Native Relations	Immersive	Strategic Plan
Climate Smart	Being an instructor	Strategic Plan; Tools
Climate Vulnerability Training	N/A	N/A
Crucial Conversations	N/A	Partnerships
Indigenous Racial Equity Dialogues	Good instructor; immersive	
Meeting Facilitation	N/A	Strategic Plan
Nationwide Meetings with other LCC Employees	Peer-to-peer learning	Communications
On-the-job	Building relationships	Partnerships
Program Management	N/A	Communications
Decision Making	N/A	Strategic Plan

The participants that described process attributes that made trainings effective cited elements such as being an instructor themselves, building relationships, or having an immersive experience. Table 17 displays some illustrative quotes about the process of training.

Table 18: ***Process attributes that made the training effective***

Code	Trainings	Quote
Being an instructor	Climate Smart	"Every time I trained one of these I learned as much as the students but maybe in slightly different ways. That's just been the biggest benefit I've found in training, the support to allow me to grow from a participant to a trainer..."
Building relationships	On-the-job	"...when you work in a complicated political landscape like that, you have to work with partners, there is not a lot you can do individually, but there is a lot you can do when you work across organizational boundaries and across geographical boundaries. So that was the training I had, and it was on-the-job..."
Good instructor	Indigenous Racial Equity Dialogues	"And also just awesome trainers, having people who are speaking about their personal life experiences...it's much more about personal experience which made it really effective."
Immersive	Alaska Native Relations	"...it was life-changing because we went to a seperate space, we were in a Native space...we had a potlatch, we shared foods, there were elders, they did tons of telling stories, there was ceremony...it was not a training where you were sitting for half a day...it was very immersive, it was very real..."
Peer-to-peer learning	National meetings	"Because that's where I got to sit around with my really smart colleagues and brainstorm, talk about these really wild, giant, important concepts and ideas and how could we possibly implement those."

In addition to the process of the training, participants also discussed the outcome of the training as one of the reasons it was effective. Changes to the way that LCCs approached communications and partnerships were cited, as well as the incorporation of new tools or changes to the LCC's strategic plan. Table 18 displays outcomes related to trainings attended by LCC employees.

Table 19: ***Outcomes of the most effective trainings***

Code	Trainings	Participants	Quote
Communications	National Meetings	B1, D1	"It incorporated certain ideas or a way of doing things, or even communication products and how we connected with our audiences several times after those national meetings."
Partnerships	Crucial Conversations; "On-the-job" learning	F2, H1, J1	"We applied it every day...it's really all about people. And so it's really those kind of partnership building, trust building, disarming people that come in with their guns pulled..."
Strategic Plan	Structured Decision Making; Meeting Facilitation; Alaska Native Relations	D2, E1, F1, K2	"...the sheer process of being exposed to those elements of problem analysis and decision framing was hugely influential, so there was that. So that totally changed or informed how we went about the structure of the LCC for the next, you know, seven or eight years."
Tools	Climate Smart	G1	"I would say that we implemented tools and processes that both myself and [my coworker] were familiar with..."
No Outcome or Unknown	Indigenous Racial Equity Dialogues	A1	"You know, I don't think so...we are in the early stages of trying to get there."

There were two participants whose responses followed a very similar path. Both participants joined the LCCs at the very beginning, in 2010, and had significant career experience prior to that. Table 19 displays their responses to the most effective training question.

Table 20: ***Side-by-side comparison of two similar interviews***

Code	Participant J1	Participant K1
No training	"I am going to start answering your question by saying I had very little training as an LCC [employee]. I'll honestly say that was one of the downsides, they threw me into it and said 'go.'"	"That's a strange question, actually, because there wasn't really set training for the LCC staff."
National meetings	"I will say the national meetings that we had every year, when all the LCC folks got together, that was probably the most effective and enjoyable training of all."	"There were really important meetings that were held that helped all of the staff try and share ideas and figure out how this was working and ways to proceed."
Career-long learning	"Training for this job really came at my old job, where I worked on quite a few controversial projects because of the nature of the agency I worked for...really made it less challenging for me when I ran into opposition at the LCC level about the whole concept."	"For me, the interdisciplinary understanding that is really from career learning was probably the most important thing...as far as official training, I don't know that there was any one thing that I would say was the most important. It's really the collective knowledge and experience that we bring in."
Decision analysis and/or theory	"They hired a guy who was...a decision analysis kind of guy...And he did a lot of work with our tech committee and our steering committee that helped us refine and put emphasis on things that we needed to put emphasis on, which led to our strategic plan, actually."	"...decision theory was more important to set that part and figure out how we can go make some decisions that were really complex and diverse views, so that might be one highlight."

Chapter 5. Discussion, Conclusion, and Recommendations

5.1 Discussion

5.1.1 Research Question #1

This section addresses the results related to the first research question in this study: what can the 2015 science communication workshop that was held in Fairbanks, Alaska teach us about science communication training needs of the LCCs? Workshop participants were asked about their job responsibilities; the percentage of time they spent on science communication, translation, and application; the status of communicating science for use in resource management and decision making in their LCC; barriers their LCC faced in communicating science; their goals for the workshop; and their perceptions of how the workshop changed how their LCC operated.

Despite spending a significant amount of time on tasks related to science communication, translation, and application (over 25% of their work day for 10 out of 11 participants), the general consensus among participants is that the Alaskan LCCs were not particularly good at these tasks. It is clear that the Alaskan LCCs struggled with science communication, largely due to capacity barriers (not enough time, money, and/or skills) within the LCCs themselves.

This lack of capacity drove the perceived need for this science communication workshop, with 9 out of 11 participants citing this as a reason why the communication workshop is needed. Other reasons this workshop was needed, in order of frequency, were "communicate to a broader audience" (cited 5 by participants), "insert LCCs into the decision-making process" (4 participants), "document the value of LCCs" (3 participants) and "develop a communications strategy" (2 participants).

Ultimately, the workshop resulted in changes to at least two out of the five Alaskan LCCs. One LCC hired a part-time communications employee, directly addressing the time and skills capacity constraint. Another LCC said that the workshop provided them with context and tools that strengthened their science communications capacity. The science communication outcomes of a third LCC were less clear, with one employee stating that they did not think the workshop resulted in any changes. Another employee of this same LCC said that the workshop confirmed what they had been working on previously, and accelerated their shift towards co-production and science translation.

The Alaskan LCCs had a clear capacity barrier to communicating science for use in resource management and decision making. This capacity limit was the biggest factor in determining science communication training needs. Follow-up interviews with participants highlighted two specific strategies they used to address the capacity constraints: hiring new communications employees, or focusing on science translation. Since science translation is a trainable skill (unlike hiring a new employee), focusing on science translation in the Alaskan LCCs may be a way to address capacity constraints.

5.1.2 Research Question #2

This section addresses the results related to the second research question in this study: what type of training do national-level LCC employees receive, and which trainings do they consider to be most effective in their work?

This study specifically investigated what type of co-production of knowledge or boundary spanning training that national-level LCC employees received. Although the LCCs were a boundary spanning organization, only three out of fourteen participants had received formal training in co-production of knowledge or boundary spanning. All of the participants who had formal training were from Alaskan LCCs, and received training in co-production of knowledge.

Training related to decision making was most frequently cited as an effective training, possibly indicating an important skill in boundary spanning. However, as it was only cited marginally more than other trainings and if participants J1 and K1 are excluded because they named multiple trainings, it would only be cited twice. Further study on the role of decision training for boundary spanners is needed.

National meetings with other LCC members was also cited as an important training, although again this is dependent on the inclusion of participants J1 and K1. In a new organization working on a relatively new conservation approach, peer-to-peer learning may be particularly important. The majority of most effective training took place in a professional environment (i.e. workshops, classes offered by employer, etc.) while two people saying that their training occurred “on-the-job” that is, outside of a structured environment, but still at their job. Trainings resulted in changes to the strategic plan more often than other organizational

changes. This may be because of the relative newness of the LCC program and fewer employees resulting in more structural changes to the organization.

Overall, national-level LCC employees tend to have informal training in co-production of knowledge, with the exception of Alaskan LCC employees, who attend formal co-production of knowledge trainings. Training related to decision making (structured decision making, decision theory) and peer-to-peer learning tend to be considered more effective than other trainings by national-level LCC employees.

5.1.3 Alignment with Existing Literature

The assertion by Safford et al. (2017) that the traits of individual boundary spanners are critical to the success of the boundary organization is relevant to this paper. The knowledge, skills, and attributes that boundary spanners are expected to possess are often trainable (Brugger et al. 2016; van Meerkerk & Edelenbos 2019).

Knowledge, skills, and attributes of boundary spanning individuals cited in the literature appear in this study as a result of trainings. Trust building (Brugger et al. 2016) was an outcome of the Crucial Conversations training, and the Climate Smart training facilitated the use of a specific tool in the LCC (Goodrich et al. 2020). Building relationships, mediation skills (Djenontin & Meadow 2018), and interdisciplinarity (van Meerkerk & Edelenbos 2019) are all skills that were cited by some participants as being learned "on-the-job."

While the existing literature acknowledges the importance of boundary spanners understanding the decision-making context of stakeholders (Brugger et al. 2016; Djenontin & Meadow 2018; Porter & Dessai 2017), knowing the process of decision making is an important skill that this research specifically highlights. The USFWS does offer a course on Structured Decision Making at the National Conservation Training Center (U.S. Fish and Wildlife Service 2021a).

The importance of science translation as a cornerstone activity of boundary organizations is well-established (Cash et al. 2006). The finding that a science communication workshop intended to address the needs of a boundary organization highlights the importance of science translation is perhaps unsurprising, but does reinforce its importance in a boundary organization.

The unprompted statements by participants that they did not receive much training for their role at the LCC, combined with the majority of participants stating that they did not receive

formal training in co-production of knowledge or boundary spanning, and instead learned "on-the-job", align with the findings of Brugger et al. (2016). This may indicate a need for more formal training of boundary spanners, especially because Safford et al. (2017) considers a commitment to effective boundary spanning activities as one element of an effective boundary organization. Boundary spanners need to be aware of the work they are doing in order to perform effectively.

5.2 Conclusion & Recommendations

This study used two sets of interviews with employees of the Landscape Conservation Cooperatives to answer two research questions:

1. What can the 2015 science communication workshop that was held in Fairbanks, Alaska teach us about science communication training needs of the LCCs?

2. What type of training do national-level LCC employees receive, and which trainings do they consider to be most effective in their work?

To answer the first question, interviews with 11 participants who attended a science communication workshop in Fairbanks, Alaska were coded and analyzed using Nvivo 10. The second set of interviews included 14 participants from LCCs across the network. These interviews were also transcribed, coded, and analyzed using Nvivo 10. To assess the validity of the codebook, a second researcher coded sections of the text and a Kappa-Cohen coefficient score was generated in Nvivo 10. Codes that were did not meet the agreement threshold were discarded.

Results show that training employees in a capacity-strained boundary organization can result in modest changes to the organization. In this instance, the 2015 science communication training resulted in Alaskan LCCs hiring new employees, emphasizing science translation, and providing context and tools to increase communications capacity.

Training in decision-making emerged as a key training cited by participants in this study. This is a skill that is trainable (van Meerkerk & Edelenbos 2019) and offered to employees of the USFWS, making it particularly relevant to LCC employees. Outside of formal trainings, peer-to-peer exchanges were also cited an excellent learning experience by participants in this study.

This study modestly recommends the following actions for boundary organizations similar to the LCCs:

- An early emphasis on science translation (rather than starting from the ground-up with new scientific research) to address manager needs, establish the value of the organization while building relationships and identifying end-user needs, and efficiently direct limited resources.
- Training in decision making for boundary spanning individuals.

Research on how best to support boundary spanners from a training standpoint is ongoing. This research indicates that investigating the role, benefits, and limitations of decision-making training for boundary spanners may be a particularly worthwhile area to examine further. In addition, investigating the impact of certain trainings for boundary spanners on real-life conservation outcomes is perhaps the most critical research path to explore.

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Appendices

Appendix A: Institutional Review Board Exemption No. 1

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Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

October 30, 2020

To: Sarah Trainor
Principal Investigator

From: University of Alaska Fairbanks IRB

Re: [1609446-1] HATCH - F_Rowles MS - Factors Contributing to the Current Status of Landscape Conservation Cooperatives in North America

Thank you for submitting the New Project referenced below. The submission was handled by Exempt Review. The Office of Research Integrity has determined that the proposed research qualifies for exemption from the requirements of 45 CFR 46. This exemption does not waive the researchers' responsibility to adhere to basic ethical principles for the responsible conduct of research and discipline specific professional standards.

Title: HATCH - F_Rowles MS - Factors Contributing to the Current Status of Landscape Conservation Cooperatives in North America

Received: October 5, 2020

Exemption Category: *2*

Effective Date: October 30, 2020

This action is included on the November 11, 2020 IRB Agenda.

Prior to making substantive changes to the scope of research, research tools, or personnel involved on the project, please contact the Office of Research Integrity to determine whether or not additional review is required. Additional review is not required for small editorial changes to improve the clarity or readability of the research tools or other documents.

Appendix B: Institutional Review Board Exemption No. 2

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Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

August 12, 2021

To: Sarah Trainor
Principal Investigator

From: University of Alaska Fairbanks IRB

Re: [1609446-2] HATCH - F_Rowles MS - Factors Contributing to the Current Status of Landscape Conservation Cooperatives in North America

Thank you for submitting the Amendment/Modification referenced below. The submission was handled by Exempt Review. The Office of Research Integrity has determined that the proposed research qualifies for exemption from the requirements of 45 CFR 46. This exemption does not waive the researchers' responsibility to adhere to basic ethical principles for the responsible conduct of research and discipline specific professional standards.

Title: HATCH - F_Rowles MS - Factors Contributing to the Current Status of Landscape Conservation Cooperatives in North America

Received: August 12, 2021

Exemption Category: *2 & 4*

Effective Date: August 12, 2021

This action is included on the September 1, 2021 IRB Agenda.

Prior to making substantive changes to the scope of research, research tools, or personnel involved on the project, please contact the Office of Research Integrity to determine whether or not additional review is required. Additional review is not required for small editorial changes to improve the clarity or readability of the research tools or other documents.

Appendix C: Interview Protocol: Science Communication Workshop

1. What is your job title?
2. How do you describe your job responsibilities?
3. How would you describe science communication?
4. How would you describe science application?
5. How would you describe science translation?
6. Do you consider any of these to be part of your job?
7. What percentage of your time do you spend with those activities?
8. Are there any other terms or phrases you would use to describe your job?
9. Why is this science communication workshop needed?
10. What are your goals for the science communication workshop?
11. How would you describe the current state of communicating science for use in resource management and decision making in your LCC?
12. What are your LCC's goals for communicating science so that it is useful in resource management and decision making?
13. Describe a success story in communicating science for use in resource management and decision making in your LCC.
14. Describe an instance where communicating science for use in resource management and decision-making has fallen short or is particularly challenging in your LCC.
15. Do you face barriers to communicating science for use in resource management and decision-making in your region? And if yes, what are the barriers?
16. Is there an example of communicating science for use in resource management and decision-making outside of your LCC that you have learned from and/or that would like to draw from in your work? If so, who is doing it and what are they doing? Why do you think they have been successful?
17. Is there anything else you would like to share with us related to communicating science for use in resource management and decision-making in the LCCs?

Appendix D: Interview Protocol: Most Effective Trainings

1. What was the most effective training you've had related to your LCC work, and what made it effective?
2. Did your LCC ever implement any changes based on a training you or a co-worker attended?
3. Have you ever received training in co-production of knowledge or boundary spanning?
4. Did you attend a 2015 training on science communication in Fairbanks?
5. Did that training result in any changes to your LCC?