THESIS

SCIENCE COMMUNICATION AND COPRODUCTION: APPLYING THE THEORY OF MOTIVATED INFORMATION MANAGEMENT TO THE SCIENCE-POLICY INTERFACE

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ABSTRACT

SCIENCE COMMUNICATION AND COPRODUCTION: APPLYING THE THEORY OF MOTIVATED

INFORMATION MANAGEMENT TO THE SCIENCE-POLICY INTERFACE

Science communication scholarship claims that engagement, dialogue, and interaction are important communicative components. But there are relatively very few studies of dialogic science communication processes from a science communication perspective. This study bridges science communication, interpersonal communication, and science-policy interface research and practice to learn how an *interpersonal theory* models *science-policy* communication.

When science informs policy and land management, myriad science and policy actors must work together to come to a shared understanding of how science will be used. However, there may be differences across the science-policy interface. How do scientists structure research goals, and how do policymakers and managers set research goals? How do timelines differ? How do communication styles, cultures, and values differ? Can they come to a shared understanding? This work studies the *policy* side of a particular science-policy interface (coproduction) and describes how science stakeholders, or "information seekers," evaluate the utility of working with information providers from organizations outside their own to inform their own science and policy. Information seekers were interviewed, and they provided insights into their perceptions of (1) the trustworthiness and credibility of information providers, (2) their ability to communicate across the interface, (3) the usefulness of the information provided, and more.

Results inform future coproduction practice, but also, this study demonstrates a successful application of an interpersonal communication theory to a science-policy interface. Future work might make further use of the predictive and explanatory utility of this model in science communication with high-priority stakeholders, and interpersonal theories and models arguably stand to further inform the dialogic components of science communication.

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Since this research spans multiple fields of inquiry, there are several keywords that apply, and it is the intention of this thesis to describe the research setting using concepts from multiple bodies of literature.

Keywords:

Science communication, science-policy interface, science-policy communication, knowledge broker, knowledge transfer, knowledge transfer and exchange, boundary agents, boundary objects, boundary communication, cross-boundary communication, practical science, use of science, actionable science, coproduction, co-production, co-production of knowledge, organizational narrative, interpersonal science communication, interpersonal communication, theory of motivated information management, communication efficacy, information seeking, information flow, information transfer, information provider, use of information, stakeholder, science stakeholder, values, culture, science engagement, climate change, global environmental change, land management, natural resource management, public land management, environmental and agricultural sciences, research approach, research design

Chapter 1. Introduction

Science has long operated under the assumption that through systematic, repeated inquiry, we may grow to better understand and operate within a complex universe. Those who conduct research do so with a narrow focus hoping to build new knowledge in their field, with significant findings making their way to society through innovation or through osmosis, as interested parties acquire and pass along new ideas (McClellan & Dorn, 2015).

Though science has influenced society over the centuries, the way we talk about science is now undergoing a paradigm shift. Societies are becoming more connected. Information that was once limited, difficult to access widely, is now more readily available to a large percentage of the world's population. Judging by internet access alone, the UN's International Telecommunication Union estimates that 53% of the world's population can access the web as of 2019, a figure which has probably grown in the year since, with 86% of the developed world having internet access and nearly half (47%) of the developing world having access (*Measuring Digital Development*, 2019). This change alone has triggered new questions about how science communication is conceptualized, particularly with regard to public information-seeking and engagement in science (Brossard, 2013).

As the door has opened to increased science engagement, communication scholars have begun to focus on science communication as its own distinct field of study that welcomes a variety of research approaches (Nisbet & Scheufele, 2009). This thesis research will take a closer look at one instance of high-engagement, interactive science communication called *coproduction*. Coproduction takes place when policymakers, those who use scientific information to create policies and plans, need more information, and they require science that is tailored to their policy needs, so they interact with scientists to perform research that is

applicable to policy (Burns et al., 2003). This science-policy interface is an example of scientists collaborating extensively with science users in a large network where information and ideas are spread widely (Moss et al., 2014). The better the network, the greater the amount of information flow or knowledge transfer, to borrow a term from *knowledge transfer and exchange* research (Mitton et al., 2007).

This interface is already being studied by the social science community, who seeks to develop best practices and evaluation metrics for coproduction (Beier et al., 2017; Meadow et al., 2015) and by science communication scholars who map networks and track information flow across those networks (M. H. Anderson, 2008; Crona & Parker, 2011, 2011), including those who study knowledge brokers, or individuals who act to share ideas across a boundary (Lomas, 2007; Long et al., 2013; Pielke, 2007). Bielak et al. (2008) describes the science engagement shift (Gilbert & Stocklmayer, 2012) as a transition from "science push" to "policy pull," where policy audiences are now more engaged in how scientists share their work. Taking this a step further, coproduction is what happens when the policy audience has a say in how the research agenda is framed (Bovaird, 2007).

While science communication is recognizing that a greater deal of engagement takes place across the science-policy interface, there are relatively few who study the more interactive nature of coproduction. The parties involved in coproduction include a science producer who provides expertise and sometimes funding, and a science user, who is usually called a stakeholder because they hold a stake in the science produced (Heikkila & Gerlak, 2005). Social science experts thus far recommend that for successful coproduction to take place, there should be stipulations, such as (in no particular order): (1) at least one in-person meeting for science producers and stakeholders to interact and become familiar with one another, (2) a steering

committee that keeps everyone on track and coordinates meetings and schedules, (3) some schedule of meetings to touch base and ensure that the science is on track to meeting the project needs, (4) communication from the policy audience to convey how risk is managed in their organizations and how decisions are made, (5) scientists honestly conveying the meaning of uncertainty in the results and focusing on implications for practice, and so on (Beier et al., 2017).

This is an interface with a great deal of information flow. Communication is required from the policy audience to convey information needs, and thoughtful and open communication is required from the science producer to both accurately represent their findings and to lay the groundwork for that science translating into practice. There is certainly room for failure, as Sarkki et al. (2017) argue in the case of climate science coproduction: "Instead of being truly honest brokers [Pielke, 2007], [climate] scenario producers are likely to manipulate, reconstruct, and change scientific knowledge to avoid socially and politically undesired trajectories" (p. 549). And yet, there is also tremendous room for success: "Sustainable ecosystem management relies on a diverse and multifaceted knowledge system in which techniques are continuously updated to reflect current understanding and needs" (Roux et al., 2006, p. 1), and "Implementing effective environmental policy requires not only the combined efforts of many disciplines to understand environmental problems, but also active interaction with stakeholders" (Lemos & Morehouse, 2005, p. 57).

Coproduction scholars recognize that there are issues. Roux et al. (2006) describes a cultural divide between science groups and practitioners that contributes to the challenges of communicating science in this way. Scientists may be thought of by practitioners as participating in a peer-review, self-serving, inward-looking culture; practitioners might be thought of by scientists as too caught up in the day-to-day to focus on the complexities of the ecosystems or

other spaces they manage (Roux et al., 2006). Briley et al. (2015) describe barriers to such knowledge exchange, which include mismatched terminology, unrealistic expectations, and disordered integration of science into the planning process.

Scholars working to develop best practices, such as Beier et al. (2017) and Meadow et al. (2015), suggest that while there are general principles in place, which include building relationships, making room for two-way communication, and focusing on the practical goal of how the science will be implemented, there is still more work to be done on understanding the mechanisms that achieve those goals. Recent studies like Djenontin and Meadow (2018) catalog coproduction practices and make early attempts to identify what works well and what does not and have found that institutional factors (like how science is translated into practice), legitimacy and trust, inclusivity, proficiency in knowledge exchange, and several other process-related factors like how the interactions are developed and carried out have an impact on the success of coproduction. This points to a heavy focus on the interactive, iterative components of coproduction. Roux et al. (2006) recommends that scientists stop thinking of knowledge as a "thing" that can be transferred and start thinking about knowledge as a "process of relating" in which meaning is negotiated among those involved (p. 10).

There have, to the best I can find, been no studies of coproduction from a strictly communication perspective, excepting that the knowledge transfer and network research is inherently communication related (although coproduction is not usually directly mentioned in those literatures), and excepting that communication is also inherently a component of coproduction (M. H. Anderson, 2008). The science communication perspective will be the grounding body of scholarship that this research applies to, as coproduction is ultimately an interaction across a science-policy interface (Meadow et al., 2015). Knowledge transfer and

exchange literature does discuss the fact that interacting with a practitioner changes the scope of the knowledge conveyed, but knowledge transfer and exchange assumes that knowledge has already been produced and is simply in need of packaging with concepts like "access to research," "relevance of research," dissemination, training, technical support, use of "thematic messages," providing recommendations, and sharing findings (Mitton et al., 2007, pp. 746–755). Coproduction, on the other hand, assumes that participants are involved with setting the research agenda in the first plance, rather than being involved in the dissemination and distribution of information (Beier et al., 2017). It is arguable that knowledge transfer and exchange still treats information like a *thing* that must be packaged and tailored for different audiences, with participation from those audiences, yes, but that the knowledge itself is unchanging – just the way it is communicated changes (Roux et al., 2006).

To further study the *mechanisms* of coproduction (Meadow et al., 2015), and to recognize that coproduction knowledge is not a product or *thing* but rather a *process* in which shared meaning is negotiated and the knowledge produced is transformed as a result (Roux et al., 2006), this study will apply an interpersonal communication theory to the coproduction interface. The theory of motivated information management (TMIM) was selected. TMIM applies when an information seeker has less information on hand than they need to make a decision, something called an *uncertainty discrepancy* because it represents a discrepancy between the uncertainty someone has and the amount of uncertainty they would like to have (Walid A. Afifi & Weiner, 2004). The existence of an uncertainty discrepancy kicks off an evaluation process in which the *information seeker* decides whether to approach an *information provider*, evaluating the expected *outcomes* of seeking out the information as well as (1) how knowledgeable and trustworthy the information provider is (target efficacy), (2) how well the interaction is likely to go in terms of

conveying complex information and developing shared goals (communication efficacy), and (3) how well they will be able to cope with and incorporate the information in their lives (coping efficacy) (Walid A. Afifi & Weiner, 2004). This information will inform the stakeholder perspective on the *process* of coproduction because it uncovers the considerations a stakeholder has when approaching coproduction interactions, which in turn impacts how stakeholders engage with science producers and how information is used.

This study will research stakeholders, who are *information seekers*, with the goal of understanding how they approach the coproduction interface. This is ultimately a test of how well TMIM applies to coproduction interactions. Several concepts seem to be aligned, such as credibility and legitimacy (related to target efficacy), an actionable/policy-oriented use of science (coping efficacy), and meetings to communicate shared goals (communication efficacy) (Walid A. Afifi & Weiner, 2004; Beier et al., 2017; Djenontin & Meadow, 2018; Meadow et al., 2015; Moss et al., 2014).

Additionally, TMIM is applied when there is high issue importance, usually related to health issues and relational issues like health information seeking in families (Hovick, 2014) or discussions about divorce (Walid A. Afifi & Afifi, 2009) or marital financial planning (Fowler et al., 2018). For TMIM to apply, the information seeker must actively attend the evaluation process, and this is more likely to happen with issues of high importance (Walid A. Afifi et al., 2006). Also, the high issue importance and impact of the information communicated in these situations, such as discussions about organ donation and other end-of-life conversations among families (Fowler & Afifi, 2011), implies that there may be some barrier to not readily seeking the information. In these cases, the barrier might be that the information carries a significant outcome for the relationship. I'll argue that issue importance and a barrier to communication

roughly translate from relational communication to coproduction communication because of the cultural barrier existent at the science-policy interface and because of the high amounts of trust, credibility, and communication that coproduction demands for success (Roux et al., 2006; Djenontin and Meadow, 2018).

While the goal is to determine whether TMIM models coproduction, there may be several secondary results of this work. One will be to inform science communication literature on an instance of high-engagement science-policy communication. Another will be to inform coproduction on on a method for modeling interactions from a stakeholder perspective. A third outcome will be to inform interpersonal communication literature on a new application for TMIM in highly interactive science-policy interfaces.

Interviews were selected as the study method because of the unknown nature of the study environment with regard to this theory. While others have studied coproduction, none has specifically studied coproduction from a lens of TMIM, and TMIM has never been applied to coproduction. Qualitative methods and interviews in particular allowed more flexibility for participants to, for example, elaborate on tangents that might have been unforeseen by the researcher (Patterson & Williams, 2002; Tracy, 2012). Transcribed interviews were coded using TMIM (Walid A. Afifi & Morse, 2009) as a framework. Then, analysis and discussion will dig into differences between TMIM as a model when compared to (see research question below): (a) other studies of coproduction, and (b) other science-policy interface research. The study will therefore be guided by a single research question, with additional, more flexible goals in mind.

Note that the scope of the study will be limited to the participants in the study. Though this research may contribute to a better understanding of science-policy interactions, the results may or may not be indicative of patterns in some larger group. Only stakeholders of one

coproduction-oriented organization, the North Central Climate Adaptation Center (NC CASC), were interviewed, and participants span multiple organizations as well as a broad regional scope, but the fact that only one organization's stakeholders were interviewed might introduce limitations, which will be discussed. The goal will be to capture perspectives in this use case, testing whether TMIM might be suitable model for these particular science-policy interactions. Although generalization may not be achieved, there are plenty of lessons to learn in studying this interface, and future work may test the results in different settings. A tentative revised model for TMIM at the coproduction interface will be introduced based on the results of this work.

The research question, then, is guided by TMIM as it applies to a new setting, the coproduction of knowledge and science across a science-policy interface. However, since this analysis is also rooted in science communication and literature that already studies coproduction, further thought will be put into how the results inform science communication and coproduction as fields of study. Ultimately, the overarching question will be: how can science communication research be expanded to include more dialogic, interpersonal models of communication such as TMIM? Within that broad goal, the more concrete research questions are:

1. Does the theory of motivated information management (TMIM) model coproduction interactions between (a) public land management organization "stakeholders" of coproduced knowledge and science in the NC CASC region, and (b) groups external to these stakeholder organizations who are largely deemed "information providers," including a research team funded by the NC CASC as well as other groups?
    a. How does TMIM model coproduction interactions when compared to other studies of coproduction?

b. How does TMIM model coproduction interpersonal science communication as compared to other science-policy interface research?

The study therefore attempts to expand science communication scholarship toward the study and application of dialogic communication models that equally prioritize information seekers and information providers in the science communication process.

1.1. Situating this Study – Funding and Directives

This is ultimately a thesis, meant to inform science communication scholarship, interpersonal communication scholarship, and science-policy interface practice. The use of TMIM was an effort I took on as a master's student with the oversight of my advisor and committee. However, during data collection, I was partially funded by the U.S. Geological Survey (USGS) North Central Climate Adaptation Science Center (NC CASC) and I contributed to a report that was generated for the NC CASC in early 2020. The project was funded for the purpose of building engagement and evaluating engagement practices. Participants of this study were those who have been involved with NC CASC projects at some point in the history of the organization. The data collected may be used for other purposes in addition to this thesis, but the thesis was its own undertaking as an extension of the funded project.

The NC CASC is one of eight regional CASCs that operate under the U.S. Department of the Interior (DOI). Specifically, the NC CASC serves the North Central region – Montana, Wyoming, Colorado, North and South Dakota, Nebraska, and Kansas.

The underlying study was funded in 2017 and expired in the fall of 2019. Its title is, "Adaptation: Sustaining Stakeholder Engagement and Evaluation." There were two main directives to the study. The first involves funding for increased "stakeholder engagement" – that is, engagement with those who have a vested interest in the science produced by the NC CASC.

This part of the project includes interviews, document analysis, listening sessions, and other activities to enhance and facilitate science delivery. This was conducted by a separate research team. The second portion of the project is where this study fell: the development of evaluation metrics for science organizations that perform coproduction projects. To date, there are no known metrics to gauge the effectiveness of this type of engagement and interaction oriented science. Engagement metrics should ideally improve the practices of science organizations like the NC CASC, who already operate in this manner, and could potentially inform future adoption of increased engagement at the science-policy interface.

Although the portion of the study encompassed here does not explicitly contribute to evaluation metrics, the interview questions (Appendix A) asked questions about the impact and use of past coproduction projects, so the results reported here inevitably contribute to evaluation of a sort, even if only on a small scale. (Note that Appendix B immediately following is a supplemental handout that was provided to participants, which will be explained). There will be some space in the discussion section below dedicated to arguments about whether the interview questions asked were useful metrics for evaluating past coproduction projects. Also, new insights will be provided about the evaluation process. However, the main goal of this paper will be to focus on communication theory.

With regard to science communication literature, because science is moving toward a recognition of public engagement if not also engagement with particular audiences (like stakeholders or policymakers), research into interactions scientists have with others can only serve to strengthen science communication practice and inform science communication inquiry. This was not an explicit goal of the NC CASC study, but it is a goal of this paper to recommend outcomes for science communication literature and practice. As of yet, “science communication”

is not often found as a research discipline in coproduction literature, despite the fact that communication-related concepts are discussed (trust, relationships, etc.), and it may prove to be useful. I could not find any instance of coproduction literature citing the science communication scholars I mention in the literature review, though a better search may turn up such results. Also, interpersonal science communication is not often studied, so this perspective could prove to contribute to interpersonal and science communication scholarship alike.

Finally, with regard to the NC CASC funding for this project, a report was generated when the project concluded, and that report was handed off to the NC CASC in early 2020. This thesis takes the research a step further and applies TMIM to studying coproduction without the goal of developing evaluation metrics for coproduction. Instead, the purpose of this thesis from the perspective of the NC CASC is to gain more insight about their stakeholders and perhaps to inform a method for modeling coproduction through the application of TMIM.

1.2. Structure of Thesis

Since this work was partially funded by the NC CASC and is conducted on their behalf, and since the theory used originates from *interpersonal communication* scholarship (Walid A. Afifi & Morse, 2009), and since the entire context is viewed through the lens of *science communication* (Burns et al., 2003; Gilbert & Stocklmayer, 2012; Logan, 2001; Nisbet & Scheufele, 2009), there will be three components to the literature review and discussion sections. The literature review begins with a summary of science communication research and trends in the field, followed by a closer examination of science-policy interface communication (Hinkel, 2011) and such iterations as knowledge brokering (Long et al., 2013) and knowledge transfer and exchange (Mitton et al., 2007), since these describe science communication with stakeholders in a manner similar to coproduction (Beier et al., 2017). Coproduction differs from science-policy

interface communication in the level of engagement. Where science-policy interface communication might include something as simple as generating a report for a policy audience (Bielak et al., 2008), coproduction is a more interactive process that involves working relationships, collaboration, and a focus on generating science that informs particular management, planning, and governance concerns (Meadow et al., 2015). Nevertheless, this work seeks to inform science communication literature, so a review of similar work will be conducted.

The second part of the literature review will explore coproduction in its own right. The study of coproduction does include some communication elements like building trust (Djenontin & Meadow, 2018) and directly interacting with stakeholders (Roux et al., 2006). However, no studies were found that researched coproduction from a communication perspective, such as using a communication theory as the basis for modeling coproduction. Additionally, coproduction is not a field, but rather a collection of best practices that have emerged from science-policy interactions (Lemos & Morehouse, 2005). The *practice* of coproduction is largely informed by social science concepts and principles, like Star and Griesemer's (1989) concept of "boundary objects," which are stable, reproducible things like texts and maps and people that exist at boundaries and are recognizable by scientists and non-scientific actors alike. These social science concepts will come up repeatedly in this section of the literature review (Johri, 2008; Long et al., 2013; Moss et al., 2014). There will also be a review of coproduction as a concept.

Third, the literature review will explain the theory of motivated information management (TMIM) (Walid A. Afifi & Weiner, 2004). This interpersonal communication model describes the process an information seeker goes through, from realizing they have less information on hand that they need to make a decision, to evaluating the possible outcomes and efficacies related to obtaining that information, to making a decision about whether and how to obtain the

information needed (Walid A. Afifi & Morse, 2009). Fitted to the coproduction process described in the introduction, TMIM will be applied to the stakeholder group to learn more about their motivations and the considerations they face when reaching out to scientists to collaborate on coproduction projects (Heikkila & Gerlak, 2005). A case will be made for applying TMIM to the coproduction interface.

Following the literature review will be a methods section that describes the chosen interview method (Tracy, 2012), the hermeneutic coding and analysis method for drawing themes from the interview transcripts (Patterson & Williams, 2002), the pragmatist ontological perspective driving the analysis and discussion (Bohman, 2002), limitations of the study and reflexivity (Silverman, 2013), sampling procedures (Tracy, 2012), and a justification for the ways in which data will be presented. This will include discussion about how the data are anonymized and attributed (Corden & Sainsbury, 2005) as well as a justification for themes and headings chosen for the analysis (Creswell, 2007). The methods section will therefore describe both the ways in which data were collected and the ways in which data were analyzed. The discussion section will follow with evidence and themes gathered from the data, and finally, a recommendations section will discuss how this research informs the fields of science communication and coproduction practice.

Chapter 2. Literature Review

To understand interactions at the science-policy interface, an interactive communication theory, thus far mainly applied in health and relational communication, settings will be considered. However, other fields have researched science-policy interactions. Several bodies of knowledge will be reviewed. First, there will be a review of *science communication research* and major themes. Second, there will be a review and critique of the *theory of motivated information management* and its applications and a justification for its application in this setting. Third, there will be an overview of how other fields study the *science-policy interface* and specifically, *coproduction*, in which scientists actively interact with stakeholders to produce science that has a particular policy application. This work should be considered to follow such coproduction studies and add new knowledge to the coproduction setting from a lens of science communication, using an interpersonal communication theory and framework.

2.1 Science Communication Inquiry

Communication about science has ostensibly occurred for as long as science itself has existed. In the early years of what we now consider the modern, systematic practice of science, which emerged with the Scientific Revolution in the 16th century, there was much debate about the legitimacy of science as compared to more "traditional" ways of knowing (McClellan & Dorn, 2015). Science presented a more objective and less certain (that is, more comfortable with uncertainties, viewing our understanding as limited) way of seeing the world as compared to the traditional authority model (McClellan & Dorn, 2015). Traditional "ways of knowing" include, for example, culture, as stories and the lessons and prescriptions they contain are passed down within communities (Lejano et al., 2013). Science differed as a way of knowing in that it encouraged testing and questioning previously-held knowledge in an objective and falsifiable

manner (Lejano et al., 2013). The term "uncertainty" reminds scientists that, "We can say nothing with certainty, but can only make probabilistic predictions" (McClellan & Dorn, 2015, p. 370). This is a powerful statement to the scientific community, but uncertainty has continued to be a point of contention surrounding the use and communication of science (Schneider, 2016).

Over the years, scientific practice has gained acceptance and even popularity. Historians claim that tensions between traditional and scientific ways of knowing lessened when science came to be known as a way to better understand divine creation, indicating that science need not entirely contradict traditional knowledge but could rather coexist with traditional knowledge (McClellan & Dorn, 2015).

In these early days of scientific practice, *communication* about science mostly happened face-to-face, and eventually, results were printed in journals that were made available to peers (Gilbert & Stocklmayer, 2012). In other words, scientific knowledge was contained and communicated among the elite, though not necessarily intentionally, as mass communication and mass literacy came about much later. Nonetheless, science's tradition of apparent exclusivity continued as science education was introduced in schools as a way to screen for students who might excel in scientific inquiry at universities, even if the process was still somewhat elitist until more recent history (Gilbert & Stocklmayer, 2012).

Science still carries a stigma of elitism for some people to this day, which can be problematic in societies where public support can influence whether science receives funding (Gilbert & Stocklmayer, 2012). Public opinion polls have found that people who are more knowledgeable about science tend to have more positive opinions about science funding, but they may also be less supportive of "morally contentious" areas of science as well, such as human embryology (Evans & Durant, 1995). Additionally, studies of the politicization of science

indicate that support for science may be developing a political divide. In the 1970s, according to one study, conservatives trusted science more than liberals and moderates; by 2010, however, conservatives had become the group that trusted science the least (Gauchat, 2012). Gauchat (2012) also found a similar result to the Evans and Durant (1995) study – *educated* conservatives, in particular, showed a decrease in trust compared to conservatives with less education. Hart and Nisbet (2012) tested this phenomenon in an experiment and found that when exposed to simulated news stories about the health impacts of climate change, people's partisanship significantly changed their support for climate mitigation: for Democrats, support for mitigation increased; for Republicans, exposure to the same messages decreased support for climate mitigation. Scientific literacy is not enough to guarantee science support.

What do these types of studies mean for science communication? Findings that some political parties might be more likely to mistrust science may be caused by some other common trait – Gauchat (2012), for example, also stated that conservatives were more distrustful of political institutions than liberals or moderates for the entirety of their period of study, which ran from 1974 to 2010. Perhaps a mistrust in institutions in general means that some people are more skeptical of any institutional authority, including the scientific institution.

Whatever the cause of differences in public trust of science, there are some broader implications we can draw from these studies. For one, public opinion and science are, in some ways, codependent. Public opinion can influence science funding and policy, and science can impact the public as well, as new scientific findings lead to changes in policy or advancements in knowledge or technology. The National Science Foundation (NSF) has conducted surveys of public attitudes and understanding of science and technology intermittently since the 1970s, and the study integrated public attitude and understanding of science questions into the General

Social Survey, a widely recognized and broadly utilized survey conducted twice per year by the University of Chicago's National Opinion Research Center, starting in 2006 (Besley, 2018). These surveys help the NSF, as one of two major science funding groups in the U.S., to decide how to allocate funding (Besley, 2018). In this way, public opinion of science makes a direct impact on how science is carried out. The scientific institution is both dependent on and in service of society at large.

Secondly, science communication research into trust and politicization of science strongly signals that the "deficit model" – broadly, the idea that people misunderstand or mistrust science because they lack a clear understanding of that science – is false (Pielke, 2007). Simply increasing the quantity or reach of science communication transmissions will not result in a greater level of understanding, trust, and support.

In the case of one controversial science topic, embryonic stem cell research, science literacy has been found to have no correlation with attitudes. Rather, a study found that Christian conservatism and social ideology along with other factors predicted attitudes about stem cell research, while knowledge about the issue had no predictive effect (Nisbet & Goidel, 2007). Similarly, a review of 25 years' worth of *public understanding of science* literature suggested completely cutting science literacy questions out of science and technology attitude surveys, saying that this framing "plays into the hands of technocratic attitudes among decision makers: a de facto ignorant public is disqualified from participating in science policy decisions" (Bauer et al., 2007, p. 80).

This is a common thread in science communication literature: the deficit model is faulty. Before digging into this idea further, it is also important to document how science communication has taken place over the years and outline significant trends.

2.1.1 History of Science Communication and Trends

Science communication scholar Robert Logan (2001) divides the history of science mass communication into a "science literacy" era and an "interactive science" era, claiming that science communication, health communication, and risk communication scholarship ought to collaborate more and learn from each other more moving forward. This trend away from science literacy concerns and toward interactive science concerns echoes the shift mentioned in the previous section from a transmission model, in which science comprehension and literacy are blamed for scientific controversy, and a more modern mindset, in which interactive elements like science engagement are more frequently studied (Burns et al., 2003).

In the time since the scientific revolution, when scientists mostly shared knowledge within elite circles, new communication venues and audiences have arisen. According to Gilbert and Stocklmayer (2012), these include communication both to and from scientists, the media, funding agencies, politicians, and any number of "publics," using venues that range from science journals – which are now much greater in numbers and variety – to mediated formats like magazines, newspapers, television and online video, museums and science centers, social media, and more, including a wide variety of digital communications. In addition to having a greater say in science funding and science issues, therefore, the public – or many different publics – also have much greater *access* to science information. (Gilbert & Stocklmayer, 2012)

This increase in networked, digital technology and information access has effectively changed the information people see (Wilcox, 2012). The digital trend has implications for mass communication and media that are still being realized, as different media outlets have been forced to change their practices and models and as information gets produced by a much wider array of groups and individuals (Waldman, 2011). As for how this impacts science information,

Brossard (2013) states that in the past, the media took on the role of science translators, making scientific findings relatable and accessible for different audiences. Now, however, scientific institutions, scientists themselves, and unspecialized "lay" audiences may produce science content for any number of audiences, complicating the nature of science communication (Brossard, 2013).

A number of categorical differences exist between online media and so-called traditional media, like newspapers and television. These include (1) self-reinforcing information regimes – search engines and social media sites like Google and Facebook filter and prioritize results and stories; (2) representation of information trends – sites like Twitter and Facebook make use of hashtags to categorize, track, and display different topics; (3) interactivity – audience members can interact in comments with both the author and other readers; and (4) as already mentioned, a wide variety of media outlets and individuals alike can produce the content that becomes widely available (Brossard, 2013).

The interactivity of online content makes a difference in how science topics are interpreted (and perhaps other topics as well). For example, when exposed to uncivil comments, readers are more likely to see bias in a news story than if only civil comments are presented, despite the articles being otherwise identical (A. A. Anderson et al., 2014). Additionally, the number of hours spent online is positively correlated with people's levels of scientific knowledge (Brossard, 2013), a finding that, when coupled with the potentially increased polarization among scientifically knowledgeable individuals, may have greater implications for the age of digital communication about science.

Because of these significant changes in media types and information accessibility, many researchers have called for changes to the way science communication takes place, though these

recommendations are still relatively untested (Brossard, 2013). Nisbet and Scheufele (2009), for instance, have called for "dialogue, trust, relationships, and public participation across a diversity of social settings and media platforms" (p. 1767).

This digital media trend encapsulates the science communication shift from older, more regulated communication models to the newer, perhaps messier, more involved modern science communication context. Within that broad framework, there are many other types of science communication. There is one important commonality in science communication literature: a wide variety of audiences are now more engaged in science communication than they used to be in the past, in great part because of information access (Gilbert & Stocklmayer, 2012). Again, this has implications for political alignment on science issues, cultural views on science, how people react to science, and much more (Nisbet & Scheufele, 2009). Therefore, increased engagement in science topics sets a foundational background for all types of science communication.

In this study, one type of science communication will be the focus of attention, with the recognition that all science communication follows these trends and that the issues associated with increased engagement underly every type of communication discussed here. For example, the participants interviewed in this study access science information in different ways. Some rely on newsfeeds and mass newsletters, while others rely only on science produced within their own organizations. This, along with links between coproduction and science communication issues at large, will be discussed in more detail in later sections. The type of science communication being studied here is, in some literatures, coined science-policy interface communication. The remainder of the science communication literature overview will therefore delve more into this type of science communication.

2.1.2. Science-Policy Interface Communication

The science-policy interface can be thought of as the interaction between those who *produce* and those who *use* scientific information for policy decisions (Hinkel, 2011). Like science communication research broadly shifted in focus from science literacy to interactive science over the years (Logan, 2001), science-policy interface communication has undergone a similar shift, mimicking the model of an evolution from one-way transmission to increased interactivity (Roux et al., 2006). This has been described by some as a shift from science push to policy pull, with a corresponding shift in focus from "big C" communication – one-way communication through media outlets or news releases – to "little c" communication, in which policy audiences in particular require specialized approaches (Bielak et al., 2008). This specialized approach is sometimes called knowledge brokering, and this will be discussed in more detail below. In science communication literature as a whole as well as in science-policy interface communication, there is a newfound recognition that simple transmission of scientific information can be insufficient. Some scholars have even modeled why that shortcoming might take place.

Pielke (2007) developed a conceptualization of four different types of science-policy interactions, with three of the four interaction types requiring a different type of communication from scientists and science organizations (Figure 1). The model conceptualizes that when science is higher in uncertainty, lower in values consensus, or both, the transmission of science becomes more complicated than simply publishing a report and expecting others to pick it up and use it (Pielke, 2007). (Though, to add to this argument, this is close to the direct transmission model, which many believe to be inaccurate, such as Burns et al., 2003).

Examples of sciences that may *require* higher levels of engagement (though all may partake in higher levels of engagement anyway) include *climate* science communication, which is characterized by Pielke as having a high amount of uncertainty when compared to other scientific disciplines, as well as a low values consensus, as there are indications that differences in opinion about climate science are at least partially predicted by political affiliation (Fielding et al., 2012).

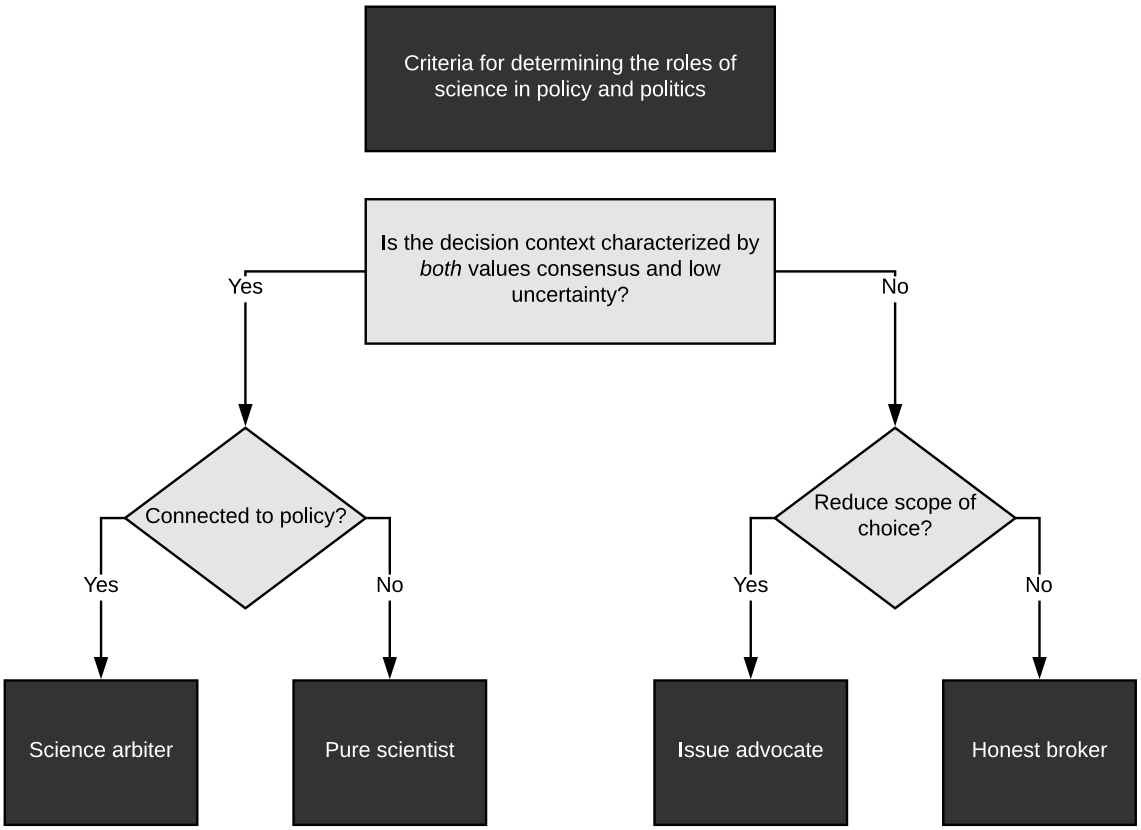

Figure 1. Criteria for determining the roles of science in policy and politics.

Adapted from R. A. Pielke, Jr. (2007), *The Honest Broker: Making Sense of Science in Policy and Politics* (p. 21). Cambridge University Press.

The model is not a requirement for behavior, of course, and often, scientists simply use the old transmission method to communicate science, corresponding with "pure scientist" in Figure 1 (Pielke, 2007). However, they may also choose to communicate about their work

differently with different audiences. For example, they may act as a "pure scientist" when submitting journal articles and as an "issue advocate," taking a stance based on their research and arguing for it, when engaging with policymakers (Pielke, 2007). They may also choose to serve as a "science arbiter," answering questions about their fields when called upon by the media or by policymakers or other audiences (Pielke, 2007). Lastly, they may choose to work as an "honest broker of policy alternatives," objectively taking no stance on policy and demonstrating to policymakers the entire range of policy outcomes and how the science informs each of those outcomes (Pielke, 2007).

Pielke recommends that scientists take values and uncertainty into play when making this decision in how to communicate about their work. When there is *values consensus* (i.e., more agreement) about science, *and* when both political and scientific *uncertainty* are low, the left side of the flow chart is followed, such as, for example, in the case of scientific recommendations to wear sunscreen (Pielke, 2007, Figure 1). Scientists may choose to either act as arbiters, answering direct questions as they come up, say from healthcare professionals, or they may choose to simply publish reports with the knowledge that the science will be read and incorporated by healthcare professionals and others. The level of interactivity as an arbiter, according to Pielke, depends on whether the issue has a policy focus.

On the right-hand side of the flow chart (Figure 1), a scientist communicating about low-uncertainty and high-values-consensus science, like climate science or stem cell research science or other apparently controversial (low values consensus) or uncertain topics, then the scientist or science organization may either offer a stance on a topic based on their knowledge and research and argue for that stance (issue advocate) or choose to present all the possible policy options without reducing the scope of choice (honest broker of alternatives) (Pielke, 2007).

Similar to Pielke's "honest broker of policy alternatives," the word "knowledge broker" has emerged in the last several decades of science communication literature as being related to an individual or even organization with a skill in transmitting knowledge in a way that is useful for a policy audience (Long et al., 2013). Knowledge brokers are generally defined as individuals who span boundaries between organizations or groups to both share information and build connections that facilitate further information flow (Lomas, 2007). Knowledge transfer and exchange (KTE), on the other hand, refers to the *practice* of sharing knowledge between those who hold knowledge (usually researchers) and those who use that knowledge (Mitton et al., 2007). KTE and knowledge brokering, or the actions carried out by a knowledge broker, may be thought of as functionally equivalent in this review because of their core similarities – the communication of information between knowledge producers and knowledge users.

Research in this area is approached from many angles. For example, this type of communication is studied and practiced in both health communication settings and science-policy interface settings (Long et al., 2013). Another commonality among knowledge transfer literature is the idea that the skill of the knowledge broker or knowledge transfer agent is paramount to the success of knowledge transfer (Roux et al., 2006). These skills can include trust and credibility, clear communication, an understanding of both of the cultures between which the broker is translating, and an ability to facilitate, mediate, and negotiate (Lomas, 2007). The knowledge broker may play roles like the information manager, linking agent, capacity builder, facilitator, and evaluator, and ideally, the knowledge broker benefits both the knowledge producer community (by bringing in research needs) and the user community (by facilitating knowledge transfer) (Glegg & Hoens, 2016).

Research of knowledge brokering and knowledge transfer typically takes the form of social network analyses and ethnographies to identify the presence of knowledge brokers or facilitate the knowledge brokering process (Long et al., 2013). KTE literature includes both implementation studies involving an implemented knowledge transfer practice and a review of that practice as well as non-implementation studies, which includes reviews, commentaries and surveys of KTE practice (Mitton et al., 2007). KTE strategies identified by Mitton et al.'s literature review (2007) included face-to-face interaction, educational sessions, networks and communities of practice, facilitated meetings, workshops, capacity building, web-based information provision, and steering committees.

There are those who critique knowledge brokering and knowledge transfer. Kislov, Wilson, and Boaden (2017), for example, explore the "dark side" of knowledge brokering, questioning whether assigning this boundary-spanning role to one or multiple individuals results in a universally effective transfer of knowledge. There are many complications, they argue, that might undermine the utility of knowledge brokering: (1) the deployment of knowledge brokers that are more embedded in science communities may result in a perpetuation of the "us versus them" mentality if the brokers are not perceived as being embedded in user communities; (2) the idea that trust and credibility require relationship-building that may be lost if the broker leaves; (3) knowledge brokering can be isolating; and (4) by operating in a liminal space between communities, the broker may have limited vertical career growth opportunities (Kislov et al., 2017). The authors instead recommend a transition to "collective brokering" at the organizational and policy level (Kislov et al., 2017).

In the following section, this interactive science communication setting will be explored in terms of coproduction and actionable science, concepts that describe knowledge transfer at

these broader, organizational and policy-oriented levels. Then, the theory of motivated information management (TMIM) will be applied to science-policy communication, a first for TMIM, which has mostly been applied to health and relational communication. Although there has been a push for interaction information flow between science producers and science users, there have been relatively few examinations of how communication takes place in these settings. Because information flow is needed in some science communication settings, because there is a cultural divide between the groups communicating, and because the knowledge broker role is usually taken on by the science community (Bielak et al., 2008), it is also important to understand how and why the policymaker community approaches these interactive settings.

2.2 Coproduction, Actionable Science, and Boundary Organizations

The communication of science between science producers and science users, and specifically policymakers has indeed spurred some organizational and policy-level practice. Coproduction literature usually describes one of two real-world settings: the coproduction of science (described herein) and coproduction of municipal and public services (Brudney & England, 1983). There did not appear to be any studies linking the concepts and practices in these two settings, which could indicate a gap in the literature. It is unclear based on this review whether coproduction was thus named because of its historical use, or whether the names originated spontaneously and simply describe similar work because of what the word "coproduction" implies.

Coproduction of public services can stem from budget shortages and calls for public participation in services typically offered by local governments, including participation in both "soft services" like education, health care, counseling, volunteerism, and crisis intervention and "hard services" like water, fire, and policing (Brudney & England, 1983, p. 59). Coproduction is

defined by the degree of overlap between those who work for public service agencies and consumers of those services (Brudney & England, 1983). Brudney and England (1983) also call coproduction the "self-service" government (p. 59). Linders (2012) proclaims a "re-emergence" of this citizen coproduction, which he calls "citizen sourcing" or "do-it-yourself government" (p. 446). Linders (2012) also describes the persistence of budget deficits, which require governments to call on citizens to take part in civic actions, taking advantage of new communication technology to organize mass collaboration in public services.

In another review of public service coproduction, Bovaird (2007) states that, "Policy making is no longer seen as a purely top-down process but rather as a negotiation among many interacting policy systems" (p. 846). Bovaird (2007) goes on to say that, "Coproduction means that service users and professionals must develop mutual relationships in which both parties take risks" (p. 586). That is, the "user" must be willing to trust professional advice and support, but the professional also has to be able to trust the communities and users who are also taking part in decisions, and the professional should not dictate those decisions (p. 856). Joshi and Moore (2004) also provide a definition of public services coproduction: "the provision of public services (broadly defined, to include regulation) through a regular long-term relationship between state agencies and organised groups of citizens, where both make substantial resource contributions" (p. 31).

Coproduction may also happen in other settings, such as within private companies. For example, Auh, Bell, McLeod, and Shih (2007) discuss the application of coproduction to financial services and marketing as a way to build customer loyalty. They quote Bendapudi and Leone (2003) in saying that coproduction may be the next frontier in promoting customer

satisfaction – customers work alongside the firms providing services for them to both reduce the work load of the service provider and add customer value (Auh et al., 2007).

Commonalities among public and corporate services literature include a focus on maximizing output for budgets by recruiting additional labor and relationship- and trust-building outcomes (Joshi & Moore, 2004). While the former may not apply to coproduced science, relationship-building and a shared creation of outcomes do apply (Linders, 2012). Science that involves coproduction can in fact take extra time and effort on the part of the science organization funding this type of research, so it must be demonstrated that coproduced science is useful – this is, in fact, one of the primary motivators for the research proposed in this paper (Meadow et al., 2015).

Before understanding how coproduction of science takes place, it is also necessary to understand some concepts and terms used in this setting. One is the "science-policy interface," a term that refers to the interactions that take place between scientists and policymakers, as described above. Another is the term "stakeholders." Although the word stakeholders is used in this study to indicate the study participants, stakeholders will now be defined more broadly, as they play a role in science-policy literature. As described elsewhere in this report, stakeholders are, quite literally, those who hold a *stake* in the actions of a company or organization, and in the case of the science-policy interface, they can include any variety of groups ranging from municipalities, industry, and policymakers to interest groups and other publics (Siebenhuner, 2004). Stakeholders are also referred to in coproduction literature as "users," "managers," and "policymakers," depending on the context; users are simply those who use science, managers are those who use science to manage something (like public lands or water resources), and policymakers are those who use science to govern (Lemos & Morehouse, 2005).

Coproduction in science is more common among the environmental sciences. Armitage, Berkes, Dale, Kocho-Schellenberg, and Patton (2011) conducted case studies of coproduction in environmental change adaptation science in the Arctic. Meadow et al. (2015) and others call for deliberate coproduction of *climate* knowledge. Beier, Hansen, Helbrecht, and Behar (2017) describe coproduction in conservation and natural resource management settings. One synthesis study describes several case studies across several environmental and agricultural science organizations (Djenontin & Meadow, 2018). Djenontin and Meadow (2018) conducted a grounded theory review of nine published case studies of research projects that crossed disciplines or involved cross-organizational collaboration. They used this analysis to build a guiding methodology for conducting coproduction research (Figure 2).

Case studies evaluated in this study included marine park management and conservation, urban forestry management, urban water management in the face of water scarcity, coffee commodity-based livelihood strategies, use of seasonal climate forecasts in decision-making, industrial contamination and mediation, co-management of Pacific fisheries, agricultural extension practice at local scales, and oil palm seed quality improvement (Djenontin & Meadow, 2018). A wide variety of groups were involved in each study, ranging from federally funded research organizations (the Environmental Protection Agency, the Department of Fisheries and Oceans, etc.) to "boundary organizations" (governmental, non-governmental organizations, academia, and others who could both affect the research and the outcomes) to practitioners (managers, decision-makers, farmers, industry, etc.). Each of these studies included some component of either "stakeholder engagement" or participation from across multiple groups, and methods ranged from qualitative case studies, focus groups, interviews, and observations to quantitative document analysis and experimentation (Djenontin & Meadow, 2018). The variables

presented in Figure 2 represent the emergent categories from this analysis that either facilitated or hindered effectiveness. Success or failure was categorized into contextual variables, like institutional factors and organizational culture differences; this context fed into inputs like legitimacy and trust and credibility, then activities and outputs, followed by bigger picture impacts (Djenontin & Meadow, 2018, Figure 2).

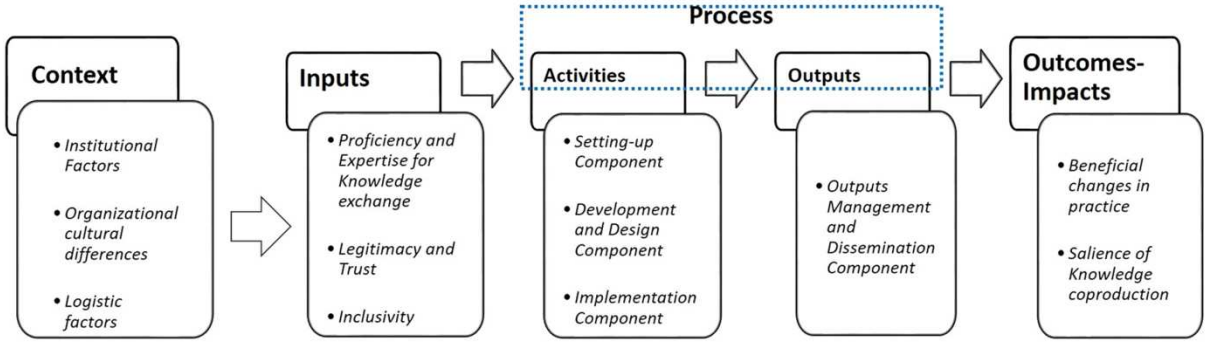

Figure 2. A conceptual model for practicing coproduction research.

From I. N. Djenontin and A. M. Meadow (2018), The art of co-production of knowledge in environmental sciences and management: lessons from international practice (p. 5). Copyright *Environmental Management*

As an aside, while the entire model informs the study performed here, the beginning components are where this study will overlap the most. As will be discussed below, the theory being applied, TMIM, is a cognitive theory that models what happens when people need more information to make a decision (Walid A. Afifi & Weiner, 2004). The decision to engage in coproduction happens at the beginning and therefore, the TMIM findings here will most likely overlap with "context" and "inputs" in Djenontin and Meadow (2018)'s flowchart (Figure 2). In fact, as will be outlined below, TMIM includes efficacy components that conceptually overlap with many of the "inputs" in Figure 2: legitimacy and trust, for example, align with TMIM's *target efficacy* concept, defined as an information-seeker's perceptions of the information provider's truthfulness and capabilities (Walid A. Afifi & Weiner, 2004). "Proficiency and expertise for knowledge exchange" from Figure 2 overlaps with TMIM's *communication*

efficacy concept, defined as an information-seeker's anticipation of how well the interaction process between themselves and the information provider(s) will go (Walid A. Afifi & Weiner, 2004). This link will be discussed further in data analysis and discussion.

To further evaluate Djenontin & Meadow (2018), the study indicated some commonalities across the cases studied, such as funding mechanisms accounted for and some level of support already in place for collaborative research. Although presented in a flow chart model, the authors also state that these components do not always occur in sequence. Challenges included limited time on the part of the stakeholder/manager groups that both prevented them from spending extra time keeping up to date with the latest research and from spending time on these types of projects. It was stated that research operated on a different time scale than the decisions that needed to be made (Djenontin & Meadow, 2018).

Other challenges included logistic factors, such as geographic space differences that limited in-person conversation; language barriers; and power and gender dynamics – for example, cultural differences in different groups in which women were less likely to talk in the presence of men (Djenontin & Meadow, 2018). Five of the case studies identified common traits and qualities that coproduced research must have to be successful, including an aptitude for engagement and facilitation, a knowledge of the context in which the science would need to be applied, and effective relationship-building and trust (Djenontin & Meadow, 2018). Overall, it was concluded in this study that coproduction research is effective in cases where there was more flexibility in funding and process deadlines, where those involved possessed communication and facilitation skills, and where there existed some overlap between the groups – either stakeholders who possessed science experience or scientists who possessed management knowledge or experience (Djenontin & Meadow, 2018).

Within this study as well as in other descriptions of coproduction, *actionable science* is often defined as a goal – if the science is to be applied in some way, or if stakeholders are to be involved in the research in a coproduction-style process, then the science must be "actionable" (Meadow et al., 2015). That is, it must be useful and usable in the context in which it is to be applied (Meadow et al., 2015). Additionally, as identified by Djenontin and Meadow (2018), there are some boundary organizations that exist at the science-policy interface border, which can include various academic institutions, private institutions, non-governmental organizations, governing bodies at federal and state and local levels, and local groups that include farming collectives and fishing communities and more (Djenontin & Meadow, 2018). Moss et al. (2014) detail processes that take place at this boundary (Figure 3).

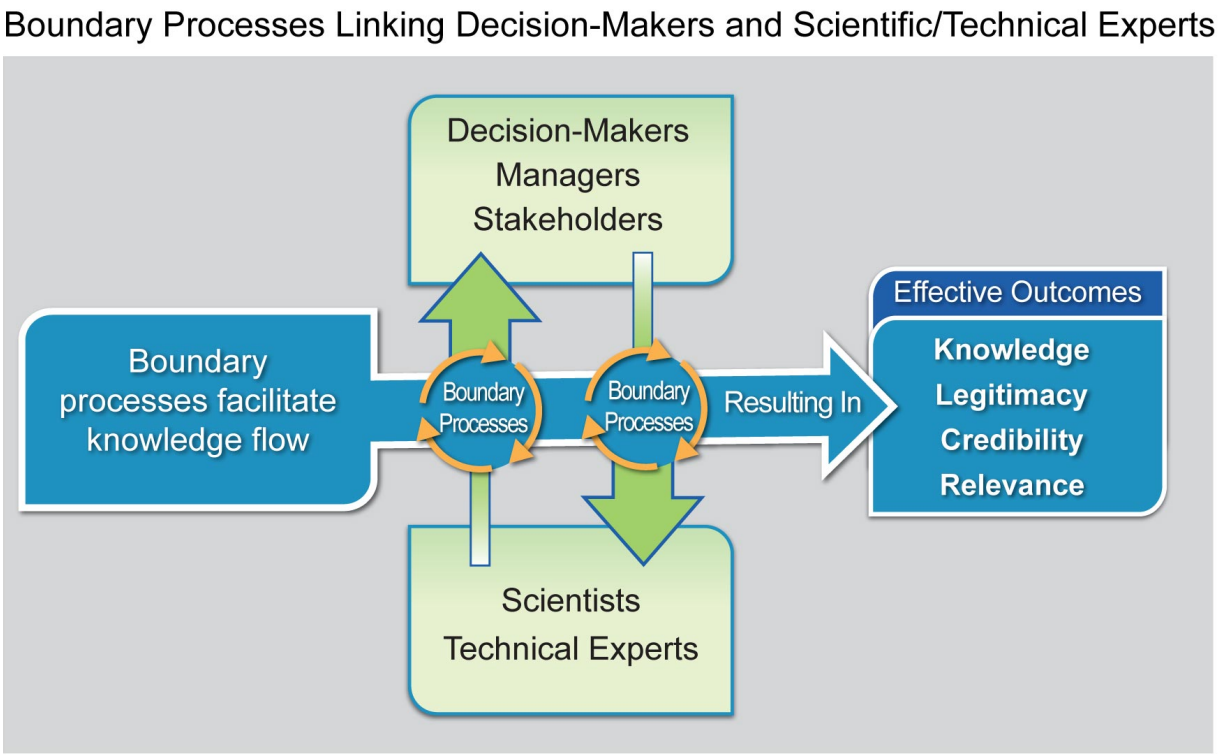

Figure 3. Boundary processes facilitate the flow of information and sharing of knowledge between decision-makers and scientists/technical experts.

From R. Moss et al. (2014), Chapter 26: Decision Support: Connecting Science, Risk Perception, and Decisions, *Climate Change Impacts in the United States: The Third National Climate Assessment* (p. 623). Copyright U.S. Global Climate Change Research Program.

Boundary processes identified by Moss et al. (2014) include science translation, decision support, management of risk perception, relationship-building, synthesis, capacity-building, and coproduction. All of these involve a great deal of interpersonal interaction, again highlighting the importance of boundary organizations and agents who work specifically at the boundary to ensure that information flows between decision-makers and science experts as much as needed to inform decisions (Moss et al., 2014).

There are significant overlaps between these ideas and coproduction, actionable science, knowledge brokering, and knowledge transfer and exchange. Returning to Bielak et al. (2008) and the shift from "big C" to "little c" communication methods, policy audiences are of particular focus in what has been deemed a shift from information push to policy pull, where more emphasis is placed on a consideration of the audience and their information needs. This necessarily entails more interaction with policy audiences to gather feedback and tailor communication (Bielak et al., 2008), which Roux et al. (2006) called a shift in focus from knowledge as a *thing* to knowledge as a *process*.

Again, this is another sign of the trend in science communication toward a more interactive, engagement-oriented model as opposed to a direct transmission model (Bielak et al., 2008). These newer ideas and perspectives in the field of science communication research help move the field closer to accounting for the many dimensions of what actually takes place in science communication, and perhaps the research proposed here will help continue to expand that understanding – particularly, a development of a better understanding of who uses science and how they approach the science-policy interface (Moss et al., 2014).

Additionally, though, interpersonal communication scholarship has a lot to offer to this highly engaging type of communication. The theory used in this study, TMIM, is one of many

communication theories and models that are being used across interactive communication applications. Another is the community-based participatory research (CBPR) philosophy. CBPR is similar to coproduction in that it encourages researchers to work with and consider applications of research (Wallerstein et al., 2017). According to Wallerstein et al. (2017), CBPR is usually applied in health settings where issues of morbidity and mortality disproportionately impact communities of color, and yet health research frequently excludes these communities from the benefits of health research. Wallerstein et al. goes on to define central tenets of CBPR with these issues in mind:

> These challenges [of higher morbidity and mortality and lack of benefit from health research], as well as the systematic exclusion of non-researchers from influence over the research process, have made it important for researchers to address fundamental questions such as, What is the purpose of research? Who benefits from research? How are the results of research used? How can research contribute to reducing health inequities? And what role does research play in community change and knowledge generation? (p. 31)

This quote shows that CBPR has a very similar philosophical and ethical approach to coproduction. Like CBPR, coproduction aims to include the voices of those who will be using the research to help frame the process. Key principles of CBPR include that CBPR *recognizes the community as a unit of identity* (common symbol systems, shared values and norms), *builds on strength and resources within a community* (uses existing organizational structures within the community), *facilitates collaborative, equitable partnership* (all parties participate equally across the entire research process), *promotes co-learning and capacity building among all partners* (the idea that the researchers learn as well), *integrates and achieves balance between research and*

action for the mutual benefit of all partners, *emphasizes public health problems of local relevance*, *involves systems development through a cyclical and iterative process*, *disseminates findings to all partners*, and several other tenets (Wallerstein et al., 2017).

While knowledge transfer and network analyses continue to think of knowledge as a *thing* that can be modified and tailored to an audience (Roux et al., 2006), it is clear that CBPR models communication more in terms of the process. In fact, Roux et al.'s discussion of group identity differences between scientists and practitioners harkens CBPR's concept of *community as a unit of identity* in which communities share values and norms. In the TMIM analysis below, this will be described using Czarniawska's (2009) organizational narrative ideas in which collectively, organizations operate according to set flows and processes and share language and other identity aspects in common. Since the practice community in coproduction identifies with an organization like a government agency, the organizational narrative is still a useful way to conceptualize differences between scientists and practitioners, but it is clear that this idea has many overlaps with CBPR.

Additionally, CBPR hopes to build on strengths already present within a community, such as already existing support structures. This is similar to a concept employed in coproduction called *capacity building*, in which science teams like those studied here work not only to provide information but also to support future efforts for the communities of practice to do the same (Carter et al., 2015).

The similarities go on. There have even been studies as to which practices predict these outcomes. A 2008 study by Wallerstein and colleagues created a model (Appendix C) that mimics the processes described by TMIM (see results and discussion) and by Dnenontin and Meadow (2017)'s coproduction process model but with many more components, including topics

that might be related to coproduction like “attends bi-directional translation/implementation/dissemination,” “fits with community explanatory models,” “community capacity and readiness,” and “appropriate research design,” along with components that might not fit as well such as changes in power relations (p. 381). Although, there are some communities of practice in TMIM, such as indigenous communities, e.g., per Diver (2017), that have been historically disempowered in white society as well as within the scientific community, so there may yet be room for these types of considerations in coproduction.

For now, the literature review moves on to TMIM, but it should be recognized overall that while coproduction has largely been attempting to inductively construct models for practice, there are plenty of examples from other fields where models and practice have gone a long way toward coproductive considerations. Perhaps TMIM is not the only model that stands to contribute to interactive science communication.

2.3 The Theory of Motivated Information Management

Thus far, trends in science communication and trends in science-policy interface practice, including coproduction, boundary organizations, and actionable science have been introduced. There are already some links between these scholarships and the theory selected for this analysis, such as communication concepts identified in Djenontin and Meadow’s (2018) case study analysis of the factors that positively and negatively influence coproduction. The theory of motivated information management (TMIM), introduced to interpersonal communications scholarship in the early 2000s, may provide a way to evaluate stakeholder information needs and motivations for interacting with researchers (Walid A. Afifi & Weiner, 2004). In the decade and a half since the theory was introduced, it has been verified as a method for understanding why people interact to seek new information about a decision (Fowler et al., 2018).

TMIM, the theory of motivated information management, is not the first interpersonal communication theory to attempt to explain how and why people use interpersonal interaction to manage information under uncertainty. The theory has strong ties to earlier information-seeking and uncertainty-related theories, including the theory of uncertainty management (Brashers, 2001), problematic integration theory (Babrow, 1992), and the comprehensive model of information seeking (Johnson et al., 1995), all of which also seek to explain how people manage information (Walid A. Afifi & Weiner, 2004). TMIM also utilizes concepts from other communications theories, such as Efficacy Theory (Bandura, 1982), to explain what goes into people's decisions to engage in information-seeking behavior (Walid A. Afifi et al., 2006).

In a definitional article, Afifi and Weiner (2004) proposed a framework and a model for TMIM, describing how the theory builds on prior research. They identified four areas where current literature required improvement. The first: other, similar theories failed to outline a scope of application contexts. Afifi and Weiner suggest that TMIM is largely interpersonal in application such as, for instance, in cases of a student or employee seeking information from an instructor or supervisor, in the case of patients deciding whether to seek information from a healthcare professional, or in the case of romantic partners seeking relational information (Walid A. Afifi & Weiner, 2004). The focus on interpersonal communication, in which aspects like immediacy and interactivity are present but aspects that would muddle the interaction like the communication channel are not present (Walid A. Afifi & Weiner, 2004). It would seem, therefore, that Afifi and Weiner called for unmediated interpersonal communication as the model's first constraint, but they also imply that interpersonal communication like email might be studied as well. The most important aspect of restricting the channel to interpersonal communication seems to be that, "the [information provider]'s feedback affects the entire

information-management process for seekers" (p. 184). Therefore, in the process of seeking information, the way the information provider responds should be considered as impacting aspects of the model, like the information seeker's outcome expectancies.

The second limitation with prior research: with a few exceptions, other theories fell short of accounting for the complex nature of uncertainty in the information-seeking process (Walid A. Afifi & Weiner, 2004). In previous theories, uncertainty was studied as a motivating factor, but it was often considered to be a negative experience for the information seeker until theories like uncertainty management theory opened the door to uncertainty as a more complex experience (Brashers, 2001). Information seekers may wish to increase or decrease or maintain uncertainty rather than simply decrease uncertainty (Brashers, 2001). This recognition of the complexity of uncertainty as a motivating factor was carried over to TMIM as an "uncertainty discrepancy" that motivates information-seeking, with a careful definition to avoid describing uncertainty as exclusively negative (Walid A. Afifi & Weiner, 2004).

A third limitation with prior research: the concept of "efficacy" was underrepresented in other theories. Only a few scholars of information seeking theories had incorporated efficacy into their theories at all, and none of the theories incorporated efficacy in a manner that differed from efficacy literature (Johnson et al., 1995). Efficacy was deemed a highly significant component of information seeking by Afifi and Weiner, and they theorized and distinguished the three types indicated in Figure 4 that apply to information seeking in particular (Walid A. Afifi & Weiner, 2004). And finally, the fourth limitation of other theories: existing frameworks did not account for the information *provider* as an integral part of the information-seeking process, failing to account for the dyadic nature of interpersonal communication (Afifi & Weiner, 2004). Afifi and

Weiner therefore incorporated the information provider into the model (Walid A. Afifi & Weiner, 2004).

The conceptualization of what kicks off the information-seeking process is somewhat simplified from uncertainty management theory's attempts to explain the breadth of possible information management behaviors (Hogan & Brashers, 2015). Rather than incorporate multiple behavioral outcomes, TMIM is limited to the decision-making process that an individual attends as they determine whether or not to engage in information-seeking behavior (Hogan & Brashers, 2015).

To explain this process, TMIM includes three "phases" (Figure 4). The first is the *interpretation phase*, in which a person becomes aware of an uncertainty discrepancy, defined as a gap an information seeker experiences between the amount of uncertainty they have about a topic, such as a health decision, and the amount of uncertainty they *wish* to have about the topic (Walid A. Afifi & Weiner, 2004). No judgements are made about the positive or negative nature of uncertainty. Rather, the discrepancy between actual and desired levels of uncertainty now serves as the motivating factor that kicks off the information seeking process, along with the accompanying affect that arises, such as anxiety (Walid A. Afifi & Weiner, 2004). Anxiety was the only emotion associated with the first model of TMIM in 2004. The theory has since been revised somewhat to rethink the role of anxiety in the interpretation phase (Afifi et al., 2006). New propositions state that uncertainty produces an *emotional response*, which varies based on the appraisal theory of emotion; this emotional response is what mediates uncertainty discrepancy and information-seeking (Walid A. Afifi & Morse, 2009).

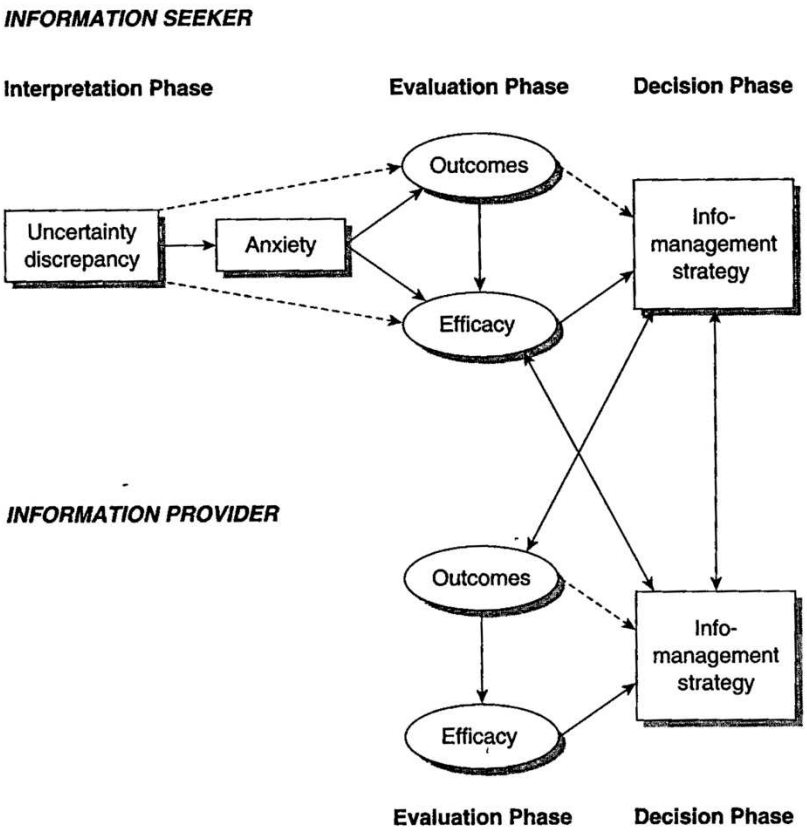

Figure 4. Graphical model of TMIM's propositional structure.

From "Expanding the role of emotion in the theory of motivated information management" by W. A Afifi and C. R. Morse, 2009, *Uncertainty, information management, and disclosure decisions: Theories and applications*, p. 88. Copyright Routledge/Taylor & Francis Group.

The expansion of the role of emotion more effectively accounts for multiple emotions that may arise from uncertainty discrepancies, such as trepidation or anxiety or even positive emotions like optimism (Fowler et al., 2018). Additionally, TMIM's founders clearly state that TMIM is an ultimately *rational* theory, meaning that it is concerned with thoughts and conceptualizations (Walid A. Afifi & Weiner, 2004). The role of emotion is devised per Hanoch (2002) as playing a role in rational thought processing by either restricting the range of options someone contemplates, or by focusing one's processing on a particular aspect of the situation at

hand. Higher anxiety might, for example, focus one's thoughts on higher-impact efficacies or outcome expectancies.

The second phase in TMIM is the *evaluation phase*, in which the individual considers an information seeking behavior and its potential *outcomes* and *efficacies* (Figure 4). Efficacies will be discussed in more detail below, but to summarize, this phase is when the information seeker forms expectations about the outcomes of their information seeking behavior and evaluates whether their abilities and the abilities of the information provider will be sufficient to yield an attainable and useful bounty of information (Walid A. Afifi & Weiner, 2004). Outcomes are further defined as outcome expectancies, outcome importance and the associated costs and benefits with the information at stake, and finally, outcome probability, defined as the likelihood of the outcome expectancies actually taking place.

Finally, in the *decision phase*, after weighing the information-seeking process, the individual makes a decision about how to move forward (Walid A. Afifi & Weiner, 2004). Afifi and Weiner (2004) note that "although space limitations prohibit us from adequately addressing the active role of information providers here, we take seriously the interactive nature of interpersonal encounters and consider that interactivity is a crucial aspect of the process" (p. 171-172). Therefore, although the model does not specifically account for the information provider, Afifi and Weiner consider the interpersonal interaction with the information provider to be of distinct importance, and they also state that the information management strategy pursued in the decision phase may impact future evaluation phases.

2.3.1. TMIM and Efficacy

The concept of *efficacy* is a new addition compared to most uncertainty models (Walid A. Afifi & Weiner, 2004). Bandura (1982) defined self-efficacy as a mechanism of human agency,

meaning the ability to carry out different courses of action in different situations. Agency, or efficacy, is key to the decision-making process because an individual's belief in their ability, or the ability of others, to carry out a task greatly impacts people's decisions about how to act (Bandura, 1982). With regard to information-seeking, for example, studies have found that low efficacy estimations contribute to a lack of information-seeking and information-providing communication, such as in the case of parents providing sexual health information to their children (Warren, 2013).

TMIM introduces three dimensions of efficacy: *coping efficacy*, or one's perceived ability to handle the new information received; *communication efficacy*, or the ability to carry out the interpersonal interactions to arise in the process; and *target efficacy*, defined as the individual's perceptions of the information provider's truthfulness and ability. These factors combined, according to TMIM, should describe conceptual processes when someone is deciding whether or not to interact to gain more information. These three types of efficacy account for the self (information seeker), the other (information provider), and the interaction, and more specifically, how well the information seeker believes that each component will carry out. This reflects the dyadic nature of interpersonal communication that Afifi and Weiner intended to capture with this theory.

2.3.2. Applications of TMIM

The concepts, assumptions, and propositions outlined by the theory's founders have been applied in a handful of contexts in the decade and a half since TMIM's emergence. These have included health information and families (Walid A. Afifi et al., 2006; Hovick, 2014; Rauscher & Hesse, 2014), health testing (Banduch, 2014; Dillow & Labelle, 2014), relational communication (Fowler et al., 2018), and even a successful attempt to apply TMIM to online information-

seeking (Tokunaga & Gustafson, 2014).These studies have been quantitative in nature, usually using some combination of surveys and other methods.

Fowler and Afifi (2018) studied relational communication in families: how children seek information from aging parents about preferences for eldercare. This study claims to be the first test of TMIM after the model was modified from *anxiety* response to a broader *emotional* response to an information deficit, or uncertainty deficit (Fowler & Afifi, 2011). A 2x2 experimental study (n=43-46 for each condition) was conducted in which uncertainty discrepancy were high/low and communication efficacy were present/absent, and the manipulation tested whether providing information about ways to initiate the conversation about eldercare made a difference in efficacy evaluations and uncertainty discrepancy (Fowler & Afifi, 2011). Emotional responses were recorded in the survey where participants were asked the degree to which they experienced 18 emotions as categorized by Afifi and Morse (2009) on a scale of 1 (not at all) to 6 (extremely). The highest ranked were calm (4.18), thoughtful (3.71), secure (3.68), encouraged (3.41), inspired (3.13), happy (2.87), worried (2.50), sad (2.50), and pensive (2.29). Below that were nervous, scared, anxious, disappointed, distressed, frustrated, upset, irritable, and anger (1.51) (Fowler & Afifi, 2011). This study proved that a range of affects may be considered simultaneously to varying degrees when information-seekers face uncertainty. Additionally, many of the top-ranked emotions were effectively neutral (calm, thoughtful, secure) and many were positive (encouraged, inspired, happy), which holds implications for the revised TMIM model (Fowler & Afifi, 2011). The study found that communication efficacy was the strongest predictor of information management strategies.

Another relational application is an Afifi and Afifi (2009) study of the impact on divorce on adolescent information-seeking. Parent-adolescent dyads (n=112) took a 15-minute survey

before sitting in a videotaped interactive portion of the study where small talk was recorded, then four topic cards were presented (parents' relationship, marriage and divorce, child's sexual attitudes and behaviors, and negative things the child had done or that had happened to them), and they were asked to eliminate one of the cards and then talk about the other three for as long or as little as they would like. Then another survey was completed. The study measured uncertainty discrepancy about the parents' relationship, anxiety about the uncertainty discrepancy (this was before the shift to emotion instead of anxiety), outcome expectancy using a ranking scale from "a lot more negatives than positives" to "a lot more positives than negatives," all three efficacies with the exception of adolescents' beliefs about their parents' target efficacy since they are presumed to know information about their own relationship, and an added post-measure of topic avoidance, in order to measure the mediating effect of avoidance on outcome expectancies (Afifi & Afifi, 2009, pp. 496-498). Though this older TMIM model posits that anxiety partially mediates the relationships between uncertainty discrepancy and both efficacy and outcome expectancies, anxiety did not significantly mediate for outcome expectancies. It did partially mediate the relationship between uncertainty discrepancies and the two efficacies tested, communication and coping (Afifi & Afifi, 2009). This may have implications for the role of anxiety and possibly other emotions in efficacy evaluations.

To evaluate this alongside the previously mentioned study, Fowler and Afifi (2011) reported that anxiety and communication efficacy (unless otherwise noted, measured on a Likert scale of 1-7, with 7 being high) had a negative relationship of -0.216 ($p<0.05$), and happiness (measured on a different scale of 1-6) and communication efficacy had a positive relationship of 0.248 ($p<0.01$). Additionally, coping efficacy had a positive correlation with happiness at 0.209 ($p<0.05$) but there was not a significant correlation between anxiety and coping efficacy. Target

ability and target honesty, components of target efficacy, had a negative correlation with anxiety at -0.183 ($p<0.05$) and -0.216 ($p<0.01$) respectively, and only target honesty had a significant relationship with anxiety at positive 0.219 ($p<0.05$) (Fowler & Afifi, 2011, p. 520). The existence of a relationship between efficacies and anxiety are reinforced by both Afifi and Afifi (2009) and Fowler and Afifi (2011), and beyond anxiety, Fowler and Afifi only reported on happiness and anxiety out of the 18 emotions tested, but taking one as a positive affect (happiness), results indicate that happiness and possibly other positive emotions are positively correlated with communication efficacy and coping efficacy, meaning that a more positive affect is associated with higher evaluations of how well the communication will go with the information provider, as well as how well the information seeker will be able to cope with information (Walid A. Afifi & Weiner, 2004). Similarly, there was some evidence of negative correlation between anxiety, and possibly by extension other negative emotions, and these efficacies (Fowler & Afifi, 2011). Taken together, these studies demonstrate that the components of the TMIM model may impact each other as the information seeker evaluates the information-seeking situation.

Fowler, Gasiorek, and Afifi (2018) takes the emotion consideration a step further by comparing another positive emotion, optimism, and the negative emotion anxiety, alongside outcome expectancies and information management strategies. This was another relational communication application (couples discussing financial uncertainty) and was survey-based. Outcome expectancies are categorized into *knowledge* and *relationship* expectancies – the information seeker's expectations about how their own knowledge will change, and expectations about how their relationship will change (Fowler et al., 2018). Additionally, multiple information management strategies were tested, which include direct and indirect information seeking,

avoidance, and cognitive reappraisal. The study found that indirect information seeking, avoidance and cognitive reappraisal were negatively correlated with efficacy, meaning that higher efficacy beliefs prompted less of the indirect or avoidant outcomes. Anxiety partially predicted both direct and indirect information seeking, with a positive correlation for both, but optimism had less of a clear impact on information seeking, which may be due to the topic studied (Fowler et al., 2018, p. 385). An interesting contribution of this study was that *knowledge* outcome expectancies were *positively* impacted by optimism and *negatively* impacted by anxiety, implying that different types of emotion can impact knowledge outcome expectancies (Fowler et al., 2018). Taken with the other causal relationships uncovered, there are multiple pathways to explore in more detail with the type of study done here.

In an early TMIM study that neatly summarizes the settings in which TMIM should be employed, Afifi et al. (2006) found that a factor they called "issue importance" predicted how active an individual was in pursuing information-seeking behaviors. This idea is echoed in uncertainty literature: "Persons are most likely to manage actively those uncertainties that they appraise as most important" (Hines, 2001, p. 502). TMIM adopts these uncertainty conceptualizations into its own foundational proclamations (Walid A. Afifi et al., 2006). In other words, TMIM applies when people want or need more information than they have on hand (Walid A. Afifi & Weiner, 2004), and they place a high level of importance on that information (Hines, 2001). There may also be a reason why the information-seeker might avoid those conversations, perhaps because of emotional impact, as in the case of Afifi et al. (2006), which studied organ donation conversations. Sexual health conversations (Walid A. Afifi & Weiner, 2006; Dillow & Labelle, 2014), end of life planning (Fowler & Afifi, 2011; Rafferty et al., 2015), family health information seeking (Banduch, 2014; Hovick, 2014; Rauscher & Hesse,

2014), adolescent information-seeking about parents' divorce (Walid A. Afifi & Afifi, 2009), and even couples discussing financial matters (Fowler et al., 2018) are all examples of arguable high-stakes communication settings where there are (1) reasons to seek out information, such as reducing relational uncertainty (W. A. Afifi & Robbins, 2015), and (2) reasons why the conversations might be avoided, such as the level of difficulty of the conversation (Walid A. Afifi et al., 2006).

Given those conditions, are there any non-health or non-relational applications of TMIM? Crowley and High (2018) studied how parents seek information about their adolescent childrens' career development in another family-relational study. The study researched efficacy evaluations of parents who sought information from school counselors, teachers, and both offline acquaintances and online peer networks, and a higher efficacy evaluation was tied to career counselors and teachers, though the study implied that online information-seeking was seen by the study participants as a viable alternative to face-to-face information seeking (Crowley & High, 2018). Kanter, Bevan, and Dorros (2019) tested TMIM in online information-seeking among support groups for chronic illness and found that target efficacy and communication efficacy were positively correlated with online information-seeking. Online information-seeking may partially contradict TMIM's first scope condition of interpersonal interaction. Given the range of communication types studied in science communication and given that this study drew results that apply to both immediate communication and mediated communication as well as online information-seeking behaviors (see results), the question of whether TMIM can be applied to multiple channels will now be addressed.

2.3.3. TMIM Applied to Online and Mediated Information Seeking

Afifi and Weiner (2004) called attention to interpersonal communication in particular because of qualities of interpersonal communication that merited particular focus, such as immediacy and feedback. They state that even over the course of a conversation, an information seeker might receive signals that influence their evaluations of outcomes and efficacies. They gave the example of someone deciding whether to pursue a romantic interest, sparking a conversation, and receiving signals that changed their mind about their predicted success in the romantic pursuit. The interpersonal and dialogical component is deemed significant in TMIM. The information seeker might start a conversation with one informational goal in mind and change their mind through the course of the conversation.

However, the model has also been interpreted in a more static sense, like in Tokunaga and Gustafson, where there were no interpersonal feedbacks (2014). Tokunaga and Gustafson created a modified version of the TMIM model for online information seeking behavior that follows much the same flow from uncertainty discrepancy to an anxiety (simplified affect) response to an efficacy and outcomes assessment to a decision phase, with the notable differences that target efficacy is missing from the model and that "Internet self-efficacy" replaces communication efficacy, as well as an optional bypass of the outcomes and efficacies assessment phase in which the information seeker may proceed directly from anxiety to the decision phase given the low-risk nature of online information-seeking (Figure 5).

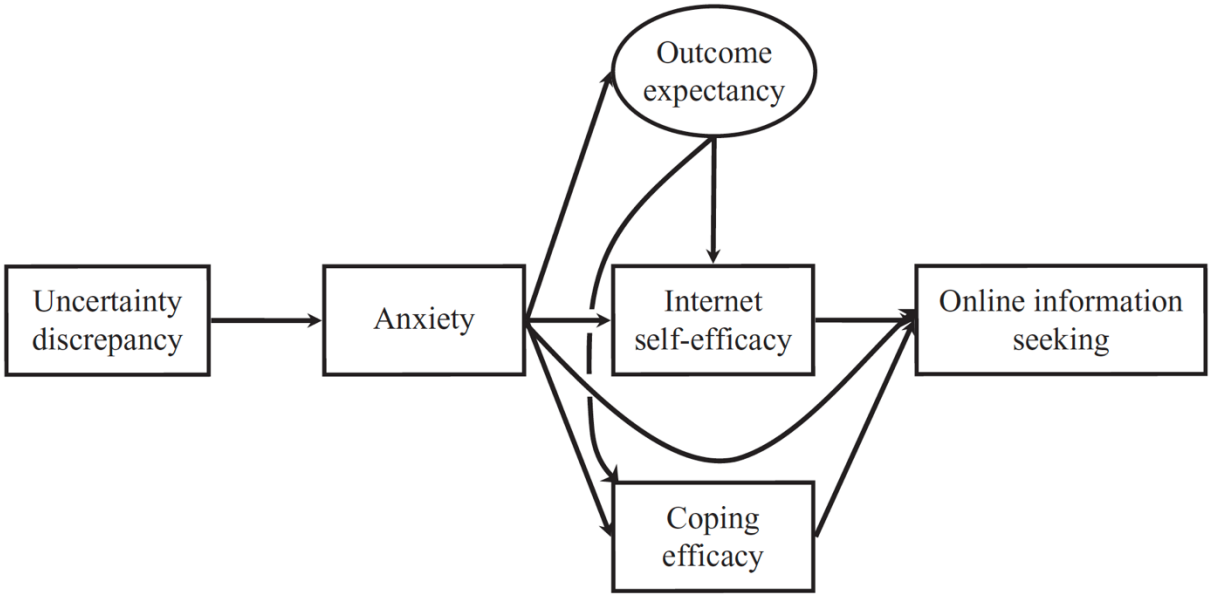

Figure 5. Though TMIM is an interpersonal communication theory, it has also been applied in online information-seeking per the above modified TMIM model.

From "Seeking interpersonal information over the Internet: An application of the theory of motivated information management to Internet use" by R. S. Tokunaga, and A. Gustafson (2014). *Journal of Social and Personal Relationships*, *31*(8), 1019–1039.

Tokunaga and Gustafson have demonstrated that an altered TMIM model may be applied to a single individual seeking information from multiple online sources. From a mass communication perspective, however, Tokunaga and Gustafson need not have elimiated target efficacy. According to mass communication scholarship, the source of information plays a role in the consumer's evaluation of the information provided and more than that, the source plays a role in whether consumers trust or find credibility in information (Slater & Rouner, 1996). Trust and credibility of the source are near facsimiles to the Afifi and Weiner (2004) definition of target efficacy: "target efficacy is an assessment about who has the information and how likely they are to be honest" (p. 179). Therefore, a revised model to account for the apparent one-way nature of online information seeking need not elimate the consideration of the information provider, even though a dyadic interaction is not taking place. The idea of source credibility is more often studied in terms of traditional media like news outlets (Stroud & Lee, 2013), but

source also matters for new media like social media. One social media study, for example, found that stakeholders of government agencies, emergency responders, organizations, and individuals/celebrities perceived Twitter feeds to be more credible when they were updated more frequently (Westerman et al., 2014).

Since target efficacy need not be eliminated, how else does online information seeking differ from interpersonal information seeking? As Afifi and Weiner argued, the information seeker might change their internal evaluations of information management strategies over the course of an interaction. It is reasonable to argue for a modified model to account for that missing component, but TMIM may still be a useful model for these types of information seeking behaviors (Tokunaga & Gustafson, 2014). Afifi and Weiner also argue that the effects of the channel complicated TMIM (2004). This may also be the case. To reiterate, though, modifications may be made to the model to account for these differences (Figure 5).

Taking that a step further, theories like hyperpersonal computer mediated communication (CMC) theory also postulate that more information can come from CMC than in-person communication even when immediacy is not reached, as people often disclose more information in CMC settings, possibly as a way to make up for the lack of interpersonal indicators like body language and eye contact (Walther, 1996). Additionally, information-seeking behavior is deemed a lacking component of CMC research (Ramirez et al., 2002). A cousin of TMIM, uncertainty management theory, is even being applied in information retrieval research, or research of database indexing and searching, meaning that information-seeking behaviors and conceptualizations are taken into account when databases are built (Brashers & Hogan, 2013). While information-seeking models are being called for in CMC (Ramirez et al., 2002), why not apply something like TMIM, which accounts for expectations and efficacies of information-

seeking in a way that other models do not (Walid A. Afifi & Weiner, 2004), and which has been proven successful in applications to online information-seeking, albeit from a specialized perspective (Tokunaga & Gustafson, 2014)?

2.3.4. Justification for the Application of TMIM in Science Communication

CMC and online information-seeking may be of particular importance in this study, since the stakeholders interviewed claimed a multitude of information sources, from searches to newsletters to workshops and meetings to coproduced projects. See the results section for more discussion about this. If TMIM can feasibly apply to interpersonal and mediated communication, then it may do more to explain the scope of information-seeking behavior performed by the stakeholders interviewed. This is not the only compatibility that TMIM holds with the chosen study context.

This study seeks to apply TMIM to interactive communication at the science-policy interface. There are times when science groups and policy groups interact to either share or produce knowledge. This can take the form of face-to-face interaction, educational sessions, networks and communities of practice, facilitated meetings, workshops, capacity building, web-based information provision, and steering committees (Mitton et al., 2007). Despite the sometimes existing geographic distance barriers and misalignments in the timing of research compared to management decision schedules (Djenontin & Meadow, 2018), coproduction of science usually involves at least some component of communicative interaction. Figure 6, below, modified from Lemos and Morehouse (2005), depicts a typical prescriptive model for coproduced science, which includes as a central component these interactions.

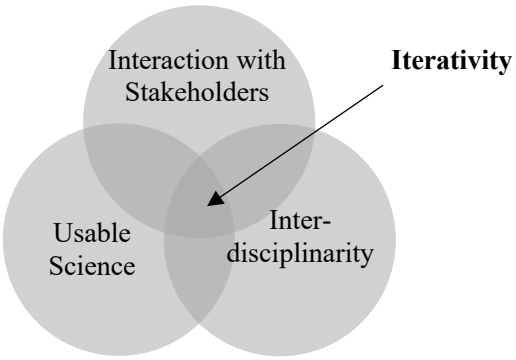

Figure 6. Model for coproduction of science and policy, wherein interactions with stakeholders, usable science, and interdisciplinarity come together in an iterative process.

From "The co-production of science and policy in integrated climate assessments" by C. A. Lemos and B. J. Morehouse, 2005, *Global Environmental Change*, p. 61. Copyright Elsevier Ltd.

Roux et al. (2006) describe characteristics of the potential cultural divide that may exist between the groups interacting, including commonly held perceptions on both "sides" of the science-policy divide. For example, Roux et al. state that science is a self-serving and inward-looking culture, that scientists are driven by curiosity and have no interest in the real-world applications, that managers spend too much time on day-to-day workings and little time on intellectual reflection and long-term research and development, and that managers do not articulate their needs effectively. These types of preconceptions can have an impact on the interactive process that take place in coproduction, because it indicates that there may at times be fundamental value conflict as well as other organizational cultural tension between scientists and managers, such as a difference in goals between satisfying intellectual curiosity and a consideration for immediate, real-world applications of science (Roux et al., 2006).

With this potential for disconnect, which would be inherent in any organizational boundary interaction (Czarniawska, 2009), there have been many prescriptive recommendations for how interactions between science groups and management groups should take place, but the

effectiveness of these practices is still largely undocumented, with the exception of the 2018 synthesis that analyzed characteristics of effective coproduction interaction (Djenontin & Meadow, 2018) and others.

Therefore, a setting exists within which an interactive communication theory may be applied. Additionally, similarities across health and environmental communication research applications also exist, as demonstrated in knowledge broker and KTE research (Mitton et al., 2007), meaning that other interpersonal theories may apply. Science communication scholar Robert Logan (2001) calls specifically for this: "…the pace of research might be accelerated if there were a more comprehensive collaboration among science communication, health communication, and risk communication scholarship" (p. 135).

Accordingly, knowledge brokering and KTE literature describe a need for the skills and capabilities that must exist for cross-boundary information transfer to be effective (Long et al., 2013). TMIM, on the other hand, stands to capture why people decide to engage in this type of interaction (Walid A. Afifi & Morse, 2009). Although coproduction is often called for to facilitate cross-boundary and specifically science-policy communication (Meadow et al., 2015), there are relatively few tests of its various communicative processes, and they are rarely if ever called out specifically (Djenontin & Meadow, 2018). The practice is still, for the most part, driven by science agencies and other research groups, creating a potential imbalance and incompatibility (Moss et al., 2014). By understanding more of how and why people on the other side of the interaction choose to participate, the coproduction process stands to become better informed and more effective.

Finally, all of these applications are quantitative in nature. This study proposed a qualitative analysis of TMIM. A qualitative analysis was chosen because of the researcher's

interest in exploring the concepts more in depth, seeking to understand through interactive questions with information seekers how they think about and approach coproduction. Coproduction has never been studied from a TMIM perspective, and it was unclear based on a review of TMIM literature whether the concept of "issue importance" as a core requirement for TMIM processing would translate. Interviews would allow for probing questions that would better illuminate and lay the groundwork for scope conditions to applying TMIM to coproduction. In selecting the interview method, care was taken to identify major concepts in TMIM (uncertainty discrepancy, affect, outcome evaluation, coping efficacy, target efficacy, communication efficacy, and information management strategy), and questions were created that asked about each of these (Appendix A).

Causal and directional relationships have been proven among these concepts by other TMIM scholars such as Fowler, Afifi, and others, but this work will not attempt to prove or disprove causal relationships. That work might come later if future research applies this theory to coproduction. The goal of this work will instead be to discover whether the concepts of TMIM exist in a coproduction space, as a review and comparison of the two literatures suggests. Proof of TMIM's application will be based on whether interview participants describe, for example, evaluating target efficacy when facing the coproduction process. Based on the existence and quality of these concepts in coproduction, then, a model will be recommended for the application of TMIM to this interface.

Chapter 3. Method

This study will be part of a larger study conducted alongside two other researchers with the goal of understanding the results of coproduced science. This section will situate the thesis research within that larger study and will outline the qualitative interview research method and hermeneutic analysis method selected for use in this study.

3.1 Overview of the Study

As introduced in section 1.1, this work falls under the purview of a larger research effort undertaken on behalf of the USGS North Central Climate Adaptation Science Center (NC CASC), a regional CASC that serves the north central region of the United States under the Department of the Interior (DOI). The study proposed two key directives: (1) enhanced engagement with science users ("stakeholders") and (2) evaluation metrics for science that involves engagement with these stakeholders. This research falls under the latter directive.

Within the evaluation portion of the study exists an additional subdivision of work: one study team will be conducting a survey, and one team will be conducting interviews. The workload therefore fell to three people – the master's student conducting this work, including collaborating on conducting interviews; a PhD candidate taking part in the survey; and a third researcher (who holds a master's degree), who will be collaborating on both efforts. Three goals identified for the interviews and survey are: (1) collect information about manager decision schedules, so that research funded by the center may be better planned; (2) "close the loop" to determine whether coproduced science was actually useful; and (3) apply TMIM to describe the motivations of managers approached by the NC CASC to collaborate in the creation of coproduced research. Although the researcher proposing this thesis work may be involved in the

analysis of the other two goals, the thesis researcher will be the only member of the team conducting the TMIM application and analysis.

3.1.1. Reflexivity

One could argue that the researcher is never removed from their research. "[K]nowledge does not exist outside of its creation and exchange by communicators" and this poses a challenge for the qualitative researcher, because "[w]hen our writing is insufficient, [our audiences] can be merciless in asserting an ironic gap between what (they believe) we study, and how well we appear to be studying it" (Lindlof & Taylor, 2017, p. 373). The purpose of reflexivity in qualitative research and writing is to provide enough information that the reader understands the context and reasons for research decisions, and that the reader therefore has fewer questions and notices fewer gaps in the logic being presented (Silverman, 2013).

The reasoning for the study and my role in the study play a role in the audience of this research understanding why I made the choices I did. In this section I will briefly outline my role and some of the choices I made, and this entire methods section will at times describe data collection procedures my colleague and I performed and will at times explain how this research fits into broader goals and directives. I will also return to the conversation of my role as an interviewer and how that impacted this study. Additionally, I recognize that my identities play a role in how others interact with me. This impacted the interviews, because others may hold similar or different identities, and it also impacts how I interpret the research. I identify as a white, cis-gendered, female with progressive ideologies and a background in media communication and science communication practice.

When I began this research, I was employed as a communication specialist by the NC CASC, who funded this work. I was familiar with strategic planning that happened at the center,

and many of our staff meetings revolved around concepts like actionable science and land management and environmental change. My role at the NC CASC was to upkeep the website, process and translate science for different audiences, and maintain a social media presence. I got to know a lot about the science that was conducted, and I learned about climate projections and land use mapping and drought monitoring.

A colleague at the time, Jill Lackett, was the lead interviewer, and another colleague of ours asked if I would like to join the project and contribute questions to the research. The project was initially intended to build evaluation metrics for coproduction, and it was divided into a set of surveys that would go out to all the stakeholders on the NC CASC project list. Interviews were meant to follow up and go more in depth about the results of the surveys. The timing ended up not working out, and the interviews needed to be conducted in parallel with the survey.

This was an opportunity for me to study something I had been noticing in my work – that the scientists I worked alongside put a lot of time and effort into interacting with stakeholders, and that all of the projects handled coproduction differently. That difference is to be expected given such a broad variety in the problems they researched, the varied geographic landscapes where that research was located, and also the variability in where those stakeholders worked and lived (Projects - Climate Adaptation Science Centers, 2019). It was also recognized that this was a fairly new type of research, in which the NC CASC acted as something of a consultant to land management organizations like the National Park Service and U.S. Forest Service and Bureau of Land Management and tribes (and more) to bring in expertise to change their policies and help them adapt to global environmental change (Hackmann et al., 2014). This exposure to a communication interface led me to do some digging and informed a lot of my research papers as a master's student.

I ultimately consider myself to be a science communication scholar, and I am also a mediator at heart, looking for connections and trying to draw similarities between bodies of research that study similar ideas (and wanting to research the science-policy interface, where cultural and communicative differences have been researched by many). I see this project as foundationally situated in science communication scholarship, and I see trends in science communication scholarship (such as the trend away from direct transmission of science, per Nisbet and Scheufele, 2009) as serving a backdrop within which this study is conducted. Interpersonal communication scholarship and science communication scholarship can inform each other more, based on my reviews of the literature, and coproduction involves a lot of communication concepts, so a communication theory may apply. What follows will be a description of the procedures my colleague and I went through to conduct the interviews as well as a discussion of the reasoning and ontology behind this method and behind the analysis.

3.2 Participants and Sampling

To understand how and why the participants in this study were selected, it is necessary to first understand why this study came about in the history and practices of the NC CASC.

The study originated as part of a directive from leaders in the DOI at the time to "close the loop" and see whether the eight total regional CASCs, including the NC CASC, had been functional in their relatively short history. In particular, the DOI wondered whether science user groups, after collaborating with the NC CASC, now had the information needed to incorporate CASC-produced science into their decision-making. The centers were established by Congress in 2009 with a secretarial order from then-Interior-Secretary Ken Salazar to "synthesize and integrate climate change impact data and develop tools that the Department's managers and partners can use when managing the Department's land, water, fish and wildlife, and cultural

heritage resources" (Secretarial Order 3289, 2009). The centers were established with the explicit goal of serving science and expertise to land managers, so a science-management spanning role was always part of the mission.

The centers have since partnered with the Bureau of Indian Affairs, another DOI group, to identify tribal climate information needs and work to address those needs. Other milestones have included contributions to the National Climate Assessment, collaborations with other agencies to inform State Wildlife Action Plans, and a name change in 2018 from Climate Science Centers to Climate Adaptation Science Centers to better signify the centers' focus on adaptation science – science that informs climate adaptation (*History of the CASCs*, n.d.). The name change came after months of budgetary uncertainties following the 2016 changeover in presidential administration from Obama to Trump (Shogren, 2017). As reported by Cusick (2018), the name change does not alter the type of research done by the NC CASC (or the other CASCs), but politically-related budgetary concerns for climate research were a source of uncertainty for the interview participants (see results).

Science projects funded by the CASCs may be considered to differ somewhat from the initial directive to meet fish and wildlife resource manager needs (*Projects - Climate Adaptation Science Centers*, 2019). The centers do serve the public lands governed by the DOI according to the centers' directives (*History of the CASCs*, n.d.). "Stakeholders" as defined in this study ("managers" as defined in the secretarial order) manage for natural resources on public lands. This includes federal agencies like the U.S. Forest Service and National Park Service, state agencies like Colorado Parks and Wildlife, tribes like the Northern Arapahoe and Shoshone, local municipalities, interest groups like Trout Unlimited, and local communities (*Projects - Climate Adaptation Science Centers*, 2019).

Though a diverse range of stakeholders with a diverse range of research needs, they all hold one commonality that sparks engagement with a research group like the NC CASC. Each of these groups experience or expect to experience environmental change. Warming rivers threaten indigenous fish species (Staso & Rahel, 1994), droughts have impacted (and will continue to impact) water resources (K. D. White et al., n.d.), a combination of forest management and warming temperatures have increased fire intensity and duration (Dale et al., 2001), and increased variability in temperature and precipitation regimes necessitates adaptation among multiple levels of society, from community-level norms and behaviors to federal governance (Smit et al., 2000).

In fulfilling these research needs, the CASCs have funded primary science studying climate drivers, such as evapotranspiration; climate change impacts on ecosystems; social science research studying human adaptation to climate change; and a host of collaborative and interactive activities to train both public lands managers and early career climate scientists in how to tackle the broad and interdisciplinary field of climate adaptation research (*Projects - Climate Adaptation Science Centers*, 2019). This has also included syntheses of past work in related fields to build reports that are more useful to resource planners. Some of the science funded at the CASCs has included stakeholder participation or engagement, some has sought to inform stakeholder groups, and some has focused on collaboration across agencies to leverage resources and knowledge and minimize project overlap, a goal that arguably makes science more accessible to outside groups (Secretarial Order 3289, 2009).

3.2.1. Selection of Population

The NC CASC itself was established in 2011, with projects funded thereafter, meaning that only about seven years of research exist at the present moment to study. This includes 43

projects for fiscal years 2011-2018 included in this study, according to a count in September of 2018 on the USGS-maintained website that tracks the status of CASC projects (*Projects - Climate Adaptation Science Centers*, 2019). Many of these projects are continuations, however, so a smaller sample of 16 unique projects was utilized for this study.

The *population* of the participant pool for this study encompassed *all* stakeholders associated with all 16 identified projects funded by the center. To gather a list of all of these stakeholders, one of the researchers in this study sent a request to the primary investigators (PIs) for those projects to ask for a list of stakeholders they interacted with during their research. Primary investigators are required to be affiliated with the NC CASC or a set list of affiliate organizations (*History of the CASCs*, n.d.). The list, therefore, depended on hearing back from those PIs and depended on the PIs providing a complete list for projects that might be as old as 2011-2012 fiscal years. From that list of stakeholders, an email was sent to the entire study population with the survey, and a separate email was sent to a smaller list of individuals selected for interviews. The selection of those interview participants will be detailed below. Emails to gather participants first started with a collection effort, where the primary investigators (PIs) of each of the 16 projects were emailed with a blank Excel template to gather stakeholder names.

Of the 16 projects selected, four did not send stakeholders. One replied and said, “I have to admit that, as a project funded relatively early in the history of the NC CASC, this project didn't really have any stakeholders” (*Evaluation Initiative*, personal communication, October 2018). The tone of the email might imply that as the CASC aged, more stakeholders became involved in the projects and in the context of the coproduction literature, the projects became more collaborative and less of a one-way transmission of science and therefore became more aligned with coproduction goals and practices (Beier et al., 2017), even though the goal of the

CASC was always to bridge the science-management gap on public lands (Secretarial Order 3289, 2009). Two others responded a similar lack of stakeholders to report, and those projects were all from early projects that the NC CASC funded. Similarly, the PI who did not respond was funded in the first round of project funding in fiscal year 2011, which might also explain the lack of response, be it from a lack of stakeholders or simply a factor of the time that had passed.

Is an early lack of project stakeholders a result of a lack of coproduction directives early in the CASC? While I did not have access to early requests for proposals (RFPs) for early NC CASC projects to confirm whether coproduction was a project directive, there are founding documents, annual reports, and the current (2020) RFP to reference. The NC CASC was founded because: "Management decisions made in response to climate change impacts must be informed by science and require that scientists work in tandem with those managers who are confronting climate change impacts and evaluating options to respond to such impacts" (Secretarial Order 3289, 2009, p. 3). This implies some level of direct engagement with land managers. An annual report from 2014 mentions coproduction as part of the central mission of the NC CASC: "The strength of the [NC CASC] is bringing state-of-the-science climate information into simulation of ecological impacts in a collaborative, co-production of knowledge with scientists and managers" (*North Central CSC 2014 Annual Report*, 2014). This is echoed in an earlier, 2012 annual report: "The mission of the NC [CASC] is to provide the best available climate science and tools to inform natural resource management within the North Central Domain" (*Key Documents & Reports*, n.d., p. 1). The 2017 annual report uses the phrase "co-development" to refer to working with managers (*Key Documents & Reports*, n.d.). Interestingly, the 2020 RFP science engagement along a continuum from communication to coproduction (*NC CASC Announces FY20 Funding Opportunity*, 2019). Figure 7 is pulled from that RFP.

Communicate	Consult	Collaborate/Co-Develop	Co-Produce
• Few engagements • Little extra time	• Several engagements	• On-going engagement	• Long-term & on-going engagement • Intensive time commitment
Example: Give a webinar or make a fact sheet about project results	*Example:* Consult with stakeholders regarding key species for which to run a model and later ask which are most useful variables from model outputs to summarize	*Example:* Stakeholders help refine research questions and provide input at regular points during research process	*Example:* Stakeholders are an integral part of science team and help define research questions and approach

Figure 7. The NC CASC's 2020 RFP has been made available online, and it encourages those applying for funding to consider engagement across a spectrum from communication to coproduction of science.

From "NC CASC Announces FY20 Funding Opportunity" (2014). https://nccasc.colorado.edu/news/nc-casc-announces-fy20-funding-opportunity

With no access to previous RFPs, it is unclear whether this example of coproduction was given in the past. However, for the purposes of this analysis, the continuum will be noted and referenced in the analysis. The RFP cites coproduction scholarship that was described in the literature review, including Beier (2007), Cross (2012), Glick et al. (2011), and Dilling (2018). The NC CASC also provides an informational video created by the NC CASC in 2019 that describes engagement for actionable science (NC CASC, 2019).

This RFP and resource were developed for the 2020 round of funding, and only projects funded through 2018 were included in this study. However, although the NC CASC does not always specifically mention coproduction in its foundational documents like annual reports, the mission of linking science with land managers has always been central to the NC CASC, and even across a spectrum of communication to consultation to collaboration/co-development to coproduction (Figure 7), there is science-policy interaction to be studied by an interpersonal theory. Over time, the NC CASC has incorporated the coproduction mindset more thoroughly as

evidenced by the development of resources like the NC CASC coproduction video (2019), but the focus on actionable science has always been present.

This does not explain why early projects might not have had stakeholders, but given the recency of the video, it could be that the goal was for NC CASC science to inform land management and have a practical focus, and coproduction, with its models and best practices (Meadow et al., 2015), grew as global environmental change became a more central research focus (Hackmann et al., 2014), so coproduction became more prevalent. It could also be that the centers were new – the NC CASC funded its first projects in 2011 (*Projects - Climate Adaptation Science Centers*, 2019) – and it can take time for an organization to find its footing and develop a culture, identity, and set of practices (Czarniawska, 2009).

3.2.2. Selection of Sample

To review, there were 16 unique projects to choose from over the first seven years of the NC CASC's existence (2011-2018), and though the NC CASC was founded to perform science that would be used by land managers, it is unclear whether coproduction was a focus in the early years of the NC CASC. Nevertheless, of those 16, 12 project PIs responded to a request for a list of stakeholders.

***Note**: for portions of these sections, in keeping with reflexivity considerations discussed in later sections, the author will write using the first person. Rather than say, "the researcher who authored this thesis" or "the researcher who collaborated on the interviews with the thesis author," I will use "I" and "we" pronouns. Jill Lackett, formerly University Deputy Director for the NC CASC, was the interview collaborator, and when I say "we" from here on out, I mean Jill and myself. For clarity, the third researcher mentioned frequently who was in charge of the surveys was Aparna Bamzai-Dodson.*

Of the 12 projects that reported stakeholders, at least one stakeholder was reported for each. Some PIs reported working with as many as 58 individual stakeholders, and some reported working with just one or two. A spreadsheet was compiled with each stakeholder's name, position title, agency or institution, email address, and phone number. The survey conducted by another NC CASC researcher was sent to this entire population of stakeholders. For the interviews, Jill Lackett and I had to devise a selection method. We decided based on conversations among our project team and based on guidance from qualitative literature such as Cresswell et al. (2007) to select two interview candidates for each project or, in the case where one candidate was suggested, we would only contact the one. We then needed to come up with characteristics to narrow down the stakeholder lists to interview candidates. We came up with two qualities: (1) that the stakeholders be involved to a higher degree than other stakeholders listed, with the assumption that some were more central to the work; and (2) that since the stakeholders came from a variety of agencies or institutions (broadly called "organizations" in this analysis), we would prefer representation from multiple organizations to represent multiple viewpoints where possible. Jill therefore sent a follow-up email:

> Hi [name] - thank you for submitting the stakeholder list for the [project name] project. Is there some subset of the highlighted folks that might be the best choices to interview for that portion of the study? We are looking for folks who can speak knowledgeably about the project, and that represent a diversity of affiliations. Or, we could pick a random sample from the highlighted folks to request interviews from if you think that is the best way to proceed (Lackett, Jill, personal communication, December 2018).

Based on the shorter lists, which included at least two and as many as 3-5 suggested names, we worked together to narrow down the list further.

Since co-production is generally defined as a collaborative effort across organizations to produce some shared effort, like a research project (Bovaird, 2007), and since organizational culture has already been identified as a factor that affects the outcome of coproduction (Djenontin & Meadow, 2018), and since organizational culture is studied in terms of how internal organizational identity impacts language and communication (Czarniawska, 2009), we decided to continue prioritizing *variety* in the organizations where stakeholders worked. We also took into account personalized notes about each stakeholder as sent to us by the PIs who sent their names for consideration. This included things like, "primary contact who passed information on to cooperators; now retired" (*Stakeholder Information*, personal communication, November 2018). When the PI indicated that the stakeholder had more involvement in the project or was more knowledgeable about the project, we prioritized those names.

Based on these criteria, Jill and I spent time individually winnowing down names once again. We then met up and compared our final lists and discussed any discrepancies in our lists. Though our goal was to come up with two participants for each of the 12 projects, apart from the project that only provided one name, our criteria often left us with more than two names. In those cases, we assigned each of the remaining candidates a number from one to however many candidates were remaining on the list, and we used a random number generator to select from among those names. We listed the remaining names as backup options in case those first two did not respond to our interview requests.

Within that total of 12 projects reported on, four projects had two responders. For one of those projects that two people responded to, they worked in the same office, and we scheduled a joint interview where they each reported on their roles in projects and their insights into information needs. One identified as a manager/decision-maker/planner (M), and one identified

as a combination manager/decision-maker/planner and researcher (RM), and they answered based on their roles and perspectives within the organization. Additionally, one participant was able to answer questions about two projects, including one that had minimal stakeholders that we had a hard time connecting with, so we revised that interview so they could report on multiple projects. They identified as a combination RM. That left us with 12 projects and 15 participants.

3.2.3. Limitations and Scope

Though some limitations were already mentioned, such as the fact that some PIs did not send a stakeholder list, and the fact that some sent only a few names, other limitations should be noted. First among these is the scope. Although every effort was made to select interview participants in a way that would be as impartial as possible while also yielding useful information, for the purposes of this thesis, the entire study is somewhat limited in scope. It is true that we succeeded in collecting at least one interview participant from each project that reported stakeholders, which is in its own way a success. Any replication in themes as they apply to TMIM as well as any replication in emergent themes may be considered a test of validity. However, the interviews were only conducted in one region, while the CASCs operate across the U.S. in multiple regions (*History of the CASCs*, n.d.), and coproduction takes place internationally. Djenontin and Meadow (2018) identified coproduction case studies in Australia, Indonesia, Guatemala, Argentina, Canada, West Africa, East Africa, and the U.S. That project used a grounded theory literature review method and used snowball sampling and a random search to collect research papers from past coproduction projects that they could analyze, sampling 34 papers and selecting papers from those that "provided detailed descriptions of the research teams' collaborative research methods" (Djenontin & Meadow, 2018, p. 887).

In contrast, this study's scope is limited to the stakeholders of the NC CASC, an organization nominally built to fund and conduct research that spans the science-management gap, specifically in the area of public land management (Secretarial Order 3289, 2009; (Bovaird, 2007). The NC CASC claims, "The mission of the National and Regional Climate Adaptation Science Centers (CASCs) is to deliver science to help fish, wildlife, water, land, and people adapt to a changing climate" (*Climate Adaptation Science Centers - About*, n.d.). The Djenontin and Meadow project (2018) searched for collaborative work across organizations with topics and keywords like coproduction, knowledge exchange, and interdisciplinary, which were paired with keywords like climate change, agricultural science, environmental science, and environmental management. The definition of coproduction is very similar between the NC CASC mission and the Djenontin and Meadow project. Therefore, similar types of environmental and climate land management coproduction projects are being researched. However, this project had a limited geographic scope.

It is possible that the single-organization scope might benefit this study. Since the geographic scope is limited, participants might report similar information, like information needs, a component used in the analysis of TMIM to equate with "uncertainty discrepancy," in which the information seeker has less information than needed to make a decision (Walid A. Afifi & Weiner, 2004). The limited scope can, of course, also be a detriment, as information gleaned from a more international sample base would demonstrate how organizations other than the NC CASC perform coproduction.

Another aspect of this study's geographically constricted scope is the ability to delve into the perspectives of multiple types of stakeholders while holding factors like geographic location and funding organization (NC CASC) and other resulting similarities the same. This is

essentially an in-depth case study of one coproduction context, rather than a general analysis of multiple organizations. Given that the stakeholders all come from their own organization, and given that variety in stakeholder organization representation was a goal in sampling, and also given the variety of roles stakeholders played at those organizations, the research setting for this study is still broad and diverse.

In addition to geographic scope, there is also a second limitation. To speak a little on reflexivity in advance of the reflexivity section, it should also be noted that the interviews were carried out by two former employees of the NC CASC on behalf of the NC CASC. The interviews were anonymous, but it cannot be ruled out that some of the participants had at least name recognition of if not familiarity with the interviewers before the interviews took place. This is not necessarily a negative impact on the study. It could be said that any professional familiarity between the interviewers and the participants facilitated an ease of conversation that might not have been attained if the interviewers were not known.

Additionally, qualitative methods literature strongly suggests that the interviewer *always* influences the interviews, given that body language, tone, phrasing, amount and type of follow-up questions, and more necessarily affect the way participants answer questions and converse with interviewers (Tracy, 2012). Other scholars also claim that the interviewer-interviewee interaction is a relationship that benefits from things like reciprocity and self-disclosure, implying that mutual understanding aids in information sharing (Gubrium & Holstein, 2002). Finally, based on the method selected for this analysis, the hermeneutic method, interviews are considered a conversation in which both the interviewer and interviewee interact to co-create meaning in the time and space of the interview (Patterson & Williams, 2002). These

conceptualizations of interview methods indicate that a certain level of familiarity is a strength that may serve to benefit the co-creation of meaning in the interviews.

To elaborate on the familiarity between us and the interviewees, Jill Lackett was at the time the University Deputy Director of the NC CASC and I was the NC CASC's communication specialist. The stakeholders we interviewed were more familiar with Jill than they were with me, because she handled collecting reports from PIs and therefore occasionally interacted with the stakeholders we interviewed. Many of the stakeholders were less familiar with me, but some knew me by name because of the newsletters and other communication materials I prepared for the NC CASC. At times, since I was involved in communication, the conversation drifted to science communication practice, which was ultimately beneficial to the study, since a science communication lens is being applied to TMIM as a model for coproduction interaction.

These two limitations – geographic scope and professional familiarity – are therefore noted, along with their potential strengths. To summarize, the geographic scope was limited to the boundaries of the NC CASC study region, an eight-state region which includes Montana, Wyoming, Colorado, North and South Dakota, Nebraska, and Kansas (*History of the CASCs*, n.d.). Stakeholders from across this region were interviewed, in addition to one in a more remote location that will not be disclosed because it might identify the individual. The scope is limited, therefore, which limits the breadth of data collected, but it allows the researcher to go into more depth (Creswell et al., 2007).

Secondly, the interviews were conducted by individuals with inside familiarity with the NC CASC, and the research was part of a funded project sponsored by the NC CASC. This introduces the limitation of familiarity among the interviewers and the participants, and it is recognized that that level of familiarity did impact the interviews. However, it is perhaps enough

to acknowledge that familiarity and acknowledge its potential impacts on the interviews as the analysis unfolds while keeping in mind that co-creation between interviewees and interviewers results in a type of data unique to the interview method (Patterson & Williams, 2002).

3.3. Research Philosophy and Data Collection Methodology

The NC CASC funded parts of this work, and this thesis study took that NC CASC project a step further to introduce an interpersonal communication theory to the data. The philosophies governing this thesis will now be discussed to contextualize the remaining research procedures, which will also be described, such as how interviews were conducted, how they were coded, and how they were analyzed. Leeway was given during the interview question selection for me to add questions that would inform TMIM, but the interview question selection was collaborative, and the data collected from many of the questions were used for other purposes, such as informing the strategic direction of the NC CASC. However, interestingly, a lot of the data we collected, even when it wasn't answered in response to my TMIM questions, proved to be applicable to TMIM. Therefore, all the questions will be briefly discussed, since many of them fed into the analysis.

Toward the data analysis performed for this thesis, a pragmatist ontology was employed. Because this was a relatively new application of TMIM, qualitative *interviews* were selected as a way to illuminate aspects of TMIM concepts that might not have been uncovered with different methodologies (Creswell, 2007). They were analyzed using *hermeneutic analysis*, a method of coding concepts into themes and meta-themes, or relationships between themes (Patterson & Williams, 2002). Considerations about validity will also be discussed in the sections below.

3.3.1. Pragmatism: Roots, Philosophies, and Application to Environmental Policy Communication

A 2010 study examined the prevalence of four ontologies – postpositivism, pragmatism, critical/transformative, and constructivist – among four social science disciplines – two "pure" disciplines (sociology and psychology) and two "applied" disciplines (education and nursing) (Alise & Teddlie, 2010). After classifying the ontological nature of 600 articles from the 2005 journal year, they found that 71% were primarily postpositive in nature, 16% were constructive, 10% were pragmatic, and 3% were critical (Alise & Teddlie, 2010).

Positivism and postpositivism hold several assumptions, including the idea that physical and social reality exist outside human understanding, and that human beliefs are partial and inexact. Within a communications research setting, therefore, positivists seek to identify patterns in interaction as well as the causes and mechanisms for those interactions. Postpositivism calls for peer review, replicability, and other measures to reduce subjectivity in the research process with the goal of describing reality objectively (Lindlof & Taylor, 2017).

This attainment of objective, pure reality is ultimately not possible, of course, depending on who you ask. Constructivist scholars might be more likely to argue that we only see the world through a lens (Lafont, 2004). Historic scholars Max Weber and Edward Shils suggested that the selection of a researcher's object of investigation is entirely dependent on what that researcher finds meaningful based on the portion of reality where we focus our attentions, a selection which is colored by our histories, values, and personal experiences (Weber & Shils, 1949). From there, scholars disagree about how to reduce or eliminate subjective inquiry. Weber and Shils recommended that research should focus on significant phenomena that are not dependent on an individual researcher's thoughts, and they also recommended that social scientists not take a

stance on what should be done with their research (1949). Positivism and postpositivism remain among the most prevalent ontologies for social research, at approximately 71%, if Alise and Teddlie are to be extrapolated (2010).

Constructivism in communication science, also called interpretivism, focuses more heavily on the social aspects of communication. Communication is inherently social; therefore, in studying communication, the rules that govern natural science inquiry matter less than the way in which we interpret nature (Lafont, 2004). Rather than focusing on patterns to ascertain a single reality, constructivists see reality as plural. It is unique, subjective, and context specific. Additionally, communications research is interdependent (is influenced by the researcher) and partial (Lindlof & Taylor, 2017). The fact that social science is not impartial, according to constructivism, is not necessarily a weakness.

Reviewing constructivist philosopher Immanuel Kant, social scientist Cristina Lafont describes the Kantian ideal of *reasonable agreement* as the source of social science validity, and shows that this philosophy's apparent tension with objective reality can be tempered with a careful consideration of broad societal norms as compared to the individual's values (Lafont, 2004). Knowing that objective reality may be tempered by our views and histories arguably improves social science and non-social research, allowing us to address the role of the researcher head-on rather than attempt to remove the researcher from the process (Lafont, 2004).

Critical approaches are less common in the social sciences, at 3% of the studies Alise and Teddlie uncovered (Alise & Teddlie, 2010). This type of research deals primarily with power, knowledge, discourse, and historical and cultural struggles (Lindlof & Taylor, 2017). Where the positivist and constructivist ontologies discussed have attempted to rationalize research validity by either acknowledging or removing the researcher, critical studies often find validity in

refuting previously held claims and questioning presumed relationships between phenomena (Silverman, 2013).

At about 10% of the studies uncovered by Alise and Teddlie (2010), pragmatism is also one of the less common ontologies selected by social scientists. However, there are links and ties between all of these ontologies that can inform social science research. Creswell (2007) says that pragmatism "is not committed to any one system of philosophy and reality," that pragmatists do believe in an external world independent of the mind as well as a constructed world, but that pragmatists would altogether do away with the conversation of which is which and examine a reality free of such dualisms (p. 23). Pragmatists are ultimately concerned with the application, with the problem being studied, and that research questions should stem from this consideration (Creswell, 2007).

Silverman's (2013) handbook for qualitative research states that all science should consider its application toward practice and policy. This is seen by Silverman (2013) as a factor in validity and reliability in interview method research:

> [S]some qualitative interview studies may lack the analytic imagination to provide anything more than anecdotal 'insights'. When there are also legitimate doubts about the rigour [sic] of the data analysis, then, I suggest, policy makers and practitioners should doubt the quality of the 'answers' such research provides. (p. 319)

This is essentially a pragmatist perspective on research, but Silverman (2013) states that all qualitative interviews should consider the application of their work.

Historically, pragmatism has been attributed to scholars like Charles Peirce, William James, John Dewey, Charles Horton Cooley, Jane Addams, and George Herbert Mead, scholars in the late 1800s and early 1900s whose work has been collected and reviewed over the years

(Cochran, 2002; Peirce, 1997; Schubert, 2006; Sleeper, 2001; H. White, 2010). Deweyan pragmatism is sometimes affiliated with education: "The ultimate problem of all education is to co-ordinate the psychological and the social factors. . . . [T]he child [needs] be capable of expressing [themselves], but in such a way as to realize social ends" (John Dewey, 1895, quoted in Simonson, 2001, p. 7). Dewey's focus on education was an application of pragmatism to a social concern of the time, but as a social philosophy, pragmatism extends beyond education to communication across social systems (Goldkuhl, 2012).

Among the founding ideologies of pragmatism is the refutation of several dualisms, such as that between mental reality and physical reality. The dualisms pragmatism has been said to reject include: (1) knowledge and action, meaning that knowledge and action are intertwined and inform each other rather than being separate entities; (2) mind and body, meaning that the mental world is linked to how we live in the physical world; (3) fact and value, meaning that, like constructivism puts forth, so-called facts may not be free of value attributions; and (4) individual and society, meaning essentially that we are all social creatures and that individuality arises from society just as much as society is comprised of individuals (Simonson, 2001). Another guiding factor of pragmatism is *symbolic realism*, or the shared reality created when people communicate that is deemed both separate from and arising from individual reality and objective reality (Goldkuhl, 2012). Pragmatism is rooted in a focus on shared meaning (Meyer, 2001).

Pragmatist scholars Cooley and Mead described this shared reality of communication at the time of rapid communication technology development, like the invention of the telegraph and the ability to travel the U.S. via locomotive. Society, argued Mead, is one of *ceaseless interaction* where even inner conversations can be thought of as a response to an imagined other (Joas, 1985). These philosophies informed well-known scholarships in communication fields,

like Burke's dramatism (Brock et al., 1985), which analyzes human motivation, and Habermas's communicative action and discourse ethics (Habermas, 1988), which focuses on participation and argumentation. The symbolic realism philosophies of pragmatism also influenced the Chicago school of thought, including *symbolic interactionism* (Blumer, 1986) and even the contributions of Lippmann, who contradicted pragmatism and returned to dualities of objectivity and subjectivity, but whose writings are nevertheless rooted in pragmatist ideology and the debates arising from its philosophies (Simonson, 2001).

Pragmatism is finding a revival in modern-day communication studies. Neopragmatism partly differentiates itself from traditional pragmatism in that the older pragmatist tradition prizes the *experience* of communication, with concepts like *perceptual immediacy* (Koopman, 2007). Neopragmatism focuses on linguistics, such as the semantic meaning of communication (Senft, 2007). The apparent conflict between these emphases is partially tied to an older philosophical standpoint called *foundationalism*, in which scholars before pragmatism argued that there is some metaphysical ultimate source of knowledge based in natural traits that are found in all humans (Aikin, 2009). A focus on experience is seen as being tied more closely to foundationalism, and a focus on linguistics is more behavioral and therefore easier to operationalize and quantify (Koopman, 2007). Ultimately, scholars argue that these are not disparate perspectives but rather two ways of interpreting pragmatism in symbolic interaction (Aikin, 2009), and they may even stand to learn from each other as nuances of each interpretation are parsed out by scholars in the modern conceptualization of pragmatism (Koopman, 2007).

To summarize, a positivist or postpositivist perspective can be interpreted as an attempt to remove the researcher from the research, presenting an objective view of reality (Alise &

Teddlie, 2010). Constructivism leans more in the other direction, claiming that reality is filtered through the human experience and that the best way to achieve research validity is through reasonable agreement (Lafont, 2004). Pragmatism is similar in some respects to each, but it may even be considered a middle ground of sorts, given that pragmatism encourages us to reject dualisms like facts versus values and view communication as a co-created, evolving, unfinished action that we all participate in (Shepherd, 2001). Through this lens, TMIM is poised to illuminate the shared communication space that emerges from coproduction.

Sarkki et al. (2017) brings an interesting perspective to the application of pragmatism to climate science communication, which is very similar to the science conducted by the NC CASC that is being researched here. Like Kislov et al. (2017), Sarkki and colleagues point out a "dark side" of increased engagement across the science-action (science-policy) boundary, but where Kislov et al. demonstrated concern for the knowledge broker who existed between those spaces without belonging to either, Sarkki et al. question the ethics of climate scientists messaging and packaging climate information. They discuss climate scenario planning, in particular, which can have a wide range of variability and requires skilled interpretation to unpack and understand. For example, a series of climate models produced by the NC CASC predicted four climate scenarios by 2049 for central North Dakota: warm with wet summers, hot summers with soggy springs, a "hot flood seesaw," and severe sustained drought (Symstad et al., 2017). Each of those scenarios requires different types of planning, so it is important for managers to understand their likelihood and impacts. Sarkki had the following to say about the potential for scientists to selectively present climate scenarios:

> [F]acts may not always be free from values, and since scenarios can have simultaneous positive and negative implications for sustainable development, they open up space for

> the pragmatic behavior of scenario producers to promote the scenario that best fits into pre-existing policy agendas (p. 550).

Sarkki et al. point out that tactics like reduction, or only presenting a selection of policy options, and repackaging, or reframing climate scenarios given desired objectives, might be employed by climate scientists communicating scenarios, and therefore, the scientists might not meet the qualities of being honest brokers of policy alternatives, per Pielke (2007).

This is interesting here firstly because it draws a parallel between pragmatism and the communication of climate science across boundaries. Climate science is pragmatic when it focuses on outcomes, like in the case of coproduction. In this sense, all of the science conducted by the NC CASC is pragmatic, given the foundational objectives of producing science that can be used by land managers (Secretarial Order 3289, 2009). This indicates that a pragmatist ontology for this research is also appropriate, since science should be performed in consideration of its applications (Silverman, 2013).

However, there is another aspect of this that informs this study. We did interview a stakeholder from the Symstad et al. project that conducted and reported on climate scenarios, and some of the issues discussed by Sarkki et al. did come up in the interview – the stakeholder said that it seemed to them like the science was oversimplified at times, which is essentially Sarkki et al.'s reductionism problem (2017). This stakeholder perception holds implications for TMIM as a model of coproduction interaction, which will be discussed in the results section.

Pragmatism is clearly an applicable lens for this type of communication and for coproduction type research, and there is room for disagreement and miscommunication in coproduction, as multiple scholars have pointed out, including scholars who simply attempt to classify and understand coproduction (Djenontin & Meadow, 2018; Roux et al., 2006) as well as

scholars who attempt to directly critique this type of science communication (Kislov et al., 2017; Sarkki et al., 2017). A dark side of pragmatism is also discussed by scholars of this paradigm. Communication is a relationship that does not obey the dualities of personal and social, so communication is both personal and communal/societal, and in the shared generation of meaning at any given point in time, there is room for error in the form of missed opportunities, missed attempts to come together and create a meaningful act of communication; in short, miscommunications (Shepherd, 2001).

Miscommunications and other problems at the coproduction interface are what drive this work. If the communication were always meaningful and positive for all parties involved, there would be less of a need to research coproduction. There may be a reason simply for the sake of describing and cataloguing different types of communication, which is also a goal of this research – to inform science-policy interface communication science by describing this instance of science-policy communication. However, the pragmatist ontology focuses on the context, the problem, as a source of generating research questions and conducting research (Creswell, 2007).

Similar to how Brashers (2001) developed an improved understanding of uncertainty and stated that people might wish to increase or maintain uncertainty rather than simply decrease uncertainty, miscommunication might not always be a bad thing. However, from a pragmatist perspective, what matters most is the creation of shared meaning, so miscommunications represent a failing, though perhaps they may be instructive or have other positive benefits to communication. Overall, miscommunications are worth studying, because they help inform us of how meanings can be lost in translation and how the shared creation of meaning can result in a less than ideal result moving forward, if measures are not taken to correct misunderstandings. The ideal result for the NC CASC is likely a demonstrated practical use of the science produced

– in fact, the study that funded this work had a broader goal of "closing the loop" to demonstrate that the science was actually used in policy. The miscommunications are worth studying, then, because the NC CASC, as the funding agency of this type of work, might improve their process and improve their ability to conduct science in this manner in the future.

Pragmatism leaves us with a note of hope. Early pragmatists were influenced by idealism, a philosophical movement characterized by freedom of thought and individuals' abilities to critically attend our realities and ask how we can improve them (Pinkard, 2002). Communication from a pragmatist standpoint is the action that drives social change (Shepherd, 2001). Communication comes with a charge of personal and shared responsibility, with the recognition that participating in communication results in something akin to a shared reality, a shared stream of consciousness of sorts, in which we collaborate toward shared goals (Shepherd, 2001). While there may be room for miscommunication, there is also room for collaboration in which both parties walk away with more information and therefore a greater ability to address major challenges. In this case, there is the potential for land managers to learn how to plan for global change, such as how to plan for floods and droughts and fires, for invasive species, for land use changes, and more, and therefore a greater ability to manage the resulting impacts these changes have on our societies (Hackmann et al., 2014).

3.3.2. Respondent Interviews and Attaining Validity and Reliability

Interviewing is a common practice for qualitative studies because of the types of information gathered. Interviews allow participants and interviewers to collaborate toward gathering information that both parties perceive as meaningful (Silverman, 2013). This creation of shared meaning with the interview participants reflects the pragmatist ontology that frames this study (Bohman, 2002). I will be using the interviews to gather the information that

participants wanted to share with Jill and myself, based on their previous knowledge of us and based on the questions we asked. Jill and I are not removed from the process – rather, the participants knew at least Jill by name, if not me as well, before the interviews. They were stakeholders of projects that the NC CASC had funded, and as such, some had attended meetings with NC CASC staff and representatives. This is not a limitation, but rather something that I acknowledge. Reflexivity is a common practice in qualitative research studies – the researcher cannot physically remove themselves from the interactions required to gather data (Creswell et al., 2007).

Qualitative methods were selected because of the nature of the study. We hoped to take a deeper dive into past coproduction interactions with NC CASC project teams and learn information that would help inform future coproduction interactions. Surveys and other quantitative methods would not have allowed the flexibility we wanted in exploring different ideas with the participants – we wanted their feedback and we wanted to be able to ask follow-up questions.

Interviews are, of course, not the only qualitative method to choose from – observations and the gathering of texts and documents are listed as other options of data sources by qualitative scholar Silverman (2013). In this case, observations would have been unwieldy and extremely time-consuming, since the projects being researched take place over the course of multiple years, and only a fixed amount are funded every year. Observations could have been conducted through traveling across the U.S. to multiple simultaneous coproduction project meetings, but the meetings also took place intermittently and some of the interactions were over email or phone, while some were in person. Disregarding the time and cost of doing observations, I also would not have gotten information that would inform my theory, TMIM. The information would have

been what happened in coproduction interactions, but they would have told me little about the thought processes, efficacy evaluations, outcome evaluations and other aspects of the TMIM model that take place internally to the information-seeker.

The other possible data collection method, collecting and analyzing documents, can be done and has been done by others (Djenontin & Meadow, 2018). Again, though, the information collected there does not lend much insight into the cognitive processes associated with the act of information seeking, which takes place before and during interactions. Reports such as those studied by Djenontin and Meadow were generated after the projects were completed, and they were usually generated by information providers rather than information seekers.

The interview method worked best in this case. TMIM has not been applied in science-policy interactions, so more information is needed to explore whether this theory might be useful in this context. Future research might use more superficial, quantitative-type methods to gather information about a larger sample of participants and study coproduction and other science-policy TMIM in a more generalizable way.

The purpose of this study is not necessarily to generalize, but rather to take a deeper dive into coproduction interactions and explore in an interactive way with participants their memories and experiences with regard to information seeking. From there, recommendations will be made, but it should be noted that the scope limitations (this study only interviewed stakeholders from one organization) mean that results may not be universal to the coproduction experience or to science-policy interface communication as a whole. The fact that we were able to get at least one respondent per project that reported stakeholders for the entire history of the NC CASC is meaningful to the NC CASC, as they are interested in gathering insights about each of their projects. For the purposes of rigorous research into coproduction, a larger population would have

probably been necessary to reduce the possible bias introduced by a limited geographic scope and a limited information provider scope (projects funded and conducted by NC CASC affiliated PIs and select partner organizations, according to NC CASC's funding announcements, *Apply for 2015 Research Funds*, 2014).

However, the fact that each project was represented by at least one interview may produce some variation, such as through research topic, timing across the history of the NC CASC, and variability in responders, that allows this test of TMIM to interrogate whether concepts from TMIM exist across as many factors as possible. The geographic scope is indeed limited to the states and organizations involved in these projects, mostly in the West and midwestern U.S. To the limitation of the type of information providers, all of the projects were different, so most of the PIs and project teams were different (and even when they weren't, as in one case, the stakeholders interviewed were different, and the projects were different, unless we were knowingly interviewing two people about the same project, which happened in four cases).

Again, getting multiple responses about one information provider would have reduced the amount of variability and introduced redundancies, and the results of this analysis would be more likely to be attributed to similarities with those individuals than with the coproduction interface overall. Therefore, while sampling limitations were a concern, since only participants from NC CASC funded projects in the NC CASC region of practice were interviewed, there is a high amount of variability among the participants. This is a good thing in terms of validity, because, as will be discussed more (after the interview method is described for context), one way of attaining qualitative validity is to search for anomalies in the data. If one or more cases are anomalous, then the data are considered invalid (Creswell, 2007). The more variety in the cases, then, the stronger the case for validity.

According to Berger (2015), there are four interview methods: informal, with few controls and little organization; unstructured interviews, with a focus on gaining information but still minimal control over how the interview goes; semistructured interviews, in which a list of questions is brought in but the interviewer remains open to information that extends beyond the question list; and structured interviews, in which questions and follow-up questions are always asked in a similar manner with little deviation. This study used structured-to-semistructured interviews to gather information relevant to the inquiry at hand while still maintaining flexibility should unanticipated information arise.

The possibility of new and unexpected information may be higher than normal in this study, since similar research has been done in coproduction (Djenontin & Meadow, 2018) but none following the TMIM model. There will be some flexibility in the questioning process to allow those conducting the interviews to follow trains of thought not previously considered in the construction of the interview questions.

The study used a *respondent* format, per Tracy (2012), meaning that all of the participants are stakeholders of NC CASC science and should therefore be able to uniquely respond to questions about interactions with NC CASC researchers or with other researchers and information providers. Each of the participants represents a group of people the NC CASC has reached out to and collaborated with in some way, either across disciplines or across the science-policy gap, so each participant should be able to answer questions about why they chose to interact on the projects. This commonality should allow those conducting this study to gain insight into the motivations of those who enter into these collaborations. Since we also asked about other information seeking behaviors, we also collected information about motivations to participate in information seeking with parties other than NC CASC funded scientists.

3.3.3. The Selection of Interview Questions

Using TMIM's definitional article (Walid A. Afifi & Weiner, 2004), a list of concepts were derived and a set of one or more interview questions is proposed for each:

1. **Uncertainty discrepancy** - defined as an awareness of the difference between the amount of information on hand and the amount of information needed to make a decision
    a. How would you describe the information gap or research need that was being addressed by this project? (If not mentioned, follow-up: How important was this information for carrying out your planning needs?)
    b. In what ways did the information/tools shared through the project meet or fail to meet your needs?
    c. How did you and others involved (modify during interview as we get more info about who was involved from their standpoint) use the science produced? Prompts, including continuum of science use.
        1. Other prompts: How did things change based on the tools or information shared? How did new information, processes, tools, or other results of this project influence a management plan or action?
    d. (broader information seeking) In what ways do you currently receive new information and tools to help with planning activities? Which of these avenues work well? Are there other ways that you would like to receive information or tools to be more useful to you in incorporating into planning?
    e. (broader information seeking) What are the types of uncertainty you face in planning? (prompts: bring up study - political, climate, scientific; other interview - controversy) Can you describe them?

f. (broader information seeking) What are your top agency science needs (or high-priority natural resource issues) currently? How do you envision these science needs or information gaps changing in the future?

These questions illuminate the specific information need affiliated with the NC CASC funded project as well as the participants' broader information seeking behaviors, where indicated. More than a third of the questions asked address an information gap or an uncertainty. The information use question speaks to an information gap as well in that answering this question allowed participants to talk about how new information was actually incorporated. It also informs the information management strategy concept from TMIM. The information use spectrum is defined by Taylor (1991). An additional document was provided via email in advance of the interviews (Appendix B) with brief definitions of these information uses, which include enlightenment, problem understanding, confirmation, projective, motivational, and personal/political information use. Jill slightly modified personal/political to include actionable use – use that was actually put into practice. These information uses can be practical, as coproduction so often demands as an edict of this type of science (Beier et al., 2017). However, we also wanted to discover information uses that were more cognitive in nature, expanding the role of "actionable science" to include science that had uses other than directly informing policy.

2. **Outcomes expectations** - defined as expected outcomes of approaching information provider
    a. Before these (meetings, etc.), did you have any expectations for walking away with new information, skills, or other resources?
        1. How did the encounters go, compared to what you expected?

3. **Target efficacy** - whether information provider has the ability to provide information and is trustworthy
    a. Again, looking back to before you spent time interacting with this project team, how would you have described your expectations of the team's abilities, knowledge, and trustworthiness on the topic?
        1. How did the skill level, knowledge, and trustworthiness of the members of the project team differ from those expectations?
4. **Communication efficacy** - defined as information seeker's belief that they have the ability to complete the communication task at hand - slightly modifying this to ask whether there were sufficient mechanisms in place for the sharing of information
    a. How did you expect the interactions to go in terms of being able to share necessary information? (possible prompts: Did you anticipate the research team being able to spend the time necessary to develop an understanding of your agency's needs? Did you anticipate shared understanding or shared goals? Did you expect that the research team would be able to synthesize complex information for shared understanding?)
5. **Coping efficacy** - whether the information seeker believes they have the ability, resources, and connections to carry out the information-seeking behavior
    a. ~~How would you describe the biggest challenge(s) you face in planning management actions?~~ This was included because it was part of the original protocol but was later scrapped due to time constraints after the test interview. Even though we did not ask for challenges specifically, however, that type of conversation did emerge from the interviews.

b. *How did you and others involved (modify as we get more info about who was involved from their standpoint) use the science produced? Prompts, including continuum of science use.
    1. Prompts: How did things change based on the tools or information shared? How did new information, processes, tools, or other results of this project influence a management plan or action?
c. How likely are you to engage in similar projects in the future? Why/why not? (prompts: resources available, mechanisms, internal support, etc.)

    Note: by the time we got to this question, most of the other answers had covered their likelihood to engage in similar projects, so this felt repetitive.

*question has the potential to be analyzed across multiple concepts

6. **Affect** – an emotional response regarding the uncertainty discrepancy and the possibility of seeking new information. This was originally characterized as an anxiety response to the uncertainty discrepancy (Walid A. Afifi & Weiner, 2004) but was eventually expanded to include multiple emotions (Walid A. Afifi & Morse, 2009). TMIM studies after this revision typically found the strongest causal interactions across the model with a single negative affect, like anxiety, compared to a single positive affect, like optimism (Fowler et al., 2018; Fowler & Afifi, 2011), though 18 emotions were identified by Afifi and Morse. Therefore, the question was framed in terms of positive and negative affect, with a few examples provided as prompts.
    a. Before you interacted with the project team, did you have positive or negative feeling about how you thought the interaction would go? For example, optimism, hope, trepidation, concern, etc.

3.3.4. Steps in Data Collection and the Hermeneutic Analysis of Coding

Before the interviews were conducted, Jill and I performed a test interview with someone who fit the criteria for our sample but had not been listed by the PIs as a potential interview candidate. They were someone the NC CASC had interacted with on a previous project. We did this pretest to check whether the length of the interview was too long or too short, to see whether the questions were phrased in a clear and understandable way, and to practice taking turns answering questions. We decided that Jill would ask questions in the first two sections, which had to do with the specific details of their management plans and information needs. I would ask the questions in the TMIM section, section 3, in addition to the broader questions that concluded sections 1 and 2, to somewhat even out the number of questions we each asked (Appendix A). We also practiced pausing to see if the other interviewer had any prompts or follow-up questions.

The pretest resulted in us cutting the question about challenges, since the topic overlapped with the uncertainty question we asked, and since the interview was too long. We also cut down on some of the follow-up prompts due to the time issue. We decided we wanted to try to keep the interviews to under an hour. The prompts were left in the protocol in case conversations were shorter and we needed to expand.

All of the participants were in remote locations, so none of the interviews took place in person. We scheduled interviews over video chat where possible so that we could reduce misunderstandings through the use of nonverbal communication. When video chat was not possible, we conducted phone interviews. We recorded the video chats and stored the videos on a password-protected server solely as a backup, and we relied on an audio recording device to capture the audio. We also uploaded those recordings to our password protected server and then securely uploaded them to a transcription site. We then created our codebook and coded the

transcripts when they were sent back to us, storing the codebook in a separate, also password-protected location. These related to the participants' self-identified roles at their organizations as a researcher, manager, combination of those, or neither (R, M, RM, N) along with a number, so R1 was the first researcher interviewed, and so on. The choice in how to anonymize and report these participants by their roles will also be discussed in section 3.4, presentation of data.

Only the three researchers who were on the IRB request have access to the password-protected original transcripts, and names and other identifiers (such as the name of the stakeholder's employing organization) were either removed or will not be reported in analysis. These transcripts were analyzed by the researchers involved in the study. There is a possibility of someone in the NC CASC analyzing results to help inform strategic planning and operations of the center. For the purposes of the thesis portion of the research, the results were analyzed according to the hermeneutic method, which will inform TMIM and uncover broader themes that will contextualize the TMIM analysis. At the conclusion of the project, a report was generated for the NC CASC and delivered in early 2020. This thesis will also be sent as a product of the NC CASC research.

For the purposes of this thesis, the interviews were coded into themes using the hermeneutic method (Patterson & Williams, 2002). The hermeneutic analysis calls for a close reading of each individual interview first to understand their own context, culture, and reality. The participants' meanings and systems of meanings must be taken into account when analyzing the interviews. From there, interpretations arise. Hermeneutics rejects the ideas that unbiased observation is possible, that observation is free of prior conceptions, and that numerical systems are passive forms of data representation (Patterson & Williams, 2002, p. 18). The burden of interpretation, of acknowledging the meanings the researcher brings to the process and

identifying the meanings the participants bring, is placed on the researcher. An interpretation-free analysis is not possible – rather, interpretation is the goal of the research process.

A hermeneutic analysis proceeds from an analysis of individuals' meanings to a *hermeneutic circle* in which themes are coded and relationships among those themes are discovered. The hermeneutic circle refers to the relationship between parts of an analysis and the data as a whole. This includes the idea that the individual participant accounts are interpreted with regard to the data as a whole, to the idea that researcher preconceptions relate to how the research is interpreted, and to the idea that the research process is open-ended, and the final meaning assigned to the data represents the researcher's best account of the data at that moment in time (Patterson & Williams, 2002).

Finally, the end goal of a hermeneutic analysis is not to predict relationships among variables. Rather, the goal is to "provide a better understanding of the nature and meaning of human experience in context, independent of the ability to wholly predict or control the outcome" (Patterson & Williams, 2002, p. 29). This is a more holistic, process-oriented approach that studies the values and meanings associated with experiences.

The important aspects of hermeneutic analysis include that the focus is on meaning, that the researcher is not separate from the process and that they should cyclically revisit their own assigned meanings to data, that both themes and relationships between themes should be uncovered, and that reporting is holistic, focused on the meaning in the participants' answers rather than in predictive relationships between themes. This is consistent with the goals of this research, which are to discover the existence of concepts related to TMIM in coproduction. It has already been stated that predictive relationships are not sought in this analysis, and a more holistic view is consistent with the analysis method. Additionally, the search for meaning, or the

intentions behind communication, is consistent with the pragmatic ontology utilized here. Pragmatism conceptualizes communication as a continual, never-ending process of the creation of shared meaning, the result of which is social change (Meyer, 2001). The hermeneutic analysis similarly describes analysis as linked to the researcher's assigned meanings to the data, and the process is open-ended, so a different reading of the data might produce different themes given different research goals (Patterson & Williams, 2002).

In practice, the hermeneutic analysis can be summarized as a careful consideration of individuals of analysis (interview participants) followed by the construction of themes and a consideration of the relationships among those themes. This lays the groundwork for how themes will be coded. In addition to this, concepts from the theory of TMIM will be coded, so there will be some structure going into the coding. However, emergent themes will also be coded, and they will be related to concepts from the literatures reviewed (science communication, coproduction, and TMIM). As TMIM codes are analyzed, there will be some introduction of analysis methods presented by Tracy (2012), in which structured themes from a theory are considered as part of the scope of themes to be discovered in the data.

3.3.5. Validity and Reliability

The interview method comes with its own questions of reliability and validity. Reliability in quantitative work is related to how well data generalize to other, similar research settings – if the study were performed again, would the results be similar (Jensen, 2013)? Reliability can therefore be achieved in qualitative studies through careful documentation, such as memo writing, careful transcription, and intercoder agreement, wherein two individuals compare codes and see if they coded the same passages with the same themes (Creswell, 2007). Intercoder reliability was a consideration for this project, but the co-researcher on this project had to finish

the project early, and it was not possible to perform intercoder reliability. The co-researcher (Jill Lackett) and I both reviewed the transcripts to ensure that there were little if any mis-transcriptions, and we both coded the data, but our methods differed, and we were focusing on different parts of the data. We did collaborate on the report to the NC CASC that was generated in early 2020 and agreed on a summary of results that would be useful to the NC CASC to close out the funded project. Additionally, I wrote memos throughout the process of coding to explain what I coded and why, and that information is part of the data consulted for the analysis.

On a similar note, and to situate this in the realm of hermeneutic analysis, Patterson and Williams (2002) say that validity is attained through credibility of the argument. That is, enough of the data should be shared, and enough of the path toward uncovering that data should be shared, that the reader can develop their own understanding of how the researcher came to the conclusions they did. This helps the reader make their own judgement about what they would have done and whether they agree with the results. This approach will be included here, too, especially in the first part of the results, which is a more hermeneutic reading of the codes that emerged. However, I have also tried to do this throughout, which has resulted in a lot of detail that is hopefully useful to the understanding of my approach.

In the second part of the results section, I will come back to TMIM, which will require a slightly different interpretation of validity, which will now be discussed in more detail and from multiple literatures. There may be biases introduced in the sampling of participants for this study (see the participants and sampling section), so it is unclear whether the results translate directly to other science-policy interface communication. Instead, what this study aims to do is search for TMIM concepts in one particular coproduction interface. The findings therefore are not related to

causal relationships among tested concepts, but rather related to discovering whether TMIM concepts exist in coproduction, and to recommend a tentative model for TMIM at this interface.

Validity is assessed in multiple ways, including through face validity (a judgement of whether a variable actually measures what it is intended to measure), predictive validity (a measure of causal relationships), concurrent validity (whether a measure has been proven to capture the same information as another measure that is already known to be valid), and construct validity (a measure of whether a set of related concepts collectively measure a phenomenon), and additionally, validity can be internal to the project – as in a research design that is free of apparent error – and external, as in the likelihood of the same thing happening in a different setting, though this concept is usually applied to experiments (Jensen, 2013).

External validity does not necessarily apply here, but similar to reliability, the careful notes and descriptions associated with this project should serve to describe the details surrounding this research context so that others interested in researching TMIM in coproduction may understand where differences exist and why. Predictive validity does not apply, because this study does not examine predictive or causal relationships between the components of TMIM. Construct validity may apply. TMIM has been shown to operate as a series of concepts that work together, and the various relationships among those concepts have been proven in multiple studies to date (Walid A. Afifi & Afifi, 2009; Walid A. Afifi & Weiner, 2006; Fowler et al., 2018; Fowler & Afifi, 2011). Because of this work done by others, the fact that TMIM operates as a construct may be a given, and finding evidence of each concept therefore implies a validity of the application of TMIM as a whole.

Concurrent validity does not really apply, since no other studies have applied TMIM to coproduction, but there may be some level of concurrent validity attained by comparing the

information captured by TMIM to other studies of coproduction, and this is something the results and discussion sections will attempt. Lastly, face validity is a judgement of whether the measurement tools (in this case, interview questions) seem to actually be measuring the variables of interest. To that end, there were several iterations of the research questions that were reviewed by multiple researchers, and there was also a pretest, which compared our expected answers with what a participant actually talked about. Based on that pretest, Jill and I revised some of our questions. For example, I rephrased a question on one TMIM concept, affect, based on a lack of understanding on the part of the pretest participant to add examples and prompting language.

In addition to these validity constructs, there are additional validity measures to take into account for qualitative data. Creswell et al. (2007) adds concepts like (1) a focus on *emergent design* in that the researcher must prove to be flexible in their data collecting and analysis, (2) a focus on participants' meanings, (3) a theoretical lens through which to view the data, (4) an interpretive inquiry in which the researcher's own meanings and understandings play a role, (5) an inductive data analysis in which the researcher is open to new codes and themes, and (6) a holistic account in which cause-and-effect relationships are not evaluated but rather an entire picture is painted with multiple and variable interactions among the themes identified (p. 39-40). This is all very similar to the hermeneutic method's stipulations, with the addition that a theoretical lens may be applied. This research does apply the lens of TMIM.

The manner in which qualitative data are collected and presented help paint a picture of how valid and reliable the data are. This study does attempt to describe the entire research context as well as the interconnected nature of the themes discovered, and there was a focus on describing things in the participants' own words, including a careful consideration of how to

quote and attribute as well as a focus on how to present themes with their interconnectedness (Patterson & Williams, 2002).

In addition to the matter of presentation of data, other qualitative validity considerations include examining patterns and describing why patterns are broken in the data (Silverman, 2013). For example, if a majority of the participants provide examples of a phenomenon of interest and one or two participants do not, then those anomalies should be investigated, since they might disprove the pattern, or there may be additional factors that preclude them from reporting on those experiences. Either way, the results are more valid through what Silverman (2013) calls "deviant case analysis" in which breaks from patterns are traced down and explained (p. 289). Another method Silverman (2013) introduces is the "refutability principle" in which initial assumptions about the data are interrogated throughout the analysis process, and assumptions are broken down when evidence is found to the contrary. There are no assumptions going into this research except maybe that the TMIM model applies, so the refutability principal will be employed to interrogate whether TMIM actually occurs in this setting.

Yet another Silverman (2013) principal is the comprehensive data treatment. Since qualitative methods study a smaller data set, the researcher should take any deviation from the patterns as a refutation of said patterns. According to qualitative methods scholar Mehan, "The result is an integrated, precise model that comprehensively describes a specific phenomena [sic], instead of a simple correlational statement about antecedent and consequent conditions" (1979, p. 21). This again reiterates many of the validity concepts discussed above – qualitative validity is dependent on the way in which the results are described, and the entire, holistic (Patterson & Williams, 2002) picture must be conveyed with all its intricacies in relationships among data.

Finally, for the purposes of TMIM, something akin to saturation will be sought. Saturation occurs in qualitative analysis when with each new case examined, there begins to be less new information, since new data mimic already discovered patterns and themes (Silverman, 2013). Since the goal in this analysis is simply to discover whether TMIM concepts can be applied at the coproduction interface, the analysis will start with the assumption that it does apply. As new themes are analyzed, any refutation of TMIM concepts will be considered a likely refutation of that concept existing in coproduction spaces, since the sample size is so small (as compared to a quantitative study). However, these anomalies will be investigated, and any alternative explanations as to why the concepts were refuted might add insight and suggest that the concept in fact does apply to coproduction interfaces.

To summarize, all emergent themes will be considered with the recognition that the researcher had preconceived concepts and constructs in mind, based on a review of relevant literatures (Patterson & Williams, 2002). From there, the individual participants' meanings will be examined through memo writing. Then with these ideas in mind, and with the intent to describe concepts in terms of the participants' meanings, themes will be analyzed, and a more holistic picture will be drawn with descriptions of each participant along with the connections drawn among themes. The goal will not be a predictive or causal analysis but rather a descriptive analysis using the refutibility principal to examine deviations in patterns and when such patterns fall apart upon closer examination, saturation will not be achieved and those concepts will be discarded from the analysis (Silverman, 2013).

Additionally, construct validity will be presumed (Jensen, 2013), since TMIM has been successfully applied elsewhere, so if all or most of the concepts in TMIM are existent across all participants, then the existence and applicability of TMIM as a whole will be assumed. This will

be how TMIM is tested. Though there may be apparent relationships uncovered among TMIM themes, the relationships will not be predictive, and they will only serve to paint a picture of TMIM's existence as a whole (or in parts, as the case may be).

Interviews served to draw in-depth data in the participants' own words about their outcome expectancies, efficacy evaluations, uncertainty discrepancies, and affective responses. Recommended adjustments to TMIM may be highly contextual to this group of stakeholders, and future work may help discover additional relationships and instances of TMIM concepts in this setting.

3.4. Presentation of Data

When reporting interviews, a hermeneutic analysis will be followed, which most broadly starts at the level of understanding the individual before moving to an analysis of themes (Patterson & Williams, 2002). There are multiple ways to report interview data, and most researchers use some combination of quotes and themes analysis. There are ethical considerations that accompany the attribution of quotes (Creswell, 2007), and those will be discussed here, along with a discussion of how themes will be presented in the results section.

3.4.1. Ethical Considerations, Participant Anonymity, and Quotes

When reporting interview data, it is usually deemed appropriate to report some combination of themes and quotes. However, it is important to consider how and when to quote participants. It was noted by Corden and Sainsbury (2005) that a qualitative researcher could, utilizing their multiple transcripts of interview data, probably dig enough and find a quote that would support any point of view. Therefore, simply quoting one participant, for example, is not evidence of the existence of a theme or concept across all the interviews. The strength of interview data reporting accordingly lies in thematic coding (Corden & Sainsbury, 2005;

Patterson & Williams, 2002). However, while quotes cannot necessarily be used as evidence of themes across multiple interviews, they do have other uses. Hermeneutic analysis of interviews is rooted in hermeneutic analysis of cultural text, so participant experiences and voices necessarily play a foundational role in the overall analysis, much like a cultural reading of a text (Patterson & Williams, 2002).

Quotes may therefore be used in interview reporting as long as they are not used for one-off anecdotal evidence. Other goals of using quotes may include: to illustrate certain concepts in the participants' words, to provide a deeper understanding of the concept being discussed, to engage participants' voice in the analysis and, lastly, to enhance readability, another consideration of a qualitative analysis (Corden & Sainsbury, 2005). Based on these goals, quotes will be used throughout. They will be attributed using a coding system that indicates their self-identification as a researcher, manager, both, or neither. This decision somewhat differs from the American Psychological Associations (APA) 7th Edition recommendations for quoting participants. The APA suggests assigning a pseudonym or, alternately, presenting aggregate information only for obscuring identifying information, or some combination of these (American Psychological Association, 2020). Since this analysis will be using quotes, the aggregate data reporting suggestion will not be taken here. Based on the nature of the interviews, all information that identifies participants directly such as names will be obscured.

There remains the discussion, then, of identifying participants by pseudonyms or the previously mentioned researcher, manager, both, or neither codes. Pseudonyms are certainly an option. Selecting pseudonyms takes careful work, since pseudonyms can carry assumptions about age, gender, socioeconomic status, and ethnicity (Allen & Wiles, 2016). Creswell (2012) advocates for the researcher taking full responsibility for the anonymity of their research

participants by “assigning numbers or aliases to individuals” (p. 172). Other methods scholars clarify a distinction between *anonymity*, in which the researcher has no knowledge of who answered which question, and *confidentiality*, in which the researcher or research team is privy to participant identities, but they make every effort to protect those identities in reporting, with care to protect identifying characteristics like cultural background, occupation, family relationships, and more (Saunders et al., 2014).

Both of these conceptualizations of anonymity (and confidentiality) place the onus of protecting identities on the researcher. With that in mind, and with the anonymity agreement, care will be taken in reporting quotes to not collocate quotes with particular organization names or other descriptors like cultural belonging that might reveal identities (Saunders et al., 2014).

Additionally, other scholars note that even when such identifying characteristics are removed, participants’ manner of speech may also identify the participant to their communities of practice (Damianakis & Woodford, 2012). Therefore, extra care will be taken to paraphrase when a participant’s words might identify them to their community of practice. This is ultimately a case by case decision, and there is no definitive guide for when to paraphrase and when to directly quote (Damianakis & Woodford, 2012), so a balance will be struck between maintaining confidentiality of participants and achieving the goals of allowing participants to have a voice in the report and providing a deeper understanding of certain concepts, as well as improving readability (Corden & Sainsbury, 2005).

However, this does not take care of the question of pseudonyms. Since direct quotes will at least be occasionally used, and since APA recommends attribution of some sort (American Psychological Association, 2020), some type of code or pseudonym will be used for attribution. Other hermeneutic analyses have also wrestled with these questions. A phenomenological,

hermeneutic, interview-based study of parents' experiences with neonatal home care identified quotes from their 22 participants with the label "mother" or "father," leaving solely a binary categorical distinction among their participants (Dellenmark-Blom & Wigert, 2014). The researchers then used those categories to describe differences between mothers' and fathers' responses.

Hermeneutic interviews researching the nature of wilderness experiences were labeled with a six-digit number denoting the month and day of the interview and the ordinal number of the interview on that date, and quotes were attributed using a gender, the six digit code, and a numbering system for that labeled each quote as excerpt #1, #2, #3, etc. for the purposes of referring to the quotes later in the analysis (Patterson et al., 1998). The decision to categorize the subjects as male or female was never explained in the text, and the two categories were never directly compared, unlike the mother and father categories in Dellenmark-Blom and Wigert (2014). The gender categories were apparently only used in discussion to assign pronouns to the interview participant being quoted.

A third example of hermeneutic interviews is Xiao et al. (2018), which studied cross-cultural communication in aged care homes. In Xiao et al., participants were coded as residents (R), family members (F), staff (S), and management (M), and those categories were used comparatively in the analysis, with sections in the discussion dedicated to topics like empowering *residents* in communication, restructuring communication between *staff* and *residents*, and "*co-developing communication resources"* among these groups (2018, sections 4.1-4.4). Co-development in this case has a similar ring to coproduction, but instead of co-producing new knowledge and science (Brudney & England, 1983), Xiao et al. (2018) were discussing residents, staff, management, and family members working together to build

communication structure, resources, and support programs for cross-cultural communication. Corden and Sainsbury (2005) say the following about attributing quotes to participants:

> There is growing recognition that pseudonyms have moved from being a simple way for a researcher to confer confidentiality and anonymity on research participants to a far more nuanced act of research, affected by issues of power and voice, methodological and epistemological standpoint, and considerations of the research consumers (whether institution, funder, participants, or journal reader) (p. 5).

Corden and Sainsbury (2005) go on to argue that participants should play a role in identifying themselves, even suggesting their own pseudonyms. In a study of positioning theory and aging, where childless older people were interviewed, participants were asked to select their own pseudonyms. One participant chose her mother's name, one chose her niece's name, and one chose the middle name of his partner of 46 years, a relationship that had been largely unacknowledged by society at the time (Allen & Wiles, 2013). These conversations, since they were part of a study about position theory and aging, contributed to the results in a meaningful way (Corden & Sainsbury, 2005). They also allotted agency to the participants in choosing how to best represent themselves in the research rather than imposing a naming system chosen by the researcher (Allen & Wiles, 2016).

Combining these ideas, hermeneutic analysis of interviews often results in participant attribution schemes that may identify any number of participant characteristics, from gender (Patterson et al., 1998) to family role (Dellenmark-Blom & Wigert, 2014) to organizational role (Xiao et al., 2018). The ethics of selecting pseudonyms call for both careful anonymity (Creswell, 2012; Saunders et al., 2014) and thoughtful selection of pseudonyms or other participant attribution (Corden & Sainsbury, 2005). The selection of pseudonyms or other

attribution names therefore plays a role in how interview participants are perceived in the study, so care should be taken, but the interview participants themselves may also be able to play a part in how they are identified (Allen & Wiles, 2016; Creswell, 2007).

Of all the hermeneutic interview studies mentioned, I will return to Xiao et al. (2018) as the study that most similarly mimics the interpersonal dynamics of the study researched here. Xiao et al. interviewed residents in aged care homes as well as staff, family, and management with the goal of improving cross-cultural communication. Similarly, this study interviews stakeholders who receive a service of sorts – coproduced knowledge and science – with the aim of understanding the communication that takes place across that boundary. The participants in Xiao et al. (2018) were identified according to their *roles* in the aged care home, with a lettering and numbering system such as F# for family members, R# for residents, and so on. This system was not explained in detail, but these roles made a difference in prescribed actions, and Xiao et al. analyzed each group's actions and needs as applicable. Though not as clear cut in this case, the roles that stakeholders played at their organizations made a difference in how they approached the coproduction interface and in how they interpreted the flow of information across that interface and into their own organization and broader networks. This finding will be discussed further in the results section, but for now, I conclude the discussion of anonymity and pseudonyms with the following argument about the naming scheme.

Firstly, given Creswell (2007) and other qualitative methods scholars' (Silverman, 2013; Tracy, 2012) emphasis on care toward anonymity; secondly, given Allen and Wiles' (2016) and Corden and Sainsbury's (2005) discussion of the cultural and other considerations that go into selecting a name along with their suggestions that participants play a role in selecting their own names; and finally, given examples of other hermeneutic interview reports that utilize

pseudonyms and naming schemes as categories for analysis (Dellenmark-Blom & Wigert, 2014; Patterson et al., 1998; Xiao et al., 2018), this study will use interview participants' self-identified roles within their organizations as both a pseudonym/coding scheme and unit of analysis. Hermeneutics calls for the study of individuals as a whole as a first step of analysis, followed by the coding of themes across individual transcripts with attention to the relationships among those themes (Patterson & Williams, 2002), so effort will be made in the results section to discuss both individual responses as a whole in places, as well as use pseudonyms/name codes as a "theme" that transcends individuals and can speak to trends across these roles. As a reminder, those roles were (1) manager/decision-maker/planner, (2) scientist/technician/researcher, (3) some combination, (4) none of those. This segues into the next analysis description, which will be headings/themes selected for analysis of results.

3.4.2. Overview of Themes

One theme, as already discussed, is the stakeholder/IS's self-identified role at their organization. The codes will be as follows: R (researcher/scientist/technician), M (manager/decision-maker/planner), RM (some combination), and N (neither). Based on a review of coproduction literature, no other studies of coproduction have identified stakeholders using these roles/labels. They usually are identified by the broader category of stakeholders, land managers, or user communities (Beier et al., 2017; Djenontin & Meadow, 2018); as resource managers, policymakers, or communities of practice (Roux et al., 2006), as individuals and groups/communities that collaborate on institutional practices like decision-making, resource transfer, and information sharing (Armitage et al., 2011); as institutions or citizens who collaborate toward knowledge production framed for decision-making (Miller & Wyborn, 2018); and more. Based on a review, stakeholder and manager are among the most commonly used

across these literatures, and at least one is usually mentioned in passing (Armitage et al., 2011; Beier et al., 2017; Djenontin & Meadow, 2018; Meadow et al., 2015; Miller & Wyborn, 2018; Roux et al., 2006). These scholars also make room for researchers in the coproduction interaction, but the researchers are usually not aligned with the management groups. However, the participants interviewed here were considered by the NC CASC PIs they worked with to be "stakeholders," and some of them identified as researchers, and they also pointed out that within their land management organizations, there are sometimes teams of researchers that are housed internally. Based on all this, the first section of results will be regarding participants' roles at their organizations.

This was one of the high-level themes that will drive much of the analysis. Hermeneutic analysis further recommends that themes emerge from the data in an inductive manner and be winnowed down through cyclical cross-comparisons across the datasets (Patterson & Williams, 2002). The hermeneutic analysis method per Patterson and Williams (2002) does not specifically mention inductive coding, grounded theory (Corbin & Strauss, 1990), constant comparative methods (Glaser, 1965), or anything of the like. However, it is similar in some respects to such inductive methodologies. According to Patterson and Williams (2002), the coding process is flexible to allow for reconsiderations of codes and the discovery of new, meaningful codes:

> …Do not make the mistake of thinking you will define a final organizing system at the beginning…you may find a theme strongly evident in a later interview and, upon re-reading earlier interviews, find it is there but you missed it. That is good, that is what is supposed to happen and the reason for the hermeneutic circle of analysis (p. 49).

The hermeneutic circle of analysis enables codes like the self-assigned identity code, described above, to emerge from the analysis and hold more meaning than initially intended.

However, this is ultimately a study of TMIM (Walid A. Afifi & Morse, 2009). A multitude of themes emerged from coding in this more inductive manner, but for the purposes of TMIM, this analysis also follows guidelines set forth by Tracy (2012) which states that "one of the most common and intuitive organization strategies" for a qualitative interview analysis is an organization around several themes/topics, which may be preordained by an established theory (p. 262). Since the pre-established theory of analysis was TMIM, and since questions were selected for the interviews based on how they might inform key concepts from TMIM (Appendix A), much of the results will center around TMIM concepts, and the more emergent hermeneutic themes will also be discussed in terms of TMIM.

Chapter 4. Results

The themes discussed in this section will be broken into two parts: (1) broader themes, which include codes introduced by the interview questions that were not immediate to TMIM; and (2) an analysis of TMIM codes. Also, the relationships among these will be discussed. The interview research team, Jill Lackett and I, worked together to come up with the interview questions in the protocol (Appendix A). When we conducted the interviews, Lackett was the University Deputy Director of the NC CASC, and the interview questions she selected were guided both by social science and coproduction literature as well as the evaluation initiative of our funded project, "Adaptation: Sustaining Stakeholder Engagement and Evaluation" (funded by the NC CASC, 2017-2019, with reports completed in early 2020; *Projects - Climate Adaptation Science Centers*, 2019). Given that an additional, separate report was produced for the NC CASC, this analysis will focus mainly on the interview questions pertinent to TMIM and the communication of science.

TMIM concepts will be easier to parse out, since they were determined in advance; the additional themes discovered in a hermeneutic reading of the interview transcripts could encompass a lengthy analysis, as well. A selection of themes will therefore be presented as those that held the most meaning across multiple if not all of the interviews that also serve to introduce the TMIM analysis that follows. A nearly complete (apart from those removed early in the process) list of themes can be found in Appendix D. (Note that the interviews were coded in NVivo, and figures like number of instances of each code are available but not included here.)

4.1. Broader Themes: A Hermeneutic Reading of Stakeholder Interviews

The hermeneutic circle of analysis calls for the researcher to code for concepts at the individual level before connecting themes across the data, while also paying attention to the

relationships that exist between the themes (Patterson & Williams, 2002). This section will use hermeneutic analysis to describe and contextualize the results of the interviews and discuss themes that emerged across multiple interviews. Many of the codes that emerged were preordained by the interview questions, such as a theme called "management plans" emerging from the question, *Could you briefly name and describe the long-term resource management planning documents and planning schedule of [your organization]?* (Appendix A). According to the hermeneutic circle of analysis, these themes might have additional meaning and relationships to other codes that were not predicted when the questions were formulated (Patterson & Williams, 2002). For example, data from the *management plans* theme could hold implications for the *information needs* theme, which arose from the question, *In what ways do you currently receive new information and tools to help with planning activities?* The types of management plans might inform the types of science and other information the participants said they needed. Additionally, the theme for *uncertainty* might overlap with both *management plans* and *information needs,* since uncertainty drives decisions made in management planning and also dictates at least some of the participants' information needs, and perhaps more so for information needs from outside their organization, since uncertainty implies that they do not have enough information on hand to proceed.

To briefly recap the purpose of the interview questions (Appendix A), section 1 was meant to gather information about the participants' organizations broadly. We asked questions about their management planning and the schedules for those plans with the goal of understanding how new science from the NC CASC might fit in, and we asked how they usually go about gathering new information to feed into those planning processes. We also asked what types of uncertainty they faced in planning with the goal of uncovering barriers or difficulties to

the flow of information from science to management plans, with prompts for political/controversy related uncertainty, climate uncertainty, and budget uncertainty, per White et al.'s (2008) investigation of water managers' perceptions of the science-policy interface. Section 2 narrowed in on the coproduction project the stakeholders had conducted with the NC CASC, with questions about how information was used (Taylor, 1991), the information gap that was addressed by the project, the participant's role in the project, ways the information produced met or did not meet needs, and then more broadly, top information needs for their organizations moving forward. The final section asked TMIM-specific questions about outcome expectancies, efficacies, and interactions.

The first two sections were not necessarily intended to address TMIM concepts. Nevertheless, the first section regarding broader information seeking and information needs, as well as the second section regarding project specific information needs and information uses, are nearly all applicable to TMIM, a theory that revolves around information seeking. This study specifies coproduction interactions, but it is possible that broader information seeking are also relevant to TMIM. That will be explored further. Additionally, the *uncertainty* concept informs uncertainty discrepancies (per TMIM, Walid A. Afifi and Weiner, 2004), and this concept partnered with several other themes like *affect* and management priorities together inform issue importance, which is one of the necessary conditions to ensure that the information seeker is actively attending the TMIM process rather than bypassing any of the components (Walid A. Afifi et al., 2006). Therefore, multiple concepts will be discussed in tandem in this analysis.

4.1.1. Participant Role at Organization and Other Participant Demographics

The theme of participants' roles at their organizations is introduced first because it was selected as the identifying theme to assign pseudonyms/codes to the participants. The first formal

question we asked was whether the participants identified most as a researcher or some variation thereof (technician, scientist), as a manager or some variation thereof (planner, decision-maker), as some combination of these, or as neither of those things (Table 1).

Table 1. Participants' self-assigned role at organization

Identified as…	**#**
Researchers or scientists or technicians (R)	2
Managers or decision-makers or planners (M)	3
Some combination of those (RM)	6
Neither (N)	4
Total	**15**

Side note: participants will be referred to in the gender-neutral form of "they/them/themselves/theirs" throughout this section. Of the 15 participants interviewed, two called themselves researchers/scientists/technicians, three called themselves managers/decision-makers/planners, six were some combination, and four were neither. The bins were selected by my co-interviewer, Jill Lackett, who had some experience working with many of the stakeholders we interviewed and drew both from her experience with them and coproduction literature (Beier et al., 2017). Of those in the researcher bin, R1 worked out of an academic setting with an appointment that placed them at a boundary where they were expected to share science with local science users and also bring back land management issues to the academic setting to be researched. The other researcher, R2, was a scientist for a federal land management agency's task force that gathered data from the field, doing work like setting up plots and monitoring water levels and species behaviors, and the information they collected informed land use change policies at their agency.

Of the three managers, M1 worked with a state agency that monitors recreational use of public lands. Their responsibilities included land acquisition, providing technical assistance to teams in their division, and overseeing mitigation decisions in their division. M2 was a team lead for their federal agency's landscape management plan, and they worked alongside RM1 (not yet introduced), who was in charge of a science-based subset of that plan. M3 worked at a federal agency as well as a superintendent of a smaller office at the time of the coproduction study and later, when we interviewed them, was a supervisor of their successor at that office (and one other) in their new role as a superintendent at a different site. M3's responsibilities were described as mostly supervisory and involved with the development of management plans for those agency lands.

The combination researcher/manager group was the largest. RM1 was, again, the person in charge of a subset of the management plan that M2 was overseeing. RM2 described themselves as a combination of everything except decision-maker: "I would say a combination. I'm not a decision maker. I would say ... I mean, I'm not a scientist with a PhD. I'm more on the management and applied management side of the scheme of things. Kind of all of the above, so to speak, in little bits." They worked as a "branch chief" for a state office's natural resources division and they oversaw a team of multiple scientists who gathered information on species and landscapes. They also considered themselves to be the unofficial climate adaptation lead for their office, actively searching for climate science to incorporate into their planning. RM3 said they had a hand in planning, but that actual planning was an old role, and that they now acted like a manager of science initiatives like monitoring landscapes in their federal agency's region. Their office specifically monitored species of concern in their domain.

RM4 was an interesting case, because they were interviewed as a stakeholder of one of the more internal projects to the NC CASC – they were a member of an NC CASC funded project, but they were not interviewed about that project, but rather about the information they received from a separate project team. Describing the type of information they received would likely identify the individual to those who are familiar with the NC CASC's projects, so I will limit such descriptions. However, at this point, it is useful to mention that the interwoven networks of information collection and management action are starting to become clearer for their complexities.

One of the NC CASC projects served to inform multiple NC CASC researchers and research partners, including RM4, who took that information and applied it to their project, which had to do with gathering information for local environmental planning. This connection is close enough to the NC CASC that it is internal to the research teams being funded, who are usually considered in this study to be the information providers, on the science production side of the spectrum. However, this is not the only complicated interface. Even within state and federal agencies mentioned so far, there are interwoven teams of scientists and managers who perform activities like conducting field research, supervising the scientists that collected field research, translating that research into management plans, and overseeing those who translate science into management plans.

This is one of the most significant, over-arching findings of this study: the coproduction and science-policy interface are complex, interwoven, and networked, which is something that coproduction literature often describes, so this is not new information (Meadow et al., 2015). What is relevant for this analysis is that the boundaries are less clear for the application of TMIM, which usually involves a small group of people like an aging parent and their adult child

(Fowler & Afifi, 2011) or two sexual partners discussing sexual health testing (Dillow & Labelle, 2014). In the more complex and interwoven networks of coproduction, how are the information seekers differentiated from the information providers?

Firstly, TMIM applies to interpersonal communication, and there is a great deal of interpersonal communication happening across these interfaces. When science is conducted *within* federal agencies, there is less of a boundary for transfer, because the organizations have mechanisms, roles, and protocols in place that help move information along (Czarniawska, 2009). We are therefore not interested in learning about scientist-manager communication *within* land management organizations. Where the challenge comes in, and where this study is situated, is where those organizations interact with outside groups that are not part of their usual, historical repertoire of external partners because, again, there are mechanisms in place for those types of interactions, and there is less of a precedent for external communication. The challenge in this study, then, will be piecing out and describing the qualities attributed to the TMIM coproduction interface. Is the interaction between RM4, who was transmitted information from another NC CASC funded project, an example of a TMIM coproduction interface?

In a pure coproduction sense, yes, it was coproduction, because RM4 described receiving "tailored" information from the other project team. Since the interaction was from one NC CASC project team to another, it should also be mentioned that the researchers were not necessarily colleagues. They were scientists at different institutions who partnered with the NC CASC and they applied separately for this funding. Therefore, a boundary exists, and TMIM can be considered. Based on these considerations, RM4 is an information seeker who received NC CASC project information, even though they were also using that information on their own NC CASC project.

Moving onto RM5, at the time of the NC CASC project, they were affiliated with a federal agency as a combination of researcher/planner but with a "heavy emphasis on the planning part of the first [category]". They described themselves as a coordinator who was in charge of bringing individuals of expertise together to solve "wicked problems" facing public land management, which they listed as climate change and land transfer and exchange (van Bueren et al., 2003). This is what happens when, for example, forests or wetlands are developed and turned into farmland or rangeland – the change in land use can impact ecosystems and species in the area and cause issues like impeding species migration, reducing food sources, etc. (Hackmann et al., 2014). As a side note, the wicked problems concept might help inform issue importance in terms of TMIM, since wicked problems are problems that have no best solution. Usually there are multiple values assertions at play, and any decision is a balancing act in compromises on those values. In the case of public land management, and specifically in the case of land use change or land conversion like here, the wicked problem RM5 is likely referring to is the balancing act between converting lands to an economic and food production use (farmland) or leaving the land to protect species and landscapes of aesthetic or conservation interest (Hackmann et al., 2014).

This is the only participant who mentioned wicked problems, so based on the evidence collected, I cannot postulate that all of the participants were definitely experiencing wicked problems. However, the uncertainties they discussed may reveal evidence of multiple values considerations on land management in other settings, so I will keep this one-off theme in mind later in the analysis in terms of describing issue importance. Additionally, though, since environmental management has been deemed by many to be a wicked problem (van Bueren et al., 2003) where scholars recommend the application of transdisciplinary thinking, usually

referring to multiple science groups rather than science-management groups (Brown et al., 2010), it would be safe to assume that a wicked problem construct applies to many if not all of the management problems the coproduction problems addressed, so this will be considered as evidence of issue importance in the application of TMIM.

As another brief aside, many of these individuals work as leaders or as subordinates of teams that work to collect information about global environmental change or to implement the results of science that informs global environmental change (which includes climate change and land use change). This is not a corollary for wicked problems, but it may serve to exacerbate wicked problems, adding another dimension of concern public land management decisions. For example, land use change may need to be further constricted to allow landscapes to be more resilient and interconnected in the face of droughts, which are predicted to be more severe in the future in parts of the U.S. (Borgomeo et al., 2014).

Continuing on the theme of global environmental change, one data relationship here that is possible but which cannot be proven in this analysis is the idea that coproduction is happening more frequently in the face of such environmental changes. The NC CASC often cites (*North Central CSC 2014 Annual Report*, 2014) the National Climate Assessment as a foundational document (Moss et al., 2014), which says that:

> Decisions about how to address climate change can be complex and responses will require a combination of adaptation and mitigation actions. Decision-makers – whether individuals, public officials, or others – may need help integrating scientific information into adaptation and mitigation decisions. To be effective, decision support processes need to take account of the values and goals of the key stakeholders, evolving scientific information, and the perceptions of risk. …Steps to improve collaborative decision

> processes include developing new decision support tools and building human capacity to bridge science and decision-making. (p. 957)

This demonstrates evidence that the emergence of coproduction (as a method of supporting/providing science for management decisions, Dilling & Lemos, 2011) is a method to address the challenges of environmental changes like climate change. There is a need for such outside assistance, and based on the evidence so far, many of the participants work in offices that study or incorporate environmental change science into their organizations. This holds implications for information seeking and issue importance per TMIM.

To that end, the stakeholders said the coproduction projects at times has mimicked work they were already doing, such as in the case of RM5, who was an informant on two projects. One was of great interest to their agency's leadership and they said that as a result of their interest, many people in their organization were heavily involved in the project with regular meetings and conversations. The other project RM5 described was less popular among leadership at their organization, and the organization had little to no interaction or interest in working with the project team or receiving the results.

The level of interest speaks to outcome evaluations. One of these organizations had high expectations for the outcomes of the information seeking process, and the other did not. Additionally, there was apparently some lack of communication with these individuals, unless the goal was not after all to produce science they could directly use. Either way, this case shows some issues for either goal-setting or for communication among information seekers and information providers, both of which are factors of communication efficacy (Walid A. Afifi & Weiner, 2004). It is unclear based on the interview whether it was the RM5's responsibility to convey such information between the organization and the NC CASC project team, but they did

say that "my involvement with the surrogate species one was to kind of pay attention to it, but it was never, if I remember correctly, it was never vetted much in front of our [leadership]" and that the project was more relevant to another agency. The issue could have been balancing multiple agencies' information interests and needs and choosing to prioritize one over another.

This tangent will be explored more in the TMIM section, but it does demonstrate more of the nuances in the roles that the participants played at their organizations. To close the loop on global environmental change, there is already some evidence that information seeking individuals and organizations pursue environmental change information to inform their work, and this is evidence of issue importance (since it merited funding and collaboration, and since environmental change concerns are of interest to managers, per Moss et al., 2009). Additionally, factors like uncertainty (to be discussed later) and wicked problems may complicate management decisions, further driving issue importance and information seeking behavior per TMIM.

Not *all* of the participants talked about global environmental change science as being their teams' primary aim, but I did code for mentions of climate change, which was the most frequent type of global environmental change mentioned. About half of the participants specifically mentioned climate change planning or science already happening at their agencies, and nearly all of them (14 of 15) mentioned *mechanisms* in place at their organizations for incorporating climate science, which was an unprompted question. Mechanisms described included, for example, staff at the organization whose job is to actively seek new climate information, management plans that incorporate climate science, and established relationships with partner organizations that provided climate science. Beyond direct mechanisms for seeking and incorporating climate information, all of the participants (15 of 15) mentioned climate change as at least an issue of concern.

As a side note, although the NC CASC along with the other CASCs changed in name from Climate Science Centers to Climate Adaptation Science Centers, the NC CASC is on record since the administrative changeover as saying that climate change is happening and that it is important to research climate change (Shogren, 2017). Where this organization differs from other climate efforts may be its focus on *adaptation* (evidenced by the name change in 2018, Cusick, 2018) as opposed to other actions against climate change, which may include, for example, mitigation of carbon emissions or installation/support of renewable energy measures. The existence of climate change related work is therefore probably less of a concern to the NC CASC and other climate researchers in this type of work than the budget concerns reported by Shogren (2017) and what that uncertainty meant for continuing work. One participant said that they made changes to the way they talked about climate change after the administration change, and one said that they were concerned when they sent a report up the federal chain for approval because it did include climate change language, but they said it went through anyway. This would be interesting to research further, but for the purpose of this study, the uncertainties pointed out by these individuals will be included as evidence of the uncertainty concept in TMIM and will therefore be discussed more in later sections.

The fact that 14 of 15 participants described mechanisms for incorporating climate science is not concerning (in terms of the mechanisms being present at *all* the institutions). The only participant who did not describe climate science mechanisms was at an academic institution and was removed from actual policy and planning apart from their own community-level stakeholders. It was unclear whether their stakeholders were incorporating climate science into their work. It *was* clear that even if climate change were a concern, R1 would not have described it using those terms: “I've found that often just the language you choose is important. Talking

about maybe drought more than climate change, you know?" R1 was part of an established network that provided such information, so the mechanism of at least discovering climate-related science is clear from this interview. What is less clear, since R1's stakeholders are individuals and therefore do not have organization-level science incorporation mechanisms, is the degree to which climate-related science was incorporated along these pathways. R1 did say that drought was of concern to a large percentage of their stakeholders (they described a survey in which about 70% saw drought as a direct or long-term threat to their land management).

A facsimile of saturation has been achieved in this principal of at least some type of global environmental change incorporation or interest occurring at each of these organizations. Without a more thorough understanding of each organization these participants work at, I cannot say how large those climate efforts are. At larger agencies, how large are the climate science focused staff teams? How ubiquitously are the management plans incorporating climate science information? RM2 said they were unofficial leaders of climate science and planning at their organization:

> I've had the opportunity with support from my supervisor to kind of be the climate (change) adaptation lead. I don't deal anything with the mitigation side of greenhouse gas emissions. More of, you know, here's what we can do to adapt to a changing climate. That's kind of my nutshell in my position. [RM2]

This may not be as important as the fact that many of the participants interviewed were on global environmental change related teams or described global environmental change concerns as important to their organizations.

This tangent has illuminated starting grounds for TMIM analysis and serves to describe the many facets of participants' roles at their organizations. At this point, threads of an

elaboration of the scope in which TMIM applies are starting to become clear. Though participants and their organizations are already working on global environmental change science incorporation, they are also actively seeking out new information, as evidenced by their involvement in the coproduction projects being researched here.

Additionally, they uniformly described climate change (and other environmental change concepts, like land use change) as topics of concern. Many of them described climate and other environmental change concepts as a source of uncertainty in their science and planning. Global environmental change concepts, therefore, should be considered in the application of TMIM, at the least to describe uniformity in the types of information being sought. The uncertainty surrounding environmental change may even contribute to whether these types of interactions happen at all. It is clear from the interviews that many of the organizations already had access to internal information sources like science teams that produced new science to inform decision-making. It could be that global environmental change is a cause of external information seeking. This analysis does not seek to prove causal relationships, so this idea will not be described as entirely conclusive.

However, the idea has some merit, since the NC CASC and other CASCs was founded to provide environmental change research and decision support to land managers (*History of the CASCs*, n.d.). Therefore, based on the remainder of this analysis, I might also recommend global environmental change as a contributing factor to TMIM-related information seeking.

The last participant described was RM5, who informed on two projects and was involved with a federal land management agency. Returning to the description of the participants, RM6 is one of the three tribal participants we interviewed. They described their role as one of informing,

guiding, and supporting tribal land management decisions, as well as acting as a scientist who conducted environmental research for the tribe.

Finally, the *neither* category mainly categorized themselves as advisors or coordinators. N1 was a board member who worked on "extensive long-range planning" in the capacity of chair of a land management planning board. "I'm not a direct resource manager. I have no real background in this other than a longstanding interest…and some knowledge. … Deeply involved citizen, I guess, would be another way of saying it" [N1]. In the past, they had worked as a local board member for a smaller subset of the land management collective they were chairing, and they described some of their responsibilities in their past roles, which included organizing work crews, spreading the word through local media, and volunteering with various organizations that performed land management work in the area.

N2 said they were neither of the research/management categories we mentioned but were somewhere in between:

> Definitely not decision maker and…definitely not a researcher. …I think I'm kind of in between a manager and a scientist. Just trying to collect the best data to make judgements on my resource and provide that information to decision makers. I don't have that capability…Or authority, I guess is what it is. [N2]

They described their role in a local office of a federal agency as providing information for planning documents and conducting field work toward conservation and restoration, so in a sense both informing and acting on management plans.

N3 was the second of three tribal interview participants, and they worked in a research and teaching leadership capacity. They described their role as one of offering guidance to researchers and coordinating research partnerships and funding. With regard to the NC CASC

project, they described their role as facilitating and promoting as well as offering an indigenous lens to the work being conducted.

N4 was the third tribal participant, and they described themselves as an advisor, coordinator, communicator, and planner: “I have my hand in the tech, in the research for sure and I have my hand in the writing. I definitely have my hand in the planning…I'm just one of those…idealist planners” [N4]. Although this participant described themselves as a planner, they specifically stated that they preferred to defy such labels, saying they didn’t really like talking about themselves in that respect, and that it mattered more what the people around them thought. Their current projects mainly involved coordinating local communities to manage the wilderness spaces in their regions, almost in a sense of citizen science, such as communities installing and maintaining water monitoring devices. N4 also coordinated projects across the tribe and brought in external funding to make those projects happen.

The theme of role at the participants’ organizations is an overarching one and one worth exploring early in this analysis because it describes many aspects of the research context. Based on this analysis and the tangential analysis of several related themes, some patterns are becoming apparent, such as the ways in which science is incorporated into planning, ways in which new information is sought (such as through the NC CASC funded project), and the types of information that are often sought. The theme “institutional mechanisms for science incorporation” is an emergent theme (one not directly tied to any of the questions we asked), and “information sources” is a theme from Section 1, Question 4: *In what ways do you currently receive new information and tools to help with planning activities?* (Appendix A). There are also ties between these codes and global environmental change.

Though not explicitly discussed, this section also touched on themes of boundary work, as some of the participants' roles meant coordinating with their own local communities or between federal agencies or with research teams. Additionally, though, they all coordinated with the NC CASC to some degree, since they were listed as stakeholders on the projects. I coded for "coordination work" as well as "boundary work," although after analyzing those themes, I decided "coordination work" was of lesser importance. When I initially coded coordination work, I was also noticing some differences in the language people used. Participants who used the terms Jill and I were familiar with as being related to coproduction literature, like trust building and relationship building and uncertainty and credibility, seemed to be uttered more often by people who also performed a lot of coordination work at their organizations. This is probably a self-explanatory relationship. Since some of the participants described themselves as coordinators, it stands to reason that they are more familiar with communication and relationship-building concepts. And since they interfaced with the NC CASC research team, it also stands to reason that they might have more exposure to coproduction concepts.

Boundary work will be described in more detail in this themes section, since boundary work characterizes the interaction with the NC CASC team as well as with other organizations. It will be important to the TMIM analysis to have an understanding of what the various boundaries look like between (1) the organizations we interviewed as so-called information seekers, and (2) outside organizations that can largely be characterized as information providers.

The boundary work theme section below also serves to uncover layers of the interwoven complexities of the interactions at the interfaces between the stakeholders' organizations and other organizations, rather than just the NC CASC. At times they are the information seeker, and they look for new information sources to inform their research or planning. At times they are

information providers, taking the information from the NC CASC project or other sources and distributing it to their own stakeholders, like farmers or smaller, local offices of their organizations or community members with a stake in public lands, like tribal members. The flow of information is by no means temporally or directionally bound across these interfaces. Even attempting to isolate the NC CASC projects and related interactions proved difficult, since some of the stakeholders interacted with the NC CASC project team for the first time on the project, and some had longstanding relationships with the project team and stated that the projects would not have been successful without those preestablished relationships.

To better isolate when TMIM is applied, therefore, a discussion of participants' roles at their respective organizations, alongside related themes as discussed here, has already provided some idea of scope. Firstly, a condition of TMIM in this space is that information is being shared across some organizational boundary. In the case of the NC CASC project providing information to another NC CASC project researcher, it was determined that TMIM would still apply, because the information seeker and information provider worked different organizations and their primary connection was through the project rather than within their respective organizations. This contrasts with scientists and planners/managers interacting within a single organization, since there are knowledge/information transfer mechanisms in place within organizations.

Organizational narrative literature like Czarniawska (2009) helps to describe this scope. An organization is an identity built up of processes and procedures and rules that keep things moving. When information transfer is a given because of these structures and pathways, TMIM is not applicable, because there are fewer barriers to information flow and therefore, the information seeker does not have to weigh the possible successes and failures associated with gathering new information.

Therefore, to recap, the first scope for TMIM applying to science-policy interfaces is a cross-organizational interaction that is outside the scope of typical, historically proven, institutionally built mechanisms for information flow. Since all coproduction projects are new in that they have a new research question and a new goal, and since there is an organizational barrier, coproduction projects fit the bill for a TMIM interaction. Some of the participants described organizations that they worked with regularly and received information from regularly. This is a challenge to the organizational boundary as a scope of TMIM. At what point do interactions with outside organizations become routine enough that information flow is a given?

Even if information flow is a given, perhaps conditions like familiarity with the researchers or information providers plays a role. When there is familiarity between information seekers and information providers, there may be improved communication efficacy, but coping efficacy might differ depending on the type of information, and evaluations related to target efficacy might fluctuate depending how much the information seeker believes that the information provider knows or is able to speak about different topics.

To inform this debate, I'll return briefly to other TMIM applications. TMIM has been applied in cases where there is already a longstanding relationship among the individuals involved, such as parent-child relationships (Walid A. Afifi & Afifi, 2009; Crowley & High, 2018; Fowler & Afifi, 2011), partnership relationships (Dillow & Labelle, 2014; Fowler et al., 2018), and close friendships (Chang, 2014). Therefore, lack of familiarity is not a prerequisite for TMIM to apply. The way TMIM applies in these already familiar relationships is with issues of high importance, meaning that although there might be an already-established relationship, the outcome of the conversation of interest is not entirely known by the information seeker (Walid A. Afifi et al., 2006). Efficacies are usually evaluated according to their relationships with other

variables, and multiple interrelationships, both positive and negative, have been found across applications of TMIM. It does not seem to matter, therefore, whether there is a positive or negative outcome evaluation, a positive or negative efficacy assessment, or a positive or negative relationship among any of these (although this analysis is not attempting to predict such relationships). What matters is the *existence* of either a positive or negative evaluation that can be classified within one of these concepts. Therefore, even if a longstanding relationship exists, TMIM still applies, as long as the issue carries high importance.

However, the conversation about organizational boundaries as a scope for coproduction TMIM is still useful because the scope of this application of TMIM is much larger in terms of the number of people involved (at the least, a stakeholder, the stakeholder's organization, and the NC CASC project team, although other partners and partner organizations were also involved in many of these projects). The question, then, is whether TMIM still applies when it is translated to such an interwoven and multidirectional information network.

The scope definition of an organizational boundary will still be considered. Inside of an organization, per Czarniawska (2009), there are patterns and flows through with information is transferred almost without intention, unless changes are made to the way the organizations are run. Between organizations, there may be similarly entrenched pathways, but since the organization does not operate in a way to promote the flow of information, there must be some level of intent and effort behind the information seeking. A routine may exist between organizations through which information is regularly passed. But an email must be sent, a meeting must be held, or some other intentional action must be taken to share that information.

To complicate the discussion yet again, knowledge brokers (Bielak et al., 2008; Johri, 2008; Lomas, 2007; Pielke, 2007) exist at the boundary between organizations. They usually

belong to one organization, but they interact with other organizations or individuals frequently to share information across the organizational boundary. Knowledge broker literature recognizes that organizational boundaries prevent or complicate the flow of information, so knowledge brokering as a skill is related to the successful transmission of information back and forth between organizations in a way that is useful to both (Long et al., 2013).

Coproduction literature acknowledges that for coproduction to take place, there must be some institutional mechanisms at the knowledge broker (information provider) institution that supports boundary spanning work, such as funding, incentives, and resources for boundary work (Dilling & Lemos, 2011). Then, at what point is the knowledge broker (information provider) part of the community they are informing, as opposed to part of the organization that funds or employs them?

Again, although the boundary spanning information provider might integrate well and work well with the information seeker organization, there is still an institutional boundary. At least in the case of this study, there is usually a geographic boundary since many of the NC CASC funded scientists work at universities and their stakeholders work at land management agencies or organizations (*Projects - Climate Adaptation Science Centers*, 2019). In addition to the still-existent organizational boundary, there is also a geographic boundary that necessitates some level of added intent. Rather than routinely interact with other members inside one's organization, the information seeker has to set up meetings or phone calls or send emails to connect with the information provider (or, more likely, the information provider will usually do that work). And, since at the start of each coproduction project there is a new research question or set of questions, a new type of interaction might be agreed upon at the start of the project.

That is to say, the type and amount of interaction is not necessarily a given at the start of the projects, though it may become routine over the course of the project.

Again, then, the first scope is still an organizational boundary existing between the information seeker and information provider. Within an organization, there are passive pathways for information sharing, but between organizations, there is some added effort required for information to be shared. Even when longstanding relationships exist between organizations, this added effort is still required to overcome the organizational boundary when compared to passive information pathways. And, even when boundary spanners intentionally act to share information in a more useful way for information seekers (Long et al., 2013), they still need to overcome that organizational boundary. Additionally, at the start of each coproduction project, the communication pathways to be used are not a given. They may become familiar and routine over the course of the project, but they need to be intentionally established. The fact that the interactions are not a given means that information flow is not always passive, or at least that it is not passive at the start, so TMIM may be more closely attended by the information seekers. (Interaction types across the projects will be discussed more in the next section.)

A second possible scope based on the analysis so far has to do with participants' self identified roles as scientists, managers, both, or neither. This scope relates to the organization the participants belong to. The information seeker is bounded by an organizational boundary, and within their own organizations, they may be generators of knowledge or they may be practitioners and policy leaders (or coordinators or advisors). Taken at face value, the science-policy interface categorizes scientists in one bin and policymakers in the other (Janse, 2008; D. D. White et al., 2008), and coproduction does the same, describing land managers as those who make decisions and scientists as those providing new information through the coproduction

process (Beier et al., 2017; Dilling & Lemos, 2011). However, coproduction literature does identify networks of managers and scientists working together (Meadow et al., 2015). The fact that the science and policy audiences do not overlap is probably a result of simplification of the categories for the sake of description rather than a lack of recognition of the complexity.

Since the complexity was noticed here, the distinction will be further described. It does not especially matter if the participant we interviewed was a scientist or a policymaker, a technician or a team leader for a management plan – they all belong to the same organization as the one that will be implementing the information into practice, and therefore, per Czarniawska (2009), they share a common internal set of mechanisms for science being incorporated into practice. Their level of influence at their organization may impact the degree to which new information is incorporated, but this does not change the fact that information is flowing across the organizational boundary and into the active and passive information channels that exist within that organization. Therefore, the second scope is that the information seeker may be any of the above mentioned roles – what matters is that they belong to an organization that is seeking new information.

Additionally, on that note, this analysis will add some layers of complexity to the conversation about whether a stakeholder can be a scientist or whether they must have a direct role in management plans. Since the stakeholders operate with an organization that conducts management planning, or since they have a hand in information production that is used in management planning, they are still considered information receivers. Their organizations' active and passive flow pathways allow at least some information to flow toward management decisions once the information seeker has accepted and adopted the new information into their work, be it scientific or managerial.

A third scope discussion will return to the directionality of the flow of information. For each of these projects, at least some information was exchanged from the stakeholders to the project teams and vice versa, even in just an advisory capacity. In some cases, pure coproduction took place, in which the stakeholders worked with the researchers to set up the research questions and goals and also helped carry out the research and apply it. In some cases, stakeholders were involved as coordinators or go-betweens, sharing information with the NC CASC project team that fed into the project and then taking information back with them to others who would use the information. In some cases, the goal was to produce actionable science, but the stakeholders did not end up acting on the science produced. However, even in those cases, each of the participants did demonstrate at least a cognitive information use such as enlightenment or problem understanding (Taylor, 1991). (Information use will be describe in a later section).

So, to reiterate the complex nature of the interactions at this interface, the flow of information is not always one-directional. Coproduction requires a two-directional flow of information to feed into the scientific process (Moss et al., 2014). Additionally, information can flow from the participants of this study to secondary stakeholder groups, and that is still considered a coproduction interaction because it does not ultimately matter if the information seeker used the information provided.

Therefore, to adjust the TMIM model to fit a coproduction interface, I will introduce a third scope of multidirectional information flow. However, information seekers are generally categorized as stakeholders looking to participate in funded research that informs science and management at their organizations or in their domains of practice, and information providers are still largely classified as those initiating and performing the work, who are also from an

organization outside the information seeker's organization and are working to contribute information to the information seeker's organization.

True to a hermeneutic reading of these interviews, several relationships among themes have already been discussed. Another goal was to lay the groundwork for a TMIM analysis, and since coproduction is a different interface than where TMIM is usually appled, several scope conditions have been suggested. The scope conditions are not intended as prerequisite for coproduction or as a prerequisite for any of the information seeking behaviors, but rather as a definitional outline of how and why TMIM might apply. The goal of this analysis is to piece through the intricacies of TMIM-related concepts and ask the question of whether TMIM explains the interactions in coproduction. The definitional scopes include:

1. **Organizational boundaries between information seekers and providers**: Information seekers work at land management organizations or within land management communities of practice, and information providers are affiliated with an outside organization. Information providers might act in boundary spanning roles and they may have long-standing relationships with the communities of practice, but their funding and accountability lie elsewhere.
2. **Definition of information seekers and providers**: Information providers have been described in coproduction and knowledge transfer literature as scientists, and information seekers have been identified as stakeholders or managers or some variation of practitioners. However, stakeholders can be researchers and generate information in addition to information providers. Therefore, the distinction of *scientist* versus *stakeholder* or *manager* (etc.) does not apply. Instead, the distinction is at the organizational level. Information seekers (called stakeholders usually) may be scientists,

technicians, researchers, planners, decision-makers, advisors, managers, and coordinators. What matters is that they belong to an organization that is seeking new information toward land management planning. If the information seeker adopts the new information produced by coproduction, then their organization benefits from the knowledge, albeit to different degrees depending on their roles and levels of influence. Information seekers are defined as those belonging to a land management organization or community of practice, and information providers are those from external groups that contribute expertise or knowledge or science to that organization.

3. **Multi-directionality and complexity of information flow**: Unlike the usually small-group interpersonal communication space where TMIM is usually applied, the science-policy interface is made up of a high degree of networked, interwoven, multidirectional information transfer. TMIM is typically applied when there are communicational feedbacks such as nonverbal language (Walid A. Afifi, 2015), and a similar type of feedbacks and communicative adjustments exist at the networked science-policy interface. However, the scope is larger and there may be multiple actors and communication channels at play.

Additionally, underlying factors that may contribute to issue importance and uncertainty discrepancy have been discussed. These include climate uncertainty, scientific uncertainty, and other types of uncertainties (to be detailed in a later section); use of information and mechanisms for science incorporation, which lend to a discussion of whether the information seeker found the information to be useful; global environmental change concepts like climate change and land use change, which coupled with coproduction literature might explain why outside information is sought; boundary work, coordination, and other information flow concepts, which describe how

information flows across the interface itself; interaction types, which will lead into a discussion of channels; and relationship and trust themes, which also relate to the interaction space.

Among these, several apply to TMIM. Information flow concepts and interaction concepts can be used to describe the context and scope of TMIM, which will be one of the major challenges of this analysis. It is still unclear whether TMIM can be reasonably applied, since the settings differ between this application and other typical applications of TMIM. There are a few examples of TMIM being applied across multiple channels, such as information seeking in online support groups (Kanter et al., 2019) and online information seeking without an interaction with an information provider (although the mediated source may be thought of as an information provider with evaluable attributes, combining TMIM with mass media concepts like source credibility) (Slater & Rouner, 1996; Tokunaga & Gustafson, 2014). Another TMIM concept discussed has been issue importance, and whether a coproduction interface holds enough issue importance (or something similar) to merit a consideration of TMIM as a closely attended mental process by information seekers. It has been discussed that information seekers might not actively attend routine, passive, intra-organizational information, but rather information across an organizational boundary.

With that summary of the concepts introduced in this meta-theme analysis of participants' roles at their organizations, and with a description of those participants' roles, additional demographic information will be discussed as it contributes to an overarching understanding of the study setting.

As may be ascertained from the participant descriptions above, a majority of the participants came from federal agencies (Figure 8). These include, for example, the National Park Service, the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the U.S.

Forest Service. Usually they served in one of the parks or one of the regions of those agencies rather than at any sort of national headquarters. Three were indigenous tribal members who spoke for their tribes' interactions with information providers. One was from a state agency, much like the federal land and wildlife agencies but on a different scale, and two were local – one of those was with an academic/practitioner network, and the other was from a natural resource board.

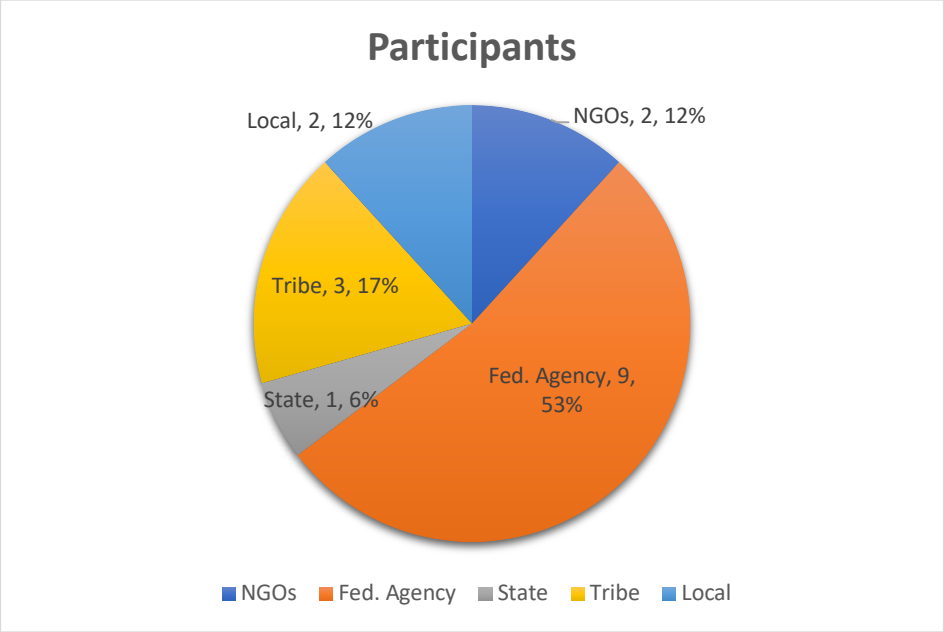

Figure 8. Breakdown of participant organization types shows that most of the participants were from federal agencies.

Additionally, each of the participants worked as either a scientist or manager of some sort for the management of public lands (Figure 9). Their land management purviews within those organizations and on those public lands include the management of recreation like park visitation, hunting, and fishing; the oversight of landscapes and species of conservation importance; and the understanding of human uses of public lands like for ranching and other resource use, such as water storage and use (*Projects - Climate Adaptation Science Centers*, 2019). Public lands make up about 40% of the total landscape in the region the NC CASC

studies, which includes Colorado, Wyoming, Montana, North and South Dakota, Nebraska, and Kansas (*History of the CASCs*, n.d.). Figure 9 shows how these lands are broken out.

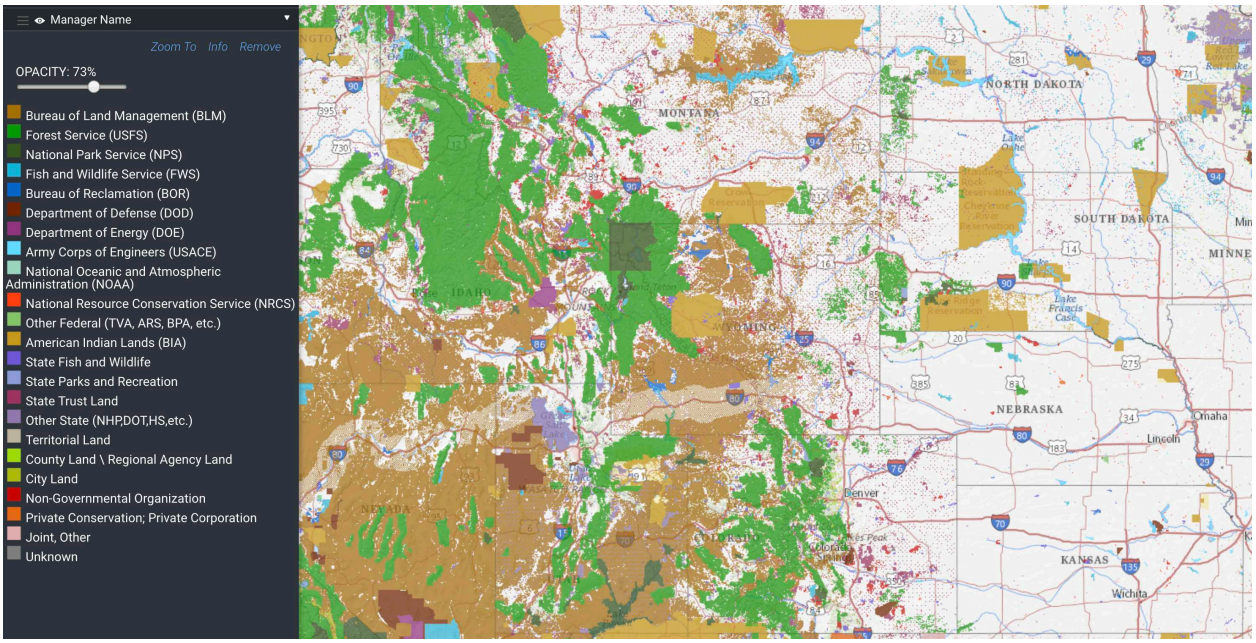

Figure 9. Public land composition in the general region of study, comprised mainly of BLM, USFS, NPS, and FWS lands.

From "Mapping Public Lands in the United States," USGS, https://www.usgs.gov/news/mapping-public-lands-united-states

Comparing this map with Figure 8's breakdown of participant organizations, we can see that the sample is fairly close to being representative of the region's public land holdings. Most of the lands are managed by federal agencies, and most of the participants are from federal agencies. American Indian Lands (Bureau of Indian Affairs managed lands) are in the orange-y tan color, and they are a smaller portion of the map than the 1/5 of the sample tribal participants represent, and state managed lands are in pale purple – there was only one state agency participant in the study. These make up a smaller footprint than Bureau of Indian Affairs land. Nongovernmental organizations are in bright red and are nearly impossible to detect on the map. Two participants were interviewed from nongovernmental organizations. The local participants category roughly corresponds with the city, private, and other lands.

There will not be an effort in this analysis to describe the differences between the types of organizations, although differences among the organizations might contribute to differences across the data. For example, a small, locally-based organization might have fewer mechanisms for incorporating science into planning actions. A lack of information use, then, might be tied to a more limited ability to immediately incorporate new information. Conversely, larger, more complex organizations might be slower to respond to new information, and it might be more difficult to say whether information was impactful. These are not actual findings, since information impact and use are only explored in this analysis to describe TMIM concepts like issue importance. However, these are the types of considerations that might utilize demographic information like organization type and role at organization.

This concludes a discussion about the roles the participants play at their organizations, a meta-theme that introduces and interplays with several other concepts discussed in the review section. TMIM will be discussed in later sections. The remaining broader themes analysis will explore in more detail some of the themes that emerged from a hermeneutic reading of the interview transcripts, and these sections will be used to continue to illuminate the study context and scope and to introduce and contextualize TMIM in coproduction. Subsequent sections here will detail the types of interactions that took place across this interface, "boundary work" or the work performed to coordinate and share information and resources across these boundaries, and information flow themes to further describe the setting.

4.1.2. Types of Interactions

Participants were interviewed because their names were provided as stakeholders of NC CASC projects in the past. Each project was an instance of coproduction in some sense of the word, although I should take some space here re-defining coproduction. Figure 7 showed that the

NC CASC has recently (in their 2020 RFP) classified communication as one end of an engagement spectrum between research teams and their stakeholders, and coproduction, with a heavily involved stakeholder group, at the other end.

Nominally, this study researches coproduction. In actuality, though, TMIM can be applied when information seekers need more information than they have on hand and when they make the decision to seek out that information. Whenever I say "coproduction" in this analysis, I may not be strictly referring to interactive coproduction where stakeholders are as involved in the research as the research team themselves. Pure coproduction, as I'll call it, entails a higher level of involvement.

Beier et al. (2017) describes conditions that improve coproduction, which include the following guiding principles: (1) "Coproduction begins with decisions that need to be made" (p. 289), (2) "Partners should give priority to processes and outcomes over stand-alone products" (p. 291), and (3) Connections should be built across disciplines and organizations among scientists and decision-makers and stakeholders. Beier et al. (2007) also recommends practices like conducting at least one in-person meeting at the start of the project, understanding the problem context before suggesting products (like climate scenarios), founding a steering committee to manage the process, returning to the goals repeatedly and ensuring that the outcomes are still desirable, and communicating the science honestly and openly with regard for the management context. They also recommend that there be support of boundary work and recommend incentivizing such interactions, which goes back to Kislov et al., 2017, and the downsides of acting between organizations like lack of room for promotion and lack of belonging to an organizational culture.

This is essentially a brief overview of the coproduction literature section with some additional emphasis on the communication practices associated with coproduction (or, at least, that are recommended for successful coproduction – whether they are always applied is unclear). A question that will be addressed in this section is whether full coproduction was conducted, and whether that matters for this analysis.

Each of the projects we interviewed stakeholders for clearly had stakeholders. Therefore, there was at least some focus on the use of the science and on the management application of the science. However, these projects exhibited the broader range of engagement types. There is an information provider and information seeker in each instance, but interactions differed.

First, the nature of the projects will be described. Some of the projects we interviewed stakeholders for generated new knowledge, and some involved a research team, led by the PI who was funded by the NC CASC, conducting secondary research and reporting useful information to their stakeholders (*Projects - Climate Adaptation Science Centers*, 2019). I'm including scenario building, for example, as a secondary type of information provision, because although new models are constructed, they are usually based on previous information that is scaled to a landscape and time frame of interest (Sarkki et al., 2017). New information is still generated, because stakeholders may provide the desired scope conditions, and the project team may select how to interpret and translate the scenarios for the stakeholders, but the climate science is usually based on already-built models (Symstad et al., 2017).

The PIs were at times directly employed by the NC CASC, and at times they were from similar organizations in the region that also conducted environmental or climate research to inform land management. Either type may receive NC CASC funding and conduct these stakeholder-driven projects (*NC CASC Announces FY20 Funding Opportunity*, 2019; NPLCC,

2014). The projects included things like evaluating the climate change related vulnerability of plant and animal species of concern, documenting societal mechanisms for climate adaptation and providing resources to local governments and interest groups, and applying climate and other environmental change models to landscapes of interest, like water basins (*Projects - Climate Adaptation Science Centers*, 2019).

The NC CASC founding documents (Secretarial Order 3289, 2009) call for the NC CASC to fund projects that allow scientists to "work in tandem" with managers to develop science that informs their policies (p. 3). It is unclear how much this directive called for specific types of interaction, if any, and it was likely that at least in early projects, NC CASC PIs decided for themselves what level and type of interaction was required to meet each project's needs. Figure 7 describes a more explicit set of examples of engagement, may have been recently developed, since there was no evidence of such suggestions in older RFPs (that I could find).

Even in the case of the 2020 RFP, though, no specific types of interactions are *required*, and PIs propose the amount and type of interaction they plan to have with stakeholders when they apply for funding (*NC CASC Announces FY20 Funding Opportunity*, 2019). Throughout the history of the NC CASC, then, there have been a variety of engagement and interaction types across the projects. In these interviews we asked how the stakeholders usually interacted with the project team. The answers to this question hold implications for how TMIM is applied (Walid A. Afifi & Weiner, 2004). I will return to this discussion in the TMIM analysis below and also make the case that TMIM should apply to all land management information-seeking, including online information-seeking, rather than just to coproduction and engagement interactions through these projects.

While the interaction types will be explored further with regard to TMIM, for now, the hermeneutic circle (Patterson & Williams, 2002) asks that researchers examine relationships across the themes. Patterns included both a variety of interaction types across all projects, from highly interactive to less interactive, and a blurred line between interactions related to the project and other types of interactions.

First, to summarize the interaction types reported, 11 participants reporting for 10 projects (two participants answered jointly for one project) explicitly mentioned workshops, the most common type of interaction mentioned. One of those participants was talking about another past interaction with the PI, however, rather than an interaction that happened during the coproduction project at hand. Of those who did not mention workshops, I was able to cross-reference with project reports and confirm that they attended at least one workshop affiliated with the project. When asked about interactions with the project team, they did mention meetings and a symposium, and they mentioned phone calls and emails, so it is unclear why they did not mention the workshop. This person considered themselves to be a researcher, so it is possible they thought of themselves as mostly contributing to the project and taking the research to their own communities of interest rather than as a stakeholder who benefitted from workshops.

While workshops were the most common type of interaction mentioned, participants also recalled in-person professional meetings and symposia, emails and phone calls, and meeting in the field. One participant even mentioned that some of the project's best conversations happened in a bar. Of those that mentioned calls, three participants remembered having regular calls, either monthly or bimonthly. One participant said they were less involved in the project, with meetings that sometimes took place twice per year with "radio silence" otherwise [RM5]. Some said the meetings were more frequent at the beginning of the project, with calls and meetings to establish

the direction of the project, and then less interaction took place over the course of the project. Some were heavily involved, assisting with the research and visiting field sites regularly over the course of the project. One of the less involved participants described their participation in the project as such:

> "I think if we were to do something like this again, I think one way that it could be improved, at least at first when we started down this process, it was a sense that this is [the PI's] process or [the PI's] project, this is the scientist's project that they want to make useful to you. As opposed to going into it with, we are co-owners, 50/50 in developing and executing a thing. It's not that the end product is going to be something I want or something you want, or it's really a co-ownership mentality that at least when we started, I felt it was more, [the PI] has this project and [they] wanted some help with it or some participation in it." [RD1]

Another participant echoed that sentiment for the same project, saying that, "…one thing that the scientists are always saying is, 'We need a management question to answer, we need a management question to answer.' To what extent are they answering a management question because they need to check that box." [D2].

This sentiment almost conveys a sense of frustration with the type of interaction and the way the interaction was perceived. One of these two participants reported high target efficacy of the PI, saying that they were confident in the PI's work and the people they could pull together. They both had a lower evaluation of the communication efficacy they would have with the PI and project team, saying things like, "a lot of scientists are pretty invested in their way of seeing the world and want to proselytize it that way and sometimes that can be a little counterproductive if we've already made some big decisions that are not seeing in the world that way" [RD1] and "I

feel like people, for good reasons, might just disagree with that decision and it's not that they're necessarily wrong, but it's just that's not going to get us anywhere "[D2]. This holds implications for communication efficacy.

This was also an example of a project that entailed less interaction, although two workshops did take place. The description of the workshops, however, details some time wasted in getting everyone on the same page: "[The PI] started thinking it was going to be one thing and then it finally got to where we all were on the same page about what we needed, his project I think, really morphed into something really different which I appreciated [the PI's] willingness to do that." In this case, even though interactions took place and attempts were made to incorporate stakeholders in the project, the project team and the stakeholders interviewed did not see eye to eye about the goals of the project at the start. The workshop helped stakeholders and the project team morph and adapt the project to meet stakeholder needs better, but this work was not done in advance, and the stakeholders were left wondering what their part was in the project, even years after the project concluded. This is a case where the types and amount of interactions did not necessarily lead to successful coproduction. There were other factors at play that made the project less successful than it could have been.

The quality of interactions played a role in other projects, as well. Several participants talked about building relationships and even trust with the project team, and some described elements like a respectful and culturally aware disposition as leading to successful partnerships. Instances where interactions began with listening to stakeholders to determine their needs were described as being more successful. One participant said that "…the other bit that was much of importance was the ability for [the project team] to listen to the conversation after the climate models were produced and then…look at seasonality and understand those kind of nuances to

how our system works" [RM4]. Another participant also described listening as a component of the workshops and meetings they participated in:

> They took a hydrology [sic]. They took in the wildlife. They took in everybody. They tried to be as inclusive as possible. And the way they interacted...they listened to everything. They were very methodical in writing ideas down, and capturing everything. So I knew that they were going to put on a good organized workshop and keep things moving and come out with a great product. [N2]

This anecdotal evidence indicates that beyond the interaction type and frequency, more is required of a coproduction interaction in order to yield success. Flexibility and listening were mentioned by multiple participants, but shared goals, respect, trust, and even the concept of buy-in were often discussed in relation to the interaction type. For one project that was largely deemed unsuccessful by the interview participant, one of the reasons for the project's failure was that the project team did not recognize the sociopolitical landscape of the organization they were working with. While some of the organizations involved supported the work, the organization the participant worked for at the time did not. "It was politically a bad place to step, at least out here, because the states…didn't like it. They didn't like the fact that they thought the [other stakeholder agency involved] was going to run roughshod over them and tell them what to do." This same participant also answered questions about another project they were involved in, and they described it as successful because that same group of people, rather than having little to no buy-in, were instead "excited" and engaged in the topic. They therefore interacted a lot more with the research team. The interaction that went poorly might be attributed to multiple stakeholders having conflicting interests and goals. In that case, not enough was done to get the stakeholders involved on the same page, if that was a goal of the project.

This idea – that interaction type and quantity alone do not make up for a positive interaction – will be revisited throughout the TMIM analysis. If a surface-level metric like quantity of interactions is not enough to result in successful coproduction, then what else goes into the process? How can these other elements be described and modeled?

This returns the discussion to the question of whether the interaction types here may apply to TMIM. In each of the cases interviewed, there was always an information seeker, or a representative of an information seeking organization that interfaced with the NC CASC project team. The project team is an example of the obvious information provider, though there may be others. Therefore, TMIM does apply in all of these instances.

The reason this study focuses so heavily on coproduction is because the project that funded this work cared to develop evaluation metrics for coproduction based on past coproduction-type projects. The less positive interactions noted in this section sometimes occurred when the stakeholder was not as engaged with the project (which again, is not necessarily related to quantity of interactions), either because they had less interest in the outcome or because there were not procedures in place such as Beier et al.'s (2017) recommended steering committee, shared goals discussions, and meetings to iterate and touch base. This is an example of pragmatism's negative side of communication, or miscommunications, in which rather than come to a shared understanding, those involved do not interact in a productive way. Meetings did occur in all of these projects, so I would argue that a lack of communication overall is not the sole cause of the miscommunication. Rather, it was a lack of structure, lack of communicating shared goals, and poorly managed time that contributed to many of the miscommunications here.

To answer the question posed at the beginning of this section, no, pure coproduction did not happen in all of these instances. At least one participant described a lack of engagement with the project team over the course of the project, and at least one project described an instance where shared goals were not achieved. However, the lessons learned in these interactions further inform the coproduction model, and regardless, there was an aim to work toward a management need in each of these cases, and there were information seeking interactions to explore with a TMIM model.

4.1.3. Boundaries, Partnerships, Working with Stakeholders

Boundary work is one of the high-level emergent themes that arose from a hermeneutic reading of the interviews. I noticed the boundary work theme because of my familiarity with boundary processes and boundary organizations (Moss et al., 2014), but it also came up because the interview participants were familiar with the term as well and brought it up on their own. The biggest implication of the boundary work theme was that the stakeholders we interviewed worked with the NC CASC, of course, but they also worked with other organizations and often mentioned having their own stakeholders. They were, therefore (or at least a majority of the participants were), well versed in boundary processes.

Insights also reinforce the idea that modeling coproduction and engagement interactions is not simple and often involves networks of individuals and groups that perform science and planning (Cvitanovic et al., 2016). This theme also holds implications for TMIM, which is mostly utilized at the level of small group interactions, like families (Walid A. Afifi et al., 2006; Banduch, 2014; Hovick, 2014; Rauscher & Hesse, 2014) or groups, like support groups (Kanter et al., 2019).

Boundary work was coded any time a participant talked about working with outside organizations (other than the NC CASC) to gather more information for their planning, any time they talked about cultural differences across boundaries (such as academia's drive to produce information which might or might not plug into management plans), and any time the participants talked about bringing science to their own stakeholders, which may have included agricultural producers or local field offices. Some of the participants had a vantage point within their agencies, institutions, or organizations (referred to as "organizations" through this section for simplicity) which lent their perspective to these boundary issues. Some participants even used the word "boundary" in their responses:

- "I think it's vital that we are taking a trans-boundary approach. So to that side of things, I also want to say that I think this is a continuing and growing trend at all levels." [M1]
- "There are a lot of those types of interactions in and out of the [region] that we're finding the…boundary really blurs because you have to manage an ecosystem or a larger area in order to most effectively protect the resources within the [region]…" [M3] [ellipses indicate organization name redacted]
- "…we're a boundary crossing organization for the people that manage actual lands, the agencies and the scientists. It's like sometimes those groups connect directly, but oftentimes it's through an organization like ourselves that are helping bring the different people together." [RM4]

These participants were the three that specifically mentioned working across "boundaries," which might indicate at least a passing familiarity with the concepts of practical science use, such as the Moss et al. chapter on decision support in the third National Climate Assessment (2014). RM4 merits further discussion, since they considered their organization to be a boundary

spanning organization. Theirs was a nongovernmental organization that conducted science and land management support and sought outside funding such as that provided by the NC CASC. This is an example of another boundary-spanning organization, presuming that the NC CASC is a boundary spanning organization itself, that conducts actionable science.

In addition to those explicit references, I also coded boundary work in all 14 interview files (14 rather than 15 since two participants were interviewed together). I also coded boundary work when participants talked about working with "the scientific community" [D2], with other land management organizations (seven of the interviews), with academia (at least five of the interviews), with land owners and extension agents (two of the interviews), and with states and other groups. This came up throughout the interviews, including when participants were talking about project teams, when they were describing their organizations and their roles within those organizations (for example, one participant said they served as a bridge to a few local agencies where they used to work before being promoted to a higher-level agency), and, in instances important to the information-seeking nature of TMIM, boundaries came up frequently when participants discussed how they usually received or sought out new tools and information. One participant said, "We certainly partner with adjacent land management agencies. We partner with state and university entities for information. It's really kind of a 360 way of looking at information gathering" [D3].

Since project interactions, decisions, and information-seeking are so complex and networked in the coproduction space, I will argue in the TMIM section for a revised scope and a slightly revised TMIM model to accommodate information seeking from multiple places and across multiple types of interaction, from workshops and meetings to even the more passive

methods for information seeking, like emails and newsletters, which some participants said were primary sources for outside information.

The existence of such a complex set of boundaries ultimately reinforces coproduction literature (Crona & Parker, 2011) and science communication engagement literature (Lomas, 2007; Long et al., 2013; Mitton et al., 2007; Pielke, 2007), and it also opens the door for a consideration of the importance of the qualities that go into successful cross-boundary interactions. Czarniawska (2009) discusses the building of an organization to the point where the organization has its own agency and identity because of the processes, regulations, cultural norms, and other factors that influence how people work within those organizations. This organizational identity is worth considering in this analysis because with much cross-boundary work taking place, there are bound to be differences in organizational landscapes like processes, timelines, goals and expectations, and more. The consideration of what goes into boundary processes is nothing new, and scholars like Kislov and colleagues (2017) point out that working at a boundary between two organizations can leave a person stranded, with no vertical growth opportunities and with a difficulty operating within each organization.

Based on the results of this set of interviews so far, factors like listening to stakeholders and achieving their buy-in are considered important to a successful coproduction interaction, but when the research teams working to achieve coproduction prioritize stakeholder needs, they may be compromising on their own organizations' or cultures' (such as scientists') norms and ideals (Kislov et al., 2017). To provide some anecdotal comparison from the interviews, RM4, who described their entire organization as a trans-boundary organization, was an example of a participant who was also a project lead on another NC CASC funded project. Therefore, I can

draw the connection and show an organization like RM4's also had a stakeholder that we interviewed, and that stakeholder reported positive outcomes with RM4's project, such as:

> The information was laid out for us, we always had ... At the beginning of every season Betsy would hold a workshop with Bill there to get everybody on board, or back on board. Remind them what we're doing. What the overall goals were. … They're meeting our needs. The process [recommended by the project for land management planning] actually works. [N1]

This participant's language indicates a clear link between the abilities and actions of RM5 and positive impressions of the project overall. The fact that a successful science application in the field happened here matters less than the participant's impression that the project went well and was a positive experience. Another participant was interviewed about RM5's project as well:

> I've got conceptually what we did. These decision chains. And so we came up with a couple of these things. And I think, I think we came out with a good product. Just been kind of working in these groups that we normally wouldn't have worked in. Just kind of working in a BLM or Forest Service-centric, or researcher-centric... So kind of like getting all these different ideas in is very useful. We wouldn't have done that otherwise. [N2]

It probably helps, of course, that the project was considered a success in terms of applying to a management decision, but both of these participants mentioned a level of success in the *process* that was created and facilitated by RM5's project team.

I do not plan to dig up organizational norms for all of the project teams that participated in these projects, but I will for contrast's sake quote another participant's negative coproduction experience:

> It was almost like they would invite the management team to respond to things, and then they went back into their behind the curtain and did their stuff, and then they would come back and ask for a response versus like it might have been really helpful to have more management on that team… the researcher's coming in with this preconceived like, "This is what we're going to do to help you out" versus maybe coming in and being like, "Hey, here's this opportunity. What do you guys think or need?" [RM3]

I again do not intend to draw predictive conclusions from this report, but the PI for RM3's project is from an academic university, and others in coproduction literature have identified cultural differences similar to those described here (Roux et al., 2006). Either way, though, what is important to this analysis is that again, meetings were held, but the intent conferred differed. In one case, the participant said they learned a lot from the process of the coproduction interactions. In the other, less of a shared understanding was achieved.

This ties back to boundary work and what it entails. Assuming, and we cannot be certain that this is the case but the literature points to it being likely, that differences were at least partly cultural, where one project team's organizational culture maybe supported coproduction more than the other, several questions arise. Where does a coproduction team leader strike the balance between upholding their own values and organizational goals and listening to stakeholder goals and needs? Is a successful coproduction interaction one that is entirely listening-based?

To pull in another branch of interpersonal communication that lends to this conversation, listening scholarship dispels the myth that "listening" is simply the act of hearing sounds, such as sitting in a room and hearing someone speak, or tuning into the radio (Pasupathi & Billitteri, 2015). Instead, listening can be thought of as the "other side of communication," without which communication would not take place (Fiumara, 1995). More than that, though, listening is not

passive but can be enacted in the form of actions, such as a company responding to customer feedback by making changes to company policies (Lacey, 2013).

Kislov et al. (2017) propose that knowledge and skills be employed by those working at boundaries, and organizations need to adopt policies and cultures that support brokering rather than requiring boundary agents to work outside of their organization's culture to be successful. Dilling and Lemos (2011) support this assertion and contend that coproduction should entail some funding and incentive for boundary work.

Pairing this with the listening ethic described, and considering what elements have so far seemed to contribute to successful coproduction, perhaps some projects were more successful than others because the research teams left behind their own, at times academic goals and acted as boundary agents. The NC CASC is poised to support this type of work given their latest RFP's suggested engagement styles (Figure 7, *NC CASC Announces FY20 Funding Opportunity*, 2019). They encourage at least some type of engagement, with *communication* at the lowest level and interactive *coproduction* at the highest level, and most (12) of the 16 unique projects funded over their first seven years reported having stakeholders in land management-type settings (aka, the population we sampled from for these interviews).

Their goal is to promote "actionable" science that is used by land managers (*History of the CASCs*, n.d.). Then, given that listening and responding to stakeholder information needs was identified in the interviews as being correlated with positive coproduction outcomes, perhaps projects funded by the NC CASC, as well as other coproduction projects, ought to place a premium on detailing and recommending best practices for communication in these spaces. The difficulty probably arises in finding a balance between setting strict and unequivocal guidelines and allowing for flexibility as the funded project teams see fit. Sets of recommendations already

exist (Beier et al., 2017), but it is not clear over the course of these interviews that any such guidelines were explicitly required or even recommended to the project teams throughout the history of the NC CACS's funded projects. It matters less whether those guidelines were actually in place than whether we were able to find evidence of those guidelines through a discovery of patterns across the dataset. Not all of the projects went well, and there were immediately obvious differences among the few projects described in terms of how well interactions went. There was, for example, a participant perception that the science team did not listen or did not involve them in the project.

Boundary work is challenging and nuanced, and the literature around boundary spanning roles and knowledge brokering as well as coproduction literature (Beier et al., 2017; Crona & Parker, 2011; Long et al., 2013; D. D. White et al., 2008) broadly indicate that boundary work can be isolating and challenging (Kislov et al., 2017) because it removes the boundary spanner from their own organizational cultures. While concepts like listening have emerged from this analysis as being associated with more positive coproduction interactions, and listening in a sense that stakeholder interests and needs are clearly and intentionally incorporated into the projects, there is also a focus on the process of communication as being separate from either the information seeker side of the information provider side.

This process is described by multiple participants, and one described it very eloquently: "It's really a catalytic process. You start with something and then it completely emerges into something else. I think that's the beauty of it" [N3]. Other accounts include, "It was on a pretty tight timeline which was necessary and by design, but it is just really, really great to me, as a specialist sitting on this team in a building surrounded by people with other specialties, to have that opportunity to confer with the scientific community about something that's not

straightforward and is really fundamentally important to the plan" [RM1] and, more esoterically: "those customs that we engage in…the soft social relational customs, they have a functional purpose and a measurable outcome" [N4].

Others described the process of communicating with the NC CASC project team as one of everyone bringing information to the table, though they did not describe the interactive process of coming away with renegotiated information. One participant said, "One of the uncertainties [we face] is how to try to continue to try to make those fit. The needs of managers versus how research is proceeding and how to try to make those work with one another" [D1]. Coproduction may not always result in a production of shared meaning, but that is a potential concept this analysis will bring to the discussion of boundaries. While there may be multiple organizational cultures at play, and while success arose from listening and responding to stakeholder needs, there was also a measure of success perceived by the participants when something changed over the course of their meetings or other interactions with the project team. More than simple sharing of knowledge, when goals and outcome expectancies change (hopefully for the better) over the course of coproduction interactions, then perhaps a communal space outside of each organizations' cultures is created and the boundary becomes a new space made up of shared goals and meanings.

This discussion of boundary spaces and boundary work mostly serves to add more description and detail to the research setting. However, boundary work is also a highly interactive process, and there were examples provided here of more successful boundary work as well as less successful boundary work. The fact that both the information seeker and information provider had to attend and participate across the boundary is noteworthy, and the fact that

boundaries can sometimes be complicated when the parties involved fail to achieve shared goals is also noted in this section of the analysis.

4.1.4. Information Flow Themes

Finally, concepts related to the flow of information across boundaries and within stakeholder organizations will be explored. Where *boundary work* described in the previous section is the *action* taken to share information at the interface between information seekers and information providers, information flow concepts relate more to what happens after information is shared or generated in those interactions. The last section demonstrated anecdotal evidence of both knowledge transfer (where knowledge stays the same) and knowledge generation, where new shared meaning is created *during* the boundary interactions.

Information flow concepts are important because they show what stakeholders do with this new information, be it transferred or newly generated. One theme already discussed to some extent in the *role at organization* section is the mechanisms through which information seeking organizations incorporate new knowledge into their organizations. This was an emergent code that usually arose from questions about timing. We asked the participants to describe their management plans, and we asked a follow-up question about whether they had an idea of when in the planning process that new information would be useful. The goal of the question was to ascertain how organizations like the NC CASC might better align with management schedules.

The existence of *institutional mechanisms for science incorporation*, my lengthy name for this theme, included science staff who gathered new information and produced reports for their colleagues, individuals who curated and distributed relevant literature for their organizations, research permits that allow teams to focus on specialty topics, partnerships with external organizations and individuals who work to provide information to the organization,

working groups where organizations send representatives to learn from others, monitoring and survey initiatives that have been carried out over the course of the organization's history, public scoping procedures that gather opinions and advice from a landscape's stakeholders (like water rights holders), and even in one case an example of natural resource trials in which scientists provided testimony that resulted in land management law.

These are all active examples of mechanisms in place that already work to incorporate new knowledge into practice. They are based on the interview participant's perspectives, so there may be more mechanisms in place at each of their organizations, and the fact that these were the mechanisms described should not signify that these are the most prominent ways that new information flows into these organizations. In other words, the list is not inclusive and exhaustive. What the list does show is some sense of the variability in the ways in which new information is collected.

To be more specific, we also asked about where participants usually got *their* information from (whereas the above list was more general to their organizations). The code for *information sources* brought some more specific details. I will go through those one by one to show how each participant described their information seeking.

M1 said that literature from others' research was an important information source. Their organization tried to apply practices that worked elsewhere: We might take research that's come from Oregon or Washington and try to assume we have to apply it here… [and] make it contextual to our needs" [M1]. They also said they worked with graduate students to conduct short term research and that they also worked with a few longer-term researchers. They described one staff position in their office whose job it was to collect climate information, but they did not see a benefit to that information seeking in their own work: "[the staff member]

provides us information, but I think that's maybe either by oversight or by feeling that the information may not apply. It's not necessarily being sought after or found out. Or it's just not made readily available" [M1]. The disconnect, M1 says, is in how well the information translates.

> [T]o give you some recent example of conversations, it then goes to, "Oh, well, it's a five-year document. How would we incorporate climate into that?" So that becomes the, well, on the one side, how could you not? Or on the other side, I see what you mean, but how do you fit it into something that's viewed as more tactical in the climate context, which is a much more broader, strategic ...[ellipsis indicates pause in conversation] So this is one of the difficult back-and-forths about how to make it fit and then does it fit, does it apply? [M1]

The problem is not necessarily in a lack of information or even a lack of information seeking behavior taking place, but rather a lack of applicability to the management planning process.

M2 and RM1 were interviewed together about the same project, but they talked about information seeking very differently. Since they work on a team together, I will outline both of their answers to the information seeking question together to show how different members of a management planning team might approach information seeking differently. As a reminder, M2 is the management plan lead, and RM1 is a scientist who is in charge of one part of the plan, so they called themselves a combination of both types of roles.

As I go through this analysis, I'm noticing that the types and update schedules of management plans sometimes plays a role, as in this case where the two worked together on the same plan. There may also be some room to compare management plans across the organizations to describe when and whether stakeholders are actively considering new long-term science

initiatives in their work. When management plans are being updated, there may be more room for information seeking. Themes of *management plans* and *management plan revisions* will therefore be discussed somewhat in this section as well, but the more important aspect is stakeholder perspectives. For example M1, above, noticed a disconnect between information seeking and information applicability.

M2 and RM1's management plan is being developed on behalf of a federal agency. Their region's plan was created in 1976 with a stipulation that the plan be updated every 10-15 years, but at the time of the interview (2019), they were in the process of conducting their first revision of the plan since it was developed.

Comparing this with M1's management plans, which updated every five years, a longer term plan may have more room for strategic, climate science type thinking. Strategic components were mentioned by M2 – in this plan, a strategic is vision laid out first, followed by rules that govern land allocations and the timing of any projects like conservation or restoration projects. "It's really important that people understand that this is not an action plan. It's not a plan that, year one, we're going to do this; year two, we're going to do this. It doesn't lay out those actions. It sets the sideboard for when the [organization] does projects" [M2]. Under that strategic plan, there are additions of travel plans (which manage how people move through the area), resources plans (which govern land being used to graze livestock or tree harvesting, for example), and monitoring plans for how resources are tracked and recorded.

M2 and RM1's plan was one of the higher-level management plans we talked about with participants. M3 described general management plans for their agency (a different agency), which are supposed to be updated every 20 years, but most of their plans were created in the '80s or '90s, according to M3. "[T]he [organization] stopped doing general management plans

because they were just too expensive and we'll be ...[pause in conversation] They came with a lot of different alternatives that never got implemented, so it's kind of a pie in the sky approach to planning" [M3]. There may be a big push every so often that results in several plans being updated, and M3 described such a push in 2016, but otherwise, plans can be fairly static.

Going back to M2 and RM1 and their information seeking, M2 said that they usually had to make decisions and move forward without worrying too much about searching endlessly for new information.

> From my perspective as the project manager, we are, by our regulations, we use available information. We are not bound to go out and find information if we have something missing. We just have to move ahead with what we have because if we didn't, you'd never get done because you'd always be out seeking more information. [D2]

However, for the management plan, D2 did say that they reached out to a few new sources, such as the NC CASC project. This was also the participant who said that time was wasted in workshops, and RM1 said that there was not a sense in those workshops that the research was meant to inform the management plan as a central goal, but rather that RM1 and their office were helping out on something the NC CASC team wanted to do. Since this was one of only a few ways that M2 identified seeking new information, this could be an example of a missed opportunity to work toward a specific management goal. M2 also said that they had a good amount of trust and history with the NC CASC PI, which could explain why they decided to participate in the project.

In contrast, RM1 talked about seeking information a lot more. This is probably a function of their roles. M2 needed to take what was on hand and make decisions and keep things moving, and it was RM1's job (along with others) to bring that information to the table. RM1 said they

subscribed to “various listservs and information sources… that could be just scientific literature, publications, or listservs for various groups within the [organization] or [outside organization] that deals with various issues related to [planning or ecology].” [RM1]

They also regularly exchange emails with peer groups in other regions, and they also said that they got a lot of information through the public commenting process, which is something they were in charge of. They said the commenting process can be useful, as in the case of experts contributing comments that they would not have considered otherwise.

Even though RM1 was more involved in information seeking than M2, they both agreed that there is sometimes too much information and that it can become a challenge of how much time they have. “[F]rom my observation is related to capacity. It's not that we don't have the venue to do some of this technology transfer, it's that we don't have the bandwidth to really make that happen in an effective way” [RM1]. This comment was closely followed by M2 saying, “No, I was just going to say, it's something of a fire hose and there's plenty of digest that come through the email, but yeah how much time you have to dig into it?”

The issue with M1’s incorporation of science, then, was an incompatibility between the strategic information that they were seeking (climate information) and the tactical qualities of the plan itself, which did not leave much room for strategic level planning. M2 and RM1 were working on a more strategic plan and had the capability of incorporating more complex information, and they said that climate was still a major source of uncertainty in the plan, even though they were capable of incorporating climate science to some degree. The issue in that case was rather their capacity to take in new information and translate it into the plan. They felt that they had to limit themselves somewhat and cut off the flow of information at some point. This is also an indication that they do not lack new information sources, but rather that they might not

always seek information even when it is available. With regard to climate uncertainty in particular, M2 said that “the uncertainty is so big it's almost useless in terms of trying to plan for it.” They did not say how they planned to incorporate climate science into the plan, but the fact that they see climate as a source of uncertainty and find it difficult to manage likely implies that they either need more information and do not have time to seek it out or that they have attempted to gather the information and do not see it as being compatible with the plan.

In both of those cases, this points to clear parallels with TMIM. Climate uncertainty is an uncertainty discrepancy, and information seeking behaviors may not currently be related to climate information in particular, but information seeking in general is a challenge, which speaks to coping efficacy – neither of these individuals felt that they had as much ability as they would like to incorporate new information into their work.

Moving along to D3, their management plans have already been described – they are not often updated unless there is a big national-level push for updates. They said that their office had a “360 view on information gathering” where they approached academia, states, and other land management agencies regularly, and that they also had internal processes for new information acquisition like permits that fund projects when information is needed. They did not seem to have a diminished capacity to incorporate new information, which might point to more time or more support from institutional processes. It could also be a factor of the fact that M2 and RM1 were working under a timeline to update their plan, while M3 was not hoping to use the information provided for any of their plans. To add more detail, of the NC CASC project, they said that they wished it had gone further to continue relationships with some of their interested partners, like tribes in the region. They seemed to be interested in more engagement and more information flow than was provided.

N1 was an advisor and volunteer chair of a natural resource planning board. They are working on one large management plan that will be used to dictate how a scarce resource will be managed for the future with factors like population growth and climate change taken into account. They mainly mentioned particular information providers they consulted with regularly, and said, “I wouldn't say we're doing a disciplined literature search, but we're accumulating quite a lot of useful information that is going to help us in coming up with our own answers to some of the questions about [the resource]” [N1].

N2 was the participant who said they were not in a position to make management decisions at their organization, nor were they scientists, but rather they collected data and carried out management plans. They said that when they collaborated with another agency, they noticed discrepancies in information accessibility. Within their own agency, there was not a good library of information and they were also not part of any information transfer mechanisms in the organization. They compared this to another organization they worked with briefly, which had regular information digests and a collection of resources they could access. Instead, at their current position, they usually had to do their own information searches and they highly valued the use of conferences to interact with people and gather new information.

With N3, we skipped some of the questions about information seeking. This was because the participant was mostly involved in informing research, monitoring projects being conducted by others, and also serving as a consultant, adding an indigenous perspective to projects like the NC CASC’s. N4 was a broad-scale coordinator who put others to work monitoring and collecting data, and most of their information seeking had to do with interacting with these communities.

The variability in information uses might have implications for TMIM, which will be discussed in the next section. The manager category (as well as RM1 so far, though other RMs have not yet been discussed) all specifically described management plans for which they were looking for new information, but when the interview participant worked in a role of advising the project like N3, did information seeking take place? Even though N3 was not seeking information for their own use from the NC CASC project, they did describe broader information needs and information seeking behaviors within the tribe. It was not coded as such because the organization they work for is a research organization that does not carry out planning. Nevertheless, there are still information seeking data to gather from that interview. That will be addressed in the TMIM section.

As a side note, only a few interview protocols were modified for the interviews. One was for RD5, who informed us about two NC CASC projects. To make sure we were able to gather data about both of those projects, we decided to prioritize project-related questions. The others were R1 and N3, whose organizations did not conduct management plans. We therefore cut out management plan questions, which included some of the bigger-picture information seeking questions being described in this information flow themes section.

R1 was a researcher also affiliated with an academic institution and they had their own communities of interest, usually individuals and communities who managed large pieces of land. They said they operate in a network of university research organizations (without naming them, they are subset groups focused on natural resource science) as well as federal agencies to gather information. They also worked on their own to stay up to date on the current research in their field and also mentioned social media in particular as a way to find condensed science that is more easily digestible.

R2 did not talk much about management plans, and they did not say they worked on management plans. Rather, they were in charge of data collection that informed management treatments. They said they worked to help people applying management treatments get "the best bang for their buck" in terms of where and how to apply the treatments. In terms of information seeking, their job entailed a lot of their own research, but they also said that if they had a question, they would usually find someone from a university or agency to answer it. They said they depend more on talking to people than on catching up on literature, though they do both: "we certainly rely on scientific literature, but I think a lot of the stuff that's out there gets published more for the sake of being published than really addressing a specific need" [R2].

RM1 was already discussed in tangent with M2 above. RM2 worked with a federal agency, and they described management plans happening at the scale of field offices, or local offices that handle a landscape of interest (like a forest or a series of wetlands). (Note that the examples provided throughout are usually only similar rather than exact, because identifying the resource they manage would likely identify the organization they work with, and it was a goal to protect the participants from such identifying information that could make their identities obvious to people who know them). Those field-scale plans go through a public process, meaning that the public is given time to comment, and the plans can therefore take as many as 10 years to develop when they are really supposed to take about a year. The plans typically stick around for about 20-30 years. "We're almost talking 30 years from a plan, and they are completely out of date" [RM2].

With regard to climate, RM2 says these plans used to only nominally describe climate change in terms of air quality monitoring and required levels of pollutants, but "We had air quality issues 180 years ago at the start of the Industrial Revolution, so those two are not

synonymous with each other, and it finally dawned on me that we probably want to describe climate change" [RM2]. Now they said there are more tools to incorporate climate into the plans, like downscaled models (large climate models that are scaled to a time and landscape of interest). However, the challenge, and the uncertainty, comes in in translating this to applications, as mentioned by others.

> [W]hat we should really be doing in those land use plans is describing how climate change will affect certain resources such as wildlife. Is it going to alter for big game winter range? Is it going to alter timing and movement of animals and that? How is it going to affect water runoff, which has effects for fisheries, also recreation from a white water rafting perspective, and how we issue permits? [RM2]

R2 went on to describe how poorly climate change had been incorporated to date, and said that since climate change affects every resource they care about, they need to be doing more. This indicates a high uncertainty discrepancy toward TMIM. As far as information seeking, they have a team of scientists with varied backgrounds that they work with directly in their office, that they gathered information from public comments, and that they also heavily relied on properly constructed teams on cross-agency projects like those with the NC CASC for other information.

> So these workshops I think are real critical. I mean, we have scoping meetings. Typically what we have are these what we call scoping meetings, and basically it's like an evening meeting where the public comes in, and they can provide either oral comments that we record, or they can provide written comments. But a lot of them are just like, "Don't do this, and don't do that. Please do this, and please do that." You know, they're not really providing us any information, I mean, where we are getting real thoughtful strategies on how to manage public lands. I think workshops and scenario planning would be really ...

> [pause in conversation] I can't stress that enough, early on in the process to bring in, you know, identify the right people to bring in.

Apart from this comparison of the public commenting process, which might be less useful in terms of land management applications, and interagency project teams like the workshops with the NC CASC, RM2 did not describe many other information sources. Most of theirs were interpersonal in nature.

RM3 described a particular type of their federal agency's management plans, which were developed in the late 1980s and early 1990s and have been modified more since the 2000s. They are not intended to be static but to adapt over time. They may be modified every 5-10 years, though that has not been made official. Information sources for these include "seeking out specialists you know," "doing your own literature search," or relying on fellow staff depending on the size of the office [RM3].

RM4 was the participant who said they worked at a boundary organization, and they said that management plans were more iterative and based on the needs of each project they contributed to. Some of their projects involved public scoping, some involved collecting new data, and some involved seeking out expertise and tailored information from other organizations. This is the first participant to say that their management plans were dictated by other organizations, which makes sense in this case, since they are not a management planning agency or organization themselves but rather an organization that supports such work. Their information seeking is therefore tailored to each project's needs, but they do have their own experts and resources that they can pull from as needed.

RM5 was the participant who informed on two projects, so we opted to not ask them about management plans in lieu of asking them about both of the projects. Additionally, the

organization they used to work with (at the time of the projects) has since changed direction somewhat, so it was decided that for the purposes of the NC CASC, management plans were not relevant to future work. Project-based information needs will be discussed in a more retroactive manner instead in the TMIM section.

The last participant for this section, RM6, talked about management plans at their tribe. They established a management plan for one of the tribe's most-used resources in recent decades, and regular leadership meetings over the years since have brought together experts to inform and enact that plan. Information seeking is careful and measured, and long-standing trust relationships are generally thought to be a prerequisite for outside groups to inform this type of planning.

Something that I wanted to demonstrate with this analysis of information seeking behaviors is that it takes place across interpersonal means, like in-person meetings and workshops; computer-mediated means, like emails; and impersonal means, like through literature searches. These participants had their own means of seeking out information, and some were external to the organization, like contacting outside experts to enlist another perspective, while some were internal, such as working with scientists within their own organizations. Also, when management plans were described, there were some barriers to outside information being incorporated. These included new information not adapting to the scale of the management plans (particularly climate information) and a lack of capacity to seek out that new information. These are anecdotal evidence of challenges that these individuals face in incorporating new knowledge. Otherwise, they all have information sources they turn to regularly, though there are sometimes issues with those information sources. N2 said their organization did not organize and distribute information well, and RM2 said that inter-organizational teams should be very carefully

compiled to ensure that everyone is working toward a productive end goal. RM6 and N3 both described prerequisites to information-providing partnerships in which information providers must prove to be respectful and reactive to the community of practice before their ideas would be addressed by those communities.

Another related theme for information flow concepts is the *use of information*. Information use is classified along a spectrum from more neutral information use like enlightenment and understanding to more involved information use like motivational and personal/political, or information that deals with issues of relationships and status (Taylor, 1991). Again, though, we modified that aspect slightly to also include the idea of actionable science, or science that was put into use at the organizations. This also has implications for TMIM, since across the spectrum, some uses of information are of higher importance, and issue importance is a condition for TMIM's application (Walid A. Afifi et al., 2006). All of the participants said they used information from the NC CASC project team toward enlightenment or understanding, and some said they used information practically. This will be explored more when the projects are described in more detail.

4.2. Analysis of TMIM Concepts

While the previous section laid the groundwork for understanding the interface at play here, this section will delve more into the specific NC CASC project, the role the stakeholders played in that project, and per TMIM's concepts, the outcome and efficacy evaluations associated with interacting with the NC CASC researchers as information providers. The last section went into greater detail and followed threads of interconnected themes in the style of hermeneutic analysis. This section will do similar work but will focus more on identifying the

existence of TMIM concepts in the interface and discussing why one of the concepts is not present for any of the interviews.

For this section, stakeholders will be referred to as *information seekers*, recognizing that they also provided a great deal of information in some cases to the projects and information seekers is not the most accurate term. To return to the scope definitions that have been partially outlined, their organizations represent a single entity where information is generated and incorporated into use, and the participants also said they regularly sought extra information from outside their organizations. Their organizations as a whole use and incorporate this internal and external information to some extent, so the stakeholders' affiliations with these organizations make them a part of the broadly-defined information seeker role in this interface, even if they are information generators themselves rather than information users. The NC CASC project team will be referred to as the *project team*, but they are also largely known as *information providers* according to the TMIM interface.

To introduce this section, there will first be an analysis of the projects and their relative levels of success and shortcoming according to the information seekers, along with the projects' relative levels of use. The topic of issue importance will be introduced, which is a necessary condition for TMIM to apply (Walid A. Afifi et al., 2006). Then, specific concepts from TMIM like outcome expectations, affect, uncertainty discrepancy, and efficacies will be unpacked as they emerged from the interviews.

4.2.1. Information Seeking and Information Management Decisions

The first TMIM concepts to be unwrapped are intended to describe the projects. Since the interactions we asked about occurred in the past, we also asked how well the projects went and how well the interactions went, and we captured participants' views on how information was

used. These will be described first, although information management decisions occur in the third phase of TMIM. Also, an overview will be provided of the projects.

The idea was floated in the previous analysis section that TMIM can be applied to more than coproduction. Plus, although this study (or the project that funded it, rather) was an attempt to develop evaluation metrics for coproduction, and although we went through a careful sampling procedure in which we requested names of stakeholders that were more involved with the projects, not all of these interactions were entirely coproductive in nature.

A new RFP for the NC CASC who funded this work shows that they now suggest some level of engagement between the project team (NC CASC-funded, although not necessarily affiliated with the NC CASC) and their stakeholders (*NC CASC Announces FY20 Funding Opportunity*, 2019). The NC CASC, and the other regional CASCs that serve other parts of the U.S., are all founded on the principal of providing science that is useful to land managers (stakeholders), or science that is *actionable* by those stakeholders. This brings up all the conversations about organizational boundaries, knowledge transfer (which is not as involved or in depth as coproduction and rather entails repackaging information for different audiences), knowledge brokers, and other concepts that were described throughout this review and analysis (Bielak et al., 2008; Cvitanovic et al., 2016; Lomas, 2007; Mitton et al., 2007).

Based on the 2020 RFP, the NC CASC visualizes this actionable science as including something along the spectrum they identified (Figure 7). First is communication, which involves less engagement and less time, such as a webinar or factsheet about results. Next is consultation, which requires several engagements and may include asking for input on how to run models. Next is collaboration/co-development, which is ongoing engagement and may include regular input from stakeholders throughout. Last is coproduction, which is long-term and ongoing and

requires intensive time commitment, and stakeholders refine the research question and are a part of the research team (*NC CASC Announces FY20 Funding Opportunity*, 2019). The RFP does not require that these categories be met, but they suggest that applicants meet one of the categories and demonstrate this in project goals.

The significance of this information for this analysis is that not all projects funded by the NC CASC are expected to be coproductive in nature. Actionable science can also be generated entirely by a project team as long as there is some demonstration of intent to communicate those results or at least an intent to consider how science will be incorporated into a management decision. The RFP states that "we urge proposers to consider other frameworks to incorporate climate science into a management decision process" and provides several journal articles to that effect, most of which have to do with coproduction (*NC CASC Announces FY20 Funding Opportunity*, 2019, p. 7).

Again, this has always been part of the mission of the CASCs. The Secretarial Order (#3289) that created the CASCs in 2009 stated that, "The realities of climate change require us to change how we manage the land, water, fish and wildlife, and cultural heritage and tribal lands and resources we oversee" and that it was the goal of the CASCs to "synthesize and integrate climate change impact data and develop tools that the Department [of the Interior]'s managers and partners can use when managing the Department's land, water, fish and wildlife, and cultural heritage resources" (pp. 2-3).

The 2020 NC CASC RFP follows those guidelines in asking for proposals, and the projects whose stakeholders we interviewed did consider applications of the science, as evidenced by the existence of the stakeholders. There were 16 unique projects over the course of 2011 (when the NC CASC started up their funding) and 2018, when the participants were

sampled, and of those, three responded that they had no stakeholders to report, and one did not respond. One project only provided one stakeholder name, and some projects provided more than 50. Based on this, we know that past NC CASC guidelines have not required that stakeholders participate in the work, and we know that engagement varies across the projects.

Whether each project was an example of the highly-interactive, high-time-commitment coproduction is not necessarily a concern of this thesis. It does help to demonstrate differences among the projects that will arise throughout this section's analysis.

A point of contention that I would like to bring up here is that this study is rooted in multiple communication literatures (science communication, science-policy communication, and interpersonal communication). However, the continuum of engagement described in Figure 7 places communication at the *lowest* end of the engagement spectrum. Something this thesis has sought to accomplish is to show that communication research is about *more* than unidirectional communication of information in which a report or a factsheet is written, and no other interaction takes place. Even in those cases, it is naïve to assume that science operates independently from society and that no one takes up and interprets that information to their own ends.

To classify communication unidirectionally is reductive, and it is not reflective of science communication literature, which largely recognizes that one-way communication is an outdated model, especially in science communication (Nisbet & Scheufele, 2009). One-way communication was never happening, in fact – any and all types of communication entail some form of feedback, such as television ratings, or transmission into society, such as talking about a newscast with a friend (Katz, 1957). If no one ever saw a piece of communication, some scholars argue, it would still be linked with society, i.e., communicative – for example, our own internal conversations are based on ideas we have encountered from those around us (Meyer, 2001).

Even thinking and listening are communicative because they are reflective of what has been communicated to us, and they may be reflective of how we will communicate in the future (Lipari, 2014). Therefore, even a scientist working in isolation (which is an unlikely occurrence) is thinking using the communication of others, and is planning to communicate their work to someone – all of science is communicative. That includes every aspect of the chain of actionable science modeled in Figure 7. And the purpose of conceptualizing of science as a communicative act is that it allows us to model and study multiple aspects of science communication, including communicative *inputs* into science, which become all the more important to study when groups from different cultures have input into the scientific process (Roux et al., 2006).

We live in an era of rapidly developing technology that allows more people than ever to participate in communication, and in science (M. Anderson et al., 2019). Even mass communication research is has partly shifted away from a message transmission focus to a more audience-centric focus in which media consumers are also producers and interact with their content (Neuman & Neuman, 1991), but science communication scholarship takes this trend as a signal of scientists and science organizations participating more in how science is communicated (Brossard, 2013).

The reason a communication theory is being applied to coproduction is because communication happens across all of these types of engagement, and therefore, communication research may stand to contribute to an understanding of the coproduction interface. My humble argument is that *all* of those engagements and interactions are communicative in nature, from so-called "communication" through factsheets and webinars to consultation to co-development/collaboration to coproduction, and that *communication* should be reframed in this type of science engagement.

Burns et al. (2003) says that all modern-day scientists are communicators and should engage in dialogue with peers, mediators, and the public, recognizing that in any type of communication (even supposed one-way communication) there are always feedbacks and that this can change the meaning of the content (something that has prevented scientists from engaging in such ways in the past) (p. 195). Gilbert and Stocklmayer (2012) points to the "noise" of the modern era in which all of society can share an opinion about science, saying that various audiences now require *dialogic* interaction with science ideas to improve scientists' levels of accountability, to support decision-making, and more. Science is meant to inform society – without society, science would not matter.

A major component of this shift is a rejection of the idea that the scientist is the all-knowing expert who communicates with the layperson, who has no scientific knowledge and perhaps no way to interpret the information correctly. This is an outdated assumption – audiences are engaged with science, and their abilities to reason through information should not be so wholeheartedly disregarded (Gilbert & Stocklmayer, 2012).

In the interface researched here, especially, communication is dialogic and stakeholders are a required component of the science, so communication should be thought of as more than a one-way transmission of information and rather a dialogic process in which scientists negotiate meaning and applications of science with their stakeholders.

I therefore argue that all of the projects, since they involved a stakeholder component (since we interviewed their stakeholders), are *communicative*, and that within that broad umbrella of communication, coproduction may or may not occur. One-way transmission of information does not occur in any of these projects (and even if it did, one-way communicaiton of information is fallacious if audiences and their receptions are to be considered), because at

least one meeting was set with each of the stakeholders in which dialogues took place and the stakeholders provided input or feedback of some sort to the project team. Even if none of those meetings resulted in measurable changes to the research direction and outcome, there was still some measure of feedback, and the projects were all funded under the edict that science have a practical application, so presumably the interactions were not vacuous – presumably, there was at least some exchange of ideas and some negotiation of meaning.

The projects themselves will now be breifly reviewed, and then concepts from TMIM will be considered. Of the 15 interviews, participants only reported on 12 of the NC CASC projects. We were able to collect at least one response from each of the 12 projects that reported stakeholders over the course of the NC CASC's funding history. In consideration of anonymity, only broad strokes overviews will be used to describe the projects, though examples have been provided throughout this thesis for additional context.

Project 1: M1 was the only informant for a project that looked into the effects of global environmental change on wildlife migration and vegetation distribution (broadly). A project team made up of multiple organizations met monthly to bi-monthly via conference calls and there were several in-person workshops and meetings, as well. A success of the project (according to the participant) was that ideas from several organizations came together and information and best practices were shared. They put together a compilation of resources that can be used by others. A shortcoming was that the information did not really go anywhere. "[E]ven though there was interest, this was again, one of the other issues is ... [pause] It's not for lack of people wanting to get to these things or achieve them, but it's just, there's only so much bandwidth, and they get pulled in other directions" [M1]. As a result, there was sparce attendance at some of the meetings, and at M1's organization, the work was never really transferred into use. "[T]hat might

be that the team wasn't able to feel like it was brought to terms, so that we could then pass it along. I think the level of communication was not clear or we did not necessarily have a communication strategy" [M1].

An issue with Project 1, then, was something like a lack of follow-through in how the information would be used. Despite all this, there was still interest in the topic, but the interest was not enough to overcome the boundary of other time commitments. On the continuum/spectrum of information use we presented during the interviews (Appendix B), M1 said they reached motivational use in addition to all those that came before (Enlightenment: desire for context information or ideas in order to make sense of a situation; Problem understanding: more specific than enlightenment, better comprehension of particular problems; Instrumental: finding out what to do and how to do something, instructions; Factual: the need for and consequent provision of precise data [constraints: quality of data, user perception of quality]; Confirmational: the need to verify a piece of information; Projective: future-oriented, but not related to political or personal situation; concerned with estimates and probabilities; Motivational: has to do with personal involvement, of going on or not going on) (Taylor, 1991).

Regarding how information was used, M1 said that everyone was generally pleased that there was a new knowledge bank they could refer to later, even though action was not taken.

> [T]he whole killer to some of this coproduction or whatever is sort of, and you know this better than I do, is that the university schedule and system versus the management aspect, and how students in academia need to be produced, and have to produce, and then that drives a lot of help. Some of the best information is developed, and I think doesn't necessarily plug into management decisions or the cycle. [M1]

In Project 1, this participant perceived that there was an interest in the work and also perceived that the project fell short of where it needed to be to actually make a difference in how their organization conducted their work. This is not necessarily indicative of failure, since some of the products were noted as useful. It is an indicator that the project could have gone further if its goals were to be applicable to this organization's information use.

Information use plays a key role in TMIM as a cousin theory of sorts to uncertainty management theories. In their definition of uncertainty management, Hogan and Brashers (2015) (in a volume edited, by the way, by W. A. Afifi and T. Afifi, who are among the founding scholars of TMIM), studying *information behavior* includes an analysis of how information is used, and Taylor's (1991) spectrum of information use is one of the frameworks they recommend to analyze this. The information behavior concept loosely carried over to TMIM's *information management strategy* concept, in which the information seeker makes a decision on how to move forward with their information seeking behavior. Since these interactions happened in the past, we are starting with the information use concept to demonstrate how the project went and outline what happened during the project according to the perception of the stakeholder interviewed.

Project 2: The second project being discussed here had two informants, M2 and RM1, and they worked at the same organization on the same management plan, so we all decided they could do the interview at the same time. These stakeholders' management plan has been described, but the project has not been described much. Again, to avoid too many specifics, the project looked into global environmental change impacts on landscapes and species of interest. Some of the information generated by the project was of interest to the participants, but they indicated that the project was not developed with their needs in mind. Rather, the scientist had an

interest in including a management perspective, which RM1 described as "ticking a box," and their goals and use of the information were not discussed to the level of coproduction. There were several meetings over the course of the project, and some of those meetings were described as time-wasting, with lots of time spent toward rethinking the way information would be communicated to the participants at the end of the project. Those goals were not in mind from the beginning. Despite these challenges, RM1 did not leave with a negative impression overall: "I just want to say I really appreciate the opportunity and think it's rare and think that we could do a lot better next time."

M2 generally had a positive impression of the encounter, saying that they appreciated the level of flexibility demonstrated. RM2 had less of a positive perspective, saying that they did not get the impression that their interests were actually considered in the project, that they were never partners per se but rather that information would be translated in a way that might be useful. The workshops were described as "biting off way too much that could be done in that workshop. The way the workshop was structured" [M2].

When we asked about use of information, RM1 said that from a science perspective, they achieved enlightenment and problem understanding as well as some level of action/practical use of the information. M2 echoed all three of those categories, saying that they found a way to weave the information into a management plan and that the workshops were useful in terms of coming up with new ways to think about information.

Although Project 2 had some miscommunications, the project was overall still successful in that some information found its way into a problem understanding improvement or some level of practical use in either science or planning. Again, there were pros and cons with this project, and perhaps more could have been achieved from the stakeholder perspective if there had been

more consideration toward shared goals, more listening, or other communicative structures associated with coproduction type interactions.

Project 3: The third project had one informant, M3. The project involved global change planning for a landscape of interest.

> I think the situation for me that I was more curious about how that [the interactions, which included a workshop], the product…could help us in identifying research needs. The end product ended up being something that was a little bit intuitive and I felt like we could have reached that conclusion on our own. [M3]

When we introduced the information use spectrum, M3 said that they reached projective, problem understanding, and enlightenment information uses, and that "just thinking in that manner was enough to make me think differently about…long term planning." However, those involved in the project did not end up being able to use the information as intended, because the project "fell short in providing actions" that could be taken.

Project 4: There were two informants for Project 4: N1 (an advisor and chair of a resource management board) and N2 (a technician whose monitoring work informed plans and who carried out plans). Project 4 had to do with forward looking global change planning as well. This project did make it into action, as both N1 and N2 described action on the ground. Additionally, this work's project team included RM4, who was described as being involved in a boundary organization and who approached the project of which N1 and N2 were stakeholders with a high degree of organizational support for coproduction. True coproduction happened in this case, and interactions were successful in that multiple parties were brought together repeatedly in multiple in-person workshops and the workshops were facilitated such that N1 and N2 both walked away with positive impressions of coming to a shared understanding with others

in the team. N1 said everyone was enthusiastic, and N2 described the workshops as one of their primary ways of sharing and gathering information with outside partners.

Project 5: This project was a little more vague in its goals, and I cannot really describe the project without revealing and perhaps outing the stakeholders we interviewed. In summary, it was a project that entailed coordination and research toward teams of individuals being able to conduct more land management. This was a highly interactive project that entailed a lot of meetings. N3 and N4 both participated in different aspects of the project.

The only shortcoming N3 described was that the project funding stopped (as all project funding does at some point – there was no early cutoff point in this case). N3 felt that the project could have continued, as it had built a lot of momentum. Even unfunded, some of the people involved continued to upkeep some of the work done on the project. The successes of the project included bringing people together, catalyzing conversations, and generally supporting work that everyone involved was interested in doing but was not already doing. N4 similarly described a multitude of connections built and work performed as a result of the project. Both therefore involved a great deal of action-oriented information use.

Project 6: R1 was the only participant we interviewed about this project. The project descriptions are starting to sound similar, and that indicates the type of work that the NC CASC was doing (but also hopefully protects the participants to some degree in terms of anonymity). This project looked at impacts of global change to landscapes and species of interest.

R1 said that the information generated was factual and lent itself to to a higher problem understanding. They did not describe any actions taken as a result of the information: “we're not certain enough in these predictions yet that we're ready to prescribe very specific management actions” [R1]. The information use was also projective, though, in that it led toward

understandings of global change impacts. A shortcoming that R1 described was that federally-funded projects like this one do not really fit into their typical science-management model. They said they usually are able to take research needs from their stakeholder groups, communities of practice that they work with regularly, and feed those information needs into the project. This did not happen in this case. The project was already predetermined at a federal level, and although this person was classified as a stakeholder, they were not consulted to give input into how the research would be conducted.

On the flip side, and also related to their communities of practice, a success of this project was that a scientist from the NC CASC project team attended some of R1's stakeholder meetings. "Their willingness to engage beyond just handing off a bunch of information but actually being willing to show up and present I thought was really good. I think that helps to have the actual scientist in the room rather than hearing my version of what happened."

The project was not ultimately rolled into practical use, but the information produced was still useful. Successes and shortcomings had to do with R1's stakeholders, who they work to share information with and who they try to incorporate in advising research needs as much as possible. R1's stakeholders were not able to contribute to the research goals, which is something that R1 considers a shortcoming of these types of projects (federally funded projects). There may be room for more engagement with R1 as a project staekholder to help inform the research process, again, assuming that this community of practice is a stakeholder of interest in the projects and that there are either few competing research needs or that there is a great deal of work done to come to a shared understanding of project goals. With those same stakeholders, though, this project went a step further than most projects to engage directly on the back end of

the project and explain the science to R1's stakeholders rather than solely relying on R1 to transmit the information.

Project 7: Project 7 also had only one informant, RM2. The project was meant to describe global environmental change impacts for landscapes of concern and had a direct goal of informing RM2's decision making. RM2 often described themselves as having a lead role in how the project went, indicating that the project was highly coproductive in nature and that it responded and provided for RM2's information needs. It was put into use in RM2's agency in several ways in different offices – after RM2 shared the information it went to several other offices, and some put it into practice while others treated it as something to read but not apply: "[T]here are some offices that are not even, I'll say unenlightened, and they don't even have an understanding of the problem" [RM2]. Ultimately, though RM2 was pleased with the work and with the level of communication involved.

Project 8: Only one participant (RM3) was interviewed for Project 8, which had to do with measuring global environmental change outcomes for species and landscapes of interest. The project was needed because of a lack of information related to climate change and the management of this landscape/species of interest. The project was described as unique because a number of organizational boundaries came into play at the level of the organization – there were multiple agencies playing a part, when usually agencies in the area stuck to their own domains. Because of the project, more information has been gathered, and that is seen as a positive outcome. "[I]t did help the managers that sit on that [inter-organizational group] probably think more about climate effects, and potential effects versus kind of doing business as usual." Problem enlightenment and understanding were achieved. Also, conversations that evolved and partnerships that grew were counted as successes of the project. Motivational and projective

information use were also discussed, with an improved comfort level attained with the information. There were shortcomings associated with linking the science to action:

> I think it was useful because it did provide science. I think it fell short in that it provided like journal, peer reviewed, published science, which is fantastic, but it gets presented to the managers like, "Okay, here you go." Then it's like the researchers are kind of like, "Why aren't you using our stuff?" It's kind of like there's a disconnect there. [RM3]

To elaborate on that point, RM3 went on to describe the disconnect between scientists on the project team and land managers, saying that "managers are just on the ground running all the time. So they have less space to really start to absorb this and think about how it fits together. It doesn't mean that they're not doing it, it's just that they have a different work. You know, they're work is just different."

While the project was successful in terms of bringing teams together to share information and produce new information that could be used later, it was again less clear to RM3 (as it was to many of the other participants interviewed) how and whether that information was used in practice. However, information was used toward motivation, understanding, and other uses.

Project 9: This was the project in which the NC CASC funded a researcher to inform another NC CASC project (as well as multiple other projects and efforts). Several of the NC CASC projects were somewhat internal, but this is the only one where we identified a stakeholder who just so happened to be funded on another NC CASC project team. Project 9 was successful because it entatiled bespoke products that were delivered to RM4's project team, but in order to make that happen, it also involved several successful interactions.

> [T]hat ability to customize it…was really critical. And I also think that the other bit that was much of importance was the ability for [the PI] to listen to the conversation …and

> then, and interpolate ways to further exact that data …[to] understand those kind of nuances to how our system works was really important. [RM4]

RM4 said they would be hard pressed to find a shortcoming. One shortcoming was that the information did not come "full circle" and help RM4's team make connections with how societies impact global environmental change. That was an intentional scope limitation on the project initially, and future work might address that information need, according to RM4.

Project 10: Project 10 had two informants: R2 and RM5. The project was an effort to monitor global environmental change impacts on species of concern in a particular landscape. RD5 described several shortcomings with the project, which I have already detailed in other sections. These mainly include a lack of buy-in from the organization RM5 was working with. While RM5 was tasked with keeping tabs on the project, their organization was uninterested and even held the concern (as described by RM5) that other agencies involved might be trying to come in and dictate management goals. RM5 described this as a sociopolitical difference between the project team and the organization they were involved with.

R2 described a similar lack of interest and integration, but they described this happening over the course of the project:

> [T]here were a lot of people involved and they wanted a lot of our data, which after a while we were like, we don't really see how this is really benefiting us and we didn't share some of the data because it just sort of turned into a sort of a quest for publication. So anyhow, the … concept sort of fell apart … . People realized that it didn't take out the value that they thought it had…. And I know for a fact it didn't change anything in terms of how we identify and prioritize areas here and deliver conservation on the ground.

This was generally seen by R2 as a waste of a project. One of the specific shortcomings they mentioned was that someone was sent to help R2 conduct research, and that person was not brought up to speed about local landscape conditions, so they came in with a very poor grasp of the research and were unable to contribute to the project. R2 also said that there were multiple attempts to push back on the project: "we can be saying but, but, but, but, and the decisions have been made."

The project was overall, at least from the stakeholder side, according to both of these individuals, not a success. R2 indicated that there was a push from the researcher side for publication, so perhaps there was some hope of success on the research team's side, but that was ultimately proven a failure, as R2 said that a publication produced was heavily criticized by multiple reviewers. R2 said that the project basically died out without any admission of what went wrong or any attempt to correct the situation.

This was a therefore failure across multiple accounts, including both communicatively, in that input was apparently not sought (or was not sought enough) from these stakeholders, as well as in terms of information use. R2 participated in collecting data for the project, but they never used the information because of how unhappy their agencies were with the way the work was conducted and perhaps even the ways the project changed over time.

Project 11: RM5 also interviewed about Project 11. Talking about the same stakeholder group/organization as Project 10, RM5 said that Project 11 was received very differently and was much more of a success. Project 11 involved global environmental change concepts as applied to landscapes. In contrast to Project 10, the stakeholder group had a great deal of interest in the project and participated to a greater extent.

> This is one of the few, to be honest with you, that when you look at that question or that information on decision, this is one where everybody agrees there was some usefulness in terms of planning and decision-making and policy-making at the federal level and at the state and at the end NGO level as well. [RM5]

RM5 said that in contrast to Project 10, in which they personally talked to people involved in the project maybe a handful of times over the course of the project, and their organization interacted even less, regular meetings were established in Project 11. Conversations between RM5 and the project team happened every two or three months, and at the end, there were a series of webinars to present the information. RM5's organization was also more interested in Project 11, so they interacted with RM5 frequently as a point of contact, and they attended and used information from the webinars. Project 11 was used across the information use spectrum, RM5 said, and they specifically mentioned the personal/political category, because "this project kind of got rid of some of the personal and political biases that we were seeing amongst our [organization]."

Project 12: This project also dealt with global environmental change concepts but with a focus on planning outcomes. This was an interactive project that provided information and reports to support the organization moving forward with their own planning. The project was described as successful, and there were only minor issues discussed by the sole participant we interviewed for this project (RM6), which included allocation of staffing within their organization to ensure that the project could be carried out and that outcomes could be longer-lasting. Success was recognized in the fact that individuals from within the organization were placed in a role that would let them carry out management planning in the future. This was another highly coproductive project in which the organization largely dictated the terms and

information they needed and the project team delivered bespoke information, allowing the organization to take the lead and work out how to put mechanisms in place for future work.

A few commonalities exist in these projects. One is that some projects involved the stakeholders to a high degree, with some letting the stakeholders essentially steer and manage the project entirely. This is definitionally closer to coproduction, and it led to more successful results in terms of whether or not stakeholders and project teams shared goals and came to a shared understanding. This usually led to better results in terms of how science was used, but at times, science was used less, even though there was a lot of communication happening, because the communication did not lead to applicable outcomes. Other projects were run by the science team with less or even almost no involvement from the stakeholder(s), and some of them used the science produced, even though they had complaints about the communicative process. In some cases, the stakeholders said it seemed like the project was driven by the scientist without any consideration for how the information would be applied, and terms like science for the sake of publication were used, and in many of those cases, there was little to no use of the information later. There were disconnects in projects where communication was positive and information was conceptually useful, but applications were more challenging. Either the project teams did not take applications into account and they simply communicated data, or applications were considered and they were not useful to the stakeholders.

4.2.2. Uncertainty Discrepancy

Uncertainty discrepancy is a simpler concept, and data presented here arose from the question, *What are the types of uncertainty you face in planning? (prompts: bring up study - political, climate, scientific; other interview - controversy) Can you describe them?* This was the last question in section 2 (see Appendix A).

As a model that stems from uncertainty management theory, TMIM considers uncertainty to be an important component of the information seeking process. Uncertainty also has a lot of meaning in science as well as in science communication. Scientific uncertainty is recognized as a construct of the scientific process. We study a subset of the social or natural world and approximate models and theories the best we can, and then we assign a level of probability to those findings that tells us how likely it is that those results are accurate and representative of the entire phenomenon of interest. When communicating science, there is often confusion about how to communicate uncertainty. Sometimes uncertainty is oversimplified, and sometimes uncertainty becomes a point of miscommunication between scientists and broader audiences (Frewer et al., 2003).

In TMIM, uncertainty is associated with making decisions. Uncertainty management theories claim that uncertainty is not always a bad thing. Sometimes people may wish to maintain their current levels of uncertainty, for example – they feel they are happier not knowing more about something (Brashers, 2001). Similarly, TMIM's uncertainty discrepancy concept is defined in terms of levels of desired uncertainty. When someone's actual levels of uncertainty do not match up with their desired levels of uncertainty, they may choose to seek new information to change their levels of uncertainty. In the case of this application of TMIM, uncertainty discrepancy is simplified to uncertainty, and uncertainty prompts were generated as examples according to a similar science-policy study that found that managers faced three types of uncertainty: political/controversial, scientific, and climate (Crona & Parker, 2011).

Of the 15 interviews, 14 participants used the word "uncertainty" in their response at least once. The participant who did not use the word uncertainty did talk about uncertainties, but we were never able to ask the uncertainty question. Although that participant answered many of

our questions on their own, we only asked three questions over the course of the interview. This was still an interesting and useful interview and all of the concepts here were represented in that interview. I point it out, though, because since we were unable to dialogue as much with this participant, we did not share similar terminologies, which might have been better framed for easier analysis if we had been able to ask all of our questions. This was one of the more challenging interviews to code, because the words used were different from the other interviews (again, likely because our questions helped frame some of the answers we received). However, that interview did, at least in this case, produce the associated TMIM concept.

I will start with the challenging interview, because all of the other interviews had multiple uncertainty descriptions. The interview where uncertainty was never nominally mentioned described related concepts like lack of data, lack of measurements, and lack of resources to carry out work. In terms of uncertainty, this contributes directly to uncertainty discrepancies, because less information was on hand than the participant wanted in order to make management decisions.

The other types of uncertainty will be briefly discussed, but to summarize, all of the interviews describe uncertainty, and all of those uncertainties related to either science or management concerns. They therefore inform whether the participants' organizations need more information than they have on hand, and they therefore confirm the presence of TMIM's uncertainty discrepancy in these settings.

One type of uncertainty described by several participants was related to scientific uncertainty, but specifically, it was brought up with regard to how science can be translated into practice. For some of the projects that did not result in successful translations to management

plans or actions, the stakeholders were left feeling uncertain about whether that science-management gap would be bridged, and how that gap would be bridged.

As a subset of scientific uncertainty, climate uncertainty was brought up by several of the participants. Future variability and the high levels of uncertainty, again, with how that can be applied to management plans, was a concern.

With managers that oversaw lands that were used for recreation, there were one or two mentions of uncertainties related to population growth and demands for public land use and how that would need to be managed in the future. Also with regard to population growth, resource scarcity was an uncertainty for some, and at least two of the management plans discussed were intended to prepare for water shortages in particular, for example. Those concerned with water resources were also concerned with uncertainties like floods, droughts, wetlands, soils, and other ecosystem components linked to the concept on nonstationarity: problems of the past can no longer predict problems of the future, because natural systems have been driven by factors like climate change to a range outside of predictability (Borgomeo et al., 2014).

Political uncertainty was mentioned by a few participants. Sometimes this was because politics are tied to climate change, and doing climate change research became somewhat of an uncertain endeavor at the changeover to the current administration. The opposite was described as a problem under the previous presidential administration, though: “Under the past administration climate change was a buzzword. And people said, ‘Hey, if I use climate change I can get some funding to do some things.’ We were funding projects like stream gauge monitoring. … So it wasn't a real cohesive strategy” [RM2]. Of the current administration, political uncertainty came from new appointments and the question of whether similar types of work would be funded. At the time of the interview, RM2 was preparing for a meeting with that

new administrator, and they described not knowing whether that administrator would say they wanted nothing to do with climate change because of political leadership.

R1 talked about facing a different kind of political uncertainty, still related to climate change, in how they talked to their stakeholders. (R1 was a researcher who worked with communities of practice and both brought them science and imported their concerns into the scientific process.) I am including a larger excerpt here because it had several interesting components.

> [T]here's always some uncertainty, especially with issues that are very politically tied, such as climate change. That uncertainty goes way up because you're just ...[pause] I've actually found that there's probably more diversity of opinion on that than most people think among…land managers. I think often everybody assumes they are very, you know, the further on the right on that political spectrum, which on a lot of issues they may be but it'll still surprise me how many…will say things like, you know, in terms of climate change, "Well, it may not be man caused, climate change, but it's clear that there's something occurring." Right, so it's not this very black and white thing. There's varying degrees of acceptance on all issues, right? So, often you're left with uncertainty over exactly how you deliver that message.

R1 said that they usually treated their relationship with those stakeholders as one in which there was a certain amount of social capital at hand that they could exchange for trust in their scientific opinions. At times, they altered their messages to talk more about palatable components of climate change, like drought, rather than risk the relationship they had built.

This is an example of communicative uncertainty, but it does hold implications for how they interact with their stakeholders and therefore with how science can be incorporated into

those stakeholders' management plans. Also, it holds implications for scientific uncertainty, because stakeholders might not be willing to participate in projects related to certain topics.

R2 also talked about political uncertainty in their organizations, saying that the work done at their organization did not hold up to ideals of transparency that would allow for the inclusion of multiple research partners. "There's just a lot of politics injected into things, and a lot of decisions are made for political reasons rather than science-based reasons." This political uncertainty differs in scale from the climate change political uncertainty, but internal political uncertainty for this participant meant that it was less clear how and whether science would be used to inform decisions when other motivations might get in the way.

In addition to climate change, another participant described political uncertainty around conservation. Land conservation is a less politically charged topic, according to this participant, but it still has been described as a wicked problem in that different groups have yet to come to a shared understanding of the values behind land use decisions (Brown et al., 2010). For example, in the case of land use, some might want to develop lands into housing developments to meet a growing demand, or they may want to preserve wildlife and game species that use those lands for habitats. Such disagreements lead to uncertainty for land managers, which contributes to an uncertainty discrepancy in that more information is needed. In this case, additional information is usually related to whether land use conversions would impact habitats and species enough that conversion should be avoided or even undone.

Another uncertainty mentioned by several people was related to funding. Many of these groups are federally funded, so they rely on federal budget decisions, which can change when leadership changes, such as with an incoming presidential administration.

Even when there is an information need, sometimes projects cannot move forward because of funding uncertainty. Several of the participants mentioned this, and in some cases it was linked to the fact that they were doing climate change work and there were still concerns about whether the administration would continue funding such work. There were also those for whom budgetary concerns were more longstanding. One participant said that even when management plans are created, there are sometimes too few funds to carry out those plans. This is not directly related to information seeking and TMIM, but if lack of funding is a consistent problem, it can lead to a lack of capacity to participate in information seeking. In fact, M2, who described having a lack of time to carry out information searches, also described budgetary concerns as being an issue. There is not enough data in this type of work to formulate a prediction of causal relationships, but broadly, budget uncertainty does have the potential to impact whether individuals spend the time and resources to seek out new information and to become involved in a project like those with the NC CASC.

One participant mentioned technological uncertainty as a concern for their management of the recreational use of public lands. They already experienced issues when ATVs and drones and electric bikes were invented and popularized, so they were unsure how future technological advancements could impact the recreational use of landscapes in the future.

To summarize, the uncertainties faced by participants included political uncertainty, funding uncertainty, scientific uncertainty and climate uncertainty, population growth and technological advancement uncertainty, controversy-related uncertainty (as in the case of the wicked problem of land use change), and communication uncertainty. Communication uncertainty was described in two ways: (1) related to how to communicate about politically

charged topics, and (2) related to the ability of a project team to deliver science that could actually be used in practice.

Scientific and management-related uncertainties feed into the uncertainty discrepancy concept because they indicate that less information is available than what is needed to inform decisions. Budgetary uncertainty does not drive information seekers to seek out new information in the same way, but again, uncertainty is recognized as something that the information seeker can either attempt to increase or maintain (among other options). In the case of budgetary uncertainty, as it relates to projects with the NC CASC for example, it could be argued that the information seeker might choose to maintain their current levels of uncertainty because seeking new information would not yield feasible results due to a lack of capacity.

Of the two communication uncertainties described, communicating with stakeholders about politically charged topics does hold implications for that individual in particular, because they said they sometimes might choose to reframe or avoid political topics to avoid risking their relationships with those stakeholders. This is another example of choosing to maintain levels of uncertainty rather than find out whether their relationship might indeed be damaged by bringing up the topic.

The other communicative uncertainty, whether science teams could successfully convert science into an actionable use, is less clear. In the face of this uncertainty, the information seekers might decide to avoid future projects (we already know they were involved in at least one that might not have gone well in terms of translating science into action). We had a question at the very end about whether the stakeholder would choose to engage in the projects again, and whenever we asked the question, most said they would. One of the participants who said that the science did not translate into action said that it would depend on which landscape they were

working in at the time and whether they thought a similar project would add information to their repertoire (in this case, they said the information was too intuitive to apply). Therefore, there is some evidence that in the face of the uncertainty about whether science can translate into action, the stakeholder might choose to either engage with the project or to avoid the project.

Either way, though, TMIM applies, since an uncertainty discrepancy existed and since a closer evaluation would need to be made as to whether to move forward with information seeking or whether to avoid information seeking.

What is unclear still is whether the other elements of TMIM exist in this interface. However, based on this section at the least, all of the participants experienced some type of uncertainty, and this discussion demonstrates that each of those types of uncertainty play a role in decisions to either pursue or avoid information seeking behaviors. Additionally, though it was not mentioned in the first section of this analysis, information management decisions existed in all of these cases, since each of these stakeholders already agreed to be part of the projects.

4.2.3. Outcome Expectancies

Outcome expectancies were derived from multiple questions, including, *How would you describe the information gap or research need that was being addressed by this project?* and *Before these interactions (meetings, workshops, etc.), did you have any expectations for walking away with new information, skills, or other resources (describe)?*

Outcome expectancies were also coded for all of the participants. Any involvement with the project team probably indicates that the participants expected to gain something out of the project, but it is possible that this theme was not met with enough evidence based on how the questions were asked. I sometimes coded outcomes as actual things that happened rather than expectancies, which was confusing when I went through the analysis. For the purposes of

TMIM, it matters more what the participants thought they would get out of the interaction. I will generate a list of at least one outcome expectancy per project to see whether every interview got to a point where we were discussing expectancies rather than actual outcomes.

- M1: “I was hoping we could take what came of that and have it apply to needs we had in the state of [redacted]. Again, I don't think it got to that point… And so, while it may not have achieved the expectations we were looking for, I think we did get some of the ... At least what I had hoped to bring back to my agency and my state.”
- M2: “I guess going in, I was always wondering how is this going to work to try to do the multiple things that were trying to be done. [RM1] put it really well…”

  Note: M2 and RM1 interviewed together. See below for more detail. M2 answered this question after RM1 answered it, but I’m sorting the participants by their role category, so M3 comes next.
- M3: “I think the situation for me that I was more curious about how that workshop, the product from that workshop, could help us in identifying climate research needs.”
- RM1: “I certainly went into with basically that fundamental question that [M2] put out [earlier in the interview], does the [natural range of variation of the past] work for a climate change future. That was really the question I wanted answered. We keep coming back to that. If felt things were straying one way or another. I guess I had that expectation that I'd get some feedback on that and I did.”

As a side note about the next participant, when I was conducting the interview, I opted in the moment to skip the outcome expectancy question, because RM2 talked about how they were essentially the team lead, and I thought the question was too obvious. In retrospect, I should have asked the question anyway so I could gather the information in RM2’s words rather than

extrapolating based on other parts of the interview. Instead of what would have probably been a more clear statement, here is an outcome expectancy RM2 mentioned related to the project team and what they hoped the team would achieve:

- RM2: “I think there's a lot of camaraderie that they both, the social and ecological side, really feel this is going to be something that is I think very innovative and can really be a model for that.”

This quote is evidence of an outcome expectancy, but there was definitely more to RM2’s expectations related to the project. However, since an outcome expectancy existed here, I will simply note that I think I could have gotten more information and a stronger outcome expectancy statement if I had asked the question instead of deciding to skip it. Here is one more example of when outcome expectancies came up elsewhere, though:

- RM2: “[I]t would be great if our [leadership] could say, ‘[organization name], we want you to incorporate climate change, climate adaptation, into your daily operations.’ I would retire the next day. If the state director at that time said, ‘Yes, we will do that,’ then I have met my goal for this project.

A similar instrumentation problem came up with the next interview. With RM2’s interview, I did not ask the question, but there was still evidence of an outcome expectancy. With RM3, I did ask the question, but we ended up talking about the project team as a whole rather than RM3’s expectations in particular. This again came down to not asking the question well.

- RM3: “I think it kind of goes to that idea that the [stakeholder group] had acknowledged that there was a lack of climate change information that they can incorporate into the existing strategy and that this helped answer some of those questions. I also think that as

an outcome, it did help the managers that sit on that [stakeholder group] probably think more about climate effects, and potential effects versus kind of doing business as usual.

To elaborate on RM3's outcome expectancy evidence, they did not answer in terms of their own outcome expectancies, but rather in terms of their colleagues. They are still answering on behalf of the stakeholder group, which is the information seeking group, so this is not a concern. The other potential issue with this serving as evidence of outcome expectancies is that an uncertainty discrepancy is acknowledged – they had a lack of information to incorporate into strategy – and it was mentioned that the project helped answer those questions, but the explicit link was not made between having the uncertainty discrepancy and having an expectation from the project team. There is a case that an outcome expectancy is strongly implied, but again, it is not explicitly stated. I do not believe this to be lack of evidence of an outcome expectancy. Rather, I believe that the way I asked the question could have been better. In retrospect, I should have asked a follow-up probing RM3's own outcome expectancies in particular.

The next participant acknowledged that they had expectations, but they said that they had a hard time describing those expectations. A probing question was needed, but they did eventually describe their expectations.

- RM4: "I did have expectations. Yeah. How'd you want me to describe, that's harder. … I think that I had expectations that they would be high quality science information, high quality climate modeling information that could be tailored to our region."

The next participant, RM5, was the participant we interviewed about two projects, so I will use the project numbering system above to differentiate.

- RM5 (Project 10): "I had expectations from [PI's] project that what would come out of that would indeed be some very new and useful factual information and data that could

the point to the usefulness of surrogate species. And that people would then use that information to at least reevaluate their position on [the study topic] and take a look at that as a possible tool.

- RM5 (also Project 10): “And again, there's been controversy about [the topic] … But I was really expecting and hopeful that that project would kind of light a fire a little bit. I don't think it ever did, quite honestly, but I'm not sure.”
- RM5 (Project 11): “Now, contrast that with [Project 11], which again, was totally different because it was the question that our [organization] was struggling with. I also had high expectations for that information and that project. … I left last [month, redacted] and so wasn't able to see things totally through ... but I think … that would've been one of hallmark projects.”

RM6 was another case where I had to piece together bits and pieces to find direct evidence of an outcome expectancy. In this case the question was asked, but the answer was more tied to actual outcomes rather than outcome expectancies, so a follow-up was warranted but was not asked. However, the project information gap question and the outcome expectancies question together yielded some evidence of an outcome expectancy.

- RM6: “[W]e really don't have a specific database repository here on the reservation. We have different settings over the years, but we need to fast forward those to today's decisions and so we're building that base, so to speak.”
- RM6: [T]here was a big void in the data process that would be attributable to this location and that's why the study that came along with other folks’ help, including [the PI], but very right on time and some of those efforts of support came from [another

collaborator] that I could draw information from him on much larger stage because that's where he operates.

Taken together, there is a clearly demonstrated information need, and the project came along at the right time, to paraphrase RM6, to answer those questions. This is evidence that they expected to answer those needs through their interactions with those involved in the project.

N1 denied having any expectations about the project, but they also described their expectations about the project, so this one is a little bit of a gray area:

- N1: "I didn't know enough to have real expectations when we began the process. It was all new to me. I was just for anything that would ...[pause] I hike around the hills quite a bit and see a lot of gullies and worry about ...[pause] I didn't realize that they were responsible for converting grass meadows, or grass and sage system to pure sage, which not everything can eat. I didn't have, other than vague concerns about the state of the land, when this idea, I went to the first workshop because I'd been reading about climate change, and was concerned about it, and wondered what it was going to do around here. I was mostly in for curiosity and guess you'd say active curiosity, concerned curiosity. I had no real expectations to measure the project against. I was impressed by [a collaborator on the project], and his work. Delighted to go out with them and see how things were actually starting to change after that first soggy summer."

This was N1's response to my question about having an outcome expectation. To contextualize this answer a little, N1 is also the participant who answered that they were not a planner despite being the chair of a natural resource planning board. Their own ideas about their role were taken into account when I assigned their code name (N for "neither" of the categories we asked if they

belonged to), but in this case, there may be other evidence to show that N1 did indeed have expectations. This includes another quote:

- N2: “Well, we shared a pretty clearly stated goal, which was to restore [the landscape]…. Increase the grasses that attract bugs for baby [species of interest], and we had a ... I watched and occasionally [participated in the restoration]. Saw it happening.”

In the context of first approaching the project team, then N1 thought that they did not know enough to have project-related expectations. Over the course of the interactions, they developed a shared goal with the project team to restore a landscape they identified as being at risk. TMIM is not applied only at the beginning of interactions, but rather it can be revisited over the course of a conversation or, perhaps in this case, over the course of a coproduction project. Therefore, there is evidence of an outcome expectancy, and to remain true to this participant’s experiences, I will use this as evidence that like TMIM applying over the course of a conversation, it may also apply over the course of multiple information-seeking interactions. This is another source of concern for how I was asking questions, though, because I phrased the outcome expectancy question to ask them to think back to before they interacted with the project team. Therefore, future TMIM coproduction work should expand that type of question to ask how outcome expectancies changed over the course of the interactions.

- N2: “I don't know if you're familiar... have you seen the chain of consequences thing? I think that was [funding organization] that came up with with the Deep Horizon oil spill. And that was kind of one of the outcomes that we're trying to look at it with climate change and how it effects different, you know, two ecosystems.”

In included this even though I wasn’t quite sure at the time what exactly their outcome expectation was. However, this is still evidence of N2 holding an outcome expectation.

- N3: “I wanted to form this group because I said we've got to be there. We have good information, good knowledge, and we need to be a part of that.”

The outcome expectancy tied to N3’s quote here is that they wanted to take part in creating and sharing knowledge to benefit management action. This is an outcome expectancy, and the reason it differs from some of the others is that the project the NC CASC funded contributed to the work that this group did.

N4 was the interview where we were not able to ask many of our questions. This quote partially lends to outcome expectancies:

- N4: “[C]ustoms that we engage in from the [stakeholder group] perspective, the soft social relational customs, they have a functional purpose and a measurable outcome.”

N4 was the coordinator who described multiple projects to bring a sort of citizen science to the monitoring of landscapes and the planning of resource protection. Engagement is one of the outcomes they wanted through the project, so this demonstrates an outcome expectancy.

R1 (below) was another one where I should have asked a follow-up question and did not, but in the end, this was still evidence of an outcome expectancy at some point in the interaction, so I decided not to approach them again with the follow-up. When I asked about their outcome expectations (related to information or resources, as with the others), they said the following:

- R1: “With the first one probably not. That was my first one. With this current one, yes, I have some very specific expectations of even tools and information that will be necessary for me to fulfill my part of that project.”

R1 was referring to workshops they attended. Looking back, I should have asked the obvious question of why they attended the workshop if they had no expectations about the resources or information they would receive. However, with later workshops (since the project was ongoing

at the time of the interview), they had definite expectations. This is another case where the participant said they had no expectations at first, and perhaps R1 would echo N1's curiosity motivator for attending that first workshop. However, since TMIM applies over the course of a conversation and since I am therefore applying it over the course of the interactions, this is another case where outcome expectancies changed. R1 went on to talk at length about their expectations for current and future interactions with the project team, including data collection and the development of information and tools for their communities of practice.

- R2: "You know, yeah, we were hoping to get some spatial explicit projections of what future conditions might give in terms of [resource] conditions, and then bring that down to tie it back to [species of concern]. And the initial goal was to work collaboratively for us to provide, we have some very good fine scale [species] data, and again, I think what happened is some money came along, the group pursued the money, the research group, and just chose a different path."

Overall, outcome expectancies were uncovered in all of the interviews. They were sometimes very clear, and sometimes they were harder to piece out. This is partly because the question was worded to ask participants to think back to before they interacted with the project team. Two of the participants said they had no expectations of resource or information outcomes before interacting with the project team, and one said they approached the project because of their curiosity and concern about the topic. Both of those participants developed outcome expectations once they got to know the project team. Since TMIM is applied with relational partners who already know each other, and since Afifi and Weiner (2004) stated that TMIM evaluations can change over the course of an interaction, this is still a successful uncovering of a

TMIM concept. In the future, the question should be phrased to indicate that outcome expectances can develop over the course of the interaction.

4.2.5. Affect

Affect is part of the TMIM model and in the model, it immediately follows the uncertainty discrepancy. Again, I will list instances of affect appearing in the data. Instances of affect will be bolded and underlined – note that this emphasis is added by me.

- M1: "So when you say that, I think what comes to my mind, and I'm sure [inaudible 00:42:51] all the things it affects. When I've interacted in some of those workshops and everything we had, you'd go there, and you're attending with like-minded, **enthusiastic** folks. We all get kind of, you just ... We have tremendous insights or we've got huge brilliance, or both. And then we go back to our agencies, which are continuing to carry out their day-to-day, and it becomes ... How do I translate this back? How does it grab hold, and that is not an easy thing."
    - Also M1: "[W]hile it may not have achieved the expectations we were looking for, I think we did get some of the ... At least what I had **hoped** to bring back to my agency and my state."
    - Also M1: "Because you know there's lots of good discussions and other things happening there, but at the same time, the agency organization can't just jump every time someone's got a great idea, either. And that goes to the **optimistic** versus the reality of moving something."
- M2: "Well, I guess knowing Andy for years, if I'd any concerns, I wouldn't have worked with him. I have **confidence** in him. I also had confidence in the people that he could pull together."

- M3: “I think the situation for me that I was more **curious** about how that workshop, the product from that workshop, could help us in identifying climate research needs.”
- RM1: “One of the biggest ones for sure, that we're facing, is related to climate change given that this is the third year plan. The **daunting** amount of uncertainty relating to that, it's very difficult to form a plan around what people call a future range of variability that could potentially encompass the historic range plus a whole another order of magnitude of conditions that the uncertainty is so big it's almost useless in terms of trying to plan for it.”
- RM2: “Before I came back here we had several meetings with them, calls, and I think there's a lot of camaraderie that they both, the social and ecological side, really ***feel*** this is going to be something that is I think very innovative and can really be a model for that.”

This is one case where an affect word did not emerge from the discussion, but the word *feel* was used, and other words indicated emotions:

  - Also RM2: “I went to a workshop that they had down in there, and that was where I met [the PI]. And I was thinking, oh my god, and they were doing the social side of things. I'm going, "Oh my gosh." This was another one of those epiphany moments where I went, "Oh." Really because [organization] is a multiple use agency, and we authorize uses of the public lands. Those uses could be impacted by climate change, and how do we adapt to them as well?

This part of the conversation with RM2 indicates the presence of a positively-leaning emotion about the direction the research would go.

- RM3: “And then also being **confident** that, you know, you may not have it all, but you have enough to make some decisions and not go into the **fear**, you know kind of a

paralysis where it's like, "Oh, we don't have all the information we need. We can't make a decision." There's a balance in there.

  - Also RM3: “I think communicating and having good people to work with is a lot of what it comes down to, and **confidence** with those people, and knowing that they're not only going to be focused on their thing as being right, but they might also be able to bring in different perspectives or different research that's been done to kind of give a broader perspective or kind of the pluses and minuses.”
  - Also RM3: “I would say that the [stakeholder] team, managers, went into this very **cautiously**. Part of it was probably who was leading the research, and that there was some ... they weren't like embracing this from the start.”
  - Also RM3 (with regard to the project team): “Definitely **trepidation**, and part of it again, I think comes down to personalities and kind of the prior working relationships with some of the researchers in other work that's been done.”

- RM4: “And the question is my attitude essentially towards [how the interactions would go]? Okay, sure. **Hopeful** that the information would be useful to the stakeholders.”
- RM5 (Project 10): “I know it was **controversial** among the states, because when I talked to our state partners about it, they were **not very excited** about the idea. … You know, and a whole host of other things. So, yeah, there was **trepidation** on that one.”
- RM5 (Project 11): “That one everybody was **excited** about. That one people saw a usefulness in that… I think this one, to me, was probably the number one project and everything that, again, came across our desk or to our attention that really got people **interested** and **excited**.”

- RM6: “[T]here has to be a trust developed in a reservation community environment before there are people willing to expound their thoughts and their **concerns**.
    - Also RM6: “[The PI] knew me for several years, [they] understood my **concerns** about climate, my understanding about what we were trying to do but couldn't do, we didn't have the tools. I was just so **fortunate**, never in my wildest dreams did I think that [the PI] would have been able to do a project here because [the PI] was in Colorado somewhere doing some things. I don't know how we reconnected, probably through this project was the big thing that connected us back.”
- N1: “I went to the first workshop because I'd been reading about climate change, and was **concerned** about it, and wondered what it was going to do around here. I was mostly in for **curiosity** and guess you'd say active curiosity, concerned curiosity.
- N2: “We started that in 2014, and at some point, **hopefully** in 2019 it will be done. But that's held up at the Department of Interior.”
    - Also N2: So, here, our documents are range related, recreation related. Those are the primary **concerns**.
- N3 (with regard to engaging with project teams: “[P]eople might be tested when they first come in, like, okay, why are you here? What do you want from us? We've had people for a century come and tell us they're going to save the Indian. There's kind of a **suspicion** often and a **wariness**. I think that's real, and I think you need to be prepared to deal with it.”
- N4: “[T]here's a lot going on with degradation of those assets at the moment. My **concern** is those were the sacred grounds that the native Americans had in treaty.”

- R1: “Yeah, I was **hopeful**. I think the one thing that's caused a little bit of the gulf between researchers today and extension faculty, well there's a couple of things. [conversation about gap between researchers and practice] … Often, that's evidenced by you're not involved in writing the grant and then they call you three years in and say, "Hey, we need a fact sheet and a workshop. Can you put this together?" And so you get kind of **cynical** about that approach, obviously, because the problem is if it's not an issue or a topic that has relevance among your constituent basis, then, you know what I'm saying? This is a fairly meaningless project.”
    - Also R1: “I'm a fairly **optimistic** person so I just assumed they're all decent human beings.”
    - Also R1: “I do think, though, that that [more engaging] approach is more desirable from [a stakeholder] standpoint, than a more traditional, that research all happens in kind of isolation. I'm **optimistic** often as [stakeholders] you're involved at the very end, or not at all. Then, you're kind of, "Hey, would you, this is good information that needs to be out." Usually you're not real comfortable with that. Not that the science necessarily changes but the way it's delivered certainly changes if [stakeholders are] involved earlier on. In these collaborative processes like this where they involve us earlier certainly helps me understand the science that's being produced a lot better and then you start thinking about how that will actually be communicated, right?”
- R2: “So we were **willing** and **interested** in seeing where this went, but we didn't have real high expectations because the work that we do, we actually collect data annually, and

we have models that are based on 30 years of data going on and on that update all the time."

Multiple affectations were detected across the interviews, and there is strong evidence of an affect being tied to the information seeking process. Sometimes this came up with regard to the project team (such as wariness or trepidation or confidence in the project team), and sometimes this came up with regard to uncertainties and other information-related affectations.

4.2.4. Efficacies

The three efficacies are communication (efficacy evaluation of how well the interaction will go in terms of coming to a shared understanding and developing shared goals), coping (efficacy evaluation of the information seeker's ability to cope with the information received, in this case, to use the information), and target (efficacy evaluation of trustworthiness and ability of information provider to provide the information). Each will be listed and in cases where the connection may be less clear, the example will be discussed.

<u>Communication efficacy:</u>

- M1: "I think the level of communication was not clear or we did not necessarily have a communication strategy. While we had a strategy for trying out how to fill the gap, we didn't necessarily have a strategy about how to carry that forward."
- M2: "Everything [RD1] described, there was a heck of a lot of getting everybody up to speed and on the same page and [the PI] walked into that with a completely different idea of what this might be because nobody had really gotten forest planning."
- M3: "It was something that was easily understandable and we grasped it really quickly while we were going through the scenario planning workshop."

- RM1: “Well, I think that the challenge was that the timeframe and the communication, it took a long time to get on the same page of what it is that we're doing, how we do it, how it's going to be used? Every scientist has their way of thinking about ecosystems and how they should be divided. Should we have used potential vegetation or existing vegetation or some satellite derived thing to chunk up the landscape?”
- RM2: “Yeah, they communicate really well. I mean, they include me on all the emails, and I see the back and forth. Everybody's looped in, they're all communicating, so there's not like [the PI] and [the others] are talking without, you know, and that kind of stuff. So it's really good.”
- RM3: “It was almost like they would invite the management team to respond to things, and then they went back into their behind the curtain and did their stuff, and then they would come back and ask for a response versus like it might have been really helpful to have more management on that team fluid.”
- RM4: “[The PI] was constantly working on how do I represent this information in ways that people can understand it, and that continued through this project.”
- RM5 (Project 10 and 11): “[W]e really lacked a good way to communicate with the project teams. we really never had a good mechanism that clearly laid out this is what you're expected to do. This is what we're expected to do. This is when we're gonna touch base. This is we're gonna make sure we understand if things changes and you have a problem or some need arises or… I mean, none of that stuff was ever well thought out and that was a horrible, horrible problem for us in terms of communications with project teams.”

- RM6: “[Y]ou have to develop that trust very early on. That's the first thing. And that's what I mentioned before about [the PI]. [They] knew when to soft pedal. [They] knew how to do the right questioning. Of course, I helped [the PI] a lot because we had the trust. [They] she would pass thoughts on to me about, what do you think about this or that, and I'd say, "Yeah, that's good, whatever," and my same thought was, if you can befriend somebody from an organization such as this one, a tribe, and learn how to stay away from the problem areas, then you don't get in the problem areas. And, if you do, then you have a solution on how to solve it.”
- N1: “Well, we shared a pretty clearly stated goal.”
    - Also N1: “It was a really good workshop in that a lot of it was workshop, where we were all asked, "What do you think these changes that we've ..." They spend a little time talking about the climate changes that are probably coming, to the best they knew at the time. Then sat us down in groups to go through cost stating process on what we thought this was going to do to what. One of the things that we came to some agreement on, at the time we had all been made aware of the fact that we had a potentially, listable, threatened species in the valley.”
- N2: “I knew we would be able to communicate well but as far as implementing these things is, it seems kind of ... it still seems kind of abstract, you know? Just kind of like, at least from this agency. Kind of like, you know, taking these tools and actually put them on the ground. I just don't know how that's going to happen. If that's even going to happen.”

Note: this is an example of communication efficacy conflicting with coping efficacy. Communication efficacy was high, but coping efficacy was low.

- N3: “My feeling about this has always been that the most important thing we can do is just get together and talk because when we start talking about the issues we're facing, immediately you start seeing how relations develop, partnerships. It's really a catalytic process.”
- N4: “We all got these little hidden processes going on in our experience. So legitimate, right? It's like it's what we're bringing to the table. It's like everybody's carrying their own stuff. So we come and how do we unpack it in a respectful, in transparent and genuine way. There's a difference. I've seen a lot of people be transparent about the disingenuousness. I see a lot of that. It's like, ‘Oh boy. Were they transparent?’”

Note: this was in relation to the broader project team. There were less direct evaluations of the PI they worked with and how well they communicated across the project:

  - Also N4: “I think [the PI] just went there and said, ‘Hey, I got an idea.’ [The PI] was like, ‘What?’ And to tell you the truth, we were kicking it, right? Everybody got the, ‘Hey, [PI], go tell them.’ [The PI] was really smart about hearing through the noise, the potential. And that's hard to do, because everybody is yucking it up and have a glasses of wine at the reception. You get my drift?”

- R1: “Yeah, so some of that research was already ongoing when I came in on this. Of course, I'm not a modeler, right so I don't ... I think I felt like I had more input on how it was delivered and how it was framed. Which, for [my stakeholders], is a big deal. That certainly can change the way the research is perceived. Yeah, I was able to be involved. … I don't remember how many authors was [sic] on it, like 10 or something, which you don't see many fact sheets written with 10 authors, but importantly that made sure that the modeling was characterized properly but the message was also delivered in a way that

was palatable. To me, that's an ideal situation because I may not be able to characterize the modeling correctly if I'm left on my own to do that."

- R2: "[T]here's a little bit of testing of the waters. And I know it works both ways. People will tell you that we're a difficult group to work with because, you know, we won't share data unless we see a benefit to it or something. A lot of times sharing data, you know, datasets are huge and have some quirks and everything. It takes time and effort to organize the data, compile it, give it to somebody and then explain it, and then sometimes it gets used incorrectly. And so it works both ways."

Coping efficacy:

As a side note, coping efficacy was the hardest of the efficacies to code. This was another instrumentation shortcoming. We did not ask a coping efficacy question, and instead we initially planned to ask a question about challenges participants faced in their land management actions. After our pretest interview, we had to remove some questions, and we decided that uncertainties and challenges were similar enough that we would keep one of the two. This was a judgement call, and looking back, I should have found another way to ask about coping efficacies. Even without that question, though, I was able to find evidence of coping efficacy evaluations scattered across the interviews, even though we did not ask for it directly.

- M1: "I think the problems were that perhaps it didn't get much beyond our team. So it didn't get echoed out into for example my agency, and that might be that the team wasn't able to feel like it was brought to terms, so that we could then pass it along. …While we had a strategy for trying out how to fill the gap, we didn't necessarily have a strategy about how to carry that forward."
- M2: "Bingo." (echoing the second RM1 bullet point regarding capacity, see below)

- M3: “So, it would have been helpful to continue that relationship and that discussion with the tribes. That is a piece of that archeological resources management plan is engaging the tribes.”

Side note: I include this as evidence of coping efficacy because it indicates that beyond the way the information was presented, the participant saw additional ways the information could have been used, indicating *more* ability for coping efficacy than was considered by the project team.

    - Also M3 (with regard to whether the information was used): “They did not because the people who were involved in the … workshop all left [the region].”
    - Also M3: “It's kind of like, "Okay, well, what's going to happen with each one of these and what's happening now?" And I think that's the problem is there isn't a connection between what is happening right now that we're reacting to and what can we likely expect in the future.”

This is evidence of a change to coping efficacy over time. The office had less of an ability to incorporate the information because those involved in receiving the information were no longer there to incorporate the information, and it was specific to that region.

- RM1: “We're going through a long ... coming out of a very long period of budget cuts and loss of capacity in terms of ability to not just the implementation side of forest restoration projects that's absolutely huge, but also from the analyst side to really prioritize project areas and types of treatments. We don't have a lot of that expertise here at the forest level. There's not a whole lot coming down from the region either to help with that.”
    - Also RM1: “We don't really have that expertise at the forestry even, necessarily at the region to do that. Our ability to monitor in a way that is going to create

conclusive results that can truly inform through that adaptive management process is pretty limited by expertise I think."

- RM2 (with regard to handing off information from their science team to the practitioners): "Where hopefully they can take it, eventually what I'm trying to do is to get this team to educate enough where, you know, we got smart people in our agency. They're just resource-limited and management-challenged. So if they got the tools, which is the information, and the support from management, they can do wonderful things and come up with much stronger, and I think they would see ...[pause] Well, we're going to still always be litigated, but it would make it more bulletproof. So."
    - Also RM2: "That's our biggest roadblock, is getting the knowledge base out to our field staff. There's one, there's no direction from the Washington office back here. There's no direction from the department, and actually all the direction that was done has been rescinded. It's actually doing a disservice to those who depend on public lands."
- RM3: "I also think we all respect that they may not want to have tapped in, recognizing that managers also have limited amount of space and time for that, but I also think we need to start working beyond that."
- RM4: "It was kind of an entering premise that we would adapt as we go…. So [the PI's] ability to bring both expertise in climate modeling plus [a] desire to work directly with stakeholders … was essential. … And then from thereafter the climate model [was] also further developed some specific runoff soil moisture type of products that then again helps take the initial modeling and introduce it into products that helped our managers think about the changes in climate regime."

Side note: I chose this as an example of coping efficacy because it indicated that coping efficacy concerns were addressed through changes and adaptability in the project.

- RM5 (Project 10 and 11): “Our [organization] wasn't at that point yet where they were willing to embrace at the point in time in which everything kind of went away.”
- RM6 (when asked about management plans): “Well, that's the issue. We don't have what would be called a strategic plan. We have some evaluations that have been done in forestry. We have some soil condition lands that was done by the soil conservation service to do a soil survey of the whole reservation and so we have the basics to spring from and when I got involved with my profession and a variety of folks at the Climate Centers, and those at Fort Collins and Boulder and the University of Wyoming that all fit into my realm of protecting Mother Earth.”

Side note: one of the goals of RM6’s project was to develop resources for management planning, so this conversation about the existence of management plans showed how they planned to incorporate the new information as evidence of them considering their coping efficacies.

- N1: “…we were also lucky in that we had some new, young staff at the BLM, Forest Service, and [state] Parks and Wildlife, and the NRCS. They were still, had some idealism, enthusiasm and energy. That made a big difference. They got on board with this. In some respects, it was kind of what a lot of people were waiting for, which was a big idea with a lot of little moving parts that everybody could kick in.”

This coping efficacy is about the ability to carry out the work. The fact that they were “lucky” to bring some extra participants meant that they were considering how the work would be conducted.

- N2: “I kind of took the information there about climate change and vulnerable flora and fauna, and I was able to use that information. But didn't get included in the document. I was trying to use that for cumulative effects, just to kind of help guide. It was an effected environment to help guide the other resources, wildlife, the vegetation, forestry. But with the new kind of [management plan] and the department, that kind of got scrapped. And that's, I don't think it's more of a page limit thing with the new…documents.”

This is more of an evaluation of the actual work the participant did incorporating the information, but the language like “I was trying” and the discussion about how efforts got blocked by something else shows an evaluation of information use took place before the action took place.

- N3: “I think one of the challenges we have is a lot of reservation areas are not exactly data-rich. In other words, there might not be water monitoring. They might not have some of the equipment to do measurements, stream flow in water sources, turbidity. Water figures very prominently but so with the other features of the landscape. I think, to me, we're looking… to do some data collection, to help us change the landscape so that when people start talking about characterizing changes over reservation lines, we don't find that there's actually very little data that's been collected. I think that's still a major issue that we can work on.”

This is like D3, where the participant said that more work needs to be done, more information needs to be shared/generated. Where usually coping efficacy is considered in terms of a shortage of time or a barrier in procedures or a lack of staff to carry out the work, this coping efficacy is more of a willing and ready evaluation. They have a higher evaluation of their coping efficacy than the project provided for.

- N4: “Co-existing to create capacity to move forward. Maybe that's part of the feedback, is that we don't model as much as we examine. We do that institutionally, we'll look at anything and we'll hope to get paid to look into anything. I'm going to actually try and enact or revise culture or work the experiment on ourselves, but that might be part of the process.”

Like N3, N4 also sees their tribe as holding a higher coping efficacy than they have information to provide for. (This is tempered with a higher barrier to entry, as demonstrated in the target efficacy evaluations below, which reduces the amount of outside information gathering and information generation that takes place.)

- R1: “And so, a lot of times you think of it in terms of how much capital am I willing to expend on a particular topic if it's not going to have considerable impact or worth. You know what I'm saying? It's kind of a cost benefit. I may burn a lot of my trust capital delivering this message and I may get very little back, or you know, there may be little benefit on the ground. You might make a decision to avoid some of those topics simply because it's not worth the capital you're burning for the return you'll get on that investment.”
    - Also R1: In that sense you want to be as confident as you are that there are not any surprises, right? Or things that you don't understand well enough that if you send that fact sheet out to all the county agents and then you get barraged at the next meeting with them about a bunch of questions about that, you know, you need to be able to defend that work. Being involved just adds another level of assurances that you've got good information and that you're comfortable with moving forward.”

- R2: "…there were a lot of people involved and they wanted a lot of our data, which after a while we were like, we don't really see how this is really benefiting us."

Target efficacy:

- M1: "I think the team which was a multi-state team did some good work in kind of helping bring together what was understood to perhaps be best practices or current literature and information. I think it did a good job at that."
    - Also M1: "There were no problems in that regard. That was all, and I think that again goes to those interested came to the table."
- M2: "Well, I guess knowing [the PI] for years, if I'd any concerns, I wouldn't have worked with [them]. I have confidence in [them]. I also had confidence in the people that [the PI] could pull together."
- M3: "You know I just looked at all of these possibilities as chances to build relationships, find expertise, and find people whose brains I can pick… I kind of just went into it cold. I'm one of those very curious people, so I didn't really have an expectations going in. Didn't quite know what to expect."

The fact that M3 did not have any target expectations going in might warrant another discussion about whether target evaluations can change over the course of the interaction. I mentioned Afifi and Weiner (2004)'s condition of TMIM applying over the course of an interaction, with evaluations changing as they conversed. It is more reasonable for outcome expectancies to change over the course of these coproduction interactions, because given new information about the project, the project team, their abilities, and other aspects, an information seeker might realize that they can sustain the relationship and get more outcomes as a result, like in the case of

the two individuals (N1 and R1) who went in with no outcome expectations and started to develop outcome expectations over the course of the interactions. It may be reasonable to say that target efficacies can also change over the course of the encounter. If the participant had no knowledge about the target(s) beforehand, it is reasonable to assume they would have minimal efficacy evaluations going in. Therefore, this question was also worded poorly, or I should have asked follow-up questions to see if target efficacy evaluations changed. When preconceived target efficacies emerged, I will continue to quote those. But when target efficacies changed, I will also capture those changes as evidence of the concept. Evidence of M3 changing their target efficacy evaluations of at least one of the project members:

    - Also M3: "[A team member] has been really helpful and [is] somebody whose brain I pick a lot. I actually just was in a session with him about bison management."

- RM1: "I know [the PI] was a deep thinker in these issues that we were looking at exploring. I felt like we were in good hands."
- RM2 (about the project team): "Before I came back here we had several meetings with them, calls, and I think there's a lot of camaraderie that they both, the social and ecological side, really feel this is going to be something that is I think very innovative and can really be a model for that."
- RM3: "I would say that the subcommittee team, managers, went into this very cautiously….Part of it was probably who was leading the research, and that there was some ... they weren't like embracing this from the start."
- RM4: "I think it was highly respected and, was considered an honor to be able to work with the science team and their expert."

- RM5 (Project 10 and 11): “So, my expectation on all that for all the projects we funded were pretty high, right? I mean, so when we send out these solicitations for research, I always viewed the world this way, and I'll tell you that not everybody in my circle viewed it this way. …And I'll say over the course of time, that was mostly the case. I didn't have too many instances of a bad relationship with some of these. There were a few and there were some misunderstandings and again, part of it was this lack of some communications thing.”

Side note: this comment from RM5 is another good example of how target efficacy evaluations (and other evaluations) can change over the course of the interactions.

- RM6: “Well, the reason I mentioned, in part, [the PI] is because [they] developed the trust with tribal members and tribal committees. And once that trust is established then things happen a lot more smoothly and as a matter of fact, they happen. So [the PI’s] work, as [they] had done up in Alaska, the very first thing that [they] did up there was address the elders and that's what [the PI] did here. And that was very satisfying to know because most people, if not all people, don't understand that.”
- N1: “[The PI’s] kind of an inspirational figure for us all. [They were] wonderful to work with.”
- N2: “And the way they interacted... they listened to everything. They were very methodical in writing ideas down, and capturing everything. So I knew that they were going to put on a good organized workshop and keep things moving and come out with a great product. There's no qualms about them leading that, and also with them bringing in different experts, as well.”

- N3: “There's a good reason for a fair amount of suspicion native people have about scientists coming into their community. We're not that far off from the battle days of research science and anthropology and the social sciences primarily where people would come in and work for three months, write up a dissertation. Never give any credit to anyone in that community for the work they did, and go get their PhD and then carry on with their career. I think those days are gone. You can't do that anymore, and you have to be very conscious about building relationships with communities. I think that'd be my final takeaway point. Make sure you build some relationships.”
- N4: [W]e're big [in] honoring the people who first got in the canoe with us, you know what I mean, who made the commitment when nobody else would. I notice all kinds of people lining up because you know what I mean? Everybody can see, oh yeah, but it's still work, but [the NC CASC] made the commitment with [the PI], but nobody thought it would work. That's important to us.”
- R1: “So, I trusted these things in two ways. I trusted the people that were sending in project proposals to be sending in really good research proposals. … But the ones that we did fund over the years, my expectation was still that there'd be open communication and I always trusted the project leader from the project team to do what they said they were going to do.”
- R2: “[Y]ou have to develop that trust very early on. That's the first thing. And that's what I mentioned before about [the PI]. [The PI] knew when to soft pedal. [They] knew how to do the right questioning. …I was just so fortunate, never in my wildest dreams did I think that [the PI] would have been able to do a project here…. I don't know how we reconnected, probably through this project was the big thing that connected us back.”

Chapter 5. Discussion and Conclusion

This discussion and conclusion section will begin with a review of the findings reported in the results section, particularly as they relate to TMIM, since the emergent codes were thoroughly described and discussed already. However, the emergent codes section did reveal some potential bounding scopes that will be used in the TMIM discussion here.

5.1. Discussion of TMIM Findings

The research question being addressed in the TMIM analysis was, *Does the theory of motivated information management (TMIM) model coproduction interactions between (a) public land management organization "stakeholders" of coproduced knowledge and science in the NC CASC region, and (b) groups external to these stakeholder organizations who are largely deemed "information providers," including a research team funded by the NC CASC as well as other groups?*

Evidence was presented from each interview and from each project to demonstrate that the concepts of TMIM have some founding. In some cases, the connection between the pieces of evidence presented here and their concepts is clear. Participants described their communication efficacy evaluations when they talked about how they communicated with the project team and when they talked about factors that led to success or shortcoming in achieving a shared understanding or shared set of goals with the research team. Target efficacies were displayed when the participant talked about their impressions of the information providers, and coping efficacies were displayed when they talked about their organizations' or their stakeholders' (generally, whichever group was incorporating information into practice) abilities to use the information. Outcomes expectancies were usually clear and straightforward, with statements of the types of information and outcomes they hoped to achieve through the projects.

Affects were present in each interview but were not fully recorded or categorized. Several more questions and perhaps a different question format (like a Likert scale) would be needed to identify the full range of affects present and perhaps their relative scales. However, evidence was clear that at least some affect existed in each case. Some were positive (optimism, hope, confidence), some were neutral (interest), and some were negative (trepidation, concern). While TMIM stipulates that affect is associated with the uncertainty discrepancy concept, the affects identified here were also at times affiliated with target efficacy evaluations, with outcomes expectances, or with the information-seeking process as a whole rather than with their uncertainty discrepancy. This is likely due to the interview questions. The affect question was far removed from the uncertainty and information seeking questions. Instead, it was asked after efficacy and outcome expectation questions, so answers were more related to the evaluation phase (in which the information seeker considers efficacies and expectancies). Future work might uncover an affect associated with the interpretation phase, in which uncertainties and information needs exist.

Each of the concepts (target, communication, and coping efficacy; outcome expectancy; and affect, as well as uncertainty/information needs considerations and information management decisions) had at least one immediately apparent or demonstrative example per interview. It is also important to note that the examples included are not exhaustive. There may have been other examples of each concept present in the data. The goal was not to find every single instance of each concept but rather to find a descriptive and useful example of each concept in the data. The reasoning behind this data presentation choice was to track down and explain why anomalies existed. It was assumed that if any anomalies existed – that is, if any of the concepts had zero

corresponding evidence in the data – then it might disprove the existence of that concept in coproduction settings unless a reason could be posed as to why that anomaly existed.

Examples of how these concepts were discovered in the data include:

- Interpretation phase, uncertainties: climate uncertainty, scientific uncertainty, controversy uncertainty (wicked problems), political/funding uncertainty
- Interpretation phase, information needs: science, tools, tailored models, digestible information, capacity building support, data bank generation support
- Evaluation phase, outcome expectancies: similar to information needs but specific to the project and sometimes related to the process of engagement, such as time spent with the project team, responsiveness to needs, and products like tools and information
- Evaluation phase, target efficacy: both positive and neutral/sometimes negative target efficacies were discussed, including holding trust and high esteem for the project team or PI (positive), being familiar with the PI's work (neutral), and being disappointed with lack of engagement from the PI/project team or changing their evaluation of the project team over the course of the project toward having a lower estimation of their ability to provide information to the information seeker
- Evaluation phase, communication efficacy: mostly positive in terms of coming to a shared understanding of project goals but also some neutral, such as feeling disengaged from the project, and some negative, such as descriptions of "radio silence"
- Evaluation phase, coping efficacy: sometimes related to the participant's ability to use information and sometimes related to their organizations or their own stakeholders' (user communities) abilities to use the information, sometimes positive (some indicated that the project did not accomplish all that it could have to be useful, indicating high coping

efficacy), some positive (information was used and useful, indicating that coping efficacy matched information provision), some negative (budget concerns and lack of bandwidth, lack of time to do the work to translate information into action, lack of applicability of information to participants' organizations)

- Interpretation phase, information management strategy: will be altered slightly (see below), but concepts related to use of information and applicability of information

Since the goal was to uncover anomalies, and examples were found across the interviews even when the direct question was not asked (as in the case of coping efficacy, for which we removed the question and I forgot to add something to make up for a lack of a coping efficacy question), a couple of anomalies will now be discussed.

Some participants outright denied that they had any outcome expectancies or any target efficacies going into the project. Although they answered no when I asked if they had those expectations and evaluations going into the projects, I was able to find evidence of such expectations and evaluations at other points in the interviews, corresponding with later interactions with the project teams.

5.1.1. Discussion of Anomalies

When I initially devised questions, I conceptualized the model as occurring before the coproduction project even started. The end stage of TMIM is an information management decision, in which the information seeker decides whether to pursue the information seeking behavior. In the case of coproduction, I thought the end point, the information management decision, would be the decision whether or not to move forward with the coproduction project. However, this does not line up with what I found. Some of the participants said they went in with no expectations and had no idea what they would get out of the project. One said they went into

the interactions because they were curious, but they did not expect to get anything back, at least at first. However, over the course of the project, when they learned more about the project team and the work being done, they developed outcome expectancies and target efficacy evaluations related to how those outcomes would be met by the project teams.

Is an absence of this concept, in the participants' own words (e.g., when R1 said "probably not" when I asked whether they expected any resources or tools or other information before they started with the project), evidence that TMIM does not apply?

To answer that, I had to revisit how I conceptualized the model applying to coproduction and I had to revisit TMIM literature. Firstly, all but two of the projects I reviewed in the literature review were based on information seeking conversations between people who had known each other for a long time, such as parents and children (Walid A. Afifi & Afifi, 2009; Crowley & High, 2018; Fowler & Afifi, 2011), romantic partners (Dillow & Labelle, 2014; Fowler et al., 2018), friendships (Chang, 2014), and families in general (Hovick, 2014). The only two tests of TMIM I found that were outside of an already existing familial or friend relationship were online support group information seeking (Kanter et al., 2019) and online information seeking with no interpersonal interaction (Tokunaga & Gustafson, 2014).

Kanter et al. (2019) studied interactions among online support groups for a period of six months, so target efficacy evaluations and outcome expectancies were collected. Tokunaga and Gustafson (2014) studied the use of online information seeking to gather information about other people, and they did find outcome expectancies, but they did not include target efficacy in their study because the information seeking was passive and did not involve a direct other. Earlier, I made the case for target efficacy to be included in TMIM applications with no direct other, because concepts from source evaluations might be considered as target efficacy evaluations.

However, this study was about information seeking *about* others across various sources, so the source was less important. (I would still argue that TMIM can be applied to online information seeking, but that is a broader discussion.)

The disconnect in the application of TMIM to coproduction, then, was how I conceptualized the relationship between the information seeker and the information provider (stakeholders and project teams). I thought that evaluations of the project team would occur before the information seeker decided whether to approach the project teams, and that the decision phase would be when they decided whether or not to engage on the project. In practice, that did apply in several cases. However, I found that that was because most of the stakeholders I interviewed had longstanding relationships with the PIs or others on the project team or knew of them by reputation. The two participants who said they went in without target efficacy evaluations and outcome expectancies were new to the relationship. They were initiating the conversation to see if the information provider would be useful and informative and would later be able to provide them with information.

In those cases, I found evidence of communication efficacies because most of the participants answered with regard to the actual interactions that took place rather than answering with regard to their expectations before the projects began (though some of them answered about their perceptions before the project began based on past interactions). I also found evidence of coping efficacies, because those were also answered as related to the information being provided through the project.

The issue, then, is that there are differences between how coproduction happens and how TMIM is usually applied, though they were not the differences I anticipated. I thought that based on the highly networked and interwoven nature of information flow at the science-policy

interface (M. H. Anderson, 2008), it would be difficult to differentiate the information seeker and information provider, and that is based on a definitional difference between TMIM and science communication literature. In science communication literature, labels of audience and source are defied, because information is transferred in multiple directions across the interface, and audiences are not passive recipients of information.

In TMIM, though, the information seeker is someone who needs more information than they have on hand to make a decision. TMIM assumes interaction and negotiated meaning, while audience-source conceptualizations reduce the communication to being unidirectional. Science communication literature is beginning to acknowledge and recognize the interactive nature of communication at various science communication interfaces, but there are relatively few studies that conceptualize communication as such.

Although science communication scholarship has needed to adapt to accommodate interactive components of communication, TMIM starts with interaction as a foundational component. It does not make value judgements about who has information and who needs information, a boundary that has been controversial in science communication, since it has led to a sentiment of elitism among the science community. If only one side of the science-communication interface works to generate new knowledge and then transfer that knowledge, then the practitioner community is reduced to the level of a passive audience.

Coproduction projects aim to make science *actionable*, meaning that the veil between scientists and science use is pulled away – the ivory tower is broken down and scientists must dispel the myth that their work is pure and unchanging, that others cannot influence the research direction and take part in thinking through the problems being addressed (Baron, 2010). This is a

highly interactive interface in which the shared meaning generated matters and feeds into how research is done as well as what aspects of the natural world are researched.

Although TMIM identifies information seekers and information producers, they are not equivalent with audiences and sources. They are not isolated, and they work together to create shared meanings. Interpersonal theories like TMIM research already established relationships for this reason, because communication is an ongoing process, and sometimes there may be issues. TMIM studies what happens among familiar relationships when the decision of whether to be in a relationship is not at stake. Rather, the decision is related to seeking information from those familiar others with regard to issues of high importance. The information seeker knows the information provider, and the interaction being studied exists in a broader continuum of engagement. The momentary decision to pursue an information management strategy is made regarding a topic of particular importance, and it matters to the information seeker whether the information provider is knowledgeable, trustworthy, and willing to provide the information. It also matters what the result of the conversation might be and whether the information seeker can cope with the information given.

Conceptualized in this way, TMIM as it relates to coproduction failed when I considered the outcome of the information seeking process to be the decision to engage in the project. Information needs exist, and uncertainties exist, in this interface. Stakeholders need more information than they have on hand to make a decision, or their organizations need more information and they may be working toward that information generation (as in the case of the researchers we interviewed), but they still identified needing outside information in some cases. If they were familiar with the information providers (project team or PI) in advance, then they had a based from which to make target, communication, and coping efficacy evaluations, and

they had some idea of what information and resources they would walk away with as a result of the project. But in cases where the information seeker went in cold, so to speak, they might have had some interest or curiosity about what they might get out of it, but they had no concrete expectations or efficacy evaluations related to the information providers, because they had never interacted with the information providers before.

Therefore, I propose that for TMIM to apply to coproduction, it is more useful to think of the entire project as a conversation. In the definitional scope of TMIM, Afifi and Weiner (2004) give the example of a woman trying to decide whether to ask her friend on a date. Through the course of a conversation, the woman might change her mind multiple times about whether the friend would be willing to entertain the conversation, about what the outcome might be, and about how well they might be able to convey the question. Throughout that process, information is still being exchanged, both verbally and nonverbally. Some hints as to the answer might be given early, such as hints related to the friend's interest in the information seeker or signals about their interest in the conversation.

Similarly, through the course of a coproduction project, information is exchanged. Shared meaning is generated. Shared goals are (ideally) developed. Over the course of a project, or perhaps just at the end of a project, a piece of information (products, information, tools, resources, models, etc.) are provided. And throughout the interaction, there are early signals about the information provider and the information to be received. If the information provider (project team) is disengaged and not listening to the needs of the information seeker, efficacy evaluations might change for the worse. At the end of the project, when the information is delivered, it may be useful, or it may not be – information provision only matters to TMIM in how it changes the information seeker's evaluations of how useful the information will be.

Target efficacy evaluations might change over the course of a project, too, if the information provider started with a high level of engagement and then changed course or if little expectations were held and then expectations grew as early signals were provided in meetings or workshops or through early information provision that the interaction would indeed be fruitful.

The entire project, then, is a conversation driven by an information need and resulting in information provision which may or may not be useful. Additionally, the information seeker may choose to disengage from the project, as they did in some cases, choosing information avoidance once they found that the end result would not be beneficial.

It is reasonable that some of the information seekers said they had no expectations at the beginning. This was not a signal of low issue importance. An information need drives all of these interactions, and the various uncertainties involved lend a weight to the value of information that might help mitigate those uncertainties. Climate projections are long-scale and surrounded by a great deal of uncertainty, so typical land management plans might not have room for such long-term, high-level considerations. Many of the participants demonstrated some level of hope attached to the coproduction projects because it might help fill in knowledge gaps and it might help bridge the divide between large-scale science considerations and practical applications.

In this process, TMIM does not disparage information seekers but rather recognizes that all humans only have so much time and capacity to learn and translate knowledge into action. This is why they CASCs were generated, according to their foundational documents. And, not to belabor the point, but interaction and shared meaning are necessary to the process. When interactions went poorly, participants said time was wasted, and they had lower expectations of what would happen as a result of the interactions. Getting people into the same room and having them talk did help in some cases, where information providers demonstrated flexibility and were

willing to change their goals. It is this interactive space, this intent to create shared meaning rather than working in isolated processes, that results in the actionable science the CASCs wish to achieve. The goal of coproduction is entirely communicative in nature. Though it seeks to understand the natural world or social systems as they interact with the natural world, those considerations are modified. The ways information is collected and the reasons for collecting that information are a result of the interactive communication and shared meaning generated at the coproduction interface.

Over the course of a project, target, communication, and coping efficacies can change (coping efficacies can change, for example, if budgets change or politics change or if staffing and resources change). Therefore, the coproduction project is the conversation. It may happen over a longer time frame, but it involves the same elements. Relationships may not exist at the beginning of coproduction, so stakeholders might go in not knowing what they will get out of the interaction, but with engagement and familiarity with the project team, such expectations can increase, decrease, or remain the same.

The so-called "decision phase" is where coproduction differs slightly, because negotiations about the information received ideally start at the beginning of a coproduction interaction. The fact that there will be an information outcome (assuming that all the projects plan to deliver something to the stakeholders) is a given. The decision is not related to whether information be brought into the open, like in original conceptualizations of TMIM (e.g., whether the information provider will agree to go on a date). Rather, the decision is related to whether the information seeker wants to engage with the project and receive that information.

This is, indeed, a topic of concern to actionable science producers. This project was partly funded to close the loop with stakeholders and learn whether information was used and to

what extent. It matters a great deal to these information providers whether information seekers make a decision to engage with the project and use the information.

The information seeker's evaluation phase and decision phase, whether and to what extent they provide the information, is not explored here, because we only interviewed the information providers. However, future work might also explore how target efficacy evaluations are incorporated and managed by the information provider. The information provider might have multiple stakeholders (information seekers) and they need to continue to be present and attend the interface to decide how and where to distribute information.

This model conceptualizes TMIM on the part of the information seeker as a process that starts when the coproduction project is initiated (i.e., funding is received and initial conversations start) and ends when the project ends, as information is received. However, the decision to engage with the project team is more iterative in coproduction than in other applications of TMIM. Based on getting to know the project team (if they were unfamiliar), based on changes to communication amounts and qualities over the course of the project, based on changes to the level of engagement on the part of the information provider, and based on coping changes like whether capacity is greater or lesser than the information can provide for, the information seeker can reevaluate their decision to be engaged in the project. They can maintain engagement (neutral decision phase consideration), increase engagement (positive change to decision phase), or they might decrease engagement (negative change) as they continually evaluate efficacies and outcome expectancies.

This does speak somewhat to success and failure of coproduction, as the components of TMIM may go a long way toward explaining why coproduction was more or less successful (in terms of providing actionable science). If an information seeker changes their evaluation of the

information provider and their abilities to provide information, then they may choose to disengage. If they participated in the process and still did not use the information, it could be due to a mismatch between the information and the information seeker's coping efficacies.

5.1.2. A Revised TMIM Model for Coproduction

Note that this study was qualitative in nature and therefore cannot make predictive evaluations about the relationships between variables of interest (the coproduction concepts). It is assumed, though, based on construct validity, that the relationships exist, since each of the concepts exists in some way. Anomalies were chased down, and other evidence all points to TMIM existing in coproduction interfaces. Based on the anomalies, my own predictions about how the model would apply are shifted, and this was the reason qualitative methods were chosen – because of a flexibility in uncovering data that might not be predicted given a lack of past applications of the model in this interface.

The revised TMIM model will now be presented. Because of the implications of information provider and information seeker in science communication literature, I will come back to the conversation of what information seeker and information provider mean. The fact that the information seeker needs more information does not devalue them as a participant in the generation of new information. Instead, the fact that they are seeking information means they have a great deal of expertise and may already be working toward closing a knowledge gap. The information provider is something like a consultant who brings outside expertise and resources to the information seeker's information need, but both parties are recognized as equal contributors to the shared knowledge created through interactions that lead to the generation of a research question or other considerations of how the project will go. Information seekers are called stakeholders in this interface because they hold a stake in the resulting information, and

information providers are called a project team in this case, because they are moving the process along given their expertise and outside funding. However, the goal of coproduction is the stakeholder's use of the information, and in that, they are the subject matter experts.

Secondly, and on a related note, I also want to emphasize that knowledge is not being shared or transferred, which implies that the information does not change. Information is *generated* in a shared interface. There is still an objective reality related to the knowledge, according to a pragmatist ontology (Simonson, 2001). The fact that meaning is negotiated does not, for example, negate that climate change is happening. It does change the way that climate change is researched. It changes the location where climate models are applied, and it changes which impacts are prioritized. Shared meaning is negotiated toward developing information that is framed in terms of an information need, rather than information for information's sake. Communication is the force that drives that pursuit of knowledge (Meyer, 2001).

Coproduction TMIM will now be compared to other applications of TMIM, based on Afifi and Morse's (2009) conceptualization of TMIM (which is the same as the original model apart from the change from anxiety response to uncertainty discrepancy to an affect response). Unless otherwise noted, affect discussions are pulled from Afifi and Morse (2009) and other concepts are pulled from the original model, Afifi and Weiner (2004). Also, coproduction discussion is evidenced from the interviews conducted. Figure 4, now called Figure 10 because of its new location in the document, has been copied from the literature review for reference to the original model.

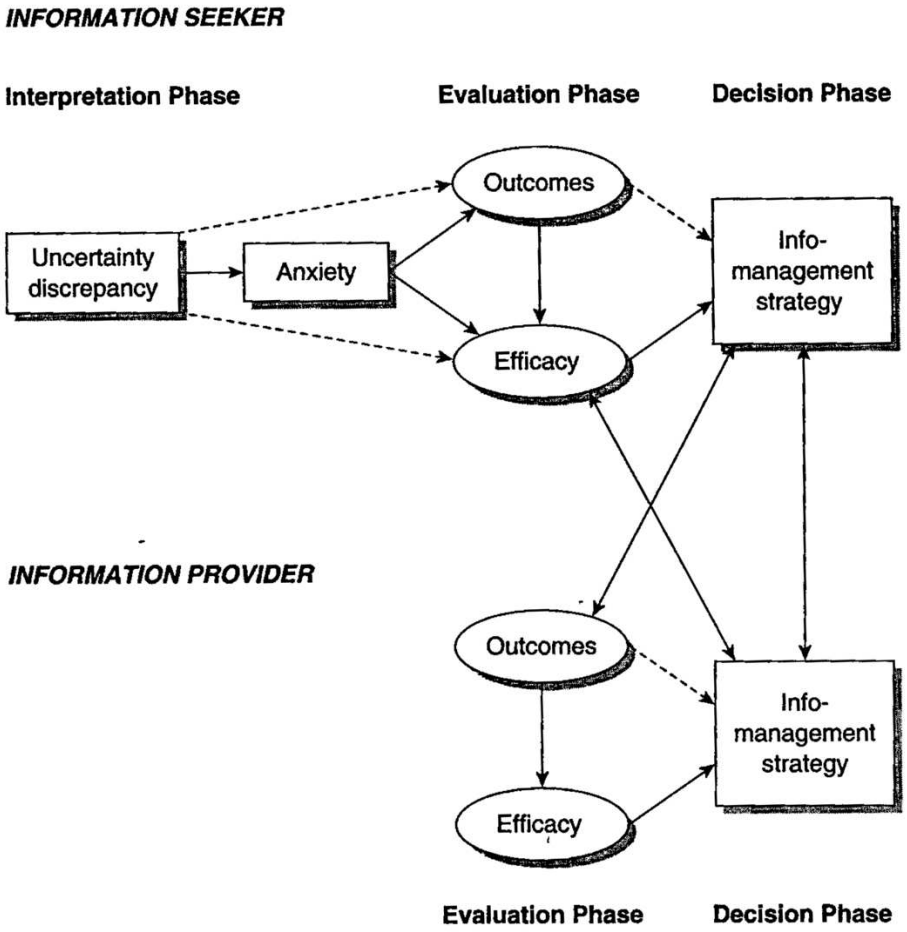

Figure 10. Graphical model of TMIM's propositional structure.

From "Expanding the role of emotion in the theory of motivated information management" by W. A Afifi and C. R. Morse, 2009, *Uncertainty, information management, and disclosure decisions: Theories and applications*, p. 88. Copyright Routledge/Taylor & Francis Group.

What follows is a comparison of TMIM in its original setting and TMIM in coproduction, which will help explain the decisions I made in revising the model, proposed below.

- Interpretation phase
    - Concepts from TMIM as it is usually applied

        - How/when the interpretation phase occurs: The interpretation phase happens before the participant engages with an information provider.
        - Uncertainty discrepancy (literally, the difference, or discrepancy, between the amount of uncertainty one has about a topic and the amount of uncertainty one would prefer to have – also defined as times when the information seeker has less information on hand than they would like to make a decision)
        - Affect (a feeling brought about by the uncertainty discrepancy that contributes to the start of the information seeking process, such as hope about gathering more information or anxiety about not having enough information on hand)
    - Coproduction:
        - How/when it happens: The interpretation phase takes place before stakeholders interact with a project team. It can occur through a short-term information shortage such as seeking new information toward a management plan or on a longer time frame like an endemic information shortage on a particular topic in the stakeholder's organization.
        - Uncertainty: Uncertainty discrepancy (TMIM) is defined as both having less information than one prefers to have, and experiencing a different amount of uncertainty than one would prefer to have (same concept, different wording). In science communication, though uncertainty has its own meanings and definitions: scientific uncertainty related to difficulties translating science into management action, political uncertainty means

less ability to act or less ability to secure funding, controversy uncertainty means information is used in different ways, etc. Uncertainty is still a driver of information seeking, but it is part of a larger concept in science communication, so it is more broadly defined.

- Information needs: Uncertainty discrepancy is essentially broken into its two components – a desire for information and a recognition of uncertainty as a contributing factor to seeking new information. Information needs were clearly defined in each of the interviews, and they are apparent in any coproduction interaction since the projects are built around a research question. Information needs and uncertainties drive the information seeking process, either toward seeking new information or deciding not to seek new information. Combined, the two contribute to the information seeker entering the evaluation phase. (Note: directional relationships are not predicted, here, although they are apparent. The directional arrow is not a result of the findings here, but a holdover from TMIM applications elsewhere that prove the causal relationship.)
- ~~Affect~~: In this study, affect was more closely tied to the evaluation phase. Future work might demonstrate a link between uncertainty and affect or information needs and affect. One reason affect was not found in this part of the process might be because the affect question was asked after the efficacy and outcomes expectations, so participants were more likely to answer based on those concepts as opposed to uncertainty, which was

asked more than 10 questions prior. Information need was also asked in previous sections (Appendix A).

- Evaluation Phase: The evaluation phase is the same, with the addition of potential affect assignations related to each concept. Therefore, only TMIM concepts as they apply to both old TMIM applications and coproduction will be explained.
    - How and when it applies: In TMIM, the evaluation phase took place between the time the participant decided to seek out new information and the time they made a decision about whether to directly ask for that information. In coproduction, this concept of a conversation is expanded to include early interactions with the project team at the beginning of the phase and a loosely defined decision phase in which the information seeker decides how much they want to engage in the project. Unlike in the original TMIM, where the decision phase happens in the span of potentially moments, the decision phase in TMIM is also expanded. Information seekers can change their minds about their level of engagement in the project over the course of the project.
    - Outcome expectancies: Similar to the original TMIM model, outcome expectancies were straightforward. Participants all described having some expectation for walking away from the coproduction project with new information or new resources or tools. In some cases, they did not come into the project with any outcome expectancies, and their expectations changed over the course of the project as they learned more about what the project could provide for them.
    - Efficacy evaluations: target efficacy, communication efficacy, and coping efficacy were all found in coproduction interactions.

    - Affect: Positive, negative, or neutral affect responses are attached to each component of this phase. For example, information seekers may be cautious in approaching a project team they do not trust (target efficacy affect), or they may be hopeful about walking away with new information (outcome expectancy affect).

- Decision phase: The decision phase differs slightly.
    - The decision phase is when the information seeker makes a call about their information management strategy, which can vary and include information avoidance (Fowler & Afifi, 2011). In coproduction, a proposed revision will be the expansion of the decision phase to include varying levels of project engagement over the course of a coproduction project. In some cases, participants said they became more involved in the project over time, and in some cases, they became less involved. This is therefore not an end point of the model, because information generation and sharing are happening throughout the model. Rather, it is a measure of how much time and effort they are putting into interacting with the information provider(s) based on the outcomes they hope to achieve and how well the process is leading toward those outcomes. The end of the decision phase is marked by the final information product(s) or services being delivered and the project concluding.
- Action phase
    - There are no phases after the decision phase in the original model, but I am adding an action phase in which the participant takes the information and uses it in some way, be it cognitively or in practice. The goal of coproduction is to create

knowledge that is put into use, so an end point of the information seeking process is the idea of whether and to what extent information was actually used. This goes beyond the original TMIM model, which for example would end at the end of a conversation. Conversational information use is harder to track in those cases, but it may be possible. In Fowler and Afifi (2011), for example, flyers were created to help adult children talk to their aging parents about caregiving. A follow-up survey could have determined whether the information they received from their aging parents led to any actions like making a plan for caregiving. This type of action is more important to the coproduction interface, where projects require some measure of accountability and funding agencies care to see the outcomes of the projects. Therefore, it is included here as part of the process.

Note: unlike in the original TMIM model, ***information provider*** *outcome expectancies, efficacy evaluations, and information management strategies are not included because only information seekers were interviewed. Future work could look into this component of the model.*

The revised mode therefore breaks the interpretation phase in to uncertainty and information needs, removed the affect associated with the interpretation phase (although it might exist – it was just not captured from the way questions were asked), modifies level of engagement with the information provider to a continually revisited process rather than a decision in the decision phase, and adds an information use phase in which information is used to varying degrees by the information seeker. See Figure 11. Lines are directional when other applications of TMIM have proved directionality. Because of construct validity, I assume that a similar directionality exists, even though this model cannot prove the strength of the relationships. The post-decision phase addition is not studied in past TMIM applications, so it is

displayed in a tentative format. The information provider exists and presumably has their own expectancies and evaluations and decisions, but they were not interviewed, so they are left as a black box of unknown quality in this model. And finally, the affect discovered by this study was tentative because of the interview questions, but it is my assertion that affect does exist at the same stage and could be uncovered with further research.

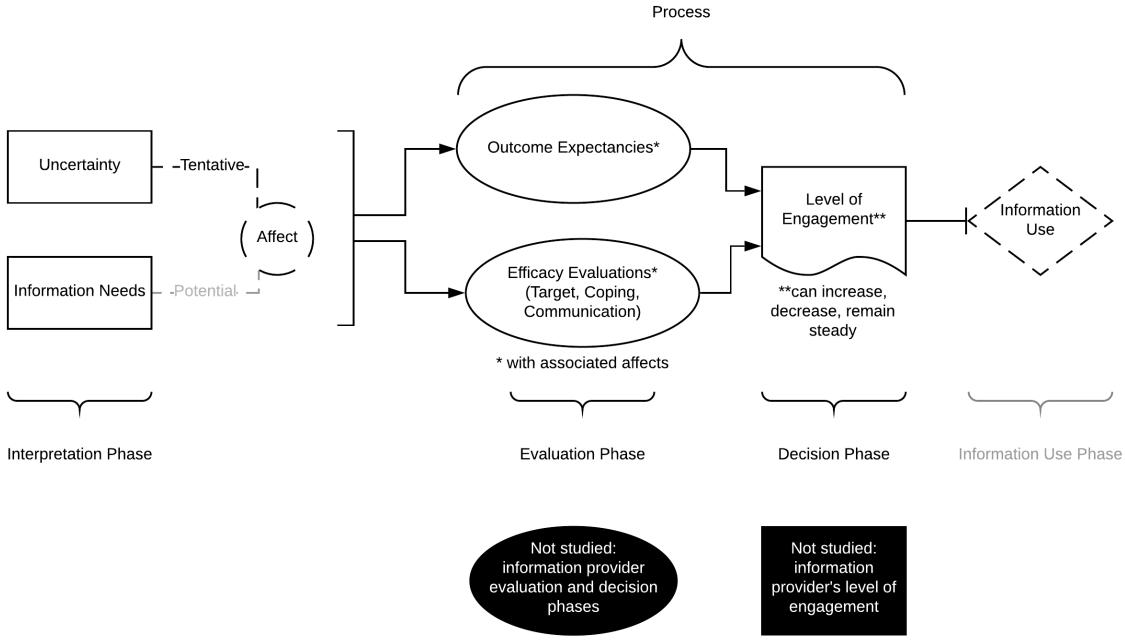

Figure 11. Proposed revised TMIM model. Information providers were not studied, but additional work could be done to study the information provider per the original model.

5.2. Implications

With a revised model presented, future work could examine the missing components of this model. Future work and implications for the three fields this is meant to merge (science communication, interpersonal communication, and coproduction) are discussed.

5.2.1. Future Coproduction TMIM Work

This model is limited by several factors. First, it was a qualitative study that sought to identify whether or not concepts seen in TMIM elsewhere even existed in coproduction.

Qualitative methods were chosen because it was unclear based on scope differences (longer time frame in coproduction with more people involved) whether TMIM would apply in the same way, so the researcher wanted some flexibility to ask additional questions if the questions proved to not detect what they were meant to detect.

The fact that all of the TMIM concepts had at least some founding is because of the qualitative nature of the study. Evidence to prove the existence of each concept was pulled from multiple places in the interview data, not simply from the question related to that concept.

A lack of an affect associated with the interpretation phrase is not necessarily indicative of affect not being present at that stage. In fact, some statements about uncertainty probably had an associated affect. N2 said, “That's just because who knows what's going to happen. With our changing climate, you just never know what ... I mean, we need to protect our springs. Just in case.” This is likely tied to an affect like concern about the uncertainty.

At least one participant did directly tie their affect statement to uncertainty: “I went to the first workshop because I'd been reading about climate change, and was concerned about it, and wondered what it was going to do around here. I was mostly in for curiosity and guess you'd say active curiosity, concerned curiosity” [N1].

Another participant linked an affect to their uncertainty and information seeking behavior overall: “And again, there's been controversy about [the topic] and all the other designations we can give things for years. But I was really expecting and hopeful that that project would kind of light a fire a little bit. I don't think it ever did, quite honestly, but I'm not sure” [RM5]. M1 said something similar, but it was more related to outcome expectancies (i.e., it was linked to the evaluation phase insead of to uncertainty overall): “I was hoping we could take what came of that and have it apply to needs we had in the state…. Again, I don't think it got to that point.”

All three of these cases, plus more of the affect statements from the participants, point to the idea that there is indeed an affect associated with uncertainty and information needs at the start of the TMIM model in the interpretation phase. However, the way I measured affect was ineffective at uncovering those affects. Therefore, I leave affect out of that point in the model. There were affect statements in every interview related to the evaluation phase, and these included affects like interest in the outcome (a somewhat neutral affect) and optimism about working with the project team. Taken as a whole, affect is definitely a component that can be investigated here. But again, since affect was captured in the terminology of the evaluation phase, it is not entirely clear that affects are associated with the interpretation phase as well. Both are related to the information seeking process overall, but interpretation phase affects are longer-standing and tied to information needs rather than being tied to how information is gathered from the project team.

Future work could therefore ask the affect question better. For reference, the affect question was, *Before you interacted with the project team, did you have positive or negative feeling about how you thought the interaction would go? For example, optimism, hope, trepidation, concern, etc.* (Appendix A). Also, it was asked after questions related to communication efficacy and target efficacy, so the conversation was contextualized by those questions. It should have been asked after the uncertainty question, which was asked earlier because it was related to management plans and information needs, which was data my colleague wanted to collect for the NC CASC so they could better meet the needs of these stakeholders.

In the future, an interview or questionnaire could more clearly draw the connection between the information need and the uncertainty, and an affect. (Still, though, it would need to be carefully worded, given that it relates to science and science is usually thought of as

independent of such considerations. Examples could be given, such as optimism related to gathering new information or concern related to not reducing the uncertainty discrepancy.)

Another improvement would be the way the efficacy questions were asked. I started the interviews thinking I would find that the decision to engage in the project was the equivalent of the decision phase's information management decision. However, I found that the entire process of coproduction acted like a conversation in which outcome expectancies and efficacy evaluations changed and fluctuated. The decision phase, then, is linked to how involved the information seeker is in the process at any given point in the project.

They might have higher expectations at the start of the "conversation" and slowly lose confidence in the project, resulting in lower levels of engagement. They may start with no expectations and develop expectations over the course of the project, resulting in higher engagement. Again, this directional, causal relationship is not a proclamation of this study but rather something that has already been proven by other TMIM scholars.

Because the decision phase ends at the conclusion of the coproduction project instead of at the decision to engage in the project, the questions should have been asked differently. I asked the participants to look back to a time before they engaged with the project team and think about their efficacy evaluations and outcome expectancies related to whether they wanted to work with that project team and whether they thought they would get useful information out of the project. However, TMIM is a dialogic model. I ran into some difficulty when I asked the questions that way, because some people had not met the project team before they engaged with the project, so they had no idea going in about what to expect. Over the course of the project, over the conversation, they developed those expectations. Therefore, I could have still asked the question

about their expectations at the start of the project. But more attention should have been paid to my follow-up question of how things went compared to those expectations.

When I asked the follow-up question, I suppose I could have predicted that I would have found data that applied to TMIM much more readily, especially for those who had little to no expectations going in because they did not have relationships with the project team. The relationship and the dyadic interaction are key to whether TMIM applies, and this should be reflected in the questions and the model.

Finally, I missed the opportunity to ask a directed question about coping efficacy. I still found coping efficacy to emerge from other conversations in the interviews, but I could have missed some interesting detail related to this question by not asking about it more directly. Future work should ask more about coping efficacy. It is directly tied to science-policy interface concepts like capacity and capacity-building (Meadow et al., 2015), which is the ability of the stakeholder to incorporate new knowledge into their work (and the assistance of improving such ability). Therefore, it is of intertest and should be studied in more detail than I was able to capture here.

The addition of the last component of the model is tentative, but it is clear from coproduction literature that information providers care what happens to the information after it is delivered (this project, for example, was funded in part to close the loop and prove that science was being translated into action). Therefore, the information use is an important component of this modified model, and future work might find ties between information use and other components, such as positive links between coping efficacy and higher information use.

5.2.2. Implications for Coproduction

The revised TMIM model presented here was only a starting point. It is possible, though it was not proven in this study, that TMIM concepts could explain why coproduction is or is not successful in practice. Problems with TMIM usually include cultural differences between science communities and communities of practice – for example, the timing and scale of science is usually not compatible with the scale of practice (Roux et al., 2006). The coproduction instances studied here were all funded by the NC CASC, which was founded under the goal of making science actionable (Secretarial Order 3289, 2009). However, even with that actionable science ethic underlying the projects, and even though each of the people we interviewed was a stakeholder who was meant to use the science, we still found that those disconnects existed. Some said that the project team or PI went in their own direction, and some said it seemed like the PI was chasing publication and seemed to care less about the application of the work. Some said there was a product delivered, but it was just not useful.

> I think it was useful because it did provide science. I think it fell short in that it provided like journal, peer reviewed, published science, which is fantastic, but it gets presented to the managers like, "Okay, here you go." Then it's like the researchers are kind of like, "Why aren't you using our stuff?" It's kind of like there's a disconnect there. [RM3]

Again, TMIM was not tested a predictive way here, but information use was added to the end of the revised model (Figure 11). Future work could link information use to other concepts in the model like coping efficacy or communication efficacy. If the stakeholder does not believe that the information can be communicated in a useful way, then they may also not use that information later.

Modeling the interaction in this way is useful to coproduction because it focuses on the *interactions* that take place in coproduction. TMIM has been shown to model what an information seeker thinks about when they need more information than they have on hand to make decisions, and they need to get that information from someone else. I outlined as a scope of TMIM in an earlier section that coproduction can be modeled using TMIM when there is an organizational boundary of some sort. Within a single organization, there are predetermined pathways of information flow, and therefore, in the practitioner agencies and organizations that act on science, TMIM would not apply to a scientist doing work for a planner in their office (Czarniawska, 2009). When there is a boundary, the information properties are not a given. The information is not definitely going to be provided to stakeholders in a way that fits well with their processes. Therefore, the interaction matters much more.

The coproduction project team might approach coproduction with their own ideas and values, with their own ideas about the outcomes of the work (which is not something I studied here but something that should absolutely be studied in future work). Similarly, the stakeholder approaches with their own ideas about what a successful project would look like for them (or they approach with open-ended expectations, and they build such goals over the course of the project). The real work of coproduction, if the goal is for science to be actionable, is in the interaction. Those involved must come together and get on the same page about what the project will accomplish.

This is the strength of TMIM: it models interpersonal communication. Returning to a point made earlier in this section, communication is not one-directional, such as the provision of a factsheet or report. If the end goal is for science to be used, then interaction is the communication that is most important. Figure 7 from a 2020 RFP from the NC CASC listed

communication as one end of an engagement spectrum, with consultation taking a little more of the project team's time and requiring a little more interaction, followed by co-development/collaboration, followed by coproduction, which entailed the most interaction of the four. Instead of thinking of communication as the most basic, simplistic level of involvement, communication should be reframed. It is present at all aspects of the actionable science interface. Interaction to come to a shared understanding lends a communication perspective to coproduction. Science may be transferred in its finished state to a completely passive audience, the stakeholder, but of course the stakeholder is not passive, even in that case. That type of science communication must take in a consideration for the audience's needs and uses for the information. Communication does not happen in a vacuum, and neither does science. Coproduction literature recognizes, this, and yet it fails to learn lessons from interpersonal communication literature. This model was introduced to see if interpersonal communication theories could be used to model coproduction, and it is my assertion that they can.

While coproduction scholars study the many skills and best practices associated with the success of coproduction projects, they may go further with this communicative umbrella consideration. Coproduction is a space between science communities and stakeholder communities (though even this is reductionistic – stakeholder communities also produce their own science) in which the research goal, objectives, and scope are negotiated, and then objective reality (nature) is studied given those conditions, and then communication products are generated and information is used (or not used) by the stakeholder. I would argue that TMIM may in fact describe coproduction in its entirety.

To compare this to another process model of coproduction, I am copying figures 2 and 6 here for comparison, now respectively called Figure 12 and Figure 13 due to their new location in the document.

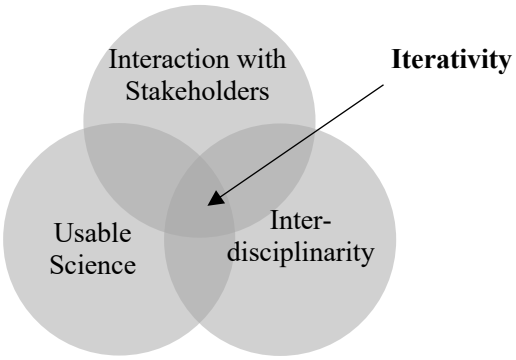

Figure 12. Model for coproduction of science and policy, wherein interactions with stakeholders, usable science, and interdisciplinarity come together in an iterative process.

From "The co-production of science and policy in integrated climate assessments" by C. A. Lemos and B. J. Morehouse, 2005, *Global Environmental Change*, p. 61. Copyright Elsevier Ltd.

Figure 12 conceptualized that at the intersection of stakeholder interactions, interactions with other scientists (interdisciplinarity), and the usable science goal, there is iterativity (Lemos and Morehouse, 2006). All three of these are communicative in nature, and the iterativity mentioned at the center of the model is the interactive communication being studied in TMIM.

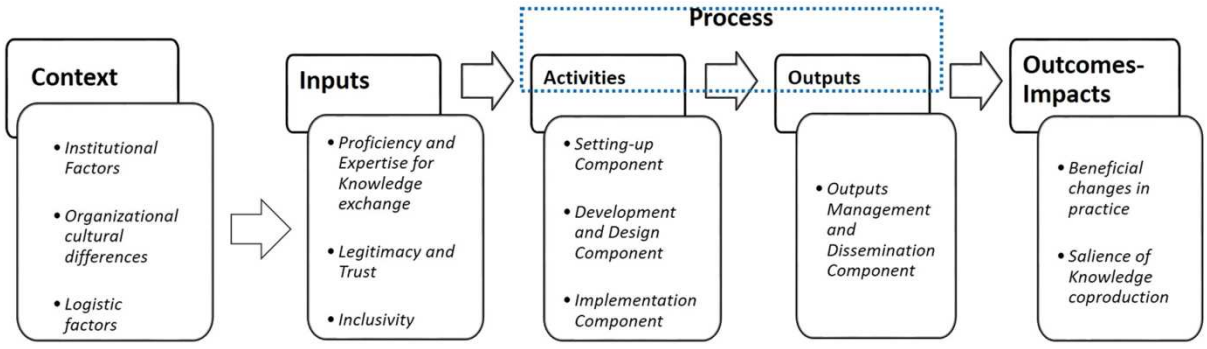

Figure 13. A conceptual model for practicing coproduction research.

From I. N. Djenontin and A. M. Meadow (2018), The art of co-production of knowledge in environmental sciences and management: lessons from international practice (p. 5). Copyright *Environmental Management*

In Figure 13, Djenontin and Meadow (2018) modeled coproduction as a process that started with context factors (cultural differences, logistic and institutional factors), led to inputs (inclusivity, proficiency, and trust), led to a process of coproduction (activities like setting it up and implementing coproduction, and outputs like dissemination), and resulted in outcomes/impacts like a beneficial change in practice.

I am copying Figure 10, now called Figure 14, which I modified based on this coproduction application of TMIM, to show the similarities and differences between Figure 13 (inductive coproduction model from Djenontin and Meadow) and Figure 14 (my TMIM revision).

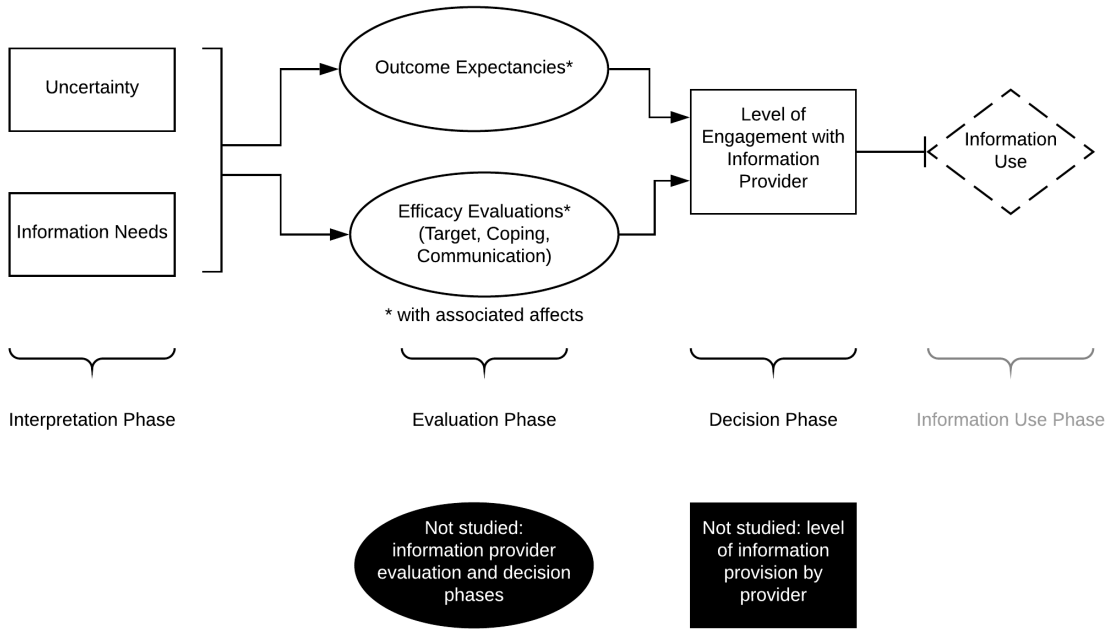

Figure 14. Proposed revised TMIM model. Information providers were not studied, but additional work could be done to study the information provider per the original model.

How they are similar:

- Figure 13 and Figure 14 are both a representative of a process that takes place over time.

- They both describe inputs, process-related factors like carrying out the work, and outcomes like information use/change to practice.
- They both include something related to target efficacy. Figure 13 describes this as trust/credibility, and Figure 14 is based on TMIM's target efficacy definition: perceptions of the information provider's willingness, trust, and ability to provide information (Afifi & Weiner, 2004).
- They both include something related to the context. In Figure 13, this is called institutional factors, logistic factors, and cultural differences. In Figure 14, this is represented in the interpretation phase.
- Broadly, the phases all align – the process is broken into similar components.

How these two models differ:

- Figure 13 was built based on a content evaluation of a sample of past coproduction reports. As such, only components that were recurrent throughout the case studies were included. It was more emergent from the practice of coproduction. Figure 14 was built based on an already existing model that has, based on this study, been found to apply to coproduction, though further work is needed to examine its applications to this setting.
- Figure 13 describes the process of coproduction, which is to set up, develop, and implement coproduction. The TMIM model does not include these things, but with added research into the information provider side of the model (the "black boxes" in Figure 14), this might emerge.
- Figure 13 describes "impacts" as either salience of the information or a beneficial change in practice. This study showed that information use is more complicated than that. Based on Taylor's (1991) information use spectrum, information may be used to enlighten, to

forecast, and many other uses. Even though the projects studied here did not all result in actionable science, there was evidence of information use in every case, even if it was only to allow the participants to develop a better understanding. This is an outcome that Figure 13 does not include, and it is an outcome that coproduction models might care to capture, even if they are not as impactful. Additionally, ignoring those other uses, and ignoring cases where information is *not* used, results in something like putting insignificant scientific results into the bottom drawer never to be heard from again. When there was not an actionable use, coproduction models should track that and learn lessons to apply next time.

In short, I would argue that the TMIM model, with the addition of the information use component in particular, captures everything that the Djenontin and Meadow study found, apart from a consideration of the information provider part of the process, but TMIM does account for that – it was just not pursued in this study (only information seekers were interviewed). Future work could build out that component of the model.

In conclusion, communication is not just about transferring information. It is about the shared communication space developed when stakeholders and project teams interact to create shared goals and generate new knowledge.

Additionlly, I mentioned this elsewhere, but I want to add that information seekers and information providers are not modeled as in some communication literature, with the implication of passivity and reception on the part of the information seeker and the implication of isolated knowledge generation on the part of the information provider. The point of a TMIM perspective in coproduction is to reframe communication as a dialogic process, and communication products like reports and factsheets are an outcome of this process. Coproduction is communication, and

science products are communication, and meetings and workshops and phone calls and emails are communication. They are inextricably linked, and they are bound by the communication ethic of generating shared meaning that informs how science (e.g., climate modeling) is conducted. Other communication models, like CBPR, might provide an even more comprehensive view of coproduction and should also be given close consideration (Appendix C).

5.2.2. Implications for Science Communication

Science communication research has generally come to the conclusion that the transmission model of information is dead – or, at least, that it may be less important than the times when "noise" complicates the transmission of scientific data (Gilbert & Stocklmayer, 2012) and there may be a need for more dialogic, interactive communication in which science users play a role in how scientific information is transmitted (Burns et al., 2003; Nisbet & Scheufele, 2009). Scholars like Brossard (2013) say that with an increasingly engaged public (or publics), scientists and science organizations are taking more of a role in communicating science to different audiences. This study pushed the interactive engagement model a step further and introduced an interpersonal communication model to science communication that happens among scientists and stakeholders when the goal is for science to be actionable.

Communicative input at the early stages of science *does* greatly impact how the *outputs* of science are conveyed, which is what science communication typically studies. What this research advocated was that scientific *inputs* are just as important and just as communicative in nature, and that the field of science communication should focus on studying communication across the spectrum of science production and dissemination, not just the dissemination of scientific results. While science communication scholars have recommended that dialogue and engagement are important, this study actually takes such interactions into account.

It is my assertion based on this work, and other interpersonal science communication work, that science communication as a field continue to develop and link communication models with science communication practice. TMIM is not the only model that might apply. I will briefly call back to the literature review to CBPR, which is an intensive, communication-based model of research being co-conducted by communities and health researchers, with high goals for success such as a balance between generating findings and applying findings, equitable ownership of the research process, and many more factors that could and probably should be considered in more applications than health research settings, such as this coproductive setting (Wallerstein et al., 2017). Interactive research with historically marginalized communities, such as tribes, might benefit from a CBPR perspective, but other research might benefit from the concepts in interactive communication scholarship as well.

One idea that might be tracked down within science communication research is the idea that TMIM has also been applied to one case of online information seeking (Tokunaga & Gustafson, 2014). However, it was a study about people seeking information about interpersonal others, like friends and public figures. It may be possible for another link to be drawn between TMIM and science communication: online scientific information seeking. TMIM stems from uncertainty management theories, and uncertainty management is one of the factors that may drive people to seek information online, including science information. Source evaluation concepts from mass communication literature (Slater & Rouner, 1996) might contribute to understanding of how scientists and science organizations are perceived.

The scientist/scientific organization as a source of information can build trust with their audiences/publics, which would be captured by TMIM's target efficacy concept (per Afifi and Weiner, 2004, applicable to all TMIM mentions in this section). Trust in science is something

surveyed regularly (Funk et al., 2019; Gauchat, 2012; Trettin & Musham, 2000). Coping efficacy might speak to how well science information seekers are able to understand and integrate new science information into their lives or practices (and obviously, this is an important component for policy audiences, a subset of which are researched here). Communication efficacy captures how well science is communicated, which is the goal of science communication as a field. The interpretation phase (uncertainty and information needs) describes information seekers' motivations for seeking out scientific information and might inform us as to why some publics/audiences more carefully attend some science and not others. It incorporates uncertainty, which is also a widely studied concept in science communication (Frewer et al., 2003). And finally, TMIM is dialogic, and focuses on shared meaning generated at the interface between science and non-science participants. Science does not happen in a vacuum, and science engagement is important to the scientific process, so why not apply an interpersonal model, which models the dialogic process itself?

In essence, this study contributes to science communication an ethic of audience-centric, uses and gratifications style (Ruggiero, 2000), motivations-oriented research. Information seekers should not be discredited as careful evaluators of scientific information who can provide input into the process (Gilbert & Stocklmayer, 2012).

In conclusion, future work should be done in science communication scholarship to extend the scope of study beyond that of mediated communication. Mediated communication study has great potential to recognize the effects of things like framing and messaging, but this perspective can minimize if not completely ignore the role of the science user. A great deal of work is already being done to study more active audiences, but this should be taken even further. There is rich potential for the study and application of dialogic, interactive communication

theories and models in science communication. The interpersonal, dialogic perspective has the additional benefit of not reducing science users to the perspective of "audiences," a term that carries the implication of passivity, and a term that primarily recognizes power in the role of the science communicator or the scientist as communicator. In dialogue, both parties are present and cognizant and providing feedbacks into the communication process. The interpersonal nature of some science communication should therefore be further studied both in terms of TMIM as well as within other interpersonal theories and frameworks in order to improve the robustness of the science communication field.

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APPENDIX A. INTERVIEW PROTOCOL

Full interview protocol:

Hello, and thank you so much for agreeing to answer some questions. As a heads up, we are recording this interview. Is this okay with you?

(I'm Jill Lackett, I'm Lindsey Middleton), and we are researchers from Colorado State University affiliated with the Natural Resource Ecology Laboratory. We are conducting interviews to help improve the utility of co-produced research - are you familiar with that term? (If not: co-production is when scientists work collaboratively with managers to set the research agenda and carry out the research together).

To do this, we are interviewing collaborators who worked on projects funded at least in part by the North Central Climate Science Center (now called the North Central Climate Adaptation Science Center). In your case, this was xx project with xx PI and project team.

This interview will have three sections. In the first section, we will ask questions about long-term resource management planning at your agency. In the second section we will ask questions about your involvement with and the outcomes of xx project. In the third section, we will ask questions related to your interactions with the project team.

This interview will take around an hour to complete. Your participation is voluntary. If you decide to participate, you may withdraw your consent and stop participation at any time without penalty.

Another part of this project includes an anonymous digital survey sent out by another member of our research team, which you may have received via email. Although the survey results and anonymized interview results may be compared at a later date, the interviews will be analyzed separately. (Jill and I/Lindsey and I) will collect personal identifiers during the interviews, but pseudonyms or code names will be inserted in the place of real names and other identifiers (like locations and places of work) before results are shared elsewhere, including with other members of the team.

If you have any questions for us later, you have our contact information, and we can provide contact information for Colorado State University's research office if you have any questions about your rights as a volunteer in this research (if they ask: RICRO_IRB@mail.colostate.edu; 970-491-1553).

There are no known risks or direct benefits to you, but the results will inform, and potentially improve, the services provided by the NC CASC and similar organizations.

Do you have any questions for us at this time? Would you like to proceed?

If yes: Proceed.

If no: Thank you for your time.

Ok, let's begin.

Section 1. First, we'd like to get to know how long-term resource management planning processes work at your (agency, etc.). Again, your name and any identifying information will be anonymized. (internal title: NC CASC Planning and Priorities)

1. Within xx agency/university/NGO, do you consider yourself to be a resource manager/decision-maker/planner, a scientist/technician/researcher, both or neither?
    a. Briefly describe your role and responsibilities within your agency.
2. Could you briefly name and describe the long-term resource management planning documents and planning schedule of xx agency, etc? (Prompts: what are the plans for your agency, on what schedule are the plans updated, etc.?)
3. Can you identify particular steps in completing those planning documents (or in other planning processes) where you often come to realize that your agency could use new information or tools? When in the process would you need this new information to effectively incorporate it into your agency's planning processes?
4. In what ways do you currently receive new information and tools to help with planning activities? Which of these avenues work well? Are there other ways that you would like to receive information or tools to be more useful to you in incorporating into planning?
5. What are the types of uncertainty you face in planning? (prompts: bring up study - political, climate, scientific; other interview - controversy) Can you describe them?

Section 2. Next, we'd like to ask some questions specific to your involvement with the NC CASC. (internal title: Use/Usefulness of NC CSC Science)

1. Confirm that they were involved with xx project and with the PI xx and team.
    a. If they confirm, continue. If not, jump down to following section.
2. How would you describe your role in xx project?
3. How would you describe the information gap or research need that was being addressed by this project? (If not mentioned, follow-up: How important was this information for carrying out your planning needs?)
4. In what ways did the information/tools shared through the project meet or fail to meet your needs?
5. How did you and others involved (modify during interview as we get more info about who was involved from their standpoint) use the science produced? (Prompts, including continuum of information use.
    a. Other prompts: How did things change based on the tools or information shared? How did new information, processes, tools, or other results of this project influence a management plan or action?
6. What are your top agency science needs (or high-priority natural resource issues) currently?
    a. How do you envision these science needs or information gaps changing in the future?

Section 3. Finally, we'd like to ask about a specific time you interacted with one person or multiple people from the xx project team. This could be in the form of a meeting, workshop, phone conversation, or other interaction. If there aren't any examples, can you think of a time you interacted with a similar research team? (If none, skip section and end interview) (internal title: interactive communication evaluation)

1. How frequent were interactions among the xx project team, and what form did those interactions take? (clarification: interactions can include in-person conversations, meetings, workshops, phone conversations, emails, and other interactive conversations - this would not include reports and other one-way communications)
    a. (If a different situation from the above-discussed project, an additional question: How would you describe the research problem or information needs?)

The remaining questions have to do with your expectations of the interactions and results of the project compared to what actually took place.

2. Before these xx interactions (meetings, workshops, etc.), did you have any expectations for walking away with new information, skills, or other resources?
    a. How did the (meetings, etc.) go, compared to your expectations?
3. How did you expect the interactions to go in terms of being able to share necessary information? (possible prompts: Did you anticipate the research team being able to spend the time necessary to develop an understanding of your agency's needs? Did you anticipate shared understanding or shared goals? Did you expect that the research team would be able to synthesize complex information for shared understanding?)
    a. How did the encounters go, compared to what you expected?
4. Again, looking back to before you spent time interacting with xx project team, how would you have described your expectations of the team's abilities, knowledge, and trustworthiness on the topic?
    a. How did the skill level, knowledge, and trustworthiness of the members of the project team differ from those expectations?
5. Before you interacted with the project team, did you have positive or negative feeling about how you thought the interaction would go? For example, optimism, hope, trepidation, concern, etc.
6. How likely are you to engage in similar projects in the future? Why/why not? (prompts: resources available, mechanisms, internal support, etc.)

That completes our questions. Is there anything else that you want to tell us or anything else that seems relevant or important to the topics we have been discussing?

Thank you for your time! This information will be used to inform the CASC's strategic plan, for Lindsey's master's thesis, and for a report on the research. If you would like to receive copies of these outputs, we can put you on a contact list for later.

May we follow up with you if we need any clarification or if any pertinent questions come up from our future interviews?

APPENDIX B. SUPPLEMENTAL INFORMATION USE HANDOUT

This handout was provided to interview participants in advance of the interviews, and in cases where they were not able to access the sheet, we read the options to them. Note that all interviews were conducted remotely, so we were unable to provide this handout in person.

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Taylor 1991, pg. 230

Chapter 7: Information Use Environments, Robert S. Taylor

In: Volume 10: Progress in Communication Sciences, edited by Brenda Dervin and Melvin J. Voight

1991, Ablex Publishing

8 types of information use

1. Enlightenment: desire for context information or ideas in order to make sense of a situation
2. Problem understanding: more specific than enlightenment, better comprehension of particular problems
3. Instrumental: finding out what to do and how to do something, instructions
4. Factual: the need for and consequent provision of precise data (constraints: quality of data, user perception of quality)
5. Conformational: the need to verify a piece of information
6. Projective: future-oriented, but not related to political or personal situation; concerned with estimates and probabilities
7. Motivational: has to do with personal involvement, of going on (or not going on)
8. Actionable, practical use of information: Either a decision was made differently because of the information or decision was made at all because of the information that was produced or an action happened on the ground because of the that information. (Originally: Personal or political: has to do with relationships, status, reputation, personal fulfillment)

APPENDIX C. COMMUNITY BASED PARTICIPATORY RESEARCH MODEL

From N. Wallerstein, J. Oetzel, B. Duran, G. Tafoya, L. Belone, & R. Rae. (2008). *What predicts outcomes in CBPR?* https://doi.org/10.13140/RG.2.2.25894.11844, p. 381

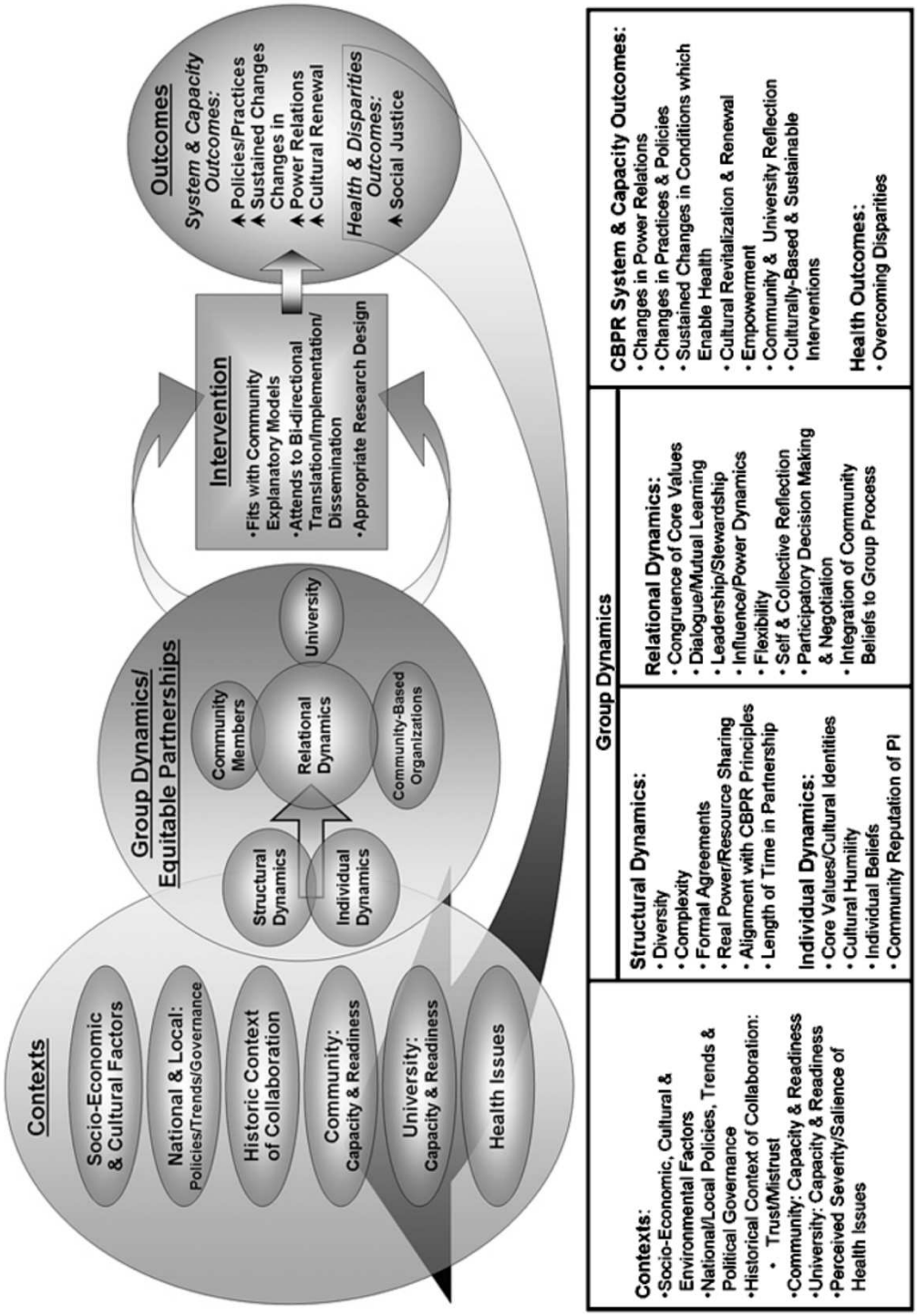

FIGURE 21.1 *Conceptual Logic Model of Community-Based Participatory Research: Processes to Outcomes*

APPENDIX D. CODES

Theme	Emerged from
_Self-Identified Manager or Scientist	S1, Q1. Within xx agency/university/NGO, do you consider yourself to be a resource manager/decision-maker/planner, a scientist/technician/researcher, both or neither? *Briefly describe your role and responsibilities within your agency.*
Adaptation	Emergent code, removed because not enough instances and not meaningful to analysis
Affect	S3, Q5. Before you interacted with the project team, did you have positive or negative feeling about how you thought the interaction would go? For example, optimism, hope, trepidation, concern, etc.
Boundary Work	Emergent code, used for analysis
Challenges	Emergent code, use to cross compare information seeking and science incorporation to describe barriers to information seeking and information flow
Characteristics of Project	Emergent code, used to contextualize other descriptions of project like interactions with project team and project information gap
Clarification	Emergent and largely unused – when participants agreed with a clarifying statement from the researchers without rephrasing in their own words, that was coded by topic and as "clarification" as a reminder that the participants did not say that phrase (happened a few times in about half of the interviews)
Climate Science Experience	Emergent and demonstrated familiarity with new, incoming science – used to contextualize information seeking (mentioned by about half of participants)
Climate Science Incorporation	Subset of information use code and mechanisms for science incorporation code (see below) that describes how climate science in particular is incorporated (useful since NC CASC funds global change science, including climate science – other instances of global change were not recorded and were less frequent)
Communication Efficacy	S3, Q3. How did you expect the interactions to go in terms of being able to share necessary information? (possible prompts: Did you anticipate the research team being able to spend the time necessary to develop an understanding of your agency's needs? Did you anticipate shared understanding or shared goals? Did you expect that the research team would be able to synthesize complex information for shared understanding?)
Coordination Work	Emergent code – used to add detail to broader level theme of self-identified manager or scientist
Coping Efficacy	S2, Q5. How did you and others involved (modify as we get more info about who was involved from their standpoint) use the science produced? Prompts, including continuum of science use. S3, Q6. How likely are you to engage in similar projects in the future? Why/why not? (prompts: resources available,

	mechanisms, internal support, etc.)
decision phase	TMIM
Expectations	TMIM
Future Management Priorities	NC CASC report
Go-Between	Emergent, not used (overlaps with coordination work)
Goals	Emergent, not used
Identifying New Tools	NC CASC report
information needs	TMIM
Information Provision	NC CASC report
Information Shortages	Removes, combined with project shortcomings
Information Sources	Emergent – used to describe information seeking other than NC CASC project
Institutional Characteristics	Emergent code – used as reference
Institutional Mechanisms for Science Incorporation	Combined with institutional characteristics for information flow analysis
Interaction Type	Informs TMIM
Lessons Learned	Removed
Limitations at Organization**	Kept as detail for project shortcomings perhaps (NC CASC report)
Management Plan Revision	NC CASC
Management Plans	NC CASC, also informed results here
Management Priorities	Related to information needs
management strategy	Removed
Manager-Researcher Collaboration	Not used, helpful for identifying network ideas
mismatch	Related to timing of research and applicability discussion
Opportunities for Engagement	NC CASC
Outcome	Used to compare expectations with outcomes
Partnerships	Not used (described how stakeholders partnered with other organizations, mostly network perspective though incomplete)
Perceived Involvement in Project	Combined with role in project
Politics	Kept as detail of Uncertainties
Practical Science	NC CASC
Project Information Need	Used for TMIM
Project shortcoming	Used throughout
Project Successes	Used throughout
relationship building	Detail of project shortcoming and success, detail of coproduction and information seeking
resource management	Removed
role at organization	Used throughout
Role in Project	NC CASC, TMIM
Role of CASC	Removed
science communication	Might be useful for future analysis
Target Efficacy	TMIM
Top-Down vs. Bottom-Up Management	Not used

trust	Detail of relationship building
Uncertainties	Used throughout
Unclear	Some of the text was not entirely clear, hard to understand what participant meant
Use of Information	Used throughout
value orientations	Not used, potential future use
Vulnerability	Climate vulnerability, removed (not useful to this analysis)
ways of knowing	Not used, ended up being a way of calling out when project team was seeing the world differently from the participant (in participant's words), possibly worth exploring more, though not many occurrences of this code
Working with Stakeholders	Used to show when participant had own stakeholders

GLOSSARY

Coproduction: As defined in this study, coproduction is the collaborative effort of science and policy actors working together to transfer, produce, and apply environmental and climate knowledge and science to land management (Meadow et al., 2015).

Information provider (IP): The information providers (Walid A. Afifi & Weiner, 2004) are broadly thought of here as the ones initiating the coproduction interactions. See *stakeholders* for a description of the chain of coproduction – the "information providers" as referred to in this study are the second link in the chain, after the funding source and before the stakeholders.

Information seeker (IS): The information seeker is the terminology used here to represent stakeholders of coproduction science. (See *stakeholder)*

Stakeholder (referred to as information seeker): Even in the field being studied, the word "stakeholder" has come to mean several things and in some cases, has lost is meaning. Most literally, *stakeholder* refers to a group of people who hold a stake in something that they may not have direct control over, such as a company's actions or a governing body's policies. In this case, stakeholder refers specifically to the *participants* of this study – those who participated in coproduced science with a stake in the outcome of that science and how it would affect their respective interests. To be more specific, there are of course many stakeholders at play in coproduction, from the funding agencies to the research organizations like the NC CASC carrying out the work to the organizations essentially receiving the coproduced work to those recipient organizations' own stakeholders. For example, starting from the beginning of the chain, a coproduction project may be funded by a government grant, which then permits an organization like the NC CASC to initiate

coproduced research, which then opens the door for a coproduction partner organization or multiple partner organizations like the NPS, who in turn likely have their own clients or stakeholders or other interested groups, like farmers and recreationists. In THIS study, the word “stakeholder” will refer specifically to the third link in the chain, the coproduction partner organizations like NPS, while acknowledging that other stakeholder groups exist – this distinction is solely for the sake of clarity in this study.