
Social Learning, Resilience & Land Management Transformations in the Northeast US

A Literature Review for the Climate Adaptation Fellowship Curriculum Design Project

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Spring 2018

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This document contains portions of a draft MS thesis and excerpts from papers intended for publication. Please do not circulate this draft externally beyond the project teams yet. Thank you.

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Introduction

There is a limited but growing body of research and outreach on climate adaptation in the Northeast, geared towards supporting agricultural and forestry communities' resilience to climate change (Schattman et al., 2015; Jemison et al., 2014). This work is matched by the on-farm adaptations and innovations of farmers and other land managers who have been on the front lines of dealing with increasingly severe, variable and unpredictable weather. Bridging these two different types of expertise has powerful potential to advance the needed solutions for agricultural and forestry communities, as well as accelerate the adoption of climate adaptive management strategies.

The Climate Adaptation Fellowship Curriculum Design Project is a collaborative initiative to integrate diverse types of expertise from the Northeast region to design curriculum, which leverages social learning to overcome challenges to climate change communication and outreach. In this collaborative project, we are embarking on 'Boundary Work', which seeks an interface between experts and decision-makers (Cash et al., 2003), with the shared goals of 1) creating valuable and usable information; and 2) delivering information in a way that positively impacts the use and adoption of the knowledge shared.

Harnessing the value of scientific research for sustainability and sustainable transitions requires understanding the failures and successes of previous approaches to connect knowledge to action. The objective of this literature review is to review key concepts and lessons learned from diverse bodies of scholarship, along with case studies specific to the Northeastern U.S., in order to provide content and methods to the curriculum design teams of the Climate Adaptation Fellowship. Specifically, the literature review aims to: 1) introduce key concepts and foundational theories for how social learning enhances adaptive capacity, 2) link this body of literature to relevance for climate change outreach programming among land managers in the Northeast U.S., 3) present case studies and examples within the region, and 4) identify trends and lessons that can be applied by curriculum design projects.

The reader should recognize that this long version was written with sector leads in mind to inform the approach they take to designing programming about adaptive management. This version is characterized by academic jargon, and extends to topics well beyond the scope of climate adaptation literature. **A concise summary of key ideas has been generated in a separate document for workshop participants who wish to forgo this dive into scholarly literature.**

Section I. General Review of Trends & Theoretical Foundations in Adaptive Management & Social Learning in Ag & Natural Resources

1. What makes farms & managed forests resilient to climate change?

Land managers in the Northeastern US are increasingly confronted with the impacts of severe and extreme weather. Climatic models for the region project heightened risk for incidence of drought, extreme precipitation events, new pest pressures, overall warming and a suite of foreboding indirect impacts which threaten the economic viability of natural resource based livelihoods (Janowiak et al., 2016; Tobin et al., 2015). In this section we examine the capacity for farms, foresters and communities to withstand, adapt or transform in the face of these shocks and stressors through the concepts of **resilience** and **adaptive capacity**.

Resilience can be defined in terms of the capacity of a system, individual or community, to absorb the impacts of shocks and stressors, to adapt to change, and to potentially transform, in a manner that enables the achievement of development results (Ospina, 2015). As a holistic systems-level approach, resilience theory asserts that social and ecological systems cannot be understood in the absence of each other (Nelson et al., 2007). For land managers such as farmers, resilience can describe the capacity of the ecosystem/agroecosystem to withstand and respond to weather extremes, or it can be applied to describe the capacity of a business or household to maintain a land-based livelihood in the face of a changing climate. Resilience can be characteristic of a system, a goal, or a principle for long term decision making.

In theory, farms and managed forests can be resilient to climate change if they have the assets, capabilities and intent to withstand, respond and adapt to the impacts of climate variability. The capability to make change with external forces in mind has been termed adaptive capacity. In contrast to ecosystems which respond to impacts through genetic transfers and storage, farms and forests are also governed by the decision-making of humans who employ learning, reasoning, and communication to respond to external forces (Norberg and Cumming, 2008; Holling et al., 1998). A strategy for resilience needs to involve more than changes to physical infrastructure, land management or livelihood diversification; it must also foster social infrastructure that offers cohesion and support (Klinenberg, 2013). Among the many indicators that researchers have identified, knowledge is an important determinant in adaptive capacity, as are access to financial resources, ecological assets, social networks and physical infrastructure (Williams et al., 2015).

Adaptive management decisions by farmers and foresters are limited by the combination of assets and knowledge that are available to draw upon. These strategies are also influenced by the unique operating context and site-specific characteristic of a farm or forest, how vulnerable they are to the impacts of climate variability, and the perceived nature of climate-related risks. For example, adapting to the risks of heavy precipitation events in spring months on a farm could mean shifting planting dates or long-term soil heath building; for others, it might mean investing in a greenhouse, or adjusting a business plan to generate income from hosting events on their farm. Understanding the vulnerability complex and limiting factors for adaptive decision making through a livelihoods asset framework can help identify key leverage points for intervention and capacity building (Nelson et al., 2010).

Adaptive capacity, as a function of farmer capability, emerges from the management of basic agricultural asset categories (Lengnick, 2015) and is widely understood through a livelihood complex in international studies on smallholder farm resilience. Agricultural management for effective adaptation and mitigation depends on both farmer willingness and capacity to pursue such actions (Howden et al., 2007; McCarl, 2010). A willingness and intent to make changes is the last crucial element to adaptation, and for climate-risk management, this poses a unique challenge to agricultural communities within the United States. In developing and developed countries elsewhere in the world, limiting factors are associated with farmers' struggle with capacity, but in the United States, adaptive management can also be limited by climate science skepticism (Chatrchyan et al., 2017). Adaptive capacity and beliefs that influence a willingness to adopt are drivers of land management decisions, which emerge from livelihood assets and ultimately influence system resilience. To support land managers in making adaptive decisions it is important that we consider and develop our understanding of how farmers view climate adaptation measures (Arbuckle et al., 2013).

Developing an agroecosystem's capacity to both mitigate and build resilience to climate change requires that farmers have the time and resources to invest in management changes, as well as access to information about the best strategies to employ. We expect workshop participants to be familiar with adaptive management strategies and want to highlight the **importance of individual and community scale capacity & capability as critical to enabling resilience and adaptation**. Detailed reviews of adaptive management techniques and strategies for farms and forests are available in Janowiak et al. (2016) and Tobin et al. (2015). This project targets building human and social asset categories through enhancing the knowledge-base of land managers and building intentional peer networks for adaptive social learning.

Livelihood Assets.

Livelihood asset categories include human, physical, natural, financial, cultural and social capitals (Flora et al., 2015), the management of which determine the farm's ability to proactively invest in adaptive management, or recover from challenging weather impacts. Enhancing the adaptive capacity of an operation requires investment in one or more of these asset categories, depending on the context, production type and individuals (Lengnick, 2015). Prior research suggests that larger producers tend to invest in technology, physical capital and financial capitals to buffer their farms from climate risks, whereas smaller and more diversified producers invest in natural and social capitals for resilience (Stokes and Howden, 2010, Lengnick, 2015).

Adaptive management strategies in northeast agriculture.

Various recent research efforts have documented adaptive management strategies in the Northeast, which buffer farms from the risks associated with increasingly variable weather and climate change. General recommendations have been made, based on prior research, as to the effectiveness of conservation practices, such as cover cropping, and riparian

buffers, (Janowiak et al., 2016; Tobin et al., 2015; Schattman et al., 2015). Extensive research has also been conducted on the promise of individual management strategies like crop diversification (Lin, 2011) and cover crops (Kaye and Quemada 2017). Two studies which represent groundbreaking work on adaptive management in Northeastern agriculture document farmers as resilient and adaptive, and identify strategies which are being employed to manage the risks associated with climate change. In Vermont, climate risk management strategies reported at the farm scale include (1) diversity of markets, production, household income and land base, (2) sustainable soil management, including water management in soils, and (3) innovative cropping systems (Schattman et al., 2015). Research by John Jemison in Maine identified over 40 different strategies which farmers are using to manage for climate risks (Jemison et al., 2014). Importantly, Jemison notes that climate risk management considerations differ based on operating context, which refers to the combination of site specific characteristics, scale, production type, policy constraints, access to resources, and other pressures which drive decision-making.

2. Understanding the nature of change in agricultural contexts.

Here we explore literature on how new knowledge is adopted and transformations happen in agricultural and forestry communities, with a focus on useful lessons for outreach and curriculum design projects.

2.1 Diffusion of Innovations Theory

Diffusion of Innovations theory offers a useful lens for understanding how a farmer's willingness to adopt a new practice is influenced by perceptions of the practice, social norms, the policy environment, and cultural context. This framework, among others, has been used to study how management decisions are embedded within social structures, and is also influenced by the perceived complexity, advantage and compatibility of an innovation (Wejnert, 2002). The Diffusion of Innovations theory has long informed outreach and extension programming, and was first conceptualized by Rogers (1958) for delivering science-based information to lay audiences. This Diffusion of Innovation model proposes that the adoption of new practices begins with an innovator, who creates a new management practice. As illustrated in Figure 1, early adopters are the influential agents who adopt the innovation first, followed by later adopters who learn from their peers (Rogers, 1958). Rogers created a clear division in roles and types of expertise, where the innovator/scientist generates new information isolated from end-users (Stephenson, 2003).

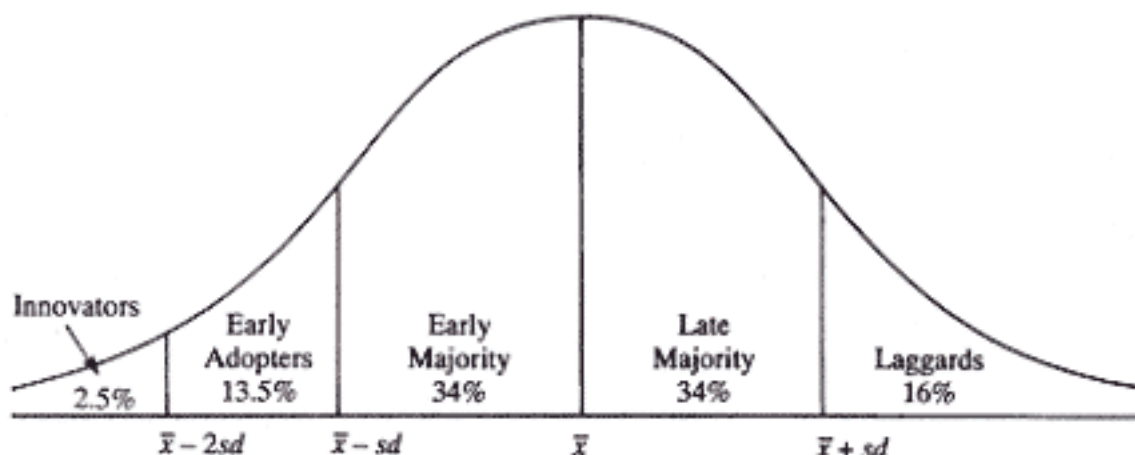


Figure 1. Stephenson G (2003) The Somewhat Flawed Theoretical Foundation of the Extension Service. *Journal of Extension* 41(4) Article # 4FEA1

This model recognizes many factors influencing the rate of adoption, such as a user's perception of an innovation and its complexity, compatibility, trialability, observability, and relative advantage (Rogers, 2003; Hubbard and Sandmann, 2007; Stephenson, 2003). The adoption of an innovation can also be impacted by the way a user learns about it, including social networks, communication channels, and external factors, such as weather, policy environment, and markets.

Influential Perceptions of Innovations

Perceived attributes of an innovation some of the most important influences on the rate of adoption (Rogers 2003). Roger's work categorizes perceived attributes into the following:

- **Relative advantage:** the degree to which an innovation is perceived as being better than previous ideas/practices. (offers economic advantages or social status)
- **Compatibility:** the degree to which an idea fits into cultural values, beliefs, previously introduced ideas, and the needs of an individual
- **Complexity:** the degree to which an idea is perceived as being hard to understand negatively impacts adoption
- **Trialability:** the degree to which an idea can be experimented with in a low risk setting
- **Observability:** the degree to which the benefits or impacts of adopting a new idea can be witnessed

2.2 Notable Adopter Groups

Diffusion theory research shows significant evidence that there are specific differences in the characteristics between adopter groups, particularly between those who adopt emerging strategies first and those who are resistant to new technologies (laggards). Understanding and

being able to identify the characteristics of the early adopter and innovator types--those who try a new management style early and influence others in their community to do the same--is critical to be able to effectively reach different sub-audiences with new and emerging information. What causes certain farmers and foresters to choose to be early adopters, while others consistently adopt emerging practices much later? Findings reveal that age, socio-economic status, education, and information flows heavily influence whether a person is an early adopter or not.

Previous studies have found that early adopters are more likely to be younger than later adopters/laggards (Daberkow et al., 1998; Sumon et al., 2014; Lapple and Van Rensburg, 2011; Bultena and Hoiberg, 1983; Asafu-Adjaye, 2008). Younger people are more likely to take risks and have more incentive for adoption because of longer-pay off period. Studies also show that early adopters commonly have more education than non-early adopters (Sumon et al., 2014.; Bultena and Hoiberg, 1983; Asafu-Adjayen, 2008). Research argues that higher education levels are attributed to more favorable attitudes towards science and can lead to greater access to and knowledge of outside resources. Additionally, early adopters have been shown to be of a higher socioeconomic status, and have greater upward mobility (Daberkow and McBride, 1998; Sumon et al., 2014; Rogers, 2003). Those with lower income are less likely to take risks because of lower economic flexibility, while households with greater economic flexibility have greater ability to make riskier investments.

Opinion leaders are those who are sought after by their peers for advice and information about a new idea or promising practice. These opinion leaders are also sought out by outreach professionals to accelerate the spread of information or adoption within a community because they play such an influential role. Opinion leaders are truly role models, and Rogers (2003) characterizes them as:

- being the embodiment of success in a community,
- being respected by peers, and
- deliberating about making changes and using new ideas with discretion.

Early majority adopters are key audience for traditional outreach programming. This group adopts new ideas before the majority of their peers, but are not sought after as opinion leaders. Rogers (2003) identifies this group as a critical link to the late adopters, and are sometimes called the “tipping point” for the adoption of an innovation. They constitute the connections in a community’s interpersonal networks and deliberate at length about whether to make changes.

2.3 Critiques of Diffusion Theory & Evolutions

In recent decades, several critics, and Rogers himself, have acknowledged the many shortcomings and failures of the theory in practice (Stephenson, 2003). Specifically, the application of the approach has biased outreach towards the success of larger, wealthier farmers, at the expense of smaller farms and rural livelihoods, thus leaving late-adopters underserved by outreach and extension efforts (Stephenson, 2003). Rogers (2003) notes that the diffusion of innovation generally results in widened socioeconomic gaps between earlier and later adopter categories. Critiques of diffusion theory suggest that extension approaches

should evolve to emphasize both participation and inclusion and be informed by end-users' unique preferences for communication (Stephenson, 2003). Late adopters, who are traditionally left behind “place greatest credibility in their peers' subjective experience with innovation, conveyed to them through interpersonal networks” (Rogers, 2003).

Rogers advises that narrowing this gap can be achieved by crafting outreach communications catered towards the late adopter & low socioeconomic audience segments, combined with creating small discussion groups that cultivate “self-efficacy and collective efficacy, a belief that have control over their environment” (2003). To actively remake the traditional “trickle down” approach, opinion leaders should be selected from within disadvantaged groups and outreach programs should be targeted to the peer networks of vulnerable groups (Rogers, 2003).

Advancements in information delivery have followed the same trajectories in both the scholarship of extension professionals and in analog fields of study. Case studies of extension professionals' best practices confirm that participation, engagement and social learning are crucial tools for transforming agricultural management (Carolan, 2006; Hassanein et al., 1999; Heleba et al., 2016; Warner, 2006). Forestry and natural resource education efforts have also emphasized the value of peer learning and social networks in reaching challenging audiences (Ma et al., 2012; Schraml, 2003; Johnson et al., 2006). Other fields concerned with improving the delivery of science-based information, such as risk communication and technology transfer studies, also emphasize the benefits of engaged relationships between information producers and end-users to positively impact the use and salience of information (Agrawala and Broad, 2002; Cash et al., 2006; Meadow et al., 2015; Peterson et al., 2010). Participatory approaches and the process of co-producing knowledge are increasingly being leveraged to address the shortcomings and challenges of information-deficit technology transfer strategies (Shiner, 1999; Schraml, 2003; Johnson et al., 2006)

2.4 Influences on Adoption & Drivers of Change in Agricultural Contexts

While top-down technology transfer models, like diffusion of innovations theory, have been jilted by scholars of climate adaptation and complex social-ecological systems, the body of research offers many useful understandings of mechanisms in peer-to-peer learning and how information moves through a community to influence management changes. Much of this scholarship can be leveraged by our project team. *“Management is about bringing together old knowledge, from diverse sources, into new perspectives for practice” (Westley, 1995).*

A recent review of agricultural stakeholder views and decisions by Chatrchyan et al. (2017) on climate change offers a thorough analysis of available research on factors that influence farmers' decision-making on climate change mitigation and adaptation (Figure 2). “These factors include farmers' knowledge and capacity to make change; beliefs and perceptions (including a fear of additional regulation); political and economic factors (including costs of changes or incentives); environmental factors on the farm (including personal experience with extreme weather or on-farm conditions); and the social networks that include trusted relationships with Extension specialists, advisors, industry contacts, family, and peers” (Chatrchyan et al., 2017). Outreach efforts can use this understanding to craft the content and

framing of information, as well as shape their approach to communication and delivery. We offer more in-depth exploration of a few key factors that relate to the content of this review.

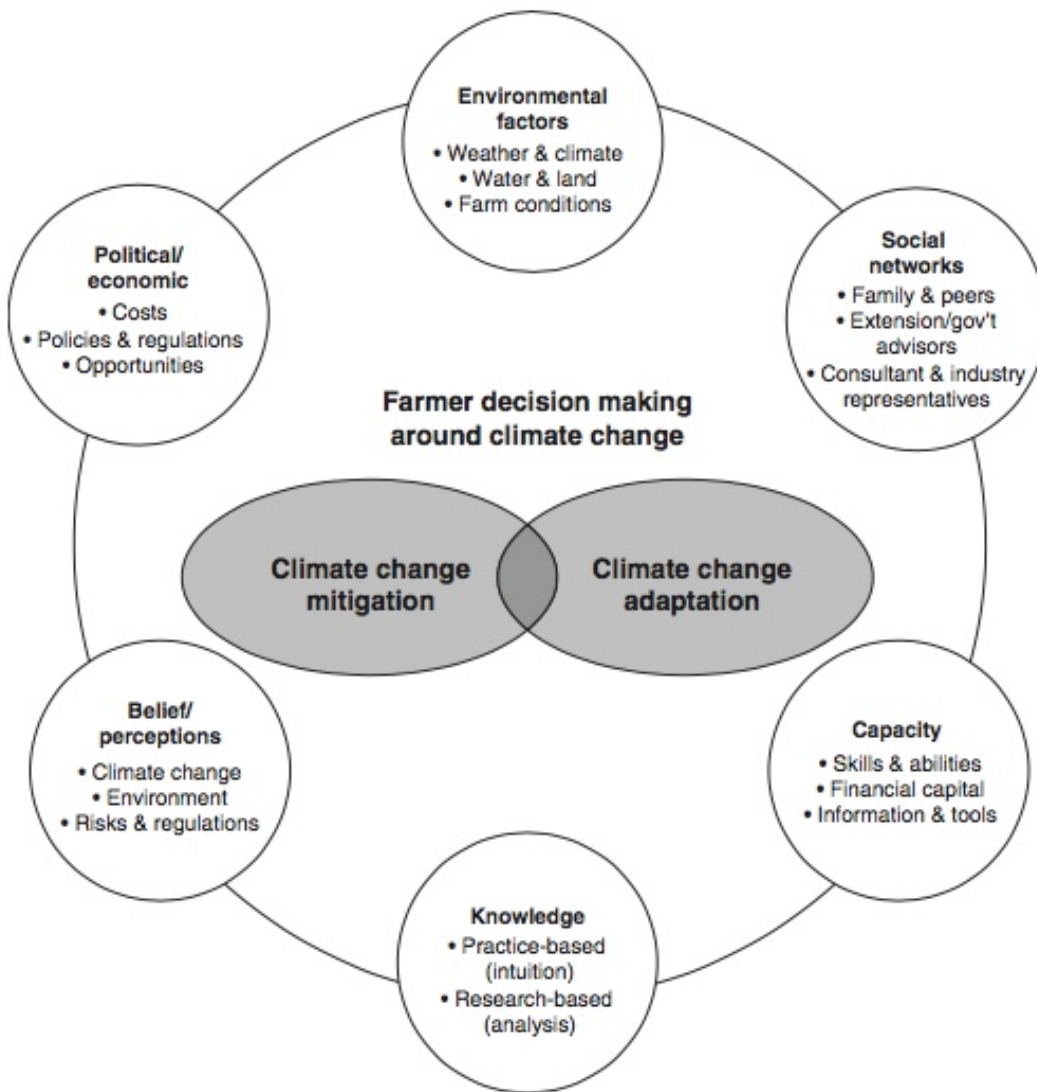


Figure 2. Conceptual framework of the factors that affect U.S. farmers' decision making around climate change. Adapted from Chatrchyan, A. M., Erlebacher, R. C., Chaopricha, N. T., Chan, J., Tobin, D., & Allred, S. B. (2017). United States agricultural stakeholder views and decisions on climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 8(5).

2.5.1 Perceptions & Beliefs

Theory of Planned behavior identifies psychological constructs which must be addressed before behavior changes can occur (Ajzen, 2006). These include knowledge attitudes and perceptions both about a management practice of innovation, but also how management

changes fit into their social identity (Hogset and Barrett, 2010). Farmers perceptions are as diverse as are farmers, and their concerns and beliefs influence how they think about climate change and their willingness to make adaptive management decisions (Niles et al., 2013; Niles et al., 2015; Haden et al., 2012). Programming designed to support the adaptive capacity of land managers should consider the unique and diverse social, cultural and political perceptions of a target community and be framed appropriately. Chatrchyan and colleagues argue that advisors frame information carefully with skeptical audiences in mind (Chatrchyan et al., 2017). Connecting outreach with extreme weather events and local impacts may reach audiences that are skeptical of climate science (Kahan et al., 2011; Chatrchyan et al., 2017; Easton and Faulkner, 2016).

2.5.2 Information & Knowledge Sources

Information access is associated with increased adaptation and helps land managers navigate decisions about which management changes will help them manage weather related risks (Hansen et al., 2007; Ziervogel and Ericksen, 2010; Wood et al., 2014 a). Richardson proposes that information enhances effective and efficient learning when delivered through the following three methods (Richardson et al., 2001);

- experiential learning opportunities;
- reinforcement of the knowledge;
- opportunities to integrate new knowledge with existing knowledge and skills.

Other studies have also found that farmers have differing perceptions and preferences about information delivery methods; some preferring one-on-one consultations, and in-field workshops, while others prefer paper and online resources (Radhakrishna et al., 2003). This indicates that outreach programs should use a diverse suite of delivery methods which reflect the preferences of target audiences as much as possible.

However, access to information seems to be the factor that most strongly influences management changes. When evaluating new information, farmers and foresters place greater weight on the personal relationship and reputation of individuals than they do professional titles (Wood et al., 2014 b; Hujala et al., 2009; Ma et al., 2011). Farmers also privilege farming experience, and develop knowledge with empiricist rather than rationalist techniques (Wood et al., 2014 b). Rather than applying principles (rationalist), an empiricist approach means that farmers compare and contrast examples. This entails focusing on the details of contextual differences and similarities on-site, in order to discern what they know about management and how it can be applied to their own farm (Wood et al., 2014 b). Research on farmer networks of information flows also suggest that farmers primarily exchange new science-based knowledge within durable relationships where they are primary facilitators (Wood et al., 2014b)

2.5.3 Social Networks

Social networks and organizations play an important role in influencing management choices by farmers and foresters and have the potential to influence adaptive decision making.

Peer learning within communities and across networks generates a social multiplier effect which can significantly impact management decisions (Hogset and Barrett, 2010). Farmer participation in a network with collective identity impacts their actions to conform with their identified group (Klandermans et al., 2002). This network phenomenon relies upon mechanisms of social learning and social identity and has a higher impact where bonding and identity sharing is high (Hogset and Barrett, 2010). Farmers learn readily through social networks (Conley and Udry, 2001) and often prefer to learn from and validate knowledge within their peer networks, trusting their farmer peers over extension service professionals to vet new information (Hassanein 1999; Foster and Rosenzweig, 1995).

Our review of social learning among farmers and foresters can be summarized into two primary types of learning phenomena; evidence based (active) and identity based (passive). This implies that information aimed at an actively learning target group should emphasize the attributes of the practice itself, while education aimed at passive learners should place emphasis on the identity of early adopters and encourage people to identify with the adopters (Hogset and Barrett 2010). Notably, late adopter groups tend to be more influenced by peers and social norms (Rogers 2003). Whatever the mechanism may be, direct peer-to-peer education programs have proven successful in motivating adoption in diverse conditions and demographic groups (Ma et al., 2011; Kimmel et al., 2012; Holt-Gimenez, 2006; Van den Berg and Jiggins, 2007; Dlott et al., 1994; Roling and Wagemakers, 1998; Warner, 2007).

Existing formal and informal networks are all poised to leverage peer learning to motivate adoption of resilient farm management strategies. Formal agricultural mentorships programs (such as at NOFA, UVM Extension and others), production peer networks (e.g. Vermont Grass Farmers Association and the Vermont Vegetable and Berry Growers Association), and tight knit farm family groups (Wolcott MacCausland dairy family) demonstrate the kinds of social bonding and strong senses of identity that could positively influence adoption of resilience land use management practices. Agricultural resilience to climate change will be improved by programs which strengthen bonding and social capital at local scales, increase bridging of social capital at a statewide or regional scale, and also motivate the adoption of land-use best management practices for resilience via social learning.

3. The Climate Information Usability Gap

Scholarship examining the gap in application of climate science to decision-making, points to: 1) challenges in how decision makers perceive the salience, credibility and legitimacy of knowledge; 2) how new knowledge fits and interplays with existing practices and knowledge; 3) how challenges to climate information use may arise if scale of knowledge creations and use are mismatched; 4) how limited understanding of decision-making context may impede uptake; 5) decision-makers concerned with political tensions; and 6) psychological distancing of climate impacts (Rasmussen, Kirchhoff & Lemos, 2017; Cash et al., 2003; Lemos et al., 2012; Gordon et al., 2016, Dilling et al., 2014; Phadke et al., 2015; Weber 2006).

This disparity between the creation of significant and critical climate information, and its actual application or use by stakeholders is referred to as the climate information usability gap (Kirchhoff et al., 2013; Lemos et al., 2012). This topic has prompted a wave of recent and

current research into how to bridge the gap between the creation of scientific climate knowledge and its use by relevant stakeholders in society (e.g. Moss, 2016; Kalafatis et al., 2015; Meadow et al., 2015; Eisenack et al., 2014).

3.1 Bridging the Gap: Participatory and Transdisciplinary approaches create usable knowledge to address complex problems.

Integrated and participatory approaches have been advocated as an effective way to overcome the climate usability gap, deliver complex and challenging science-based information and support agricultural communities in adapting to climate change (Gurung and Bhandari 2009; Kirchhoff et al., 2013; Bubela et al., 2009; Cash et al., 2006; Haywood and Besley 2013; Meadow et al., 2015). This body of scholarship is concurrent with a wave of recent literature criticizing academic knowledge for failing to serve the world outside university walls and advocating for greater emphasis on creating more usable scientific knowledge (e.g. Clark et al., 2016; Kirchhoff et al., 2013). This requires a shift in delivery models of science communication away from one-way “science deficit” or “loading dock” consultancy approaches towards two-way, collaborative and participatory relationships where stakeholders and researchers are both democratically engaged. Within these scholarly discussions about co-producing knowledge and delivering usable science, there is an evident correlation in the way academic and non-academic expertise are negotiated and the resulting academic rigor of end products (Haywood and Besley, 2013; Phillips, 2011).

For extension agents at land grant universities, creating and communicating new research-based knowledge for the benefit of farmers and community members is central to their mission (Dunifon et al., 2004; Heleba et al., 2016; Robinson, 2013). We recognize extension agents as key actors experienced in effectively communicating science-based information to communities through negotiating expertise and adherence to standards of rigor. Their work offers a window into what engaged and participatory approaches look like in practice. Engaging with communities to co-produce knowledge is increasingly advocated as a solution to enhancing the delivery of science-based information in rural communities (Heleba et al., 2016; Warner, 2006).

Approaches to bridging this gap have documented the importance of networks in supporting farmer learning for improved management (Kalafatis et al., 2015; Pelling et al., 2008; Roncoli 2006; Obermaier et al., 2009; Schneider et al., 2009; Conley and Udry, 2001), and the success of boundary organizations. Boundary organizations can be defined as those that stabilize the science-policy interface while enhancing the interactions among science producers and end users (Kirchhoff et al., 2013). Boundary organizations bridge and broker knowledge between scientists and decision makers, and often the organizational interface manifests itself in a chain of boundary organizations, or a boundary chain (Kirchhoff et al 2015; Lemos et al., 2014). In particular, extension programs have been cited as crucial links in boundary chains that share socially relevant outcomes of scientific outputs between farmers and policy makers (Prokopy et al., 2015; Meinke et al., 2006).

The Climate Adaptation Fellowship addresses the documented challenges of creating usable climate science by involving stakeholders in the process of knowledge production. This

will positively influence the use of information in decision making (Kirchhoff et al., 2013). Creating groups of users with similar information needs and decision contexts, will hone potential adaptive strategies to the specific needs of that group (Kirchhoff et al., 2013). Characterizing adaptive management techniques within broader sustainability motives and framing them through co-benefit, offers a less contested path to adoption of climate risk management strategies (Rasmussen, Kirchhoff and Lemos, 2017).

Studies on climate change communication emphasize the importance of ‘knowing your audience’ and communicating at the level of local and direct weather impacts rather than systemic climate change (see Easton & Faulkner, 2016). Research from the Yale Program on Climate Change Communication emphasizes that locally specific information based on climate impacts, through peers or networks with whom they have trusted relationships and share values, is an effective means of encouraging behavior change (Kahan et al., 2011). Furthermore, it is more effective among skeptical audiences than simply providing science-based facts about climate change (Chatrchyan et al., 2017; Kahan et al., 2011).

4. Social Learning Environments

There is substantial recent research and reviews of literature on how social learning enhances adaptive management to address complex social-ecological challenges. The scholarly discourse is rife with disagreement about definitions and assertions that are challenging to confirm. Our work draws on the definition of social learning advanced by Reed et al. (2010) which define it as a process which must: (1) demonstrate that a change in understanding has taken place in the individuals involved; (2) demonstrate that this change goes beyond the individual and becomes situated within wider social units or communities of practice; and (3) occurs through social interactions and processes between actors within a social network.

Recent reviews discern consensus among diverse academic perspectives. The key outcome of social learning is considered to be “improved decision making underpinned by a growing awareness of human-environment interactions, better relationships and improved problem-solving capacities for participants” (Cundill and Rodela, 2012). Reviews of social learning identify emerging consensus that processes that support social learning involve:

- iterative cycles of knowledge sharing and joint-action (Ensor and Harvey, 2015)
- sustained interaction between stakeholders (Cundill and Rodela, 2012);
- on-going deliberation (Cundill and Rodela, 2012); and
- the sharing of knowledge in a trusting environment (Cundill and Rodela, 2012).

The importance of facilitation and communication designed to build trust, address power imbalances, and bridge diverging aims and interests are critical to the success of planned social learning activities (Ensor and Harvey, 2015). This point is stressed by many studies of peer-to-peer network approaches in agricultural innovation, but contested in regards to the nature of the role (Wood et al., 2014 b). On one side, the facilitation role is best filled by someone with professional training who does not have competing demands on their time. On the other side, this professionalization of the facilitator role risks the same imbalances and challenges of top-down technology transfer models (Wood et al., 2014 b).

Social learning strategies support communities in being more flexible in their responses to changes and stressors. “Because of the uncertainties associated with climate change effects on agriculture and the complexity of adaptation processes, adaptive management strategies that facilitate implementation and the continual evaluation and revision of adaptation strategies as climate learning proceeds will be necessary to ensure agricultural systems remain viable with climate change.” (Walthall et al., 2012). Both adaptive management and social learning enhance responsiveness and flexibility of social–ecological systems, which can lead to increased resilience in the face of stress and change (Fernandez-Gimenez et al., 2008; Berkes and Folke, 1998). Though there is broad consensus on these claims, empirical research is needed to identify the extent to which social learning improves decision making, under what conditions and for whom (Cundill and Rodela, 2012).

Section II. Review of applied social learning theory in natural resource management community initiatives in the Northeastern U.S.

Introduction

In response to interest from the project team, we conducted a review of social learning initiatives in the Northeastern U.S. Our review of the available literature finds that the assertion that social learning is key to adaptive management is strongly supported, but has rarely been the subject of original research in the agricultural and forestry communities of the northeast region of the U.S. In this last section we highlight examples and address the following questions: *How have projects in the Northeast U.S. applied these theories about social learning in natural resource management communities? What key lessons can be gleaned from these projects? Are there clear trends in principles or strategies for engagement? And what research needs or gaps are evident?*

Methods

Using a meta-analysis method we found 24 papers on social learning and natural resource management within the Northeast region of the U.S. This was obtained through a search of all EBSCO Host research databases abstracts using keywords “social learning” AND a region-specific word, such as the names of each state in the Northeast, as well as “northeast” and “New England”. Researchers then identified papers that were related to natural resource management and agriculture and added additional papers that emerged using searches with analog terms. The case studies which follow are drawn from this collection. This collection of papers is being made available to the project team via a Mendeley group.

5. Case studies

In this section we share case studies that highlight diverse approaches to program structure and represent various forestry and farming groups of interest to the Climate Adaptation Fellowship Project.

Ontario Focus Farms program with dairy producers.

The Ontario Focus Farms program was designed to change dairy farmers' behavior to control for Johne's disease. The programmatic design was based on guiding principles of "(1) participatory, self-directed, and collaborative, based on group-identified priorities; (2) honest communication and trust; (3) planning, action, and implementation; and (4) reflection" (Roche et al., 2015). The program consisted of a series of meetings, with small groups of 7 to 12 people, which were facilitated by professionals. Researchers tracked behavior changes of participants and non-participants, and reported that the program influenced changes in 81% of participants, compared to 38% among the control group.

Woods Forum Program for foresters.

A pilot program for foresters in Massachusetts was designed to facilitate information exchange and networking for landowners in sessions on weekday evenings in community centers across the state (Ma, Kittredge & Catanzaro, 2011). Sessions were structured to begin with 20 minutes of brief case studies or presentations from professionals based on participant questions, and the remainder of the time was open for questions, facilitated by a professional who encouraged other landowners to share their experiences. The study assessment study found that participants of all backgrounds regarded the social learning atmosphere favorably. Participants also had a high level of information retention and willingness to share the information they learned with others. Overall, the study indicates that structured peer learning is a successful strategy to achieve behavioral and management changes, and recommends the strategy be leveraged by extension and outreach professionals who want to reach a broader audience with long lasting impact on informed decision making among foresters. Interesting lessons from this program advise that to best reach the late adopters, programs should intentionally include both engaged and unengaged land manager audiences in order to better reach audiences that are notably unengaged.

Farmer networks.

Farmer organizations and networks in the northeast are valuable spaces where knowledge is both developed and shared (Kroma 2006; Barbercheck et al., 2014). Farmer network membership and participation in the northeast have influenced behavior in the northeast through the supporting and reinforcing the use of conservation best management practices (Barbercheck et al., 2014). These networks feature both structured and unstructured avenues for social learning among peers, coupled with information delivery and facilitation by experts and professional agricultural advisors. Networks formed around sustainable agriculture are documented spaces where farmers have been leaders in the investigation and development of needed information (Kroma, 2006; Carolan, 2006; Hassanein and Kloppenburg, 1995). As well, we recognize that peer-to-peer learning within farmer networks and extension programs in the northeast has not been sufficiently documented by academic literature.

MOFGA Farmer-to-Farmer Conference.

This annual conference hosted by the Maine Organic Farmers and Gardeners Association features generous 3 hour workshops times, and is attended almost exclusively by growers. During the first half of a session two different farmers provide information or context for the topic of discussion, and the second half of the session is dedicated to a discussion amongst everyone in the room. While the featured speakers set a tone & prompt for the conversation, they did not receive more voice or power in the second half of the session. Each session has a facilitator to keep the discussion balanced and flowing. The importance of the **skilled facilitator role** cannot be underestimated. Facilitators employ many different strategies to shape the space and keep the conversations balanced and democratic. Meaningful interactions and prescient discussion take place during **unstructured times** meals, breaks and evening activities, including a traditional contra dance.

Catawba Landcare.

A multi-year community engagement initiative coordinated by Virginia Tech was organized around theories for building social capacity, promoting social learning and enabling adaptive management within the community to shape a sustainable future (Kimmel et al., 2012). Target audiences for this land-grant driven program included all businesses, organizations and individuals concerned with land stewardship or land management. Kimmel et al. (2012) chronicle successful strategies and challenges over 7 years of programmatic growth and community engagement. Reflections by program coordinators identify three key principles/strategies for social learning programs:

- **holding environments-** facilitated, neutral, safe-spaces to engage in discussion & constructive controversy where adaptive learning may occur,
- **entrepreneurship-** promoting and direct support, and
- **learning action networks-** platforms which catalyze assessment reflection, learning and action among otherwise disparate stakeholders

Community Fisheries Action Roundtable.

This roundtable program was envisioned to increase the capacity of fishing communities. A reflection on the program by Jennifer Brewer (2013) takes a critical look benefits and potential pitfalls of this participatory capacity-building workshop program with the Maine fishing industry. It was designed to consist of roundtable series which convened small groups for 5 days over 3 months in discussion-based workshops on group process, social challenges, fishing community strengths, scientific knowledge of the ecosystem, and opportunities & strategies for participation. The program highlights the experience of individuals involved, and the way their new appreciation and understanding of other fishers' perspectives transformed perspectives on spatial and temporal scales of fishery work, as well as social engagement norms.

Communicative Resilience Symposium.

In 2008, Virginia Tech hosted a symposium on resilience to surprises through communicative planning (Goldstein, 2009). Two groups of researchers were asked to share their frameworks; the first group identified as resilience thinkers, the second group as communicative planners. The two approaches were explored, and synthesized to propose a model of communicative resilience. Highlights from these models are as follows:

- Problems should be processed in democratic spaces for dialogue where credible information is shared.
- Grassroots models for organizing are recommended over hierarchical leadership.
- Stakeholders must build trust and connections among one another and be continuously engaged and constantly reassessing the effects of their actions.
- Stakeholders should organize and plan across a wide range of scales, under a variety of potential circumstances.
- Informal, socially-driven networks that exist outside of institutional regulations and control are highly valued.

To meet these goals, participants prescribed collaborative processes of engagement, “from multi-stakeholder consensus processes to learning networks, civic roundtables, and community reconciliation processes” (Goldstein, 2009).

Climate Adaptation Plan for Exeter.

A transdisciplinary, community engagement project in Exeter, NH was designed to develop a science-based climate change adaptation strategy for southeast New Hampshire. Program coordinators sought to document and evaluate their collaborative process for use by other communities in a short and accessible article (Aytur, Hecht and Kirshen 2015).

Engagement strategies included community conversations, workshops, experiential activities, asset mapping, stakeholder advisory groups, & modeling and scenario analysis. Important lessons identified by this project include:

- The importance of making expectations for stakeholders clear early in the process,
- communicating the value of the engagement process, not just the boundary objects,
- strong leadership from local champions or trusted community members,
- stakeholders are sometimes more comfortable with expert-driven delivery of science-based information, and
- climate change should be made locally relevant.

6. Trends from this body of literature in the Northeast region

The literature reviewed for this paper revealed diverse programmatic designs and applications of social learning. A notable trend from the studies we reviewed was that programs consistently valued the consideration of stakeholder perspectives and concerns in discussions about change and environmental complexity. Peer groups were often democratically involved in setting the agenda, or driving discussion topics. As a result, new knowledge or behavior changes reflect and highlight the unique contextual applications and salient concerns of local peers.

Another major trend which emerged from our review was that neutral and facilitated spaces for interaction among peers characterize the spaces where discussions take place. When stakeholders are invited to share and link their knowledge to a topic of concern in a space designed for discussion, problem solving and relationship building take place within a group. This kind of activity encourages openness to new behavior. Trends which emerge from this review of the literature parallel the findings of other review of social learning literature summarized earlier in section 4 of this paper.

Outcomes are reportedly difficult to measure (Kimmel et al., 2012), but there are many valid evaluation methods within the literature we reviewed. Some studies compared management changes among participants and non-participants, finding that the program had a significant impact on behavioral changes (Roche et al., 2015). Most programs used retrospective qualitative research methods for assessment of social learning outcomes, where participants reflect on their experience after engaging in the program. Another strategy is to conduct a survey about knowledge and behavior at the beginning of a program, and then compare that to survey results after participation in the program.

Elements in social learning program designs which consistently appear across the body of literature include:

1. The creation of neutral spaces for intentional interaction and discussion
2. Trust building & social bonding are cultivated and valued highly
3. Good facilitation skills are critical to project success, as is project management.
4. Projects are driven by a goal of community or individual capacity-building.
5. Informational content is driven by participant concerns and questions.
6. Repeated and iterative participation and reflection.

7. Conclusion & Contextualization of the Information for our project teams

Social learning and peer to peer networking can be used as a strategy to achieve two ends. First, the delivery and framing of climate-related information by leader land-managers for their peers should increase the legitimacy, salience, usability and uptake of information. Second, creating spaces and norms for social learning through outreach programs can reach lesser served segments of the population (late adopters & laggards), influence changes in behavioral norms and beliefs, and increase the adaptive capacity of the community. Leveraging peer learning strategies and social learning environments are not normative modes of engagement for extension and outreach programs, but there is an increasing interest in using them and many successful models to draw upon for designing programs.

Based on our review in section 2 of this paper, information about climate change, climate-related risks and adaptation strategies should be tailored to reflect local impacts and constituent concerns, and emphasize the complexity, compatibility, trialability, observability, and relative advantage of an innovation or management strategy. Facilitation or delivery of

information by respected peers and opinion leaders in target audiences will also encourage behavior changes and accelerate the rate of adoption

A diverse range of engagement strategies are represented within the literature we reviewed. Engagement strategies included hosting spaces for both formal and informal interaction, and targeted groups that were large and small, and using creative and nonverbal interaction techniques to enhance communication and learning between stakeholders. “Communities are unique in their assets & constraints, implying that engagement approaches must be tailored to specific contexts” (Kimmel et al., 2012). We suggest that project teams reflect on the engagement strategies that their constituents are already accustomed to, review other strategies, and combine creativity with comfort and ease of access to best reach audiences.

The role of facilitation and communication were critical to the success of case studies in our review, and can make or break the final outcomes. We recommend that this facilitation skill be valued and cultivated by project teams who wish to leverage social learning for behavior changes in their communities.

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Appendix 1. Results of our literature search on social learning in natural resource management communities within the Northeastern U.S.

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Acknowledgements

The authors wish to acknowledge funding received from the following bodies to support this work: USDA NIFA Climate Masters & USDA Northeast Climate Hub.