Opportunities and Challenges for Cooperative Extension Becoming a Major Actor in Climate Change Mitigation and Adaptation

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OPPORTUNITIES AND CHALLENGES FOR COOPERATIVE EXTENSION BECOMING A

MAJOR ACTOR IN CLIMATE CHANGE

MITIGATION AND ADAPTATION

by

Dakoeta R. Pinto

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Environment and Society

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Logan, Utah

2023
ABSTRACT

Opportunities and Challenges for Cooperative Extension Becoming a Major Actor in Climate Mitigation and Adaptation

by

Dakoeta R. Pinto, Master of Science

Utah State University, 2023

Major Professor: Dr. Sarah Klain
Department: Environment and Society

Reducing the concentration of greenhouse gases (GHGs) in the atmosphere is necessary to reduce the likelihood of catastrophic climate events. This calls for a socio-technical transition, when society and markets adopt new technologies, practices, and social norms in response to climate change. This research uses two frameworks to analyze system change: a framework for understanding transformations and the multi-level perspective (MLP). The transformation framework is used to analyze the Cooperative Extension System (Extension) as a social-ecological system that is likely in a transition towards prioritizing climate change programming. This framework highlights the elements of Extension that are likely to change during a transformation. To examine Extension’s ability to influence society and assist in a socio-technical change towards a low-carbon society, I used the MLP framework. A research team and I conducted 21 semi-structured interviews with Extension professionals between July
2020 and October 2021 regarding Extension and climate change programming. My research explores four research questions, 1) can interview respondent insights help determine how far along Extension is in a transition towards becoming a more significant actor for climate change action? 2) What obstacles and opportunities can be identified using the transformation framework and interviews for Extension becoming a significant climate change actor in the United States? 3) What obstacles exist for Extension in becoming a significant actor during a socio-technical transition towards a low carbon society in the United States? 4) Using the MLP, are there gaps in Extension’s ability to influence different elements of the socio-technical regime? According to my analysis, Extension has expanded their mitigation and adaptation efforts in recent years. Most of their climate change programming occurs in agriculture due to their historic ties to this sector; their focus on agriculture could be considered a hindrance to Extension pursuing climate change work. Evidence has revealed that there is a lack of education and concern about climate change among Extension audiences. Lastly, this study has concluded that Extension has great potential to play a larger role in a low-carbon transition if they can refocus their efforts and mission towards advancing climate change solutions.
PUBLIC ABSTRACT

Opportunities and Challenges for Cooperative Extension Becoming a Major Actor in Climate Mitigation and Adaptation

Dakoeta R. Pinto

Addressing climate change in the United States is an increasingly complex issue that requires social and technological changes throughout the country, which the Cooperative Extension System (Extension) can influence. Based at land-grant universities, their goals are to bring relevant science and innovation to the people of the United States. For a successful low-carbon transition, there are certain elements of society that must be influenced by innovators like Extension. Extension’s historical roots in agriculture prevail today with most of their programming focusing on this sector. However, there is a movement within Extension to expand their programmatic efforts to address more contemporary issues that are affecting their audiences. This research uses interview data with 21 Extension professionals, a document review, programming evidence, and two transition frameworks to answer four research questions: 1) can interview respondent insights, compared with an established transformation framework, help determine how far along Extension is in a transition towards becoming a more significant actor for climate change action? 2) What obstacles and opportunities can be identified for Extension becoming a significant actor in climate mitigation and adaptation in the United States? 3) Through the lens of the MLP framework, historical document review, programming evidence, and interviews, what obstacles exist for Extension in becoming a significant actor during a socio-technical transition towards a low carbon society in the
United States? 4) Using the MLP, are there gaps in Extension’s abilities as a niche organization to influence the United States? There is evidence to support Extension’s transition towards a focus on climate programming, however, Extension is still in the early phases of a transformation. Obstacles that prevent advancing this transition revolve around Extension faculty and their target audience’s beliefs in climate change, funding availability for climate change programming, and lack of strong leadership pushing for climate action. Extension has the ability to progress climate action initiatives, its weakness is in its lack of central focus on climate change adaptation and mitigation. If Extension were to focus its resources and efforts on climate adaptation and mitigation programming, its impact on emission reductions in the United States could be tremendous.
ACKNOWLEDGMENTS

I would like to use this space to give a very special thanks to my advisor Dr. Sarah Klain for accepting me to be her first graduate student. Her guidance and patience has been so important during my Masters program. Given the COVID-19 pandemic, we found a way to work together and get through it. Her feedback was instrumental and her kindness pushed me forward during stressful times. Her belief in me drove me to the finish line. Her dogs Baxter and Sequoia also brought a lot of joy to my life when I really needed it. I will miss this family a lot when I move.

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also a good friend to me and helped motivate me outside of school in ways that only we can understand. I am happy I had the opportunity to exchange knowledge with her through academics and through our passion for soccer.

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Lastly, I must thank my family, specifically my parents, for listening to me and helping me through the stressful times. They have always believed in me and never give up hope in me even though I had lost it myself a few times. They have always lifted me up and I would not be where I am today without their love and support. So thank you again for everything you do.

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CHAPTER I: INTRODUCTION AND MOTIVATION

This first chapter provides a background on Extension and the theoretical frameworks I use in this study. This section also includes details on methods, the thesis purpose and my research questions. First, I describe the Cooperative Extension System (Extension) and provide relevant background on Extension’s work in agriculture and the United States (US). I follow by laying out the context for the US approaching a socio-technical transition to deal with climate change issues and the relevance that has on Extension as a niche innovator.

The Cooperative Extension System

Extension is the largest education system of its kind in the world (U. S. Government Accountability Office, 1981). As an interface organization, it could play a larger part in aiding adoption of climate solutions in the US on multiple levels. Beginning with the Smith-Lever Act of 1914, Extension has used science-based research to primarily help agricultural efforts in the US. They have since evolved with further Acts, such as the Farm Bill of 2008 and later revisions of 2018, to expand their efforts into renewable energy, conservation, and environmentally responsible practices amongst other things, though much of these efforts still have a central focus on agriculture (Farm Bill, 2018). Extension agents work with the federal, state, and local government as well as local community-based institutions. Funding for Extension comes from state and federal agencies, land-grant universities, partnering organizations, and government
agencies as well as philanthropic grants (McDowell 2001; USDA NIFA 2021). The diversity of sources for funding make Extension resilient to changes in political administrations.

Based at land-grant universities, Extension programs focus on translating research in “agriculture, health, and human sciences” into practice (USDA NIFA, 2021). As of 2021, a small subset of Extension programs focus on climate adaptation and mitigation (Comer et al. 2006; McCann et al. 2020; Susko et al. 2013). If appropriately leveraged, Extension could play a transformative role in advancing climate solutions throughout the United States. This claim is supported by Extension’s characteristic abilities of nurturing innovation, particularly as related to agriculture, which is currently a major source of greenhouse gas (GHG) emissions but also has potential to sequester large amounts of GHGs.

**Extension and agriculture**

Agriculture occupies ~51% of the land in the US, the rest of the land is taken up by urban areas, special-use areas, forest-use land, and miscellaneous other land (Bigelow & Borchers, 2017). Though agriculture is not the dominant economic sector in the US, accounting for about 5.2% of the annual gross domestic product (GDP), it is undoubtedly one of the most important because it provides food and income. Agriculture is also a large contributor to climate change (Ag and Food Sectors and the Economy, 2021). This sector is vulnerable to climate variability and has already seen negative impacts. Climate change is causing stress on agricultural systems through heat increases, soil erosion, changes in precipitation patterns, and variability in seasonal changes (Hatfield et al., 2020).

Agricultural systems throughout the US are having to adapt to the increased frequency and duration of extreme weather events largely attributed to human induced climate change.
(Niles et al., 2015). These adaptations can help agricultural systems remain productive and resilient over long periods of time, help reduce the quantity of resources like water or fertilizers needed for substantial yields, help incorporate ecosystem services like pollination or pest resistance that can substitute certain artificial processes, etc. Climate change impacts agriculture and agriculture is responsible for GHG emissions (Hatfield et al., 2020; Niles et al., 2015). Even though many current agricultural practices contribute to climate change there are opportunities within agriculture to mitigate climate change (e.g., build soil carbon) (Johnson et al., 2007). If agricultural practices were changed, in conjunction with a change in eating behavior and food policy, agricultural systems could reduce their emissions of harmful gasses like CO2, CH4, and N2O and sequester CO2 (Johnson et al., 2007).

Extension has a long history with agriculture in the US that starts at its foundation. The mission of Extension, when it was created, was to provide farmers with information from agricultural research and to encourage them to adopt improved farming methods (U. S. Government Accountability Office, 1981). The US agricultural economy is now one of the largest in the world, which is at least partially attributable to Extension’s efforts in training agriculturalists on efficient practices, providing education on new technologies and opportunities to use new technologies, educating on and encouraging the adoption of new science and innovation, and helping construct market strategies and designs (Gould et al., 2014). Their mission still incorporates a focus on agricultural sciences and practices, but they have expanded their mission to address climate adaptation and mitigation, diversity, equity, and inclusion, health and well-being, economic and workforce development, youth development (4-H), digital skills and broadband access, and nutrition education, in addition to agriculture (ECOP, 2021). To this day, Extension still has an important influence on the agricultural industry by means of financial
management, weather and market forecasting, recommendations, improving practices, adapting to climate change, and land management (Land Grant Impacts, 2019; McDowell, 2001).

This strong historical tie to the agricultural sector in the US and policy regarding practices and regulations has strong implications for Extension’s influence on this sector’s environmental impact (McDowell, 2001). Extension has changed the agricultural sector tremendously over the last 100 years through their grassroots efforts, their long-term sustainable funding methods, and their deep-rooted connections that have been developed over long periods of time (Comer et al., 2006; Gould et al., 2014; McDowell, 2001). As previously stated, the agricultural sector has potential to mitigate climate change and Extension has begun internal initiatives to combat climate change which can be interpreted as an indicator that Extension has the potential to contribute to climate change adaptation and mitigation in the US to better align with goals of international climate accords.

**Climate Change & Socio-technical Transitions**

**Climate Change Solutions**

Global climate change issues require international, national, and community-level action to make progress towards goals set by the International Paris Agreement. This Agreement has 191 registered members, including the US, who are legally obligated to attain a goal of decreasing greenhouse gas (GHG) emissions to prevent a global average increase in temperature of 2°C, preferably less, with an aspirational target of under 1.5°C (Paris Agreement 2016). The Earth is on course to pass this temperature threshold, which will likely precipitate unavoidable consequences to human and natural systems (Hoegh-Guldberg et al. 2018). To reduce the
likelihood of catastrophic climate events around the world, reducing the concentration of GHGs in the atmosphere is necessary. Controlling emissions and sequestering existing GHGs in the US, paired with extensive adaptation actions, calls for changes in behavior, policies, and practices, including modification of the economic sectors that have the most impact on GHG emissions: energy, manufacturing, agriculture, and waste processing (Environmental Protection Agency, 2020). This calls for a socio-technical transition, during which time society and markets adopt new technologies, practices, and social norms in response to external pressures from new socio-technical landscapes (Geels 2002).

Adopting new technologies to solve our ecological problems has its limitations and unfortunately can not alone solve climate change, however it is a critical piece to a socio-technical transition (Geels, 2002; Huesemann, 2001). New technologies in the context of this research refer to renewable energies, energy efficient home appliances, alternatives to fossil fuel powered modes of transportation, and new materials and designs for common needs to reduce waste and pollution. Adoption of new technologies needs to be done at all levels of society to have the most impact on reducing emissions and increasing sequestration. Adoption at the individual level could decrease reliance on fossil fuel-based power plants or reduce emissions in a significant way. Adoption at a collective level would come in the form of utility scale solar energy, nuclear power, and other renewables complemented with a massive investment in infrastructure changes to support the new technologies. Demand for renewable energy technology is expected to increase by 7.3% between 2007 and 2030, but it will take time and resources from individuals, governments, policy makers, and businesses to achieve a successful and sustainable transition (Sadorsky, 2011).
Socio-technical transitions have occurred repeatedly throughout history (Geels, 2002). Some of the most recognizable transitions are the shift from sail boats made of wood to steam powered ships with metal hulls, the transition from horse drawn buggies to automobiles, and the transition from a primarily paper-based and in-person workplace to today’s computer and remote work environments (Geels, 2002; 2005). The multi-level perspective (MLP) is used to analyze socio-technical transitions by breaking down societal functions into three broad levels. These levels are a nested hierarchy with the highest and broadest level being the socio-technical landscape, the middle level is the socio-technical regime, and the bottom level (and arguably the most important) are the niche innovations being done at interface organizations.

The highest level, and hardest to influence, is the socio-technical landscape which is defined by the coevolution of social and technological relationships. Examples of elements that exist at the landscape level include environmental issues, oil prices, economic growth, wars, emigration, broad political coalitions, and cultural and normative values (Geels, 2002). Landscape level elements are hard to influence and can have an effect on the way society functions (Kemp et al., 1998). When issues arise at this level, such as environmental issues, the stress causes changes in the way society functions in order to compensate or fix the issues (Geels, 2002; Kemp et al., 1998). These changes occur on the next level, the socio-technical regime.

These socio-technical relationships that have become 'locked-in' to stable configurations over time are referred to as socio-technical regimes which comprise the second level on the MLP. Lock-ins happen for multiple reasons: institutional rules or directions that become ingrained into practices, social norms that develop over time that make change difficult, and
technological infrastructures that hinder the adoption of new technologies or practices (Kemp et al. 1998). The regime can be simplified into multiple elements of society that are intertwined and have different effects on each other. These elements are technology, industry, science, policy, culture, market preferences, and infrastructure. Each of these elements have an important role in affecting society as a whole and can even have an effect on the landscape level.

When a socio-technical transition is needed or forthcoming (e.g. the need to transition away from fossil fuels and to sequester GHGs to reduce the likelihood of catastrophic climate impacts), windows of opportunity open up for new technologies, novel practices, and innovative strategies to help in the transition (Kemp et al., 1998). These novel technologies, practices, and strategies are known as innovations in the socio-technical transition literature. Innovations are vital to large-scale transitions because they can offer radical solutions to issues that otherwise would remain a problem. These innovations are developed, protected, and nurtured at the bottom level of the MLP, places referred to as niche organizations that have different motives and rules than the existing regime. This allows for experimentation and customization of new transitional methods that are resilient to external influence (Schot & Geels, 2008). Ideally, according to this framework, a socio-technical transition will start with issues at the landscape level (e.g. environmental issues) which cannot be solved with the current configuration at the regime level. This will open windows of opportunity for niche organizations to come out with new designs, technologies, or practices that can take shape in a new regime which will then influence the landscape level (e.g. reducing the effects of climate change) (Geels, 2002).

Niche organizations play vital roles in disseminating information and in taking action around the globe in a variety of topics, including but not limited to climate change (Kemp et al., 1998). However, climate change is a complex issue that requires a strong scientific base in order
to develop solutions for a diverse set of problems. Osmond et al. (2010) define ‘interface organizations’ as specific groups that attain and/or produce scientific information and implement it through scientific communication, community engagement, and programming. Interface organizations can be considered niches within socio-technical transitions that become a source of innovation. This can facilitate progress towards adopting new mitigating technologies and practices on the higher levels of the MLP. Extension is a fitting example of an interface organization because of its innovation, connection to universities, and its influence on certain societal functions (e.g. agriculture, individual well-being, policy, environmental issues) (Comer et al., 2006; ECOP, 2021; Franz & Townson, 2008; Gould et al., 2014; Kipp et al., 2020).

Climate change is a relatively novel issue that gained more attention in the 90s and early 2000s due to rising concern of human impact on global atmospheric processes (Shaftel et al., 2022). Extension has been around for over 100 years and is only recently drawing some attention to climate relevant programming (ECOP, 2021). Using a framework used for analyzing social ecological systems created by Moore et al. (2014) I will be able to characterize Extension’s transition towards prioritizing climate change in their programming to reflect the issues currently relevant to the US.

**National Climate Emergency**

In 2021, Congress passed The Climate Emergency Act (2021) because of climate change’s rapid progression since pre-industrial times (Climate Emergency Act of 2021, 2021). A national emergency can be declared by the President of the US when deemed necessary and
gives special powers to the President that are not normally allowed. This national climate emergency allows the president to allocate federal resources towards projects and people to combat climate change; this has meant more funding for Extension’s federal partners like the USDA through bills like the Growing Climate Solutions Act of 2021 (Climate Emergency Act of 2021, 2021).

**Relevant Extension Programming**

According to the Extension Committee on Organization and Policy (ECOP), Extension programming across the US should be centered around seven topics: agriculture, climate adaptation and mitigation, diversity, equity, and inclusion, health and well-being, economic and workforce development, youth development (4-H), digital skills and broadband access, and nutrition education (ECOP, 2021). Many of these foci overlap with the solutions proposed by the Climate Emergency Act (2021). Extension programming covers a large variety of topics that reflect the needs of their communities in each state. The communities that Extension serves are located in many different regions, all with their own set of social issues, environmental issues, health concerns, and more. The way Extension is designed enables Extension agents and specialists to listen to community members and researchers on the problems that need solutions.

For example, South Florida is a unique area of the US that is very close to sea-level, surrounded by water, experiences severe storm surges, sees many ecological problems, and plenty of social equity issues (Duffourc, 2010; Harwell, 1997; Park et al., 2011). In response, the main land-grant university Extension system in Florida, located at the University of Florida, has launched many programs to help with some of the issues people are facing. One such program was formed in 2019 where Extension agents performed an experiment with the help of local
farmers to minimize flooding damage to commercial vegetable production (Liu et al., 2019). The long-term result of this type of experiment is a published resource article with information on damage prevention techniques that is available open access to anyone who is interested on the University of Florida Extension website.

Another example of how Extension adapts its programming to the communities it serves can be found in California. One of the top issues facing Californian communities today is wildfire (Williams et al., 2019). Although wildfire is a natural occurrence in California, anthropogenic climate change has drastically increased the intensity, frequency, and time span of wildfires since pre-industrial times (Dennison et al., 2014; Littell et al., 2009; Westerling, 2006). In October 2021, Extension launched a toolkit that will assist landowners in managing fuels on their land to prevent wildfire from destroying their property. This toolkit gives information to individuals, wildfire professionals, and vegetation management specialists on risk factors and hazards for areas greater than three acres (Kan-Rice, 2021).

**Thesis Purpose**

This study investigates how Moore et al.’s (2014) transformation framework can help define Extension’s potential to become a significant actor for a socio-technical transition towards climate change resilience. Using in-depth interviews with 21 Extension professionals, my first study identified key themes that point to evidence of a transition happening within Extension towards prioritizing climate change as an emergency that needs immediate attention to reflect the current administration’s intentions. Using the transformation framework for analyzing
social ecological systems from Moore et al. (2014), I identified barriers or gaps that hinder Extension’s ability to take on the daunting task of transforming the agricultural sector and communities to mitigate climate change and adapt to its impacts. This information could help guide Extension leaders and professionals through a transformation within Extension to streamline the process of incorporating climate information and action into, ideally, all of Extension programming.

The second study used the MLP from Geels (2020) to analyze Extension as a niche organization with the potential to influence the socio-technical regime and landscape levels. I incorporated literature on the history of Extension, Extension’s mission and goals, interview data with Extension professionals, and an analysis of the structure of Extension to show the role that Extension can play in a socio-technical transition in the US and what that role would look like. The MLP characterizes Extension in a comprehensive way so that gaps and barriers outside of Extension are identified and considered when framing Extension as a transformative actor on a larger scale. The results can serve to motivate ECOP, and the higher-level federal agencies that influence Extension, to invest, expand, and improve upon Extension’s networks and programming directed towards climate change adaptation and mitigation.

**Research Questions**

1. Can interview respondent insights, cross compared with Moore et al.’s (2014) transformation framework, help determine how far along Extension is in a transition towards becoming a more significant actor for climate change action?
2. What obstacles can be identified using the transformation framework for Extension becoming a significant actor in climate change mitigation and adaptation in the US?

3. Through the lens of the MLP framework, what obstacles exist for Extension to become a significant actor during a socio-technical transition towards a low carbon society in the US?

4. Using the MLP to illustrate the socio-technical elements surrounding Extension and climate change in the US, are there gaps in Extension’s abilities as a niche organization to influence different elements of the socio-technical regime?
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CHAPTER II

IDENTIFYING ENABLERS AND BARRIERS TO A TRANSFORMATION FOR
COOPERATIVE EXTENSION’S CLIMATE CHANGE PROGRAMMING

Introduction

The United States (US) Cooperative Extension System (Extension) and associated programs have influenced American society for over a century, particularly in agriculture. This agricultural focus is deeply rooted in the foundation of Extension and the land-grant universities where they are based. Extension work began in 1912 to improve agricultural techniques and disseminate agricultural information through networks of agriculturalists (Comer et al., 2006). Today the Extension system addresses much more than just rural and agrarian issues. The central vision and mission of Extension are directed by the Extension Committee on Organization and Policy (ECOP), albeit states have individual jurisdiction of their programmatic focal areas. In 2002, ECOP published a report proposing that the Extension system shift efforts to address more contemporary issues and expand beyond its traditional, largely agricultural programs targeted to rural audiences (Bull et al., 2004; National Association of State Universities and Land-Grant Colleges & Extension Committee on Organization and Policy, 2002). More recently, ECOP has recommended more programming on climate resiliency (Climate Resiliency, 2021) due in no small part to the recent prioritization of this issue at a federal level.
In 2020, US President Biden identified climate change as among the most pressing issues facing Americans today (The White House, 2021). Proposed solutions to climate change entail diverse practices, technologies and policies (Doerr, 2021; Hawken, 2017). It requires a reweaving of the elements of societal functions and technologies, otherwise known as a socio-technical change. Extension is based across the US and runs programming that has the potential to influence American society as it has in the past. The mission of this organization includes assisting with potentially novel, contemporary issues that are affecting the communities it serves (Bull et al., 2004; Comer et al., 2006; Gould et al., 2014; USDA NIFA, 2021). My research, which entailed interviewing Extension professionals, uses the transformation framework developed by Moore et al. (2014) to highlight the challenges and opportunities for Extension in becoming a significant actor in climate adaptation and mitigation in the US.

**Historical Context**

**The Land-Grant University**

The current culture of Extension and the barriers towards more programming in mitigating and adapting to climate change should be understood in the context of its institutional history, starting with the land-grant university where Extension originated and remains today. Three types of land-grant universities were established in consecutive order: 1862 institutions, 1890 institutions, and 1994 institutions (McDowell, 2001). The 1862 land-grant universities were created through the passing of the Morrill Act of 1862.
during the Civil War (Morrill Act, 1862). The bill would provide states with land-grants to establish educational institutions providing training in agriculture, the mechanical arts, and military tactics (Comer et al., 2006). The bill was signed by Abraham Lincoln in 1862 and a second Morrill Act was proposed in 1890 to increase funding for land-grant universities, specifically for agricultural and mechanical training. With extra provisions, this second act also attempted to eradicate racial discrimination in the admissions processes at land-grant universities (US National Research Council, Colleges of Agriculture at the Land Grant Universities, 1995).

The provisions to the second Morrill Act allowed states to establish separate land-grant universities for African Americans as long as they were considered ‘equal’ (Comer et al., 2006; US National Research Council, Colleges of Agriculture at the Land Grant Universities, 1995). This resulted in the creation of what is known today as “1890 Historically Black Colleges and Universities”, or the 1890 colleges, such as Alabama State University, Tuskegee University, Delaware State University, and more (Institute of Education Sciences, “Historically Black Colleges and Universities.”, 2021). There are over 100 historically black colleges and universities in the US today, 17 of which are 1890 land-grant institutions (US National Research Council, Colleges of Agriculture at the Land Grant Universities, 1995). Unfortunately, the funding for a state’s land-grant universities was pooled together, which resulted in all of the funds for both the 1862 and 1890 colleges being given to the 1862 colleges of that state to be disbursed in a ‘just’ but not necessarily equal way between 1862s and 1890s (US National Research Council, Colleges of Agriculture at the Land Grant Universities, 1995; Rasmussen, 1989). Because of this, historically black colleges received much less funding than they were promised
and most of the funding stayed with the 1862 colleges. In the end, land-grants for agricultural training, mechanical arts, and general education were created for African Americans, but they received much less funding than the 1862 colleges (Rasmussen, 1989).

The last of the land-grant universities that were established by the Equity in Educational Land-Grant Status Act of 1994 were focused on giving Native American peoples their own land-grant universities for training in agriculture, food, natural resource sciences, and related disciplines (Shorty, 2021). Over 11 million acres of land that the Federal government granted to states for the creation of land-grant institutions was expropriated from Native American peoples (Goodluck et al., 2020). These land acquisitions that the US government commissioned were backed by violent land seizures and land cessions from Native Americans in the 1800s.

**Extension Today**

**Extension’s Reach**

In 1912, Congress created the Extension system for rural and agricultural issues. At that time, more than 50 percent of the US population lived in rural areas, and 30 percent of the workforce were farmers (Bull et al., 2004; Gould et al., 2014; USDA NIFA, 2021). Though Extension originally targeted mostly agrarian audiences, it later expanded into other areas like youth development, natural resources, family consumer sciences, and community and rural development (Gould et al., 2014). Extension has made
great strides in reaching broader audiences; however, its major focus remains in agriculture (Bull et al., 2004; McDowell, 2001).

Agriculture has been a focus of land-grants since they were created and continues to be tied with Extension’s primary audiences. Agriculture is one of the most vulnerable sectors in regards to climate change, and has already seen significant impacts (Hatfield et al., 2020). With agriculture and related programming (e.g. nutrition management, food waste, local produce) being a central focus of Extension services, climate change research and programming should be a priority for Extension, but it lags behind in this area (Bull et al., 2004; McDowell, 2001; National Association of State Universities and Land-Grant Colleges & Extension Committee on Organization and Policy, 2002; NECI, 2020; Susko et al., 2013). When it comes to agriculture and food systems, Extension has historically focused on increasing yield, improving quality, and developing systems for mass production. These directions have led Extension to helping the US become one of the largest agricultural economies in the world. They succeeded in such a large impact through their reach across the US, providing research and education to agrarian communities.

Throughout the US, there are Extension offices in or near all of the nation's approximately 3,500 counties, parishes and boroughs that host both Extension agents and university-based specialists (Susko et al., 2013; USDA NIFA, 2021). The original method of Extension was to get science-based research into the hands of the people who needed it (e.g agriculturalists, ranchers, families, communities, organizations) via the information-deficit model which predicts that when there is public scepticism or hostility to science and technology it is due to a lack of information (Raison, 2014). Today,
information is easily accessible for most people who need it. This is causing Extension to shift their methods by communicating in ways that help people interpret information in ways that are meaningful and helpful to their cause or needs (Raison, 2014). This exemplifies Extension’s adaptive capacity and intentions of helping communities that they serve.

Extension exists in every state and generally works autonomously, though there are cases where Extension has developed multi-state programming and networks, e.g., Extension being a partner in regional United States Department of Agriculture (USDA) Climate Hubs. Funding for Extension is a mix of federal funding from the USDA National Institute of Food and Agriculture (NIFA), state funding, and local or county funding. Historically, Extension received about an equal amount from these nested levels of governance. Today, funding tends to be more variable. For example, 70% of funding for Extension in one state could come from the USDA NIFA and the rest could be a mix of state and local funding (Franz & Townson, 2008). Extension uses its funding to identify the needs of a community and then run programs to help fulfill those needs. Some counties and some states may receive more or less funding depending on the needs of the area, the population, and the funding that is available and applied for, which creates considerable funding disparities that influence programming (Franz & Townson, 2008). For example, an urban New York county received over $1 million for Extension programs in 2008 while a rural county in Wisconsin received about $200,000 dollars (Franz & Townson, 2008). Just like with funding that depends on the population, the availability of monies, and the various needs of a county, an Extension office could have more than 50 Extension agents working within a county or could have as little as one
with others visiting for presentations or workshops (Franz & Townson, 2008). These variations in funding and personnel affect the type and amount of programming that is accomplished.

**Extension and Climate Change**

Extension serves a diverse set of communities across the US where the impacts of climate change and other environmental issues vary. In the Southwest, drought is a natural phenomenon, but in recent years they have become longer and more severe (Anokhin et al., 2014; Environmental Protection Agency, 2017). Many water restrictions are enacted every year due to the fact that climate change has changed precipitation patterns and has had major impacts on agriculture and human well-being (Environmental Protection Agency, 2017; Hatfield et al., 2020; Johnson et al., 2007).

In the Southeast, impacts are most strongly felt by sea-level rises, temperature increases, and expanded the habitat of invasive pests due to climate change (Environmental Protection Agency, 2017). Saltwater intrusion is expected to reduce the fertility of large areas of agricultural land, heat stress will impact livestock, and invasive pests will cause problems for agricultural production and land management in this region (Hatfield et al., 2020; Johnson et al., 2007; Environmental Protection Agency, 2019).

Western US communities are experiencing serious drought conditions that are projected to get worse in the coming years (Cook et al., 2020). US Extension programs have been tasked with finding solutions to issues that their communities face. In addition, coastal communities that either live at or below sea level, and that rely heavily on the
ocean for income, are currently experiencing economic and life-altering impacts from climate change. (Cinner et al., 2012; Dolan & Walker, 2006; Park et al., 2011).

Some Extension professionals have begun organizing around climate action, resulting in the National Extension Climate Initiative (NECI). NECI is dedicated to advancing Extension work in climate change given the urgency of the climate crisis and “ensure environmental and human health, social equity and justice, and economic vitality for all generations” (NECI, 2020). Extension is trying to support vulnerable populations by running relevant programming relating to climate adaptation and mitigation (McCann et al., 2020; NECI, “National Extension Climate Initiative.”).

**Extension Leadership**

Each state’s Extension service generally works independently from other Extension programs state-by-state, but there is a central governing body that sets the intentions and recommended directions of the Extension system overall: the Extension Committee on Organization and Policy (ECOP). The goals of ECOP are to provide consistent messaging and advocacy for all of Extension nationwide. On their website in 2022, they explained four core themes: 1) Build partnerships and acquire resources; 2) Increase strategic marketing and communications; 3) Enhance leadership and professional development, and 4) Strengthen organizational functioning (Extension Foundation, 2022).

With recent concern among Extension educators and the Biden administration’s climate and social justice goals, ECOP has created a new advocacy webpage that is designed for Extension faculty and educators to refer to when considering their
programming. These advocacy topics are meant to organize all of Extension behind six themes: Diversity, Equity, and Inclusion; Climate Mitigation, Resiliency, and Adaptation; Economic and Workforce Development; Health Equity & Well-Being; 4-H Positive Youth Development; and Urban Programs. Each advocacy topic comes with background information, motivation for the advocacy actions, and evaluation on what Cooperative Extension is doing in response to the issues that underlie each of them. Extension, in the past, has recognized its need for a transition towards topical areas that are more relevant for their audiences (Bull et al., 2004; Gould et al., 2014; Rasmussen, 1989; Susko et al., 2013). To analyze such a transition, I will use a framework that is designed to understand deliberate transformations in systems like Extension to answer my research questions.

**Theoretical Framework**

In this study, I use the Moore et al. (2014) framework to see how well it aligns with the interview data I gathered from Extension professionals. Using an “analytical framework for understanding deliberate social-ecological transformations” (Moore et al., 2014, p. 1), I identify elements of Extension that show potential to transform its structure and focus more on climate change adaptation and mitigation. This analysis, including the identification of characteristics associated with transformation and lingering barriers to such changes, could be useful for various actors both within and outside of Extension who want to see this organization contribute more to climate solutions.
This transformation framework defines social ecological systems (SES) and identifies parts that are most likely to change during different phases of transformation. The four phases of transformation are 1) triggers or pre-transformation; 2) preparing for change; 3) navigating the transition; and 4) and institutionalizing the new trajectory (Moore et al., 2014). Some of the key elements that change during a transformation are 1) norms, values, and beliefs; 2) rules and practices, such as laws, procedures, and customs; and 3) the distribution and flow of power, authority and resources (Moore et al., 2014).

The first element of the transformation framework by Moore et al. (2014) are the triggers that cause a change to happen. Triggers are perturbations or crises that open up opportunities for change within a system. These triggers could happen internally or as an exogenous shock that could be social, political, ecological, new technologies, or means of production. In a deliberate transformation, actors intentionally try to disrupt the dominant state of an existing system, which can create opportunities for change and growth in an otherwise unsustainable trajectory (Moore et al., 2014).

The next category in Moore et al.’s (2014) transformation framework is preparing for the change. When preparing for a change in a system like Extension there are three important sub-processes. Sense making involves analyzing what the elements of Extension are and the scales of those elements that make Extension’s current trajectory most vulnerable. Sense making is then followed by envisioning with attempting to create a different order of things or picturing how things would look if a transformation were to be fulfilled. Lastly, gathering momentum means building up support and followers through networking and collaboration. This is especially important in complex systems like Extension where change is virtually impossible to achieve as an individual.
Navigating the transition involves selecting practices or strategies that seem to work best, learning and adapting these practices and strategies to different parts of the system, and then widespread adoption of the chosen practices and strategies. When looking at Extension using the navigating transition stage of Moore et al.’s (2014) framework, it exposes the different types of successful programming that has spanned different regions, such as the Climate Stewards program which exists in at least California, Maine, and New York with others under different names existing in even more states. Successful climate or extreme weather programs can be shared throughout networks of Extension professionals and then adopted at other universities. This process has been an essential part of Extension and has established some consistency in programming across land-grant universities, e.g., Climate Masters, Master Naturalist programs, Climate Stewards programs, and farming programs focused on climate adaptation and sustainability (names vary by region e.g., Farming and Climate Change Program, Weather Ready Farms, Climate Smart Farming), and others that are named differently but have similar goals, strategies, and content.

Building resiliency, or routinization, is the final step in reaching a transformed state. This is where the new trajectory would be accepted by Extension leaders where they then need to build resilience to future changes by strengthening positive feedbacks. For example, identifying issues in a community that are related to climate change which creates interest in a community to have climate mitigation and adaptation programming would be considered a positive feedback; making it a core theme and technique for implementing climate programming across all of Extension would be an example of strengthening that positive feedback. This solidifies the new chosen path that the system
will advance and makes sure that it is successful and builds an adaptive capacity to resist future perturbations. Future perturbations that could impact a new trajectory towards climate adaptation and mitigation action in Extension could be related to changes in administration, other Extension actors that believe in a different pathway away from climate action, or even an unforeseen circumstance that changes the motivations of Extension professionals.

I applied this framework to evaluate how Extension professionals perceive Extension’s efforts in climate adaptation and mitigation. I identify the various phases and subprocesses of transformation from this framework based on the experiences of Extension professionals expressed during interviews. Extension has proven its ability to adapt to a certain extent with various policies that were implemented with the intentions of steering Extension in a different direction based on diverse external pressures or triggers. The Farm Bill of 1933 is an omnibus bill that is revised every five years in order to address varying issues related to commodity programs, trade, rural development, farm credit, conservation, agricultural research, food and nutrition programs, marketing, etc. (Farm Bill, 2018). The purpose of this bill is to change the allocation of funding as it is needed in certain subject areas over time. This type of bill, which in part influences funds allocated to Extension programming, is an example of Extension’s abilities to be flexible over time (Farm Bill, 2018). A transformation is a form of change that is more significant than adaptation, where transformations recombine existing elements of a system in fundamentally novel ways (Moore et al., 2014). In my analysis, I have focused on deliberate rather than unintentional transformations because Extension needs to intentionally make changes to restructure their organization if they want to substantially
contribute to climate mitigation and adaptation. Without this intentional shift, they are not likely to move resources, restructure their current programming, or prioritize climate change enough to meaningfully address the current climate crisis in the US.

**Research Questions**

Can interview respondent insights, cross compared with Moore et al.'s (2014) transformation framework, help determine how far along Extension is in a transition towards becoming a more significant actor for climate change action?

What challenges and opportunities can be identified using the transformation framework for Extension becoming a significant actor in climate mitigation and adaptation in the US?

**Methods**

I conducted and analyzed in-depth qualitative interviews with Extension professionals to answer my research questions. Methods for interview data collection were approved by the Utah State University Institutional Review Board (IRB #11352). There were 14 people interviewed in the Fall of 2020 and an additional 7 in the Fall of 2021 for a total of 21. For the interviews, all participants were informed about the purpose of the project and were assured that they would remain anonymous and that any identifying information would be changed before analysis, including names of
institutions and names of participants. Participants completed a consent form online before each interview began. Participants we targeted are Extension employees working in climate and/or extreme weather programming and leaders in state Extension systems. Extension leaders were contacted directly and asked to interview for the purpose of my research and to help Extension overall. The interview protocol inquires into each person’s work within Extension climate or extreme weather programming, the challenges they faced with audiences and colleagues, where they believe more funding should go if they were given it, and if they had any other comments on the subject. Given the semi-structured design of the interviews, follow-up questions were often asked to obtain more information that was relevant to the study.

**Interview Sample**

I worked with a research team, including three Extension faculty, one research professor and an undergraduate student to collect the data for this project in 2020. Our sample was drawn from Extension professionals who work in the field of climate change or extreme weather programs. Interviewing people who work specifically in climate provides insight into the challenges associated with the implementation of climate and extreme weather programs. We reached out with an email on an Extension listserv that is centered around climate change, the National Extension Climate Initiative (NECI) (NECI, 2020) listserv, to find people who met our requirements. The email asked for anyone who is interested in being interviewed about their climate and/or extreme weather programming experience in Extension to email or call the research team to schedule an appointment and to sign a consent form. Once initial participants reached out to us, we took a snowball sampling approach to identify more participants. In the snowball
sampling approach, we asked our interviewees who they knew in their own networks and at other institutions and asked them to refer us to potential participants that fit our sample criteria (i.e., Extension professionals involved in climate programs). We then reached out to the people we were referred to and told them they were identified as a candidate for our interviews and asked if they were willing to participate. In the Fall of 2021, I conducted additional interviews with Extension leaders who offered a perspective outside of climate/extreme weather programming and provided information on higher level decision making and thinking for climate/extreme weather programming. These leaders within Extension influence the distribution of resources and funding on a level at or above the University level.

Figure 1 shows the distribution of 20 of the interviewees, one of our interviewees was a national Extension leader, not tied to a specific state and therefore could not be represented in the map. There were a total of 21 participants in 14 different states that were made up of Extension leaders, directors, agents, specialists, and those who had until recently worked with Extension. To simplify the make-up of the participants, I categorized them into two categories, Extension leaders who are directors or elected leading officials and Extension educators which consist of program managers, specialists, and agents. We interviewed 7 Extension leaders and 14 Extension educators.
Figure 1

*Distribution of Interview Participants*

![Map showing distribution of interview participants by state. Gold denotes states where interviewees are based.](image)

**Note:** Number of interviewees by state. Gold denotes states where interviewees are based. Out of the 21 interviews, 20 represented their state and one interviewee was a leader in ECOP which represented Extension as a whole rather than a specific state.

**Semi-structured interviews Design**

The semi-structured interviews allowed for a more conversational style that gave insight into the way the participants are feeling and provided a richer understanding of their experiences. All interviews took place over Zoom using the platform’s built-in tools to record and automatically transcribe the interviews. Each interview consisted of one interviewer, the interviewee, and, if possible, one notetaker. Before beginning the interview, we confirmed that they signed the consent form, gave them a brief introduction of our research protocol and IRB approval (IRB #11352), and the reasons why we were
interviewing them. We began by first asking about their experience working in Extension. We asked how long they had been with Extension, the type of programming they were/are involved in, some of their successes, and about their work specifically relating to climate change or extreme weather. After the first questions, we asked them about any challenges they had faced when implementing climate or extreme weather programming, then more specifically, what their challenges were with their audiences and colleagues within Extension.

Allowing the interviewee to answer freely, we used probing techniques to dig deeper into interesting topics they described that related to the purpose of the interview. Next, we wanted to know if the interviewees felt there were gaps or unmet needs in their community or state. This information gave us insight into the more unique issues that different regions and states face because of the geography, climate, or demographics. We continued by asking about what they would do if more funding were available to them for their work in Extension. We asked this to get an idea of what is possible for Extension in climate work if given an undetermined number of resources and funding. Lastly, we continued our snowball sampling by asking the interviewee if they knew anyone else at their institution or others that would be interested in interviewing with us and if they had any further comments or thoughts they would have liked to share with us. A copy of the interview protocol is presented in Appendix A.

**Analysis of interviews**

To analyze the interview data, I used NVivo software for coding the interview transcripts. The team of researchers and I transcribed the interviews for analysis using an
automatic transcription software that comes with Zoom, Otter.AI, while we were recording the interviews. Afterward, the research team and I cleaned the interviews to get rid of irrelevant filler words and correct any words or sentences that were incorrectly transcribed. The transcriptions were then imported into NVivo for coding. Coding the data consisted of organizing selected quotes and statements from the transcribed interviews that relate to certain topics like ‘challenges’, ‘funding issues’, or ‘successes’. With NVivo, I compiled specific quotes into certain categories that provided me with evidence to support my thesis arguments and provided further insight into the inner-workings of Extension.

My research questions aimed to identify barriers and enablers to Extension transforming into a system that is able to address climate change issues in the US. Moore et al. (2014) refined a transformation framework for analyzing the transition of social-ecological systems (SESs). This framework was created due to the increasing interest in catalyzing intentional transformations in SESs so that they are set on new trajectories to ensure that the well-being of both humans and a range of ecosystem services is sustained over time (Clark 2001, Westley et al., 2011). Framing Extension as an SES, I used this transformation framework to analyze Extension and its ability to transform into a larger actor in climate adaptation and mitigation in the US.

I used themes from the transformation framework, shown in Figure 2, including: triggers, preparing for change, navigating the transition, and other elements of transformation as codes for analyzing interview data. My codes included communication, successes, challenges, funding agencies and consistency of funding, among others. Using these types of codes, I organized excerpts of the interviews that helped me address my
research questions. For example, I identified elements that are likely to change during a
transformation within Extension, such as the flow of power and resources according to
the interviewees. Finding points in the interviews where interviewees were describing
where their funding came from or who they are trying to “satisfy” with their work
described power flows and told me who is controlling the direction that Extension
professionals go with their programming. Another example of how this type of coding
guided my research is identifying challenges Extension professionals encountered with
their audiences, colleagues, and funding agencies. The interviews included direct
questions about these topics and I organized responses into a reviewable format. With
that information, I conceptualized patterns across Extension professionals in different
places of the US that I then cross compared with themes from the transformation
framework.
Results

The results of this study show preliminary evidence of Extension potentially being in a transition. However, this transition is not inevitable and may not happen at all without tremendous effort from Extension faculty and others. I identified and categorized informative quotes and statements from the interviews into several themes to show the elements of transformation and challenges to a potential transformation that is occurring in Extension. The themes I have identified are 1) The elements of transformation from
the framework by Moore et al. (2014); and 2) different types of challenges Extension faculty experienced when implementing climate change and extreme weather programming.

**Elements of Transformation**

**Triggers**

The interviews revealed many triggers that motivated Extension educators to take various actions. The main triggers expressed in the interviews by participants were ecological and/or climate related. These ecological and climate related triggers affect communities in various ways that inspire communities to act to save themselves from future damages or harm (adaptation) and/or try to prevent or reduce the severity of such events in the future (mitigation). One central concern was for agriculturalists; because of Extension’s history of being closely tied with agriculture, anything that affects the agricultural industry will draw the attention of Extension professionals. Participant 13 recognized the strongly intertwined structure of Extension and agriculture: “I think the structural issues of how Extension and the ag industry are intertwined, which is so important because there's partnerships there.” (Participant 13). Having strong ties to the agricultural industry can cause some friction, as Participant 13 expressed by their next statement “But if there's a topic that people don't want to talk about like, the whole GMO thing. Oh my God, that's… don't even get me started on that.” But these ties also have great value for both agriculturalists and Extension. Vulnerability of the agricultural sector showed to be a trigger for many types of Extension climate change programming.
opportunities. Below are some examples of climate Extension professionals working closely with the agricultural sector around climate change adaptation given extreme weather triggers:

“I think the program started out spending our time almost entirely on raising awareness of the impacts of climate change on agriculture in (the state). Just general education of the farming community and general technical assistance to farmers would call people like myself to talk about this vulnerable area. This challenge with flooding, these waterlogged soils, in some cases drought, too – how do I build resilience to drought?”
(Participant 9)

“‘Did you see all that cotton that’s in the field?’
And I was like, yeah, it looks dead. And in fact, it was all flooded. It had been this huge El Nino event and so all the fields were flooded. And so they were freaking out because they couldn’t harvest the cotton.”
(Participant 13)

“And so I would say that more than the first half, maybe a little more of my time here, programming in this area has been focused on that adaptation mission, working to develop solutions for farmers, specifically
And really working around the challenges related to water” (Participant 9)

Events like wildfires, floods, or droughts triggered responses from Extension and increased the awareness for the rising need for Extension to do more. Communities that Extension serves, in some states, are seeing extreme circumstances surrounding wildfire: “I think there's the whole aspect of…livelihoods for people and mental health and facing anxiety, trauma, depression, and just financial stress uncertainty. I mean, it hits a lot of levels. People lost all their food in a fire and are suddenly relying on the community to feed them. I mean, talking about basic needs.” (Participant 12).

Most triggers for change occur from Extension’s audiences being affected by natural hazards that are influenced by climate change like floods, droughts, storms, wildfire, etc. Though these triggers are legitimate causes for action, according to the framework by Moore et al (2014) a trigger should be something that has a direct impact on Extension. Most of these climate change related triggers would be considered indirect, according to the framework, since they do not impact the entire Extension system directly. The direct trigger for change in Extension would be the shifting concerns of Extension’s audiences. If a community is being affected by climate change then Extension may work to administer adaptation or mitigation programming, but those programs may not be supported or adequately staffed unless there is interest from the community. Participant 2 expressed this concern “So even if the grants are out there, if
there’s not really the capacity at the local county level to go after it, then that also is definitely an impediment to doing climate work” (Participant 2). This shows a gap in climate change programming, and furthermore a gap in the transformation of Extension, involving funding and community interest. On the contrary, one interviewee mentioned how they cater to stakeholders’ increased interest in climate mitigation programming, showing how interest from stakeholders and the community can create opportunity for climate mitigation programming:

“And then in the past two years or so, I think... the interest of the farming community, and of other stakeholders in the state...their interest in mitigation has really grown...And so I would say...maybe 40% of our time and energy is devoted to that piece, the mitigation piece, where when we started it was almost 100% adaptation.” (Participant 9)

The effects that climate change and extreme weather have on Extension’s stakeholders and audiences has shown to be the main driver of change within Extension. More Extension climate programming has agricultural stakeholders than other types of stakeholders, which is due to the historical ties that Extension has with the agricultural sector. When asked what made climate programming so successful for one of our interviewees, they responded:
“the fact that the climate continues to throw curveballs at farmers. There's a [trigger] there, right? And we have a name that supposedly meets that need, ‘The Farming and Climate Change Program’....And so that generates – I hate to call it this, but that generates business for Extension.” (Participant 9)

At least three interviewees revealed that if Extension wants to promote something other than the interests of the community or funders, they run the risk of having funding cut for those programs.

Extension is a science-based system with a goal of helping communities across the US, specifically in subject areas specified by the ECOP toolkit like climate resiliency, mitigation, and adaptation. With science being a politically charged topic, causing confusion and distrust across the US surrounding issues like climate change, there are regional variances in the types of climate programming being run.

The triggers that spark climate change programming mostly revolve around a reaction to a climatic event (flood, wildfire, drought, etc.). There were interviewees that expressed an interest amongst their target audiences for preventative action against climate change in the forms of adaptations. These types of reactions are being followed by a slowly growing interest in more mitigation actions by Extension audiences in certain areas of the country.
Preparing for Change

Sense Making

When in the sense making phase, Extension educators identify key problem areas among their clientele and in their institutions. In the case of climate programming, many of the interviewees expressed that their programming reflects their audiences’ perceived needs. Therefore, audiences who are unfamiliar with the topic of climate change or who are swayed by political influence on the topic may not care to have climate programming in their community. Due to the unfortunate politicization of climate change, many communities that Extension serves have not perceived a need for climate programming. But, if Extension educators are able to frame the programming to be more relevant and beneficial to these groups of people, then their communities would probably be more willing to accept and adopt climate change programming.

“And I think that...there's a lot of work that is out there that shows the monetary impacts of weather and extreme events and some on climate as well. And so... if we can increase people's knowledge, not just Extension professionals, but also their stakeholders. Could we potentially see an economic return to our states in some capacity and the funding?”

(Participant 10)

The second most common theme among the interviewees that was identified as a challenge to climate programming was getting other Extension faculty interested in
including climate education in their programming. Many were deterred from it because they 1) thought it was not very relevant to their programming; 2) thought they needed to be an expert in order to teach about climate change and its effects; and/or 3) they did not believe in the effects humans had on climate change. The following quotes represent some of the participants feelings of disconnect from their colleagues in Extension:

“I guess one other example is I ended up being the college’s Extension liaison to the USDA northeast Climate Hub. And so I was trying to get connected with that group, but my background is in agriculture and forestry. So it felt like I was trying to make more connections to our ag and forestry staff. Like, hey, there’s this regional Climate Hub, get connected, but it was kind of hard to communicate the value of doing that because it’s a regional scale effort versus the hyper local work that our Extension staff tends to do. So that was one challenge of the more internal side.” (Participant 1)

“Another challenge is increasing weather and climate literacy of Extension professionals and confidence on how to best integrate the [climate] information into their existing programming. So here in our state I’m always trying to emphasize that I’m not asking them to become an expert in another area or to go out and do a program just focused on weather and climate, because most of the time, their stakeholders don’t
want a presentation about climate science. But there's elements of climate science that they can integrate into existing programs that their stakeholders are interested in.” (Participant 10)

“The next level [of challenges] were Extension educators, and it was just finding those educators that found it appropriate to make this climate information part of their programming. So there are certain educators where that just wasn't something they were interested in or they were on the political spectrum that didn't see any reason we do that type of education.” (Participant 7)

Participant 1 had run into some issues with motivating people to do climate-centered projects with money that came from the Climate Hubs. Participant 6 had an experience where one of the collaborators on a project did not believe in human-induced climate change.

“Participant 6: I was involved in an Extension project, this was a National Extension Initiative that was actually related to climate education and one of our Extension collaborators didn't believe the
evidence of climate change. And so that was challenging to work on a climate change project with a colleague who just really didn't buy into it.”

I3: Can you tell us a little bit more about this colleague’s position?

Participant 6: Yeah, he didn't really either grasp or believe detection and attribution studies saying that we could actually attribute cause and effect to emissions of heat trapping gasses, and he kept saying that it was just a correlation that we don't really have evidence of cause and effect. I just couldn't move him off that point. But we worked together. Ultimately, we developed the content, but he was just a little grouchy about it maybe.”

(Participant 6)

Although some Extension educators found it somewhat challenging to get other Extension faculty interested in climate programming, there were others who felt supported in their climate programming efforts.

“My Extension colleagues, since I've gotten this job, 95% of them were very supportive and on board with this being an important area of programming as long as it wasn't just about climate change education, but that had broader sort of applied climate information. And so I think I did a good job with that.” (Participant 4)
“I don't know that I've had too many problems really with Extension colleagues, aside from just natural differences that happen in the workplace. But otherwise, I think we worked really well as a team and kind of all shared the lead on different things.” (Participant 2)

During the sensemaking phase, Extension educators and actors find areas of friction or resistance for climate programming and identify areas of progress. From the interviews, it was found that areas of friction come from a lack of education or knowledge on the subject of climate change from both Extension audiences and educators along with a lack of interest due to relevancy of their current programming or beliefs in the sources of climate change. These points of resistance towards climate programming in Extension have an effect on the initiation of climate-related programs in states that lack the initiative to address climate change.

**Envisioning**

Envisioning involves taking what is gathered during the sense making process and thinking of solutions to certain issues that were identified, picturing adjustments to the current system that could work in a future system, and anticipating any friction these adjustments and solutions may cause that would prevent a steady change (Moore et al., 2014). Interviewees expressed an overall strong desire to use Extension’s potential to spread climate change education, adaptation, and mitigation. When asked if Extension could be doing more, this is how participant 5 responded:
“Oh, definitely, without a question. I mean, I think about the fact that we have Extension... we have a network across the United States,... in every state, every county. I mean, our network, our reach is huge. It's an untapped resource and how we can get our colleagues to be supported and doing this work nationwide is, it's really important. I mean, just thinking about the different ways that people are going to be affected by extreme weather events and heat waves and fires and smoke and hurricanes and floods and I could go on.” (Participant 5)

Many of the interviewees think about the problems that their state is facing and the visions that they have for a future Extension system are more tailored towards their specific state. Each state is also at very different levels of acceptance when it comes to climate change and climate programming. But a common theme was that people think Extension could be involved in bigger issues than just local and state level. There is a vision of Extension being more centralized and connected between states and regions in order to accomplish larger scale goals that will have a bigger impact on the country and possibly the world. Participant 9 expressed feelings of wanting Extension to be more connected and involved nationally.

“I think we should be doing more. When you think about Extension nationally, it feels kind of clunky, right? I mean we have a lot of
nimbleness within our county or within our state, but Extension nationally feels kind of clunky to me. I don't know how we organize and how we do that... I think the initiative that [NECI] is leading is a really great thing. But yeah, I would love to see Extension do more. I just don't know what that looks like and how it is implemented.” (Participant 9)

One question we asked a participant because of its relevance to the conversation was “I want to know if you've seen a change throughout Extension, not just at your institution, but overall across the US in any way that makes it seem like they're starting to I guess focus more on climate change in general in all programming areas rather than just in natural resources?” Participant 20 answered with “I don't think so…I haven't seen a lot of that change nationally to be totally frank. I think there are several of our Western states that I see evidence that they're integrating climate change and climate change messages in their Extension portfolio, I have probably not as widespread or as much as we really need to.” This statement supports the claim that Extension educators want to see more being done on a national level where there is a central vision and place for Extension to follow and to have larger scale initiatives begin.

One of the interview questions gave participants a chance to think big on climate solutions and Extension. The question was “If more funding and staff time became available to you for Extension programs focused on climate change and/or extreme weather, where and in what ways would you invest these resources?” Participant 18 felt that Extension is preparing for the effects of climate change:
“And if you think about climate, the climate impacts every aspect of what we do in Extension, community resource development, agriculture, all kinds of areas. So I think we're really starting to position ourselves well to address what's to come and recognizing that there is a very broad scale of what Extension can do to address climate issues at all levels.”

(Participant 18)

Most of the time it seemed that our participants were concerned with acquiring money to expand their climate programming and less often develop new areas of climate programming. Giving the interviewee a hypothetical situation where there would be unlimited funding revealed a few different directions for which Extension could follow. One common pathway was to hire more scientific communication specialists to help connect the researchers to the people they are trying to help and to better communicate the science behind climate change in a way that audiences can relate to.
“I would get more engagement from Extension faculty that can walk the walk and talk the talk. Climate change is a very... You need somebody who knows the data knows the information, but has the ability to be able to present in a coherent and understandable way and that's not always going to be the person that is running the computer models. I would beef up my number of faculty in that area (scientific communications)” (Participant 20)

There was a range of ideas that were expressed related to the extent to which Extension should continue to work primarily with agriculturalists. Three participants believed that focusing on agrarian audiences for mitigation and education programming is very important when it comes to Extension and climate change.

“I would fund some of the time of Extension to work on agricultural issues. To be educating farmers about soil health and how to use these online tools that we have, how to plan for drought, how to plan for excess water. So I would fund an Extension specialist in the inner part of their time in each region. I don’t think we need one in every county. But if there were one in every region of the state, it would be a good start.” (Participant 11)

Additional ideas that were expressed relate to expanding current climate programming to other areas around their state and networking between Extension climate
specialist programming. Some envisioned supporting the transition away from fossil fuels, getting more involved with students through internships, investing in mental health surrounding climate change impacts, and improving climate literacy. Overall, the sentiment from the interviewees was for more involvement in climate change adaptation and mitigation programming around their states.

Gathering Momentum

Gathering momentum to enact change in the Extension system first and foremost requires support from networks of people within Extension and partnerships that provide support (Moore et al., 2014). With climate change creating pressure on American society, Extension has been strengthening partnerships with USDA NIFA Climate Hubs, National Oceanic and Atmospheric Administration (NOAA), National Integrated Drought Information System (NIDIS), United States Geological Survey (USGS), Department of Defense through the SERDP (Strategic Environmental Research and Development Program), non-profit organizations, and key players in universities. Along with strengthening partnerships with others, finding people within Extension who share similar goals surrounding climate change programming and forming networks is essential in making a transformation (Moore et al., 2014). When asked about the success of climate change programming within Extension, participant 5 responded this way: “I would say collaboration, teamwork…. So being able to work with large groups of people that have similar goals can be quite powerful.” Participant 6 said something very similar: “So again, network building I think is a very effective way of building capacity and getting things done.”
Many Extension educators have found small successes through their programming efforts that create larger influences in their local communities. Connecting these Extension professionals with others across the country and sharing their success stories can inspire others, and in response, create a powerful movement within Extension. The following is an example of an Extension professional creating a long-standing network of people in their community that focuses on climate programming:

“In 2015 and 2019 I did this work on extreme heat and public health. And that was an opportunity to build a network of collaborators, and who have continued to work even after the funded programming ended. They’ve continued to work to implement programs and also to collaborate on further research proposals. So... developing that network of collaborators that included university researchers, city staff members, and members of the public health profession...is an example of something...that was very rewarding.” (Participant 6)

Another participant had created a regular meeting for community members and farmers to come and have open discussions about topics related to climate change. This program attracted the attention of several key decision makers for that region.

“You know, Senator [anonymous] was at one of the river watershed meetings and it was all about climate change, because our local Extension
directors were like we can't not talk about this anymore. Like we've got to have this discussion. And so, I had really good discussions with farmers who are...Republicans now running for Republican seats in the State House...I certainly had a reasonable conversation with them.”

(Participant 4)

One example of Extension gathering momentum by building networks of people who believe in creating a transformation is the National Extension Climate Initiative (NECI). Created in 2019, NECI is a rapidly expanding grassroots initiative of Extension professionals who want Extension to take more action regarding climate change. The growing size and influence of NECI (which has grown from 5 members January 2020 to over 650 members January 2022) suggests that Extension may be closer to a transformation than I originally predicted at the beginning of my study. This grassroots initiative is now the focal point for many climate change thinkers within Extension. Participant 8 showed gratitude for having such a network: “I just think it’s a great thought to have a national group of Extension people who are interested in this topic and who are willing to share different ideas...of what’s going on in different states...I appreciate the things that [NECI is] doing and what others are doing around the country.” One participant responded when asked about Extension’s overall climate programming efforts:
Interviewer: “In your opinion, how do you think Extension is doing in relation to climate programming in general at either the local, the state, regional, or national level?”

“I think we're still a pretty small compadre. We've got our groups that are interested and are really excited to participate in NECI... But when we get together we're primarily the natural resource educators, some of the community development educators, and the ones that are in 4-H and in Agriculture...But by and large it's not an issue so I think it's still decent...I've been at it for 20 years and we need to make it a more simple part of education because it's not going away.” (Participant 7)

The creation of NECI has brought together Extension professionals across disciplinary fields to work towards initiating change in Extension. With the push from NECI, the representative leadership of Extension ECOP has taken strides towards pointing Extension in a stronger climate change direction. In order to gain momentum and centralize decision making around all of Extension nationwide, ECOP has published an advocacy toolkit (Extension Foundation, 2022). This toolkit was made to provide consistent messaging across all of Extension and to promote national Extension’s education priorities. Nine different priority topics are listed in the toolkit, one of which is “Climate Mitigation, Resiliency, and Adaptation,” which NECI had a part in creating.
There are still many challenges involved with gathering momentum and securing funding for climate programming. A core challenge was emphasized by participants at the heart of Extension that creates friction between communities and climate change. Participant 13 explains:

“Even though they [Extension leaders] talk about this idea of extending science to people on the one side of the mouth, on the other side of their mouths, they talk about how programs have to be community driven. And so if people aren’t asking us about climate change, we’re not going to develop a program about climate change. At least that was part of the narrative like in 2004 or five, when I was in the heat of trying to do this...Because it looked like, why aren’t we creating climate change programs at this institution? But it was again like this whole political, politicized environment...A lot of Extension’s money comes from the agricultural industry and if The Farm Bureau has in a little red book of Fabio rules [the beliefs and rules surrounding climate change], that climate change is not real, and the Farm Bureau is a huge supporter of the university, it's an issue.” (Participant 13)

Identifying what programming is relevant to audiences and needing to address issues that may negatively affect those communities has been expressed in one way or another by many of the Extension faculty we interviewed. Getting these two things to
align is the challenge for climate change programming and when done correctly creates successful programs. Keeping a community updated on impactful climate risks that could affect their community can open up many doors for collaboration and funding. But Extension professionals would still need community support for the programming to be relevant and receive an appropriate amount of acceptance and funding. Participant 6 said:

“Another opportunity is working with the choir. So, you know, sometimes we get accused of just preaching to the choir, but I think there's a role in inspiring the choir by keeping them up to date on the latest science and again with success stories that we might be hearing from other parts of the country that might inspire them. There's also an opportunity with these so-called nexus issues, like food energy, water security or climate water land use, or climate and cascading hazards. Like drought, forest fires and then floods that follow forest fires that send debris flows cascading into communities. You know, I think there's big opportunities to work at those intersections and it can be very fruitful because you could work with a lot of other Extension colleagues and other, you know, state and federal agency colleagues on those kinds of issues.” (Participant 6)

Despite the opportunities that Participant 6 mentions, interviewees identified lack of funding as a major obstacle impeding the reach and efficacy of climate-related programs. To counter this, Extension professionals build networks of people to help
centralize and solidify ideas and help to secure funding. Participant 18 said: “it always comes down to resources right? I mean if folks don't have funding for Extension programs around climate we're not going to have a lot of movement in that arena”. The best example of Extension professionals coming together to gather resources to expand climate programming is NECI. This initiative recognizes the urgency of climate change and Extension’s potential to be involved in solutions.

Navigating the Transition

*Phase 1: Selecting*

Many of the interviewees shared stories about successful programs that they have run throughout their careers; some of the programs they ran were temporary and some were long term. The only limitation to most of these projects is the consistency of funding. One participant shared a program success story of how it became sustainably funded surrounding an important issue:

“Between...2015 and 2019 I did this work on extreme heat and public health. And that was an opportunity to build a network of collaborators...who have continued to work even after the funded programming ended. They've continued to work to implement programs and also to collaborate on further research proposals...developing that network of collaborators that included university researchers and city staff members and members of the public health professionals...[is] an
example of something that was a process that was very rewarding.”

(Participant 6)

Other participants expressed their concerns for sustainable funding regarding their programming and partnerships:

“At one point in time, it was called Carbon Masters and had a very climate change focus. And I think in 2013, it rebranded itself as Sustainable Community Stewards. Kind of dropped the carbon focus. I think the funding also changed with that program. And more recently, we’re kind of revisiting that because we have a contract with a big city nearby to do a series this fall, called Climate Champions. And then we just met with another city yesterday about the climate champions program that we’re developing and they were very interested. The problem is always how do you fund these programs for communities.” (Participant 5)
Interviewer: “if more funding or staff time became available for those extension programs or unmet needs that you were naming, where and in what ways would you invest the funding and resources?”

“I would also provide funding, similarly, to get this climate stewards program off the ground because right now it’s running on $20,000 and for only one more year.” (Participant 11)

Feelings of having success through a collaborative process were shared across at least half of the interviewees and seems to be what brings the most to climate programming, though this process could be applied to most programming opportunities in any field. Out of the 20 interviewees, 10 mentioned collaboration when asked about what made their programs successful. For example:

“I rely heavily on partnerships in my role...having solid partnerships and that we or I have buy-in from the very beginning on those efforts and building trust as well and respect from my colleagues, whether it's here in Wyoming or the other five states that I work in...And it's really building that trust and respect because weather...and extreme events are easy to talk about. Climate can be a little bit more tough to talk about and when climate change comes into the conversation it becomes even more challenging at times. So the more trust, respect that I have and building those partnerships and ensuring that people are part of... the development from the beginning...it's critical.” (Participant 10)
During the selection process, Extension educators identify what made their programming successful or what methods promoted the further acceptance of climate programming. The most common response from the interviewees was that collaboration between community members and other organizations is what brought the most successes and the most abiding projects. Collaboration and networking was also the key to obtaining sustainable funding for programs to run well past their original timelines.

Phase 2: Learning

‘Learning’ is the subprocess that analyzes the results of earlier programming or methods, develops an understanding of it, and then continues to adjust and refine it. Extension educators discussed taking a successful program or process, learning about what made the program successful, and adapting it to a new region to make it more relevant for another state’s Extension audiences. For example, one Climate Steward program in southeastern US might teach community members how to do citizen science through collecting data on algal blooms along the coast lines and in irrigation canals to monitor the health of coastal ecosystems that protects against things like hurricanes and storm surges; the same type of Climate Stewards program in another state in the Intermountain West would not have a need for algal bloom monitoring but instead, might teach its audiences how to measure snowpack in their area to monitor drought conditions for the next year. Although the focus of each program is different, the networking strategies, outreach methods, and evaluations could be the same.
This subprocess is instilled in the Extension system through their methods of programming. When a successful program is executed at one university, that information can then be shared, improved on, and adapted in other states by Extension. This is accomplished by networking and information sharing through Extension professionals working in climate change and extreme weather. The learning subprocess was not discussed in the interviews with our participants and therefore leaves room for future research surrounding Extension and the learning subprocess of the Moore et al. (2014) framework.

Phase 3: Adopting

The widespread uptake and adoption of successful programs is the final step in navigating the transition and signifies a tipping point for the widespread adoption of the new trajectory of a SES. In select flagship programs, Extension has proven itself an innovative and successful producer of climate programming through years of trial and error, networking, and relationship development. But, Extension is not doing enough to make any significant impact on US emissions as a whole. One of the goals of this research and using this framework is to identify where Extension is in the process of a potential transformation and how well the data aligns with the Moore et al. (2014) transformation framework.

Extension has not reached the ‘adoption’ subprocess in the ‘navigating the transition’ phase because there is no evidence that Extension has reached a tipping point of widespread climate mitigation and adaptation programming and support. The interview data points to Extension being in the ‘learning’ subprocess because educators are still experimenting with the best solutions to implementing climate mitigation and
adaptation programming across different regions of varying cultures, beliefs, and political views. Although my deductive analysis points towards Extension being in a transition towards prioritizing climate change, this transition may not come to fruition, particularly given.

Institutionalizing the New Trajectory

Institutionalizing the new trajectory describes a system that is on the back end of a transformation and is ‘routinizing’ the new/best practices that were identified during the ‘preparing for change’ phase and the ‘navigating the transition’ phase. Since Extension is still in the midst of a transformation, according to my analyses using Moore et al’s (2014) framework, this step is still being developed in Extension. Though Extension is in the transformation process, there is evidence of some routinization in the Extension system. The two main steps in routinization are 1) the dedication of funds to the new selected trajectory; and 2) the appointment of personnel involved in implementing and maintaining new standard practices.

Throughout the interviews conducted in 2020-2021, there was little mention of an overall increase of funds available for climate and extreme weather programs. However, one leader of a state Extension system mentioned that there is discussion of an increase in funding specifically for climate programming. Although this is promising, nothing seems to be set in stone: “Let's see if it holds. I mean Extension’s budget across the US [shows] that the funding that comes from the USDA is about $400 million a year for Smith lever and an increase of $600 million specifically for climate is huge. So, we'll see if it holds…there's still a lot of discussion to be had but it's really exciting to get that kind of recognition” (Participant 18).
An existing example of routinization in Extension is ECOP establishing priorities, including prioritizing climate change, to share a central message across all of Extension. A member of ECOP said, “Those are priorities of ECOP, so they have been voted upon by all of the directors and administrators of Extension across the US. And to me that says that…those priorities should be the priorities at the university level, and that the language that we develop for that toolkit provides consistent messaging…in everything that we do around the priorities” (Participant 18). A second interviewee mentioned establishing standard practice surrounding climate programming: “And they did in fact build a strategic plan and identify an array of priorities, climate being one of them. I also started a climate coalition, along with some other of my colleagues within the ECOP Community and with our partners, and that was the beginning conversation at the ECOP Level here on climate” (Participant 21).

There is still some pushback from upper administration of Extension in some universities where leaders are hesitant to support and recognize climate programming as a priority. One interviewee touched on tensions between the agricultural industry and Extension climate programming:

“I don't think our dean really made it [climate programming] a priority or...she was always very concerned [about climate programming]. I would get emails from her, or we would get emails saying, ‘Be very careful how you talk, how you frame climate change with farmers.’ And I would be thinking, that's what I've been studying and that's what I do...I very
carefully frame it. So, I don’t think it was her priority and it definitely isn’t the Director of Extension’s right now.” (Participant 11)

In contrast to leaders like Participant 11 mentioned, other Extension leaders are supportive of climate and extreme weather programming; participant 3 said “But our Extension Forestry department head is great. I’ve never experienced any pushback from him like that.”.

Based on these interviews, some Extension Leaders are working towards routinizing climate programming across the US among other priorities, but there is still a lack of solid evidence for an increase in funding for this effort. Interviewees emphasized how funding is the key for expanding and institutionalizing climate programming.

Key Elements for Change

According to Moore et al.’s (2014) framework, change in a system like Extension will affect three main things: 1) norms, values, and beliefs; 2) distribution and flow of power, authority, and resources; and 3) rules and practices. These interviews provide preliminary evidence that there has been some change at local but not system-wide scales related to these three components.

Norms, Values, and Beliefs

According to the interviews, the norms, values, and beliefs among Extension professionals involved in climate programming seems to be directed towards an
acceptance of climate change and the need for action. Extension stakeholders and audiences seem to have not fully accepted the scientific consensus that action must be taken now to reduce the chances of increasingly catastrophic impacts in the future. This lack of acceptance has regional variance based on political views, cultures, other social factors, and environmental differences. Most of the significant change in norms, values, and beliefs expressed by our interviewees were that of their audiences. Since Extension is driven by its audience’s values and needs of their stakeholders, some of Extension’s programming has shifted based on their audiences’ and stakeholders’ views. One participant described their experiences with youth-driven climate programming:

“But I think what made it successful was that it was very youth driven and that young people are aware, some of them are very aware, of what the future holds for them and what the present moment looks like in reality in terms of climate change and ecological impact. And they are very aware of what the potentially...negative outcomes will be for them. And there's a passion to do something about that.” (Participant 12)

Similar to nationwide trends on American attitudes towards climate change (Leiserowitz et al., 2021), interviewees described an increasing number of Extension audience members as perceiving climate change having a negative effect on their daily lives, as was also shown in the previous youth example. This idea was expressed by at least half of the interviewees through storytelling and direct quotes ($n=11$). Many
Extension audiences, however, still reject that climate change impacts are largely human induced as is shown in the four examples below.

“It's an interesting part of my job [handling audiences and stakeholders]. I work in a very conservative state. And climate change is, I think there's been some gradual shift in the attitude towards...accepting that changes are occurring. There's still not great wide adoption of attribution and the causes. This was something I had to learn kind of the hard way, I talked about climate change, early on and I didn't get a lot of pushback. And I realized I didn't get a lot of pushback, because there was this kind of definition issue that we were running into where everybody's like, oh yeah, climate is always chang[ing].” (Participant 4)

“I mean, you definitely know that there are events that are happening. And if you're in certain parts of the country, you know, people may not be as willing to attribute it to man-made reasons. And so, you know, they can't deny that, you know, the summer has been hotter than normal or drier than normal, or that there have been extreme weather events or whatever it is, but getting to the cause of why that's happening...that can be sometimes harder to communicate to people...you can't just always use the word climate change. And I find that better terminology than global warming.” (Participant 5)
“I think one thing is just the varying beliefs about climate change... Some people believe in it and believe that it's human caused. Some people don't believe in it at all. Some people have kind of in-between beliefs. And then not only that, it's kind of what their priorities are. So working with different communities, kind of figuring out where their priorities are and kind of how we can align... Like at Extension we're promoting research-based factual information but that doesn't always align with what people believe. And so that I think is always the biggest struggle.” (Participant 2)

“I think that by talking about adaptation people can acknowledge and embrace the changes that are happening. And when we start talking about mitigation, some people feel blame, and when we're talking about adaptation we almost remove that blame, and it's just happening and we need to be able to change and evolve with it, versus mitigation where we're placing some form of blame.” (Participant 10)

Extension professionals have noticed varying beliefs within both the external and internal Extension community. Partners that Extension professionals collaborate with and Extension faculty in other programming areas sometimes do not believe in climate change. This situation makes collaboration or funding of projects related to climate change and extreme weather difficult. An interviewee reported: “We were looking at
perceptions on climate change and we got a lot of the educators and scientists saying this is real and these are solutions we can come up with, but particularly when we talked with the practitioners or the foresters, they’ve just learned that this was not really going on. It was a political effort to kind of take control of their management and they just thought it was unnecessary” (Participant7).

Another concern relating to norms, values and beliefs involved Extension faculty in other programming areas attempting to incorporate parts of climate education into their programming. These Extension educators are not confident in their own literacy surrounding a subject matter outside of their own (e.g. climate change and extreme weather) and therefore hesitate to educate their audiences on it. Participant 10 expressed this when asked about challenges they encountered:

“Another challenge is increasing weather and climate literacy of Extension professionals and confidence as well on how to best integrate the information into their existing programming. So here in this state, I’m always trying to emphasize that I'm not asking them to become an expert in another area or to go out and do a program just focused on weather and climate, because most of the time, their stakeholders don't want a presentation about climate science, but there's elements of climate science that they can integrate into existing programs that their stakeholders are interested in. And so, helping folks to feel confident and comfortable doing that and to have the vocabulary and knowledge to do it as well. And I think it also goes another way in terms of not just within Extension, but
also I work with a lot of climate and weather professionals and work with them to increase their literacy in terms of agriculture.” (Participant 10)

Norms, values, and beliefs are changing around the country surrounding climate change which is increasing Extension’s ability to implement climate programming. There are still limitations to this involving the level of acceptance of climate change and the amount a community wants to prioritize climate change over other areas of concern. Extension’s programming focus generally follows the prioritizations of the audiences and stakeholders they serve.

Distribution and Flow of Power, Authority, and Resources

The distribution and flow of power, authority, and resources is related to financial resources, positional power, and relations and partnerships that give a person authority. In Extension, these are mainly influenced by the needs and interests of the community and that of the main stakeholders who can also be the main sources of funding for many local and state Extension programs. Whenever the community is interested in or needs a service that Extension can provide, Extension professionals and leadership generally try to find resources, funding, and information that can fulfill that need in a community. Another source of power and authority comes from funding agencies such as USDA NIFA, the Farm Bureau, and NOAA; the directions that they choose for the projects they fund can influence the language and information that Extension faculty use in their programming. This is also affected by the federal government and any administrative changes that may ensue. In relation to funders influencing programming, authority
figures in Extension (administrators) may sometimes push for a specific agenda in fear of losing support from funders. The following Extension professional was told by their upper administration to stop all work on sustainable agriculture because of concerns relating to the consistency of funding:

“At some point there was a situation where my supervisor in Extension was unhappy that I was working on climate change work and submitted a letter to me and asked me to stop doing all work on climate change and on sustainable food. And that was challenging because… I was going to jeopardize my position by continuing to work on that project for my master's degree so there's a bit of conflict there... I was very aware that other states had Extension programs that were fully going ahead with climate change work and so it was distressing and frustrating and not too surprising... It just felt really like my work as a professional was interrupted in what felt like an unfortunate either misunderstanding or blatant disregard for what I thought was important work... I'm not sure [if] he thought I was being too political... or that I was going to upset some funders... I don't know if they were Extension funders or just University funders to the university system that wouldn't really be pleased to hear someone talking about different ways of raising beef... It's something along those lines.” (Participant 12)
Extension professionals can be rejected and threatened when pursuing climate change programming due to the fear of losing support from funding agencies. Some of these funders are federal agencies that are sensitive to administrative control. Extension is a part of a larger system implemented by the federal government in 1862 and is still tightly intertwined with federal decision-making and funding. Due to the politicization of climate change in the US, the implementation and success of climate programming in Extension has been and will likely continue to be disrupted by changes in the federal and state administrations. One of the interviewees recognizes this and the effect that climate programming can have on certain industries that makes climate programming seem less desirable for these industries:

“You're always going to follow the priorities of the current presidential administration, right? But then you have, you know, you're dealing with industry and all of the different lobby groups that may have a stake in something like methane or you know, some aspect of the environment that in a regulatory way cuts into profit, right? So, you're going to have a lot of lobbying on the hill from different parts of industry. There are a lot of parts of industry that are really pro-this work and pro-environmental protection and all of those kinds of things. But you’re going to have other folks that are sort of like ‘well you know that's really hurting, you know, the environment, we don't really know if it's affecting climate.’”

(Participant 18)
The distribution and flow of power, authority, and resources surrounding climate change has increased in small doses previously, and more funding for this type of work is being discussed at higher levels. There is still concern of the consistency of funding among Extension professionals working in climate or extreme weather programming because of grant money running dry, a change in management at any level, or disagreement on a topic. Most Extension professionals in this line of work rely on several different sources of funding for personnel and programs. Below are some examples of a concern for consistency of funding among our interviewees:

*Interviewer:* “Is it ever frustrating for you that you know as a fiduciary of a land-grant university to be kind of on top of issues that affect the health, welfare and safety of constituents that maybe you change messaging because...those political concerns. Does that ever frustrate you?”

“Yeah sure like I said with Covid right now it'd be nice to be able to say some different things, but I would be concerned about our Extension funding in the future if we were out front on and more direct on some things.” (Participant 17)

“So with the county funding, that I mentioned with the County solid waste division, that has been consistent one. Um, we've had a change in the person that we've worked with there recently retired. And, you know, going forward, we're not sure exactly how stable that will be especially
given the current pandemic crisis and the financial stress that a lot of different organizations are feeling.” (Participant 5)

“I’ve described mostly project-based funding, although the NOAA RISA program that’s program funding and for a while that paid for my salary and with the USGS now with the Climate Adaptation Science Center, that is a fraction of my salary, so that keeps things going. And then I have a partially state funded position, which allows me to do Extension work and to take on work that has to do with requests where I may get a call from somebody at the city of Tucson, “could you help us out?” We’re developing a new sustainability plan and so I can contribute to that and maybe bring in a graduate student or something along those lines, but I have licensed to do it through my state appointment. Without that kind of continuity, it would really be challenging.” (Participant 6)

“Yeah, I mean so I am fully funded 100% including my fringe benefits by the USDA and because of that, I mean the university is very supportive of whatever I do and doesn’t ask questions. But they have not invested in my work. So, I guess, to answer your question, you know I feel supported in that I’m not questioned and they’re like, hey, if that’s what you want to do, do that, but if I was to say, do I feel supported and if my funding went
away from the USDA, do I think the university would try to find a way to continue to fund a position like mine, I don't think so.” (Participant 10)

To make a successful transition towards accomplishing more climate and extreme weather programming in Extension, there needs to be a change in the distribution and flow of power, authority, and resources. For Extension, this change would most likely come in the form of resource flows and the influence and beliefs of those in positions of power and authority. Currently, power and authority of programming directions and foci are in the hands of funders, individual directors of Extension at each university, and audiences through their needs and/or demands. A change to this type of power and authority could mean putting more decision-making power into upper management at the national (ECOP) level which could exercise more control over Extension programming foci at the local level. This could allow Extension faculty to overcome the fear of losing funding at the local level for running climate programming, which seems to be a barrier that directors and other local Extension leaders facilitate.

Audience needs and/or demands can be influenced by improving climate literacy and education which would expose the harmful impacts climate change presents that Extension can reduce or prevent. The interviews have shown that there has not been a major shift in administrative values and the distribution and flow of assets (money and man-power), but that there is discussion and movement towards a major shift. The momentum that has been created for this change is very susceptible to political leaders and beliefs, regional variance in practices and issues, and other exogenous factors, but can also be strengthened by things like natural disasters, administration changes, or
increased awareness and understanding of issues surrounding climate and extreme weather. As one participant provided in an example, “This week it is important to them because there's been a wildfire in the area, so they want to focus on how we do a better job in terms of emergency preparedness” (Participant 17).

Rules and Practices

Rules and practices that are expected to change during a transformation in a system include laws, customs, and procedures. As far as Extension’s rules and practices, not much has changed internally according to the interview data and Extension’s online resources, however this varies by school. The goals of NECI and ECOP are to better incorporate climate and extreme weather information into Extension programming and to change the general practices of their audiences through adaptation and mitigation. There are many success stories of Extension professionals working with their respective communities to adapt to climate change or mitigate its effects. This interviewee shared their strategy for getting farmers to keep interest in their efforts to change their practices for the sake of adaptation and mitigation without deterring them due to talk of climate change:

“We kind of start to talk about, for example, soil management practices... ‘Here's what it can do for yield improvement’, and then we come in through the back door or the side door and say, 'by the way, this has tremendous benefits in terms of resilience.’ I think this really keeps
people's ears open, those who might not have been listening otherwise, and we broaden our audience and improve the reception of our message.

We kind of start with economics and start with the nuts and bolts whenever we can. And then say, 'hey, by the way, you know, how about the storms we've been having? This would be a wonderful practice to kind of help with those, too.' Anyway, that's one thing that we try to adjust our message a little bit and I think it's been good, I think it's been working.”

(Participant 9)

Extension educators understand that in order to create change in their audience’s practices and beliefs, they need to understand them and where they are coming from. Most of the interviewees expressed some kind of relationship and rapport that they need to develop with their audiences for them to listen, be engaged, and to better understand what they are trying to present. This type of relationship with and understanding of the community increases the chances of them adopting the practices that climate and extreme weather programming offers. One of our interviewees recalled:

“When we first started to try and move the bar on climate change I had a bunch of faculty that went around and…one of the faculty presenters that normally went couldn't go, so he sent one of his graduate students and this kid was fantastic, but I remember we were in one of the most conservative counties in our state and he's talking about climate change and how this
and that and one of the county commissioners got up and said ‘yeah I don't really think and I can't believe that driving vehicles and all of this stuff is going to make any difference and the kid said ‘well it's kind of like Mark McGwire and home runs and doing anabolic steroids. You know there's a lot of things that probably contributed to him hitting all those home runs and it's hard to define how much the extra anabolic steroids played a role, but they played a role’ and I thought yeah that's one of the best examples I ever heard.’” (Participant 20)

The current change in rules and practices occurs mostly with the audiences and clientele of Extension rather than internally, though one of the goals of NECI is to incorporate climate change and extreme weather information in other areas of Extension programming. These stories of success in changing the practices of audiences and clientele are shared throughout Extension networks and are adapted depending on the audience’s interests and existing issues in each specific region. This is where Extension has power in influencing larger swaths of society and industry that can make a significant impact on the overall emissions and climate adaptations of America.

Interviews with Extension faculty demonstrate that Extension continues to operate mainly in the preparing for change and navigating the transition phases of a potential transformation as summarized in Table 1. Preliminary activities in
Table 1

Summary of Extension’s Potential Transition to Expanding Climate Programming

<table>
<thead>
<tr>
<th>Framework Summary</th>
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<tbody>
<tr>
<td><strong>Triggers</strong></td>
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<tr>
<td>• Climate disasters impacting Extension target audiences and stakeholders (emphasis on agricultural audiences).</td>
</tr>
<tr>
<td>• Funding availability can make or break climate programming.</td>
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<tr>
<td>• Political administration directions and goals that align with climate action.</td>
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<table>
<thead>
<tr>
<th><strong>Preparing for Change</strong></th>
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<tbody>
<tr>
<td>• <strong>Sense Making:</strong></td>
</tr>
<tr>
<td>o In communities that are unfamiliar with climate change or that are swayed by politicized climate change, it is very difficult to apply climate programming.</td>
</tr>
<tr>
<td>o Each state is at very different levels of acceptance when it comes to climate change and climate programming.</td>
</tr>
<tr>
<td>o Changing language and framing surrounding climate change is a common practice due to a fear of having funding cut or losing audience interest.</td>
</tr>
<tr>
<td>o Extension educators (that are not climate experts) are hesitant to include climate information in their programming because 1) they are not confident about their own knowledge on the topic 2) believe it is not relevant to their programming or 3) don’t believe in climate change.</td>
</tr>
<tr>
<td>• <strong>Envisioning:</strong></td>
</tr>
<tr>
<td>o Interviewees, selected due to their experience with climate-related programming, expressed a common interest in Extension coming together nationally to work on larger impact programming on climate change.</td>
</tr>
<tr>
<td>o Interviewees described future scenarios where Extension expands its climate programming and professionals can have tailored climate adaptation and mitigation programming specific to their states and local communities.</td>
</tr>
<tr>
<td>o If Extension makes a large-scale impact on American GHG emissions, they will have to pull resources and focus from other programming areas.</td>
</tr>
<tr>
<td>• <strong>Gathering Momentum:</strong></td>
</tr>
<tr>
<td>o Extension has been active in strengthening relations with important funders and partners that support climate action.</td>
</tr>
<tr>
<td>o The start of NECI is a leap in this sub process and is a sign of momentum building up within Extension for a transformation.</td>
</tr>
<tr>
<td>o Securing funding for large-scale climate action across Extension is still difficult for actors within Extension due to complex funding systems that are spread thin between many different programming areas of Extension.</td>
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<table>
<thead>
<tr>
<th><strong>Navigating the Transition</strong></th>
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<tbody>
<tr>
<td>• <strong>Selecting:</strong></td>
</tr>
<tr>
<td>o The collaborative process between Extension, partnering organizations, and their audiences is a crucial piece of Extension programming and an important process to successful climate change programming.</td>
</tr>
<tr>
<td>o Selecting methods and programming designs that secure sustainable funding is the most successful way to run long-term impactful climate programming.</td>
</tr>
<tr>
<td>o Finding areas of climate impact in a community and educating audiences who are unaware of the impact is another successful method of gaining interest in climate programming.</td>
</tr>
<tr>
<td>• <strong>Learning:</strong></td>
</tr>
<tr>
<td>o The learning process of the ‘navigating the transition’ phase is instilled in the Extension system through their unique design and niche organization qualities.</td>
</tr>
<tr>
<td>o Many programs have been run successfully and then adopted in other regions of the US showing that Extension could currently be in this phase of a transformation.</td>
</tr>
<tr>
<td>• <strong>Adopting:</strong></td>
</tr>
<tr>
<td>o There was not enough evidence to indicate that Extension has reached this phase of the transformation framework.</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Institutionalizing the New Trajectory</strong></th>
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<tbody>
<tr>
<td>• There are actors within Extension (NECI) attempting to standardize climate programming on the national scale.</td>
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<tr>
<td>• Funding is slowly being accumulated for climate programming in Extension.</td>
</tr>
<tr>
<td>• There is not enough evidence to suggest that Extension is at this phase of the transformation framework.</td>
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<table>
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<tr>
<th><strong>Norms, values, and beliefs</strong></th>
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<tr>
<td>• Depending on the state and audience Extension is serving there is a general increase in acceptance of climate change, yet there is still lack of belief in it being anthropogenic at its source.</td>
</tr>
<tr>
<td>• There are some in Extension that still push-back against climate-related programming which slows the adoption of climate information into other programming areas and sometimes even threatens funding opportunities.</td>
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</table>
Distribution and Flow of Power, Authority, and Resources

- At its root, power, authority, and resource flows are directed by funding agencies and stakeholder interests.
- There is some sign of more funding and resources being allocated to climate programming but not enough to warrant a significant change yet.

Rules and Practices

- Changing language surrounding climate change is becoming a regular practice among Extension professionals.
- Climate programming experts are trying to implement regular climate information into the curriculum of other Extension professionals. There is a need for Extension faculty outside of climate programming to understand that in order to teach climate information, they do not need to be experts.

Note: Interview data from 20 Extension faculty were cross-compared with each step of the Moore et al. (2014) transformation framework from beginning (triggers) to end (institutionalizing the new trajectory). Data is also summarized based on elements of a system that are expected to change during a transition (norms, values, and beliefs; distribution and flow of power, authority, and resources; and rules and practices).

Challenges and Potential Barriers to Transformation

Challenges with Audiences

The audiences of Extension vary considerably depending on the region where an Extension program is based at, the culture of the people that they target, and the resources that are available to the community at the time. Every one of the interviewee participants expressed some kind of challenge involving the audiences they were targeting. One common challenge overlapped in many of the interviews was having to change language surrounding certain climate change topics, such as the phrase “climate change” itself. As mentioned earlier, Participant 2 said: “at Extension we're promoting research-based factual information but that doesn't always align with what people believe. And so that I think is always the biggest struggle”. Many of the interviewees felt they needed to change their language or present science and solutions in a different way to meet clientele halfway.
“It's fine if you want to research climate change but you also need to know where your audience is and you have to be able to meet them where they're at philosophically and be able to talk to them in a way that you're not deceiving them or manipulating them, but in a way that opens the door to have an honest conversation and that you can hear them and they can hear you.” (Participant 10)

Reasons for changing language varied among participants but there were some common themes among them. Participant 2 summarized a major issue: “I think one thing is just the varying beliefs about climate change. So, you know, some people believe in it and believe that it's human caused. Some people don't believe in it at all. Some people have kind of in-between beliefs. And then not only that, it's kind of what their priorities are.” Beliefs in climate change and whether it is human caused or not was a common theme when participants were asked about their challenges with implementing climate change programming. Many of the interviewees come from very different areas around the country but still said similar things when it came to changing their language to increase their efficiency of reaching their audiences: “You can talk about climate in ways that people can hear it and that's...sometimes that's called extreme weather.” (Participant 21). Another common challenge that many Extension faculty leading climate change programming face is whether or not climate issues are seen as a priority by their audiences regardless of their belief in it:
“If you're a landowner, there's already so much you have to think about in terms of land management and it can be so confusing and often expensive, and now you're asking me to think about other long term planning considerations, and what do I even do about that? And most of our programming is responding to more immediate needs that we have. So it [climate change] might get mentioned here and there, but it's rarely a focus.” (Participant 3)

“Our resources are so limited that we have chosen to invest in more things that are perceived to be critical to our local audiences. So, if we were unlimited in terms of our resources, we might invest more broadly, and things like that.” (Participant 17)

Interviewees frequently mentioned that audiences are often not educated or do not understand the science behind climate change, however some Extension professionals believe that if real data is presented as evidence about the area they live in, audiences can come around to the idea and accept that climate change is happening. That does not mean that audiences believe it is human induced, but at least they can take adaptation actions to help them deal with the consequences of climate change. Participant 20 uses data to communicate the evidence of climate change but is careful not to put the blame on humans for fear of losing the audience's interest:
“I think, from our standpoint as Extension faculty and as Extension educators, we try not to get caught up in the weeds, so to speak, with the causes and so forth that's in our state where we tend to get bogged down is arguing over whether it's man made, whether it's not man made, how to live and so we've tried to stick more to the data and being able to present that to people and kind of let them make their own assessment. “

(Participant 20)

“I would say, what we've had to think about is knowing who your audience is and what part of the state or what region of the West. We might talk about things a little differently. And I know this from working with my Extension colleagues.” (Participant 5)

There have been instances where Extension climate educators are confronted with concerned people who do not believe that climate change is caused by human activities. They are then caught in a predicament where they need to relate to those people in a way that is respectful and non-combative. Participant 6 describes their methods for avoiding negative confrontations:

“Thinking about this in terms of people's politics, on the right side or conservative side of the spectrum, I've occasionally gotten pushback from folks who usually bring up alternative sources of information and often the
point that they're making is that it's not human caused. It's just a cycle. And then they will point to some scientific evidence, saying that, you know, it's a, this is part of 100-year cycle or 1000-year cycle...So, I've never had a really contentious argument. And I'll tell you how I defuse arguments...when people come off as combative. Basically, I acknowledge their concern...I say, oh, I can tell from the way that you're talking about this that you're really passionate about it because, I think we can all agree there's a lot at stake. And so for now, why don't we agree to disagree, and I'll go on with my talk.”

The challenges with Extensions audiences can be seen as a lack of education on the topic of climate change. Those who do not fully understand the science and impact of climate change will present challenging circumstances for Extension faculty for communication and implementing climate change programming. Another challenge that exists with Extension audiences, as it relates to lack of education, is the prioritization of climate change over other areas of concern. Audiences may show some concern for climate change, however there may be other issues that take priority for them.

Challenges with Personnel and Funding

The most common theme that the interviewees expressed was the available attention of personnel and available funding to support climate programming. Different types of Extension educators can come with their own set of challenges when it comes to climate programming. The interviewees explained that many of the volunteers and/or
Extension faculty already have a lot going on with other programming and responsibilities. Many expressed that they hold multiple job titles; if there were more funding, Extension could hire additional faculty or give more funding to the people working on multiple projects to increase the amount of time and effort they can put into them. Participant 1 was pointing out the capacity of the community members as another attention issue:

“And then a big challenge is community capacity. A lot of times we're working with volunteer board members. And so how much bandwidth do they have to take on a project? Or, you know, staff is limited.”

(Participant 1)

“Another real challenge among the ECOP Community was just having the time and bandwidth to have the conversations to find the time to work on those topics, because most of us who are Extension directors have very full plates. Oftentimes, Extension is one of a number of things we have to pay attention to and so carving the time out to focus on it to collaborate with colleagues to build an agenda is difficult.” (Participant 21)

The solutions to the attention issues seem to be grounded in the available funding for Extension personnel to spend more time and energy on climate programming. If more funding were provided for more permanent or sustainable positions that strictly focused
on coordinators for climate projects, volunteer management, and for the projects
themselves then it would help to push the climate agenda in Extension. The following
quotes are examples of how the interviewees think Extension could improve given the
necessary funding.

“I think if we could provide some funding for a coordinator in every
region of the state to run a volunteer program that would be phenomenal
and that could be scaled out to the northeast, or the rest of the country.
They could be supporting their local volunteers and could be supporting
local communities on projects. And that was a need that we found in our
feasibility study. Every state that we surveyed or did focus groups with
agreed that volunteers could play a critical role in helping communities
and an Extension program could be very powerful like the Master
Gardener Program, but they need a coordinator. They can't run on their
own, they would need a coordinator at the state level or county to run a
volunteer program well.” (Participant 11)

“Definitely just capacity, human capacity. You know, I think, it's more
than just having people who are dedicated to weather and climate, but it's
also individuals who can help to communicate that science through
graphics and other platforms. I'm very fortunate being a part of the
university where we have a fantastic communications aspect of our
"Extension team, but it's small and they get stretched really thin and so when I work on a project with them, it can take a long time to actually get the project completed whether if it's videos or graphics." (Participant 10)

“Expanding the climate in the classroom capacity. I feel like that could be a fulltime job. I'd love to have more resources for that. And then maybe something on workforce development. I haven’t worked much with university students, but I think there's some opportunities to do internships and things like that, that I just haven't explored yet.” (Participant 1)

The USDA Climate Hubs offer support to Extension through their partnerships by providing funds and sometimes added capacity. They are a branch of the USDA that works on climate change solutions in different regions of the US and often works in collaboration with Extension. Participant 1 expresses how the Climate Hubs helped Extension provide their educators and researchers with needed funds:

“But I guess what worked well to kind of get over that challenge was that the [climate] hub had some funding available and...they were trying to spend out and they came to me and they're like, do you want to do something with these funds and you know I didn't really have something specific on ag or forestry. So instead we worked together to develop this mini RFP process so that our ag and forestry staff could apply for those
funds to do small projects and that I think really helped our staff see a tangible benefit to partnering with the hub and start to build some of those relationships. So that's just kind of one challenge and I guess a solution that I've encountered with our Extension staff.” (Participant 1)

The second most common challenge that was reported was disagreement about the source of climate change among Extension professionals and among funding agencies. These disagreements could affect the type of programming that Extension professionals could conduct. One example is adaptation programming versus mitigation programming. Adaptation programming seems to be more acceptable because it implies that the climate is indeed changing but leaves speculation on the causes of climate change. In contrast, mitigation programming requires an understanding that human activities are driving climate change and are being accelerated by human activities, which implies that those activities need to be changed to reduce GHG emissions and sequester existing atmospheric carbon. Some Extension professionals have developed creative ways to find common ground in order to make any kind of progress towards climate action. Participant 21 said: “it became clear to me that I could spend all my time fighting a fight about disagreements I had with my colleagues, or we could spend our time working on things we agree on.” Changing language surrounding climate change in order to align with peoples’ beliefs and in order to collaborate with people of differing beliefs is a common practice with Extension personnel and funding agencies. This type of disregard for scientific consensus was partly due to the political climate at the time of the
interviews, when climate change science was being jeopardized by misinformation and politicization of the topic:

“Federal employees serve at the will of the President and so... being able to talk about climate change, but having to talk about it as variability and use those words, climate variability, was one of the things that was required. In order to move that agenda forward, being able to spin it to be appealing to everyone is something that has to be done.” (Participant 18)

“There are certain educators where that (climate programming) just wasn't something they were interested in or they were on a... political spectrum that didn't see any reason we do that type of education.” (Participant 7)

“I think the greatest challenge I faced in my career with this is the perspective of each presidential administration, right? You'll have a particular administration that is really concerned about these issues and interested in them and willing to commit resources to that you have others that have a different perspective on science.” (Participant 18)
When interviewing a faculty member associated with ECOP, participant 21 mentioned some of the difficulties associated with this politicization: “Well, there's an array of challenges [when it comes to], moving the conversation on climate forward. Unfortunately, climate became a politicized topic and the information that was being used by different perspectives on the topic were not always consistent and, in fact, were not consistent and often conflicting and led to deeper polarization among folks around the topic. So that was a problem.” Though it is rare, there are more extreme cases of Extension faculty having their projects rejected due in part to beliefs in climate change and for fear of losing funding or losing interest from clientele and funding agencies:

“There was a situation where my supervisor in Extension was unhappy that I was working on climate change work and submitted a letter to me and asked me to stop doing all work on climate change and on sustainable food...And that was challenging because...from a professional standpoint, with my job, I was very interested in helping a growing number of young people interested in this field and for my personal master's degree, I wasn't sure if it was going to...jeopardize my position by continuing to work on that project for my master's degree” (Participant 12)

When directly asked if Extension faculty were changing their framing about the causes of climate change due to fear of losing money or legislative appropriations, participant 20 said:
“I know in my state and [the] conservative nature of the legislators in my state...that's a real problem...is if we focus on certain aspects of how we might address climate change, you know they'll definitely turn, there is the potential for funding soon to turn off.”

The challenges with Extension personnel are complex and can be more prominent in certain states. Some states prioritize climate change and the Extension programs in those states draw on that to obtain more funding. Having more funding increases the number of staff and personnel available to focus on climate change. However, many of our participants expressed the need for more support.

The main barriers to Extension becoming a more prominent contributor to reducing GHG emissions, sequestering existing atmospheric carbon and helping communities adapt to climate change are summarized in Table 2.

Table 2

Summary of Challenges to Expanding Extension’s Climate Mitigation and Adaptation Programs

<table>
<thead>
<tr>
<th>Challenges with Audiences</th>
<th>Changing Language</th>
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<td></td>
<td>○ Extension educators tend to change controversial language about climate change in order to get and/or maintain the interest of their audiences. This is due to the politicization of climate change in certain areas around the country.</td>
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<tr>
<td></td>
<td>○ Framing climate change as a general issue and avoiding the science that says it is human induced is common.</td>
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<td></td>
<td>○ Focusing on more adaptation centered programming rather than mitigation programming is also common because mitigation programming insinuates that climate change is human induced whereas adaptation programming does not imply the source of climate change.</td>
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<tr>
<td></td>
<td>Prioritizing Climate change</td>
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<td></td>
<td>○ Extension programming covers a broad range of topical areas and some places around the country do not see climate change as a priority issue in their communities. When faced with a choice between climate programming and public health that does not involve climate change, most communities would pick public health as a priority.</td>
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Some areas around the country also just generally do not see climate change as an issue in the first place and therefore prioritize other things that Extension can help them with.

<table>
<thead>
<tr>
<th>Challenges with Personnel and Funding</th>
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<tr>
<td><strong>Attention</strong></td>
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<tr>
<td>- Many educators, volunteers, and faculty in Extension do not necessarily prioritize Extension programming because they wear a lot of different hats or have primary responsibilities or jobs in their lives. In other words, they can’t dedicate a lot of time and effort to climate change and new programming.</td>
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<tr>
<td>- At the community level, there is also not a lot of support because people have other priorities in their lives.</td>
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<td>- It was mentioned that this issue could be fixed with added funding specifically for full-time positions focused on climate programming.</td>
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<tr>
<td><strong>Funding</strong></td>
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<tr>
<td>- Consistency of funding seems to be at the root of challenges for climate change programming. Many climate programs that are run are short term because it has project-based funding that is limited.</td>
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<tr>
<td>- Most of the time Extension programs regarding climate change are done based on the funder’s goals and visions rather than that of Extension. (Funder: USGS, Farmer Associations, etc.)</td>
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<tr>
<td><strong>Beliefs</strong></td>
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<tr>
<td>- There are some Extension faculty outside of climate specific programming that do not believe in the sources of climate change. This presents a problem because oftentimes collaboration between disciplines is a common theme in Extension programming and is a tactic used to increase funding opportunities.</td>
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<tr>
<td>- Having some Extension faculty not believe in climate change or in the sources of climate change is an issue because Extension is supposed to promote science-based information and run programming based on that.</td>
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<td><strong>Leadership</strong></td>
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<tr>
<td>- There is a lack of leadership on the national level for climate action. Although NECI is on the rise as a national coalition focusing on climate action, there is not much authority behind them that can direct Extension resources and priorities nationally.</td>
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<tr>
<td>- In some areas of the country, Extension leaders hesitate to prioritize climate change because of the concerns of their partners or their audiences, despite the priorities of the Biden administration.</td>
</tr>
<tr>
<td>- Extension can be very focused on the needs of their local audiences who may not always care or believe in climate change. If more power were given to national Extension leadership to determine what kind of programs are run at the local level, they can more easily implement climate programming across all of Extension nationally.</td>
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*Note: Interviews with Extension faculty identified challenges with audiences, personnel in Extension, and funding as barriers to success in Extension addressing climate change.*

**Discussion**

Extension has impacted American society during many times of struggle (Comer et al., 2006; Gould et al., 2014). During World War I, Extension improved farming yields and developed better food preservation. In the Great Depression Extension helped create farming cooperatives and provided instruction on home practices to aid families. After the outbreak of World War II, Extension dramatically increased food production as part of the Victory Garden program (The National WWII Museum, 2020; Thomas & Clark, 2014). Due to the existing network of Extension professionals across the US who are committed to serving the needs of their communities, Extension has substantial potential
to contribute to climate solutions. Using the framework by Moore et al (2014), I have found that the effects of climate change have caused enough disruption to create a movement within Extension and some of its audiences, which has fostered more climate change and extreme weather-related programming. This shift has sparked inspiration and momentum in a growing number of Extension professionals that could build and ultimately make Extension a significant actor in the adaptation and mitigation of climate change in the US, which it currently is not.

Moore et al. (2014) states that triggers are what start a transformation in a system. In Extension, the main triggers to advance climate change programming are coming from ecological and environmental disruptions that affect their audiences and stakeholders, opening up windows of opportunity for Extension professionals to secure funding and initiate programming. With these opportunities to secure funding, Extension professionals and educators can create and help implement solutions tailored to their audiences which vary by region and the demographics of the communities they serve. Funding is one of the central concerns for successful and sustainable programming surrounding climate adaptation and mitigation. The interviews revealed that, thus far, climate and extreme weather program funding is mostly temporary and relies on limited grants and project funding that end after a certain period or a certain goal is reached. Our participants indicated that in order to create a change on a larger scale with longer time horizons, there needs to be more funding dedicated to climate and extreme weather programming to increase the number of Extension professionals trained to conduct climate mitigation and/or adaptation programs.
Evidence from the interviews indicates Extension is in the ‘preparing for change’ phase of Moore et al.’s (2014) framework (see Table 2). The interviewees expressed their “sense making” abilities by recognizing the issues that hinder the improvement and expansion of their efforts. Barriers that they identified included regional variances in political views and beliefs that revolve around climate change within their audiences, their colleagues, and partners. The varying beliefs surrounding climate change and its sources make it difficult for Extension to implement effective climate programming in those areas. Interviewees also explained how a main purpose of Extension is to help a community identify focal issues that they are facing and then to develop programming intended to address these issues. The obstacle herein is that many communities do not see climate change as a priority, or that they do not believe climate change is the underlying source of some community issues (e.g., increased duration of droughts, increased frequency of fires). If there is no support for this kind of programming from the community, Extension will not easily be able to obtain the funds necessary to implement climate and extreme weather programming.

The interviewees indicated that educators and professionals know how they can improve upon their programming and expand it. This is the “envisioning” phase of the transformation framework, where actors within the system find barriers and obstacles and then solutions to overcome them. Most of the solutions that were expressed by the interviewees revolved around building more networks like NECI and increasing climate literacy of audiences, Extension professionals, and other collaborators and partners. However, at least half of the interviews (10, 50%) identified that the overarching
necessity to expand climate programming is consistent funding for Extension staff dedicated to climate mitigation and adaptation programming.

Actors within Extension have begun ‘gathering momentum’ through networking, sharing information, and recognizing the similarity of issues that Extension communities are facing. One of the interviewees, a member of ECOP, shared their progress in getting the conversation on prioritizing climate change started, “And they did in fact build a strategic plan and identify an array of priorities, climate being one of them. I also started a climate coalition, along with some other of my colleagues within the ECOP Community and with our partners, and that was the beginning conversation at the ECOP level here on climate” (Participant 21). This is an example of ‘gathering momentum’ as defined by Moore et al’s (2014) framework and resulted in further development of support groups within Extension. The creation of NECI has created a place for Extension faculty concerned with the effects of climate change to reach out and share information with their colleagues all over the country. This has further improved Extension’s ability to address climate change and extreme weather in the US.

The interviews also revealed how important Extension leaders can represent significant barriers to achieving more climate action. Many land-grant institutions have a culture oriented towards pleasing stakeholders or audiences that prevents innovation and progress towards climate solutions. Some of the interviewees expressed their setbacks with superiors being concerned about funding. Some Extension faculty expressed concern that projects and funding might be cut if their climate programming covered climate change in ways that might not please funders or audiences.
Aside from these concerns, Moore et al.’s (2014) framework includes a phase for “navigating the transition” which includes selecting the processes that work, improving and adapting them, and then implementing the process throughout a system. Extension has navigated transitions in the past, particularly in regards to identifying then disseminating agricultural techniques through networks that results in the practices being adopted in other areas around the US that face similar issues.

Future research should further explore the adoption subphase of the navigating the transition step in the Moore et al. (2014) framework as related to climate mitigation and adaptation. Since Extension is still in the early stages of navigating the transition, there is much to be learned from how Extension will evolve. Research can also focus on quantifying the impact that climate Extension programs have on US emissions and how much they save their community in damages through extreme weather adaptation programming. By quantifying the impact of Extension’s innovations, they may have opportunities to secure more consistent funding for climate programming.

**Conclusion**

Extension has a position of influence within the US and could have a great impact on the mitigation and adaptation of climate change. Increased and consistent funding for climate programming coupled with increased acceptance across leadership and political affiliations could enable Extension to contribute far more to climate solutions. Extension’s connections to the agricultural industry have a range of negative effects on
the adoption of climate programming through beliefs and values of certain agricultural funding agencies like the Farm Bureau and upper administration at land-grant institutions that do not support climate programming. This same connection to agriculture also provides opportunities for Extension to conduct climate adaptation and mitigation programming that could have a large impact on the agricultural industry and US emissions as a whole.

The following recommendations are drawn from my analysis of interviews with Extension Faculty and the Moore et al. (2014) transformation framework. If followed, they could contribute to strengthening Extension’s capacity to contribute to climate adaptation and mitigation.

**Recommendation 1)** Cultivate stronger leadership within Extension that prioritizes climate action, improving coordination and the efficacy of climate programming

- Most state Extension systems have not yet prioritized climate programming. Extension interviewees emphasized that their audiences’ needs and their sources of funding drive specific types of programming.

- Stronger leadership on climate programming should include implementing incentives or progress checks towards climate goals.

- Centralized leadership would mean having Extension from every university look to ECOP for programming directions rather than mainly getting their programming goals from disparate audiences and stakeholders.
This type of ‘top-down’ leadership could have an effect on the culture of deference towards climate change programming by enacting strong leadership that changes Extension’s goals towards climate programming as a primary focus area.

Some interviewees were concerned that Extension has spread its efforts too thinly across too many types of programs. Extension significantly impacted America in the past when their resources focused on agriculture. If Extension can reduce the amount of low-impact/outdated programming, and focus resources towards climate action in the US, my analysis shows evidence that Extension has the potential to become a major actor in and diffuser of climate action and climate education. Because of their historic partnership with the agricultural sector, they could be more able to reduce the agricultural industry’s carbon footprint and its contribution to climate change.

**Recommendation 2** Partner with local, state, and federal government agencies to collaborate on creating and implementing climate change adaptation and mitigation policies.

- Increase partnerships and involvement with state and federal government agencies concerning climate change policies. Extension could do more outreach on specific policies, why they are important, and help stakeholders transition their practices to become compliant. This could give Extension more positional power for influencing climate action in each state.

  - Example: a new state policy that limits the amount of nitrogen fertilizers made from fossil fuels used in farms to help mitigate climate change. Extension could be the official
state partner in helping farmers transition away from using fossil fuel-derived fertilizers and find alternative, low emission fertilizer as well as other practices to enhance soil quality.

- This would also increase the relevancy of Extension to the average person in the US (most of whom, outside of farmers, are not familiar with what Extension is or what they do for our country) (McDowell, 2001; Mercer, 2014).

**Recommendation 3)** Focus on securing more reliable and sustainable funding for climate programming. Strategic funding for professional development, curriculum development, climate literacy among Extension faculty and leaders, onboarding of new faculty that is standardized across Extension.

- Long term project managers and educators who strictly focus on climate programming and coordination of projects are needed.

- Funding for increasing climate literacy among Extension faculty, including leaders and administrators.

- More sustainable funding could come from government agencies including USDA, NOAA and others. Extension professionals may want to cultivate more relationships with philanthropic foundations that are increasingly focused on climate solutions research and development as well as scaling up existing climate solutions.

- The majority of interviewees want priority given to hiring more Extension faculty who focus on scientific communication to educate diverse audiences on climate change
issues and to translate the research being done by Extension researchers and university researchers.

**Recommendation 4)** Increase training in scientific communication, networking, and political engagement for relevant policy makers and politicians.

- Extension could make larger scale impacts to society if they were more engaged in applying their scientific expertise to affecting policy processes.

Extension often understands and relates to its audiences. This organization has the potential to work with their audiences to find and diffuse solutions to climate change and extreme weather. The unfortunate politicization of climate change, however, has impaired Extension’s ability to work on climate solutions with conservative audiences. My interviewees identified instances of Extension working with their audiences despite their lack of belief in anthropogenic climate change. Cross comparing my interview data with the Moore et al. (2014) transformation framework shows that Extension has the potential to transform itself towards making climate mitigation and adaptation a priority through the actors that have already come together in groups to secure funding, increase awareness, and focus the direction of Extension leadership. My analysis has shown that Extension is currently ‘navigating the transition’ in the Moore et al. (2014) framework. Based on interpreting interviews with Extension professionals through the lens of this framework, the key elements for change that were most affected during this transition are the norms, values, and beliefs of some audiences and of some faculty in other
programming areas of Extension. The other elements like ‘distribution and flow of power, authority, and resources’ and ‘rules and practices’ are seeing some advancements, but there is not enough evidence to point towards an active transition. Due to the barriers summarized in Table 2, there is uncertainty on whether or not Extension can transform to make climate adaptation and mitigation a priority amongst Extension. It remains to be determined if Extension is sufficiently flexible and open to change in order to contribute meaningfully towards GHG reduction and carbon sequestration.
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CHAPTER III

DEFINING THE ROLE AND IDENTIFYING STRENGTHS AND WEAKNESSES OF EXTENSION DURING A LOW-CARBON SOCIO-TECHNICAL TRANSITION

Introduction

In 2020, President Biden identified climate change as among the most pressing issues facing American societies today (The White House, 2021). Proposed solutions to climate change entail diverse practices, technologies, and policies (Doerr, 2021; Hawken, 2017). Such solutions require restructuring elements of society and relations with technologies, all of which are components of a socio-technical transition (Geels, 2002). The US is in the midst of a socio-technical transition when it comes to addressing climate change. During socio-technical transitions, societies and markets adopt new technologies, practices, and social norms in response to external pressures from socio-technical landscapes (Geels, 2002). The multi-level perspective (MLP) framework is one way for scientists to analyze organizational levels of society during a socio-technical transition (Geels, 2014). MLP studies typically assess the feasibility of low-carbon innovations and transitions by analyzing niche, regime and landscape developments, which allows for a detailed identification of drivers of and barriers to change (Geels et al., 2016). As shown in Figure 3, the MLP has three interwoven levels that influence each other: niche organizations at the bottom of the hierarchy, socio-technical regimes in the middle, and socio-technical landscapes at the top. In this research, I apply the MLP framework to
ongoing efforts of the Cooperative Extension System (Extension) in relation to climate change mitigation. My qualitative analysis uses the MLP to define Extension as a niche organization during a socio-technical transition towards lowering carbon emissions and illustrate the regime elements that are relevant to Extension and climate change. This allowed me to identify opportunities and obstacles for the Extension System to assist in finding and implementing climate solutions.
The MLP Framework

Note: Levels and flows of the Multi-level Perspective (MLP) adapted from Geels (2020). The first level, niche-innovations, occurs when new technologies and practices emerge due to changes and pressures from the two higher levels in the MLP. The second level, the socio-technical regime, represents the compilation of established practices and associated rules that enable and constrain actors in relation to existing systems. In the highest level, the socio-technical landscape, social and technological relationships co-evolve. The dashed arrows represent the ways each level influences the others. For example, the landscape influences the regime because, with existing infrastructures and the way people interact with technology and society, the regime has to abide by the landscape standards. The regime and landscape both affect the niche innovations because the niche innovations fill in holes or problems that arise in the other levels. The dark arrows show the flow of
solutions over time. Niche innovations come up with new practices or technologies to solve problems. Many solutions are created, tested, and evaluated. Only a few of these solutions emerge as the ones that become widely implemented. Those are then adopted into a newly configured regime that is then able to influence the landscape level, which is the hardest level to influence.

The socio-technical transition that I focused on in this study revolves around climate change and the changes to society that are necessary for the US to meaningfully contribute to reducing GHG emissions. Extension is a well-established outreach institution with offices and programs in every county, parish, and borough throughout the US that could be a key player in addressing and spreading climate adaptation and mitigation practices, policies, and action. As of 2022, the Extension Committee on Organization and Policy (ECOP), the representative leadership and governing body of Extension, identified their goals as being rooted in diversity, equity, and inclusion; climate mitigation, resiliency, and adaptation; economic and workforce development; health equity and well-being; 4-H positive youth development; and urban programs (ECOP, 2021). Using the MLP framework developed by Geels (2002), I identify Extension as a niche organization that can be a source of innovation and promoter of the early adoption of novel technologies and practices that address problems rooted in climate change.

Theoretical Framework

The Multi-Level Perspective

Social scientists use the MLP framework to analyze multiple levels of society during a socio-technical transition (Geels, 2014). This framework has proven to be useful
due to its ability to guide the investigation of interconnected complex large systems as well as power and politics specifically in low-carbon transitions (Geels, 2014). Rogers’ diffusion of innovation theory is another method for analyzing transitions by focusing on technological innovations specifically and tends to revolve around individual thinking (Sahin, 2006). The MLP offers a focus on low-carbon transitions and incorporates more details relating to societal elements outside of technology. Figure 3 shows a simplified version of the MLP developed by Geels (2020), demonstrating how all levels are affected interdependently. The MLP shows the increasing structuration of activities in local practices (the different levels of complexity in a system). This creates a nested hierarchy for the different levels of the MLP. Socio-technical transitions generally begin from the top landscape level in the form of a disruption to the current regime configuration (e.g., disruption of industry, culture, technology, and/or market preferences). The disruption to the regime opens windows of opportunity for niche innovations to solve new problems at the regime level. The most widely accepted and practical solutions offered from the niche level then become widely adopted and ultimately become an important part of a new regime configuration. These happen through a process of trial and error over time at the niche level where innovations are explored and experimented with. The innovations that work the best to solve the issues stemming from the landscape level then become more widespread through the help of intermediary actors and niche organizations. This eventually becomes a dominant or regular practice in the regime, which then restructures the way that a system functions through technological changes, policy changes, cultural actions, etc. These socio-technical relationships between culture, policy, technology, etc. that have become 'locked-in' to stable configurations over time are referred to as 'socio-
technical regimes’, located in the middle of the MLP hierarchy. The regime level can be defined as “the combination of established practices and associated rules that enable and constrain incumbent actors in relation to existing systems” (Geels, 2014, p. 23). The lock-ins that establish regimes can happen for multiple reasons: institutional rules or directions become ingrained into practices, social norms develop over time and make change difficult, and/or technological infrastructures hinder the adoption of new technologies or practices (Kemp et al., 1998).

When a socio-technical transition is needed or forthcoming (e.g., the need to transition away from fossil fuels and to sequester greenhouse gases (GHG) to reduce the likelihood of catastrophic climate impacts), windows of opportunity open up for new technologies, novel practices, and innovative strategies to help reconfigure the current regime configurations (Kemp et al., 1998). These novel technologies, practices, and strategies are known as innovations in the socio-technical transition literature. Innovations are vital to large-scale transitions because they can offer solutions to issues that otherwise would remain a problem. These innovations are developed, protected, and nurtured in what is referred to as ‘niche organizations’—located at the bottom level of the MLP hierarchy—that have different motives and rules than the existing regime. This allows for experimentation and customization of new transitional methods that are resilient to external influence (Schot & Geels, 2008).

A good example of how the MLP could be applied is climate change and fossil fuel usage. These two landscape level issues create a ripple effect through the MLP. Climate change is affecting the world and causing damage due to emissions from burning fossil fuels (Anokhin et al., 2014; Environmental Protection Agency, 2020; Hawken,
2017; Hoegh-Guldberg et al., 2018; Oliver et al., 2017; Paris Agreement, 2016). This issue puts pressure on the regime level of the system, opening up windows of opportunity for new innovations (e.g., practices, technologies, strategies) to be adopted to solve the issues causing pressure. In this case, one innovation is renewable energies replacing fossil fuels on a mass scale. This replacement of technology is not simple, which is where the MLP can help researchers elaborate on the more complex pathways of a socio-technical transition. Over time, a shift towards renewable energy would certainly influence the landscape level by decreasing emissions, which could play a role in stabilizing the effects of climate change.

Socio-Technical Transitions

Climate scientists and a growing number of concerned citizens of the US (and much of the world) are demanding socio-technical change because consequences from current GHG emission levels in human and natural systems are becoming increasingly severe and many are worried about future catastrophic impacts (Geels, 2014; IPBES, 2019; IPCC, 2018). Widespread adoption of technology and methods focused on reducing emissions could propel a shift to a new regime that could reduce and potentially reverse human induced climate change (Hawken, 2017), but many constituents and political leaders find difficulty and complexity in the adoption of climate solutions (Unruh, 2000). Many US politicians consider climate mitigation excessively disruptive and/or expensive (Geels, 2014), despite international consensus that failing to reduce emissions and enhance carbon sinks will be more disruptive and expensive than taking climate action (Stern, 2007). Studies have shown the difficulty in reconfiguring a regime
because, “the elements in a sociotechnical configuration are linked and aligned to each other. Radically new technologies find difficulty breaking through, because regulations, infrastructure, user practices, maintenance networks are aligned to the existing technology regime” (Geels, 2002, p. 1258; Perez & Freeman, 2010). Many existing regimes are plagued with lock-in mechanisms and path dependencies which create market and policy failures. This can prevent the diffusion of low-carbon technologies, e.g., renewable energies, more efficient technologies, and GHG reduction strategies, despite their environmental and economic advantages (Unruh, 2000). One example of this market failure is how consumer-driven businesses recognize the potential efficiency and economic benefit of transitioning to climate-smart practices, but still resist it because of the initial investments (Geels, 2014; Unruh, 2000).

Socio-technical transitions have happened many times throughout history; e.g., transitioning from steam engines to coal powered engines, or transitioning from a paper-based office to digital platforms (Geels, 2002). To reduce the likelihood of catastrophic climate change, many sectors must undergo socio-technical transitions and adopt new regimes, namely, industrial processes, energy production, transportation, agricultural methods, waste management, and more. In order for a socio-technical transition to occur and for it to be lasting in the long-term, technological and social changes in the way everyday societal functions and needs are fulfilled need to be addressed (e.g., transportation, food consumption and production, and consumer patterns) (Geels, 2002).

In 2021, US President Biden used executive power to declare a climate crisis to justify redirecting American foreign policy and national security to focus on addressing climate issues (Exec Order No. 14008, 2021). The passage of the Inflation Reduction Act
(IRA) in 2022 marked America’s largest investment in climate solutions (Inflation Reduction Act of 2022, 2022). Additionally, in 2021, the rate of construction of wind and solar energy development was at record breaking highs (Gheorghiu, 2022; US Energy Information Administration, 2022). This political action and rapid development of renewable energy provides preliminary evidence that the US is likely in the process of a socio-technical transition and may see new regimes that will be preceded and informed by niche innovations being developed and implemented within broad reaching organizations like Extension.

**Research Questions**

Through the lens of the MLP framework, what obstacles exist for Extension to become a significant actor during a socio-technical transition towards a low carbon society in the US?

Using the MLP to illustrate the socio-technical elements surrounding Extension and climate change in the US, are there gaps in Extension’s abilities as a niche organization to influence different elements of the socio-technical regime?

**Methods**

The MLP is used in socio-technical literature as a lens for analyzing transitions (Geels, 2020). The MLP framework gives insight into transitions through its nested,
hierarchical structure of society and processes that are involved in a socio-technical transition. Using this nested hierarchy allowed me to identify the elements that affect Extension and the elements of Extension that influence higher levels of the MLP hierarchy. Analyzing these elements gives insight into the structure, barriers and challenges, and advantages to Extension being a key player in a major socio-technical transition in the US. Socio-technical transitions and the MLP are easily influenced by something as simple as framing because it matters if a problem like climate change is framed as a ‘market failure’ (which would lead to market-based instruments such as a carbon tax) or as a ‘planetary boundary’ where we pass tipping points that create irreversible catastrophe (which may lead to stronger regulatory innovation policies with greater urgency). The implication is that transitions should not only be seen as techno-economic management challenges, but also as socio-cultural processes which involve wider public and cultural meanings (Geels, 2020).

**Semi-structured Interviews**

To further add to the context of Extension as a niche organization, and to better understand the structure and culture of Extension, I used in-depth semi-structured interviews with Extension professionals. The interview data informed my characterization of the structure and culture of Extension in ways that are relevant to identifying barriers to climate work. I conducted and analyzed in-depth qualitative interviews with Extension professionals to answer my research questions. Methods for interview data collection were approved by the Utah State University Institutional Review Board (IRB #11352).
There were 14 people interviewed in the Fall of 2020 and an additional 7 in the Fall of 2021 for a total of 21. For the interviews, all participants were informed about the purpose of the project and were assured that their anonymity would be protected and that any identifying information would be changed before analysis, including names of institutions and names of participants. Participants completed a consent form online before the interview began. The participants that we targeted were Extension employees working in climate and/or extreme weather programming and leaders among state Extension systems. I identified these individuals through a request for participation in an email sent out to the National Extension Climate Initiative (NECI) email listserv, followed by snowball sampling that began with the people who responded to the listserv request. For further participation, I used recommendations from participants and selected from states that had not been represented yet to identify additional Extension leaders and asked them directly to interview with me for the purpose of my research and to help the Extension system overall. The interviews consisted of questions about each person’s work within Extension climate or extreme weather programming, the challenges they faced with audiences and colleagues, where they believe more funding should go if they were given it, and if they had any other comments on the subject. Given the semi-structured design of the interviews, I often asked follow-up questions to obtain more information that was relevant to the study. To build my characterization of Extension in relation to the MLP and climate change, I conducted a document analysis on relevant MLP case studies, Extension in relation to climate change, and other relevant literature surrounding low carbon transitions.
Document Analysis

To develop an understanding of Extension as a niche organization in the MLP framework and in socio-technical transition literature, I identified 30 papers that elaborate on the history of Extension, its systemic operations, the MLP, socio-technical transitions, and Extension climate change efforts. This allows me to characterize the different levels of the MLP surrounding Extension and climate change, describe connections between Extension and climate change, and apply socio-technical transition theory including niche innovation. Here, I conceptualize Extension as a niche organization at the bottom of the MLP hierarchy, and describe the higher levels of the MLP that surround Extension. Using evidence from Extension literature, I describe how Extension is considered a ‘niche organization’ on the MLP hierarchy and elaborate on what characteristics of Extension give it this position. I show how Extension is using innovation to spark climate adaptation and mitigation at the niche level using examples from the interviews from my first study.

reference the MLP. Since the MLP is relevant to this research, I also reviewed those papers.

**Synthesis of Interviews and Documents**

Using the literature on socio-technical transitions and the MLP in conjunction with interviews, I describe how Extension fits into the MLP framework and emphasize its potential to become a transformative actor in a socio-technical transition towards a low carbon society. The interviews provided examples of Extension climate adaptation and mitigation innovation around the country and enabled me to characterize existing Extension climate programming as innovations. Using this interview data along with the literature review, I analyze Extension using the MLP. I show how Extension, as a niche-level institution, has the potential to become an important influencer in a low carbon socio-technical transition. I conclude by identifying obstacles through the lens of the MLP that Extension must overcome to expand its influence in climate action throughout the US.

**Results & Discussion**

**Socio-technical Transitions**

A socio-technical change is when a system (in this context municipalities, states, or countries) undergoes a restructuring of the elements of society like policy, culture, industry, technology, lifestyle, resources, and practices (Geels, 2002, 2014, 2019, 2020; Kemp et al., 1998; Schot et al., 1994). This process is usually very slow—depending on
the size and complexity of the system—and could take anywhere from 20 years to over a century, typically meeting a lot of resistance from the regime of the existing system (Geels, 2019; Kivimaa et al., 2019; Schot et al., 1994; Schot & Geels, 2008; Seyfang & Haxeltine, 2012; Smith et al., 2010). There are many reasons socio-technical change happens. In my research, I focus on climate change as the landscape pressure that is causing a socio-technical transition away from carbon intense practices and technologies that exist in the current regime and the current agricultural sector (Environmental Protection Agency, 2020; Hatfield et al., 2020; Johnson et al., 2007; Oliver et al., 2017; Climate Emergency Act of 2021, 2021).

In the past, the US has experienced different socio-technical transitions that have led to the society that we live in today (Geels, 2005; van den Ende & Kemp, 1999). One example is going from horse drawn buggies as the primary form of private transportation to the modern-day automobile. This change was much more complicated than a simple substitution of technologies. This transition happened over a span of about 70 years during which the automobile industry underwent competition, infrastructure development, policy and law implementation, and market development (Geels, 2005). Today, the automobile is the main form of personal transportation in the US, and has a cultural meaning connected to individualism and freedom (Kemp et al., 1998).

Transitions, like the horse and buggy to automobile example, take time and meet resistance from the dominating regime at the time. Socio-technical regimes become locked-in to stable configurations over time as a result of dominating markets, practices, technologies, infrastructures, etc. (Geels, 2002, 2019, 2020; Schot & Geels, 2008; Seyfang & Haxeltine, 2012). For example, in 2020 fossil fuels accounted for 79% of all
energy production in the US (US Energy Information Administration, 2021). This represents the dominant configuration in today’s regime. We now know that this configuration is unsustainable for two main reasons: 1) continuing to use oil for energy will further disrupt our global climate and continue to pollute our planet, and 2) eventually we will reach ‘peak oil’ which is when there will not be enough fossil fuels left to support our current standards of living (Geels, 2002; Kemp et al., 1998; Stern, 2007). We have alternative solutions to oil, however, the socio-technical transition literature has pointed to many problems that inhibit a transition away from fossil fuels (Geels, 2002, 2019; Hawken, 2017; Johnson et al., 2007; Kemp et al., 1998; Schot & Geels, 2008; Stern, 2007; Unruh, 2000). Geels (2002) describes the difficulties of a transition: “radically new technologies have a hard time to break through, because regulations, infrastructure, user practices, [and] maintenance networks are aligned to the existing technology. New technologies often face a mis-match with the established socio-institutional framework” (Freeman and Perez, 1988; Geels, 2002, p. 1258).

A lack of leadership from higher levels of government contributes to the lack of acceptance of new technologies and practices (Kemp et al., 1998). Without policy that guides industries and niches towards a desired future regime, there is uncertainty and risk involved in the investment of new technologies and practices (Kemp et al., 1998). One example of this risk is the failed attempts at mass producing electric vehicles before Tesla. Ford originally invested in electric vehicle research in 1914 even when the internal combustion engine was dominating the market. It wasn’t until the 1950s that Ford resurrected its investments in electric vehicles. In the late 1990s and early 2000s Ford came out with two electric vehicle options that failed to produce enough revenue which is
when they gave up the idea of creating a successful market for electric vehicles. It was not until Tesla paved the way for the electric vehicle industry in 2008 that Ford reinvested $4.5 billion in electrified vehicles (Berman, 2019).

History of Extension’s Influence on the US: Agricultural innovator and technology diffuser

Extension’s history is closely intertwined with American history, particularly the Civil War, World War I, the Great Depression, and World War II (Bull et al., 2004; Comer et al., 2006; Gould et al., 2014; McDowell, 2001; Equity in Educational Land-Grant Status Act of 1994, 1994). Without Extension and its ability to diffuse innovation throughout the US, we would arguably not have the economy or standards of living that we have today, most notably in our food systems (Franz & Townson, 2008). Extension had major success in the period between 1920 through the end of WWII called the “Transition to Science" in American agriculture, however the “Golden Age” of Extension happened between the 1950s and 1960s only to have a decline in its ability to accommodate the very changes that it helped bring about according to Huffman and Everson (1993) and McDowell (2001).

During these periods of time, Extension produced innovations that helped boost agricultural production in the US and improved health standards for food. Extension consolidated food production during the times of War in the early 20th century and taught and incentivized Americans to farm in their backyards to reduce the pressures being put on farmers; at one point, backyard farming by everyday Americans accounted for 40% of all fresh produce in the country (Rasmussen, 1989). This greatly impacted the war efforts through increased food availability for troops overseas and for Americans at home. This
type of Extension work, combined with other successes, led to the American agricultural economy being one of the leading and most competitive markets in the world (Huffman & Evenson, 1993; McDowell, 2001).

Extension has a closely interwoven relationship with the US economy and the well-being of Americans. Having this historical connection to enhancing agricultural productivity gives Extension a position of influence in the US. Extension has become successful through science-based solutions during times of need and promotes itself as addressing “public needs by providing non-formal higher education and learning activities to farmers, ranchers, communities, youth, and families… using its wide reach (having an office in or near most of the nation's approximately 3,500 counties)” (USDA NIFA, n.d.). Extension’s infrastructure is well established and has the power to continue influencing the US during times of prosperity and times of need leveraging the assets of 112 land-grant universities and 35,000 professional staff; cooperative Extension translates research into action with funding by state and county governments, USDA-NIFA, and other federal agencies and foundations (Extension Foundation, 2006).

Characterizing the MLP in relation to Extension

To position Extension on the MLP, I illustrate the different levels of the MLP surrounding climate change and Extension as summarized in Figure 4. To begin, I describe the current socio-technical landscape and climate issues that are creating windows of opportunity for change in the US. Next, I describe the elements of the socio-technical regime that relate to climate change and Extension: market preferences (consumer preferences), culture, industry, policy, technology, and science. Lastly, I use
evidence provided by interview data, and recent examples of Extension programming to interpret Extension’s involvement as a niche innovator with intermediary qualities.

**Figure 4**

Extension within a Climate Change Socio-technical Regime

*Note:* The low, small arrows of niche innovations are Extension programs, e.g., Climate Masters, Climate Smart Farming, and their efforts involving policy recommendations through science-based research. As these types of Extension programs become more popular, influential, and wide-spread, they slowly influence a socio-technical change involving technology, policy, culture, science, markets and industry, that reconfigures the old regime.
The Socio-technical Landscape

In this study, I explore the socio-technical levels surrounding Extension and its ability to help the US in a transition away from carbon intensive processes that are driving climate change. The socio-technical landscape refers to deep structural trends and “wider technology-external factors” that can be a combination of different things such as oil prices, war, emigration, economic growth, environmental factors, or cultural and normative values. When issues arise from the landscape level, windows of opportunity open up for change in a system. In this research, I focus on climate change as the central trend at the landscape level that is creating disruption to current socio-technical regimes in the US.

The Earth is on course to pass the temperature threshold set at the Paris Agreement in 2016, which will likely precipitate unavoidable consequences to human and natural systems (Hoegh-Guldberg et al., 2018; Paris Agreement, 2016). Reducing the concentration of GHGs in the atmosphere is necessary to reduce the likelihood of catastrophic climate events. Reducing emissions and sequestering existing GHGs in the US calls for changes in social norms, policies, and practices, including modification of the economic sectors that emit the most GHG: energy, manufacturing, agriculture, and waste processing (Environmental Protection Agency, 2020).

According to recent studies and assessments, many communities in the US have already seen climate change impacts, with lower income and otherwise marginalized communities at much higher risk (Anokhin et al., 2014; U.S. Global Change Research Program, 2018). The risk to public health has been increasing because of climate change. Heat-related deaths are expected to rise, the distribution of certain diseases is increasing,
and the risk of waterborne and foodborne illnesses is expected to increase due to increasing storm and flooding activity. According to the Fourth National Climate Assessment, “rising temperatures, extreme heat, drought, wildfire on rangelands, and heavy downpours are expected to increasingly disrupt agricultural productivity in the United States” (Summary findings, section 2. Economy, U.S. Global Change Research Program, 2018). Millions of Americans, in addition to many agriculturalists, are vulnerable to climate change, especially Indigenous peoples, low-income communities, coastal communities, and people living in the territorial islands of the US. Many systems that our economy and livelihoods depend on are going to see the severe effects of climate change impact water systems, ecosystem services, coastlines, tourism and recreation. Extension professionals are stakeholders in most of these areas, especially agriculture, and my interviewees and document analysis provides evidence that Extension could better address many issues caused by climate change as long as needed resources are available.

The Socio-technical Regime

Socio-technical regimes are made up of complex systems of rules, practices, and procedures that align with consumer preferences, culture, science, policy, and industry (Geels, 2002). Regimes are outcomes of changes to previous regimes, and they guide subsequent changes. Regimes evolve through improvements to earlier configurations and through the introduction of innovations (Rip & Kemp, 1998). Changing a socio-technical regime (changing culture, policy, consumer preferences, etc.) can be very difficult when lock-in mechanisms, like building new crude oil pipelines and the constant lobbying of oil companies for the continued use of fossil fuels, prevent innovations from breaking
through. When innovations do break through and become established, they have the potential to cause a dramatic shift in the regime and may eventually affect the landscape level (Geels, 2002).

There has been a focus on low-carbon transitions in the socio-technical transition literature because of its relevance to climate change and the necessary changes needed to reduce emissions (Geels, 2014; Schot & Geels, 2008; Unruh, 2000). This literature focuses on the resistance to the adoption of new technologies and regime changes towards a sustainable climate future with low carbon emissions. The resistance comes from complex relationships that have formed at the regime level, for example fossil fuel-dependent industries and policy makers that create ‘carbon lock-ins’ making it difficult for innovations like renewable energy to become the new dominant energy source (Geels, 2014; Unruh, 2000). This difficulty stems from the complexities involved in adopting new technologies because there are usually complementary technologies, training, new laws to regulate them, and new processes that need to be adopted on a large scale. One example is the electric car. In order for the electric car to be adopted at a mass scale, there needs to be more charging stations, which is a type of complementary technology. Mechanics would need specialized training to learn how to service electric vehicles, which would require existing mechanics to be trained to service electric vehicles, or creating an entirely new electric vehicle servicing system. These stepping stones are some of the reasons carbon lock-ins exist. This is where Extension can play a niche role in supporting the transition towards a sustainable future through their programming helping people learn about and convert to less carbon intensive lifestyles and technologies. The “Clean Energy Resources Teams" Extension program in Minnesota is
one such innovation whose goals are to connect individuals and communities in Minnesota to the resources they need to identify and implement community-based clean energy projects.

To conceptualize the existing regime surrounding Extension and climate change, I will illustrate elements of the regime: market (or consumer) preferences, culture, industry, policy, technology, and science. Describing the specifics of each element in relation to Extension and climate change provides evidence for Extension’s potential to influence a socio-technical regime as a niche innovator (places that provide locations for learning processes, e.g., learning by doing, learning by using and learning by interacting) with the qualities of an intermediary actor (producers and users, entrepreneurs and adopters, idea generators and funders) (Geels, 2020; Kivimaa, 2014).

**Consumer Preferences**

When I refer to consumer preferences, I am referring to consumers in the US that have specific purchasing patterns and habits which can heavily influence innovation and advancements of technologies. Current consumer preferences that have the highest impact on carbon emissions, according to the Fourth National Climate Assessment and the International Panel on Climate Change (IPCC) Synthesis Report on Climate Change, revolve around car markets, certain food markets, and the burning of fossil fuels for transportation and electricity generation (Anokhin et al., 2014; U.S. Global Change Research Program, 2018). Other areas of concern for carbon emissions are food systems and waste management through packaging, excess materials being used, and people not composting or recycling after the use of their goods (Environmental Protection Agency, 2020; Hawken, 2017; Lury, 1996).
Extension’s core mission is rooted in education, a public good. Their influence on consumer preferences for most private goods tends to be limited. Extension does however run some programs that may influence consumer preferences for photovoltaic (PV) panels. Colorado State’s Rural Energy Center runs programming that helps residents, businesses, agricultural producers, and local governments from across the state make more informed energy decisions. Some of the resources they provide are group educational events, assessments, research, kits, individual consultations, and electronic resources.

Food systems and the food market exist under the umbrella of consumer preferences and is the main area that Extension has a stake in. Extension is most closely involved in the agricultural industry of the US, working with agriculturalists and consumers. Although limited in numbers, Extension agricultural programming covers a wide range of topics relevant to climate mitigation and adaptation. This includes but is not limited to switching livestock feed to reduce methane emissions, methods for adapting to drier and hotter growing conditions, becoming certified organic producers, and land management practices for increased sequestration of carbon. Extension runs programming for consumers that can influence consumer preferences by focusing on dietary changes in order to save money, improve overall health, and teach people how to access local foods and cook meals that are not centered around meat, all of which help to reduce carbon emissions (Anokhin et al., 2014; Environmental Protection Agency, 2020; Hawken, 2017). An example of this was the 2019 Externships in Sustainability program run by University of Arizona Extension. This Externship program allowed students to connect with local sustainability projects in 2019 surrounding food and farming like
‘Local Food and Beyond’ or the ‘Tucson Village Farm Seed to Table’ program which indirectly reduces emissions.

Culture

In socio-technical literature, culture refers to behaviors, preferences, and trends that are influenced by religion, ethnicity, physical location, and social institutions (Geels, 2002; Rip & Kemp, 1998). Culture can arguably be one of the most influential elements of a socio-technical regime that directs the flow of change and innovation during a socio-technical change. In the context of climate change and Extension, a consumer culture and its complementary behaviors (e.g., recycling habits, waste management, composting, etc.) are relevant (Harsch, 1999). Consumer culture is a product of the consumerist society that our economic well-being depends on. This has led to a long history in the US of influencing people to increase their consumption of material goods to promote economic prosperity (Lury, 1996). There is no question about high levels of consumption driving detrimental effects on the environment and climate through production of material goods, transportation, and waste management (Lury, 1996). There have been niche innovations, from Extension and other innovators, to reduce the environmental impact of consumer culture through promoting recycling, reduction of materials in production and packaging, and focusing on life-cycles of products from start to end (Harsch, 1999).

Consumer culture is a complex paradigm that is not easily changed. Transitioning away from levels of consumerism that push towards overshooting what the planet can sustain in the long term is difficult. Some argue that rather than trying to stop consumer culture completely, it should begin with the acceptance of consumer culture as something that will continue in our society, and working on improving detrimental consumer habits
(Harsch, 1999). This means working on recycling practices, composting, using reusable bags, improving infrastructure surrounding recycling and composting to make it easier/more efficient, etc. Extension runs programming that directly and indirectly impacts carbon emissions through reducing the effects of consumer culture. One niche innovation by Extension is the ‘Shoreline Climate Champions Series’ which is a 7 week program being run in Shoreline, Washington. This program teaches participants about the basics of climate change and what they can do in their household and their communities to help. There is a focus on strategies for households to generate zero waste, reduce carbon footprints, reduce consumption in general, and conserve energy. This type of program is used by other Extension universities around the US, but it is not implemented in most states and could be promoted in other areas. The Shoreline Climate Champions Series exemplifies Extension’s ability to address these issues through their educational programs and connections to local communities.

*Industry*

Industry plays a prominent role in socio-technical regimes. The corporations that process raw materials and manufacture goods in factories strongly influence the pace of change and can direct the development and deployment of technology (Geels, 2002, 2005, 2014, 2020; Genus & Coles, 2008). Industry is one of the leading contributors to GHG emissions and environmental degradation through their mining and manufacturing processes, transportation of intermediary goods in the supply chain within a manufacturing process, and energy consumption.

For this study, the agricultural industry is of most relevance to Extension because agriculture is at the core of Extension programming and is an important contributor to
GHG emissions. Industrial agriculture includes the raising of livestock, growing of crops, the equipment used, processing, the methods of transportation and packaging, selling, and other practices that aim to improve production or quality. Extension has greatly influenced the agricultural industry over the years through their programming and research focusing on increasing yields and teaching growers new strategies and techniques for better production. In the mid 20th century, when the US was being put under pressure from World War 2, the demands of war lowered food availability for civilians because of labor and machinery shortages interfering with production; overloaded railroads and restricted motor transport interference with distribution; and inadequate supplies of labor, steel, and tin that was needed for food storage. Extension ran programming that taught Americans how to grow fresh produce for themselves called “Victory Gardens”. This resulted in 40% of all fresh produce coming from the victory gardens in America, which relieved the burden on commercial food sources, transportation, and preservation by growing all food that was practical at home and preserving, storing, and using it over as much of the year as possible. This is an example of Extension, in conjunction with federal and state governments, temporarily changing people’s behavior throughout the US to solve a serious issue involving the agricultural industry.

Today, Extension’s main focus remains on agriculture, though some argue that this focus is an outdated lock-in due to the bureaucratic decision-making by university leadership, funding sources from important partnering organizations, and traditional programming (Gould et al., 2014; McDowell, 2001). Currently, Extension runs climate adaptation programs for agriculturalists such as the ‘Climate Smart Agriculture Program’.
In this program, the goal is to assist California farmers in applying for incentive grants in partnership with the California Department of Food and Agriculture to incentivize farmers to practice climate smart farming. This is done through actions like manure management, irrigation techniques, composting, crop rotation, and more. A second example of Extension programming focusing on agriculture and climate change is the ‘AgroClimate’ program based at the University of Florida. It provides interactive tools and climate information to improve resource use efficiency and to reduce crop production risk associated with climate variability and change. These examples are just a few of many agricultural climate adaptation programs in the US (Kipp et al., 2020).

Policy

One of the most well-known and largest actions taken to combat climate change is the Paris Agreement which was adopted by 196 parties in 2016 (Paris Agreement, 2016). This non-binding agreement, currently involving 192 countries including the European Union, is a commitment to not surpass a threshold of raising the average atmospheric temperature two degrees above pre-industrial levels. In 2017, the US declared its intent to withdraw from the Paris Agreement under the direction of President Trump resulting in a reduction in funding for climate research and programs, which impacted Extension since much of their funding comes from federal agencies (Hersher, 2020; Pompeo, 2017). In 2021, the Biden administration led the US to rejoin the Paris Agreement. Despite this agreement, emissions continue to rise globally and have only modestly decreased in the US (down 11% from 2019-2020 mostly due to COVID-19) (Environmental Protection Agency, 2020).
Currently, the federal government has put in place a number of policies for improving the US’s mitigation efforts. During the Obama administration in 2010, GHG emission standards for vehicles were created, although they were drawn back in 2020 which relaxed the GHG and fuel economy standards for light-duty vehicles. Unfortunately, there seems to be a struggle in implementing emission standards on power plants such as the Clean Power Plan and the Affordable Clean Energy rule which were never enacted (Congressional Research Service, 2021; Environmental Protection Agency, 2019). As of 2021, there are no federal requirements to limit GHG emissions in the electricity sector being implemented. Power plants were responsible for 31% of GHG emissions in 2013, this plan aims to reduce emissions from power plants by 32% through transitioning to clean energy, being more efficient, and reducing power needs. National policies have been legislated to lower passenger car emissions, increase the construction of renewable energies, cut energy waste in homes and buildings, reduce methane emissions, and invest in more clean energy research and development (2016 Second Biennial Report of the US of America, 2016). There are some states that are enacting more aggressive state laws and policy action for climate change, some of which (e.g., California and New York) have enacted quantified GHG reduction targets that are just as ambitious as the Paris Agreement (Berkeley Law, 2022; Bloomberg Philanthropies, 2017; New York City Council, 2017).

Subsidies are another political element affecting emissions in the US that creates carbon lock-ins. Fossil fuel subsidies cover support for the consumption and the production of fossil fuels which include consumption prices set below the market price, reduced retail taxes, government provision of distribution infrastructure at reduced rates,
cash transfers, loans, and guarantees. The US government subsidizes the oil and gas industry by creating a gap between the prices paid by consumers and a benchmark paid to producers; this benchmark price is often different because it is based off international market price and includes the costs of transportation, value-added tax, and taxes that cover air pollution, climate, change, and accidents (Skovgaard & van Asselt, 2019). The CO₂ emissions associated with subsidy-dependent oil and gas production in the US alone will account for about 1% of the entire world’s carbon budget (Erickson et al., 2017). Subsidizing oil and gas in the US contributes to institutional, political, technological and behavioral carbon lock-in by offering support to fossil fuel production and use at the expense of lower-carbon alternatives (Skovgaard & van Asselt, 2019).

Subsidies in the US are also affecting the lives of our farmers through internal/external subsidization (unpaid family labor, off-farm income, and decreases in inventory) and can often obscure the real financial health of many farm businesses (Lines, 1987). Given that agriculturalists are Extension’s main audience, many Extension programs help educate farmers on financial stability and the use of subsidies for their businesses. One example is Utah State University’s virtual crop information page that is easily accessible by anyone who is interested. This Extension program provides up-to-date information on the different aspects of producing the main crop staples in the state such as corn, alfalfa, hay/grain, safflower, oil seeds, and others. One of the sections that they provide is for the economics of producing and selling these crops which incorporate information on subsidies that affect their farming practices.

Extension tends not to directly engage with politics and likely does not have much influence on this element of the socio-technical regime. Although, it is more common for
Extension specialists to provide expertise to policy makers and have an effect on local policy actions. The following is a quote from one of the Extension professionals we interviewed:

“I've led them to develop their county's first Climate Action Plan and then we've rewritten the plan last year... We've put forward about 36 policy recommendations and 27 of them were adopted that would increase resiliency and mitigation, in terms of both municipal operations and community goals and objectives. Within that group we put forward recommendations to our county comprehensive plan during our comprehensive plan update, I think it was formally adopted in 2018... Our comprehensive plan that didn't exist before has a suite of policy goals and objectives that will be met by the time the plan needs updating again in the next five years. So, it has plans and benchmarks for anything from adoption of the principles of adaptation action areas to energy reduction goals and building code standards. So that's sort of on the county level what I've been doing.” (Participant 14)

Despite this example, Extension can be limited in addressing this element of the regime in that most of their efforts to influence policy come in the forms of education on climate policies, for example teaching their audiences how they will benefit their community, why they are important, how they would impact them directly, and engaging with them on how policies could be changed. Here is another example of one of our
participants engaging their audiences with policy experts to educate them on energy policy amongst other topics: “I’ve convened some meetings and brought in some folks who are more expert on energy policy…We've done a series of meetings like in 2011 we did a rural road show. We visited three rural communities in this state to talk about climate and energy and agricultural water use.” participant 6.

Technology

Technology is at the core of a socio-technical regime because it shapes the way society functions. For example, one dominant technology in today’s society is personal vehicles that people use everyday for transportation to and from work, visiting family and friends, used for transportation of goods, used by law enforcement, etc. Dominant technologies (such as cars) tend to set the groundwork for technological developments in the future. This means future developments in technology tend to match the existing regime of technology currently in place. The current dominant technological regimes in the US are rooted in carbon intensive processes mainly through the burning of fossil fuels for energy demands, transportation, industrial processes, and more. Complementary technologies are an important aspect to consider when understanding resistance to change and transitioning to a new regime. Examples of complementary technologies are gas stations for personal vehicles. In order to transition from vehicles with internal combustion engines to electric vehicles, complementary technologies, namely charging stations, should replace gas stations.

Technological development in agriculture was an important part of Extension in the 20th century because there was an array of technologies and techniques that improved agricultural production, such as the introduction of rice as an alternative crop and the
introduction of faster growing varieties of crops that helped to avoid diseases (e.g.,
cotton) (Rasmussen, 1989). In the 21st century, technology development has shifted from
an agrarian focus to a more modern approach. As of 2021, one of the advocacy topics on
ECOP’s website is broadband access which focuses on getting reliable internet to
different demographics of people who do not have easy access or may not have the
available funding (ECOP, 2021).

For example, the Oregon Coast Renewable Energy Challenge is a competition for
students in middle school to create projects powered by renewable energy, which
promotes the development of skills in science, technology, engineering, and math.
Extension also runs programs around the country that promote the use of and help with
the transition to renewable energy for homes, businesses, farms, and organizations.
Colorado State University Extension began a program in 2015 called the Rural Energy
Center, formerly the Center for Agricultural Energy. This program accepted applications
from producers with center pivot sprinklers who were interested in free solar and wind
energy assessments. The Solar and Wind Assessments for Pivots project provides farmers
with estimated renewable energy system sizes, costs, savings, and other information
needed to decide whether renewable energy is a good investment for their land. Solar or
wind systems can be installed on the corners of fields where center pivot sprinklers are
used to irrigate crops. The energy created by the renewables on site could be used to
offset the energy required for irrigation, saving the farmers money.

Although it is not directly related to climate change, Extension has shown other
interest in developing programming that would influence the technology element of the
socio-technical regime. ECOP has a section of advocacy called ‘Broadband Access and
Digital Skills’ that highlights all of the efforts Extension has led in getting reliable internet and digital skills to underserved peoples and businesses. This advocacy topic is meant to guide the future development of programming all across Extension. This initiative is not focusing on technological development but more on technological savvy and is a good representation of Extension’s involvement in the technology element of the regime. This gives more context and evidence of Extension’s ability, as a niche innovator, to influence different elements of the regime

Science

The accumulation of scientific evidence underpinning climate change and consistent calls for climate mitigation (Hoegh-Guldberg et al., 2018) has not yet had a strong impact on how Extension prioritizes its overall programming. However, there are Extension programs that focus on research and development in adapting to extreme weather, carbon emissions monitoring, quantifying other GHG emissions and finding their sources, adaptation to future climate developments and risks, and the health of important carbon sequestering ecosystems, e.g., wetlands, coastal ecosystems like coral reefs and swamps, and old growth forests.

Extension can be referred to as an interface organization, which are groups created to foster the use of science in policy, management, and education (Osmond et al., 2010). All of Extension programming is rooted in outcomes of scientific research, much of which is conducted at land-grant universities. Research and education are the fundamental pillars of Extension that mark the expertise of their work and is what makes it a niche organization that could play more important roles during socio-technical transitions intended to address climate change.
Extension as a Niche Organization

Niche organizations are at the bottom level of the MLP hierarchy where change is proposed to begin. Niche organizations serve as places of experimentation and innovation for new technologies, ideas, and strategies where they are protected and nurtured away from normal market pressures (Geels, 2002). People working in niches develop new ideas and strategies. Various organizations can help broadly implement the best ones with the help of intermediary actors (Kivimaa et al., 2019). Once the best forms of practice are fully developed and implemented into society, they become a part of a new regime with the dominant technologies and strategies that were developed and implemented by the niche organizations.

Extension acts as both a niche organization and an intermediary actor by sparking innovation with their research and applying it through education and programming. Extension has the potential to influence nearly all elements in a socio-technical regime, shifting them towards a new configuration and ultimately a new regime. In this section, I will be providing more excerpts from interviews conducted with Extension professionals about how their organization has succeeded, failed, or could do more on influencing elements of the socio-technical regime I have characterized. One element of the regime I have illustrated is consumer preferences; my interviews and document analysis show that Extension has little effect on mainstream consumer preferences. However, they still do work that involves consumer habits and climate change e.g., programs relating to food.

Extension runs programming that influences certain aspects of the food industry. One way they do this is by educating consumers and farmers about organic food and sustainable agriculture. An Extension professor who taught ranchers about the benefits of
grass-fed beef and its benefits to human health, regenerative landscaping, and marketing said:

“People really want to buy that animal because it was grass fed and research shows that for human bodies that it can be healthier to eat grass fed beef. In addition to the health aspects, this one young gentleman and his brothers actually raised beef in the same way. He was very, very aware of how raising animals in this world today with the number of people we have and the desire for people to eat meat has an impact on climate change and air or just carbon dioxide emissions and also about the benefits of grass feeding an animal in terms of soil regeneration and so he became this very young and powerful speaker locally and around that topic and was very inspiring I think to adults and other youth around this.” (Participant 12)

Along with agricultural programming and research affecting food systems and certain consumer and farmer preferences, Extension programs are assisting their state in meeting emission goals that were set in conjunction with the Paris Agreement. To do this, Extension has been working with agriculturalists and other audiences to mitigate and adapt to climate change. Although Extension may not have had a part in creating state climate goals, this one participant described what it would look like to have Extension help in reaching those goals:
“Our state passed the climate change community leadership act which sets the highest greenhouse gas emissions reduction goals. And so, that's going to be a huge challenge for our state to meet that goal. Unless there's change in the agricultural sector and much more solar brought on. Much more solar power installation, much more effort at the community level.” (Participant 11)

With these climate goals, Extension has developed more initiatives to help people transition to solar energy and reduce their carbon footprints. The voluntary “Climate Smart Farming” program, run by Cornell University, helps farmers in the Northeastern US to: increase agricultural productivity and farming incomes sustainably; reduce GHG emissions from agricultural production through adoption of best management practices, and increased energy efficiency as well as use of renewable energy; and increase farm resilience to extreme weather and climate variability through adoption of best management practices for climate change adaptation. Cornell also has a “Climate Stewards” program that also exists in Maine and California with a similar program in Washington called “Sustainable Community Stewards”.

One of the interviewees was passionate about climate change science and is considered an expert in the field. They recognize the reality of climate change and the shifts necessary to reduce its severity. The following quote shows this Extension faculty’s opinions on what is necessary to mitigate climate change on a mass scale to prevent world-wide catastrophe:
“If we want to talk about mitigation, what we have to do is talk about starting to make changes over the next 10 to 20 or 30 years that can prevent us from going from 450 up to 560 ppm [parts per million]. And what that’s going to take is a technological revolution that I can't foresee, that nobody can foresee. I mean, if somebody would have told you, and in 1895, that within 70 years, people would be able to get into a metal tube [airplane] in New York and be in London, eight hours later, they would have thought you were nuts.”

(Participant 16)

Solar energy is an example of the ‘technology’ element in the socio-technical regime where Extension acts as a niche innovator for renewable energy usage. Extension also acts as an intermediary actor that engages with and educates communities on solar energy and other renewables. For example, the New York Energy $mart Program not only does research and education surrounding renewable energy, but also provides incentives for people who are transitioning to renewables from at least 23 different county/city offices in the state.

Although each state has some type of climate programming, according to a recent database created by a team funded by the Extension Foundation, these niche innovations relevant to climate solutions are not widespread in the majority of states (Kipp et al., 2020). Extension likely has the potential to tackle climate issues around the country, but there is hesitancy to break from traditional programming, specifically around agriculture. An interviewee familiar with Extension’s climate programs said:
“Across the nation there are the typical 10 to 15 different Extension states that are doing some amazing programming in climate issues, climate adaptation, and climate resilience. And their programs are out there, the concerns are out there. A lot of good individual people within Extension spoke up and are concerned, but it is not the majority of Extension services and their Extension administration’s. So in my mind, Extension needs to drop all its boundaries for a little while and, point blank, come out and say ‘every program that we deliver across this nation for the next 30 years – at least 10 years – has to have a climate goal or climate objectives built into them’. ” (Participant 19)

Regarding the ‘industry’ element in a regime, Extension, given its history, has more influence on the agricultural industry than other industrial sectors. Extension has improved agricultural production and has helped the US’s agricultural economy become one of the largest in the world. Extension’s central focus, for climate change action and programming in general, is in the agricultural sector. However, the agricultural sector also seems to have influence on how Extension runs their programming and can affect the way that Extension exchanges information with their primary audiences. This quote by an Extension faculty member summarizes this perception:
“I think the structural issues, of how Extension and the ag industry are intertwined, are so important because there's partnerships there. If there's a topic that people don't want to talk about like, the whole GMO thing. Oh my God, that's just don't even get me started on that. But, you know, there's just a very strong industrial push on the agricultural system. And I think that that's challenging in this case because climate change doesn't really fit some of those agendas.” (Participant 13)

Participant 13 believes that the industrial push from modern agriculture, which is currently highly dependent on fossil fuels for fertilizers and running most farm operations, does not fit the agenda of climate change related programming because of their reliance on fossil fuels, industrial processing, and the limitations it can have on the industry. This makes it difficult for Extension programs to secure funding from their main partners for climate-related programming. This can also relate to the political beliefs of many agricultural audiences. When it comes to politics, another participant has experience with lobbying that affects the agricultural industry and involves policy, another element of the socio-technical regime.
“You're dealing with industry and all of the different lobby
groups that may have a stake in something like methane or some aspect of the
environment that, in a regulatory way, cuts into profit, right? So you're going to
have a lot of lobbying on the hill from different parts of industry. There are a lot
of parts of industry that are really pro environmental protection and all of those
kinds of things. But you're going to have other folks that are like ‘well you know
we don't really know if [our work] is affecting climate.’” (Participant 18)

Participant 18 is describing the agricultural industry’s lobbyists that have a strong
influence on higher municipal and state policy. Participant 18 says that these lobbyists
have interest and stake in methane or fossil fuels because it allows them to make more
profit indirectly by either making those resources cheaper or de-regulating them. This
means that they are lobbying against climate policy and action because it will cut into
their profits. Despite not being able to lobby, Extension offers policy recommendations,
does research and education in climate change science, influences consumer preferences
and industry in the agricultural sector that could help reach goals set by the Paris
Agreement, engages communities and businesses with renewable energy, and influences
certain types of maladaptive cultures that are slow to accept climate change and climate
change action. Extension addresses a wide variety of societal issues and needs, that
include climate change impediments, and seems to have the capabilities to address
climate change issues in nearly every aspect of the illustrated socio-technical regime
surrounding climate change and Extension. However, participants mentioned Extensoin
educators are spread too thin in their programming and have largely become locked-in to
specific programming areas, with little opportunity for new and/or collaborative efforts that focus on climate change.

“I'm always... trying to encourage, where I can, the urgency of this climate crisis and what Extension can and should be doing. I actually think they need to drop everything else and head right for the climate zone. Really take their specialized subject matter area and beg, borrow, steal, or write curriculum on ‘what can I do in my community to help drive this issue’ because it is not just urgent, it's leading toward a catastrophe.” (Participant 19)

“The Extension service has always been disjointed and by that I mean that...sometimes we don't know anybody in any other Extension state, sometimes we're in counties and we really don't know anybody in other Extension counties in our states. Sometimes we are specialists at our university and we've been involved in a certain kind of research forever and it's a traditional program and God help you if you're the one that stops that program and starts doing something more relevant to the time and day. So we're really locked in to a lot of what I consider programmatic roadblocks.” (Participant 19)

As demonstrated in my document analysis and articulated by interviewed Extension professionals, Extension has the characteristics of a niche organization and an intermediary actor, both of which provide it with potential to help the US reduce emissions and enhance carbon sequestration. Given more support and resources for Extension research and programming on climate change, Extension could improve its
ability to spread climate action through grass-roots initiatives. With Extension’s reach in every county in the US, they could be the bridge between government, higher education, and the people that can lead climate action throughout the US.

Extension’s climate programming may still be developing but is meeting resistance from a lack of funding for further research and expanding existing programming. Consistency of funding is a concern among the professionals we interviewed who are not sure if their position would continue if they lost the current sources of their funding. Sometimes the sources of funding that support their positions rely on federal grants, so if there is a change in federal policy on climate change, they could lose their funding and position in Extension.

“I feel supported in that I'm not questioned and they're like, hey, if that's what you want to do, do that, but if I was to say, Do I feel supported and if my funding went away from the USDA. Do I think the university would try to find a way to continue to fund a position like mine? I don't think so.” (Participant 10)
Interviewer: “What do you think has made these programs that you've worked on in your career successful?”

“Um, it hasn't been funding. (Laughter) It's been a challenge. When I came to this university in 2007, the Extension director... took special director’s project funds as the director of the ag Experiment Station...And that was providing me funding until a new director came in and said ‘we’re not going to do that anymore’. And now I'm fully grant funded. So, that has been a huge challenge. I guess I'm trying to say that I have only been able to do what I can do with my limited time and funding.” (Participant 11)

Interviewer: “My last question, is it ever frustrating for you that, as a fiduciary of a land grant university, you are kind of on top of issues that affect the health, welfare and safety of constituents that maybe you change messaging because of those political concerns. Does that ever frustrate you?”

“Yeah sure like I said with covid right now it'd be nice to be able to say some different things, but I would be concerned about our Extension funding in the future if we were out front on and more direct on some things.” (Participant 17)
Interviewer: “Do you see any unmet needs in your community or state with regards to your climate program?”

“Yeah, I think our state is interesting. I think there's a lot of funding for different regions of the state. But, I think different regions are excluded. I know in one region central to the state, I think there's not as much funding for climate stuff. There's a lot for the harmful algae blooms, that's a big thing, but other climate resiliency and planning, aside from the state Climate-Smart Communities program, there's not really as much funding. Communities in this part of the state kind of haven't gone after a lot of climate funding...So even if the grants are out there, if there's not really the capacity at the local county level to go after it, then that also is definitely an impediment to doing climate work.” (Participant 2)

As represented from these quotes, along with at least half of our interviewees (11 out of a total of 21), money and consistency of funding is a prominent concern among Extension professionals working with climate programming. Without funding for these types of programs, they are not sustainable. Participants also shared that many Extension offices in smaller communities and counties in each state also do not have the capacity to obtain funding for climate change programming, which further prevents the adoption of climate programming throughout the US.
Conclusion

Through Extension’s connections to communities, municipal governments, state governments, and federal agencies as well as access to science-based solutions, Extension has the ability to lead climate mitigation and adaptation efforts in the US. Extension’s climate leadership potential lies largely in the influence they have had on the agricultural sector. Reducing emissions associated with agriculture is critical for transitioning to a low carbon economy. Agriculture is responsible for 10.5% of US GHG emissions via manure management, nitrogen fertilizers, energy use, and enteric fermentation (Environmental Protection Agency, 2020). Extension has connections to local community members and leaders, non-profits, government funding at the state and federal level, and a history of translating the best available science to practitioners. Extension operates in every state throughout the nation, giving it a prime position to disseminate climate information and initiate climate action. Extension also works locally with research-based and grassroots initiatives, which is imperative for the groundwork in socio-technical transitions. Research-based and grassroots initiatives reveal the complexities, technicalities, and collaborative necessities in implementing climate adaptation and mitigation strategies at the local scale, allowing for learning opportunities. An example of this is the Climate Masters program of Nebraska that trained community participants with scientific communication skills that allowed them to work with conservative audiences that do not believe in climate change. This program also had participants dedicate at least 30 hours of volunteer time educating others in the community about reducing their carbon footprint and giving them the tools with which to do so.
Niche organizations, according to socio-technical literature and the MLP, can be described as interface organizations that develop and disseminate innovations, which include practices, strategies, information, technologies, etc. According to this research, Extension is a niche organization under the scope of the MLP that could help the US in reaching climate goals set by the Paris Agreement. My research also identified sources of resistance for Extension influencing a socio-technical change based on cultural issues, specifically consumer culture and habits surrounding consumerism, along with lock-ins with the agricultural industry and limitations with addressing the policy element of the regime. Lastly, in order for Extension to lead efforts in climate mitigation and adaptation in the US, one interviewee recommended that all Extension professionals be required to embed climate mitigation and adaptation goals into their programming. Additionally, there is a need to require accountability in progressing towards these goals.

I also recommend expanded application of insight from MLP literature in that niche innovations can become more powerful and build momentum through “learning processes, price/performance improvements, and support from powerful groups” (Geels, 2014). In the case of Extension, “learning processes” could mean teaching basic climate literacy to Extension faculty and specialists. “Price/performance improvements” could mean Extension working on ways to reduce the cost of lower carbon emission technologies and practices. Lastly, building momentum by gaining support from powerful groups could be securing more support and funding from federal government agencies and other powerful organizations like philanthropic foundations. Further recommendations based on the current circumstances surrounding Extension and climate change involve more funding and development for Extension climate programming
addressing the gaps and barriers that were identified in this study (e.g. engaging more with policy, addressing agricultural industry lock-ins, improving climate literacy to increase the prioritization of climate change) and expanding Extension’s current successful innovations to other areas of the US.
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CHAPTER IV

Synthesis of Results

Theoretical Background

To gauge Extension’s potential to become a significant actor in climate adaptation and mitigation throughout the United States (US), I applied two different perspectives. First, I looked at how much Extension prioritizes climate change programming and if the system was going through a system-wide transformation towards prioritizing climate change as a central focus. Using Moore et al. ’s (2014) transformation framework, used for analyzing social-ecological systems, I traced Extension’s progression in potentially refocusing their efforts to prioritize climate change. Second, I needed to determine Extension’s actual ability to influence large factions of the US and its potential to help in a socio-technical transition towards a low-carbon society. In this study, I used the multi-level perspective (MLP) as a tool to help me characterize the different ways in which Extension, as a niche innovator, could influence the different elements of a socio-technical regime. Framing climate change as the landscape issue causing problems and forcing change throughout society, Extension is able to create solutions and implement them through their programming. Both frameworks were used to help identify barriers and gaps to Extension transforming towards prioritizing climate change and to Extension becoming a major actor in climate adaptation and mitigation throughout the US. The next two sections elaborate on these frameworks and how they were used.
Moore’s Transformation Framework

The Paris Climate Agreement has set ambitious yet necessary goals for GHG reductions around the world (Paris Agreement, 2016). Reaching these goals takes a combination of global coordination, federal action, state level action, local collaboration, and individual accountability (Bloomberg Philanthropies, 2017). As previously described, the Cooperative Extension System (Extension) is a federally appointed system based at land-grant universities that runs relevant programming for the needs of the American people using applied research and educational outreach. To analyze Extension’s current progress in addressing climate issues around the US, and to determine the extent to which climate programming is becoming a priority, I used a transformation framework developed by Moore et al. (2014) for analyzing system transformations.

The transformation framework developed by Moore et al. (2014) is used to understand deliberate transformations within social-ecological systems. In this study, Extension is framed as the system undergoing a transition. Conducting interviews with Extension professionals enabled me to determine if Extension is currently in a transition towards prioritizing climate change information and action in their programming, and, if so, how far along are they? This transformation framework identifies four phases of a transition from beginning to end 1) triggers or pre-transformation; 2) preparing for change; 3) navigating the transition; and 4) institutionalizing the new trajectory (Moore et al., 2014). Complementary to the phases of a transformation are the elements of a system that are expected to change 1) norms, values, and beliefs; 2) rules and practices, such as
laws, procedures, and customs; and 3) the distribution and flow of power, authority and resources (Moore et al., 2014).

In the context of this study, this transformation framework confirmed that Extension is in the midst of a transformation towards prioritizing climate action and it helped me identify to what extent Extension is transforming their system. The four phases of transformation, and the key elements for change, used in the framework allowed me to define what initiated a transformation within Extension, how Extension is responding, specific examples of change within the Extension system, and identify what barriers or obstacles are preventing Extension from prioritizing climate change. This research contributes to this field by providing a relevant case-study of how this framework can be applied to Extension to identify road-blocks in the transformation process to prioritize climate action. After using the Moore et al. (2014) framework to analyze Extension as a system, I used a second framework that offers a holistic way of analyzing Extension and its ability to assist in a socio-technical transformation in the US, the MLP.

The MLP

The US’ climate change goals require a transition that entails diverse practices, technologies, changes in culture, changes in industry, and policies (Doerr, 2021; Hawken, 2017). The Multi-Level Perspective (MLP) developed and refined by Geels (2014) offers a more holistic way of analyzing socio-technical transitions. This tool is used to help illustrate the elements involved in a transition of different scales (e.g., national scale,
metropolitan, community level) and used to help identify and explain the innovations that help complete a transition to a new regime.

The different levels of a socio-technical system that are analyzed in the MLP are presented as a nested hierarchy. The first and bottom level, niche organizations, produce new technologies and practices, called innovations, to address changes and pressures that create issues from the two higher levels in the MLP. The second level, the socio-technical regime, represents the compilation of established practices and associated rules that enable and constrain actors in relation to existing systems (e.g., culture, technology, science, policy, industry, consumer preferences). In the highest level, the socio-technical landscape, social and technological relationships co-evolve into large scale systems that can be the source of issues that are not easily controlled (e.g., war, climate change, oil prices).

In this study, I use the MLP to illustrate the socio-technical elements surrounding climate change (framed as the landscape issue) and Extension (framed as a niche organization providing innovations to address climate issues in the US). Climate change as the landscape issue is causing pressure on the elements of the current regime. The landscape level climate change issues are a result of the effects of the current regime (carbon emissions, deforestation, degradation of carbon sinks, reduction of biodiversity, and pollution that stem from industry, culture, policy failures, technology, etc.). In response, niche organizations (in this case Extension) create and implement solutions to address issues in technology, practices, culture, policy, etc. that are contributing to climate change. As time moves forward and these innovations become more dominant in
society, innovators like Extension can help to reconfigure the regime into a new regime that is equipped to deal with climate change on multiple levels of society.

**Methods**

Using qualitative interview data with Extension professionals working with climate change or extreme weather programming, this study first explored the extent to which Extension is transitioning their central focus towards prioritizing climate change. This transition within Extension would allow it to potentially become a significant actor in the US during a socio-technical transition towards lowering and sequestering GHG emissions. Secondly, this study used literature surrounding socio-technical transitions, the MLP, and Extension and climate change, complemented with the interview data, to illustrate the socio-technical regime surrounding Extension (as a niche innovator) and climate change (as the landscape issue).

I conducted semi-structured interviews with Extension professionals identified as working in climate change and/or extreme weather programming. There were 14 people interviewed in the Fall of 2020 and an additional seven in the Fall of 2021 for a total of 21. These 21 interviewees represented 14 different state Extension programs dispersed throughout the continental US. The academic positions of the interviewees varied with seven of them being Extension leaders and 14 Extension educators. The interviews were conducted remotely and transcribed using Otter AI software and later coded using NVivo with codes that were relevant to Extension, climate change and/or extreme weather, and the theoretical frameworks used for this study. The document review was conducted
using search terms in Google Scholar and through cited reference searches that identified related research and context.

**Extension’s Transformation Towards Prioritizing Climate Change**

According to the interviews and my analysis using the transformation framework, Extension is currently in the midst of a transition towards prioritizing climate programming. I identified multiple barriers that are making this transition difficult through lock-in mechanisms, culture, and inconsistency of funding. Using the transformation framework, I also provided evidence for Extension during the different phases of transformation. Finally, using the obstacles identified in this study, I created recommendations to help Extension advance a transition towards climate change prioritization. See chapter III for additional details on these recommendations.

**Recommendation 1)** Cultivate stronger leadership within Extension that prioritizes climate adaptation and mitigation programs across the US.

**Recommendation 2)** Extension draws on its partnerships for success in their programming. Continuing to focus on strengthening partnerships with local, state, and federal agencies could support their efforts in implementing climate programming.

**Recommendation 3)** Sustained funding is needed for long-term programming related to climate adaptation and mitigation. Extension could focus on obtaining this funding for professional development, curriculum development, climate literacy among Extension faculty and leaders, and onboarding of new faculty with climate mitigation and adaptation goals articulated in their professional responsibilities.
**Recommendation 4** Increasing scientific communication skills among Extension faculty related to climate issues and climate programming could strengthen their capacities for political engagement and networking towards climate mitigation and adaptation goals.

**Illustrating the Socio-technical Regime**

My second study addressed the broader context of Extension’s role in a socio-technical transition in the US. Illustrating different elements of a socio-technical regime that Extension is a part of in relation to climate change allowed me to assess Extension’s strengths and weaknesses as a niche organization that can influence a low carbon transition in the US. According to my historical review of Extension in the US, the interview data, and real examples of Extension climate programming, my analysis suggests that Extension is a niche organization with intermediary qualities (qualities of an organization that is able to link solutions and innovations to the people who need them) that is helping in the transition towards a low carbon society, but their work is not yet influential enough to consider them a major actor.

If Extension could focus its efforts and resources on prioritizing climate programming, their connections to the communities they serve and their unique infrastructure would allow them to help large factions of the US with climate adaptation and mitigation. By breaking down each element of the socio-technical regime, I described Extension’s abilities to influence different parts of society. I recognize that my analysis captures prominent features of a changing system, but it cannot be considered comprehensive due to the complexity of any dynamic socio-technical regime.
Consumer Preferences

I do not anticipate Extension having a large effect on the consumer preferences element of a socio-technical regime with the exceptions of consumer preferences in food systems. Extension has influence in the agricultural industry of the US, working with agriculturalists and consumers. Extension runs programming for consumers that can influence consumer preferences by focusing on dietary changes in order to save money, improve overall health, and teach people how to access local foods and cook meals that are not centered around meat, all of which help to reduce carbon emissions (Anokhin et al., 2014; Environmental Protection Agency, 2020; Hawken, 2017).

Culture

In the US, there is a large diversity of cultures that come from all over the world, but in the context of this study, the most relevant part of American culture that pertains to climate change and Extension would be consumer culture. Consumer culture is a product of the consumerist society that our economic well-being depends on. This has led to a long history in the US of influencing people to constantly consume material goods to promote economic prosperity (Lury, 1996). The effects of consumer culture on the environment and climate is severe through production of products, transportation, and waste management (Lury, 1996). There are strategies and practices that people and businesses can adopt to reduce the environmental impact of consumer culture through promoting recycling, reduction of materials in production and packaging, and focusing on life-cycles of products from start to end (Harsch, 1999). Extension is one such organization that develops and implements programming that gives people the knowledge
and resources to improve recycling practices, composting, using reusable bags, improving infrastructure surrounding recycling and composting to make it easier/more efficient, etc.

Industry

Industry is one of the leading contributors to GHG emissions and environmental degradation through their mining and manufacturing processes, destruction of environments for material, transportation of intermediary goods in the supply chain within a manufacturing process, energy consumption, etc. For this study, the agricultural industry is of most relevance to Extension because agriculture is at the core of Extension programming. The industry of agriculture incorporates the raising of livestock, growing of crops, the equipment used, processing, the methods of transportation and packaging, selling, and other processes that involve increasing yields and quality. Extension has greatly influenced the agricultural industry over the years through their programming and research focusing on increasing yields and teaching growers new strategies and techniques for better production (Bull et al., 2004; Comer et al., 2006; Gould et al., 2014; Huffman & Evenson, 1993). Today, Extension’s main focus remains on agriculture, though some argue that this focus is an outdated lock-in, due to funding sources and traditional programming, that should be adjusted to match the more relevant needs of people in the US (Gould et al., 2014; McDowell, 2001). Currently, Extension runs climate adaptation and mitigation programs for agriculturalists of all types and could greatly expand these efforts to reduce the contribution of harmful GHG that come from agriculture in the US.
Policy

One of the most well-known and largest actions taken to combat climate change is the Paris Agreement which was effective as of 2016 (Paris Agreement, 2016). This agreement created a non-binding agreement between 180 countries to not surpass a threshold of raising the average atmospheric temperature two degrees above pre-industrial levels. In 2017, the US declared its intent to withdraw from the Paris Agreement under the direction of President Trump resulting in a reduction in funding for climate research and programs, which impacted Extension since much of their funding comes from federal agencies (Hersher, 2020; Pompeo, 2017). In 2021, the Biden administration led the US to rejoin the Paris Agreement, but emissions continue to rise. Extension tends not to directly engage with politics and likely does not have much influence on this level of a socio-technical regime, although, it is more common for Extension specialists to provide expertise to policy makers.

Technology

The current dominant technological regime in the US is rooted in carbon intensive processes mainly through energy demands that represent the largest amount of emissions in the US (Environmental Protection Agency, 2020). Complementary technologies are an important aspect to consider when understanding resistance to change and transitioning to a new regime. Examples of complementary technologies are gas stations for personal vehicles. In order to reduce emissions to meet goals set by the Paris Climate Agreement, we need to transition from vehicles with internal combustion engines to electric vehicles, which would mean implementing complementary technologies, namely charging stations, that would replace gas stations. In the 21st century, technology
development (nor technology development for reducing the impacts of climate change) is not a focus of Extension according to ECOP’s advocacy toolkit, however they do specialize in the use of some technologies and having people adopt them for specific needs in society (ECOP, 2021). Examples of this include Extension programming that educates people on and even incentivizes solar energy usage to help lower carbon footprints and promote the transition to renewable energy that will ultimately reduce our emissions. ECOP has a section of advocacy called ‘Broadband Access and Digital Skills’ that highlights all of the efforts Extension has led in getting reliable internet and digital skills to underserved peoples and businesses. This initiative is not focusing on technological development or climate change but more on technological savvy and is a good representation of Extension’s involvement in technology as a programming focus.

Science

The accumulation of scientific evidence underpinning climate change has not yet had much of an impact on how Extension prioritizes their programming. However, some Extension programs focus on adapting to extreme weather, carbon emissions monitoring, quantifying other GHG emissions and finding their sources, adaptation to future climate developments and risks, and research into the health of important carbon sequestering ecosystems, e.g., wetlands, coastal ecosystems like coral reefs and swamps, large old growth forests. Extension can be referred to as an interface organization which are groups created to foster the use of science in policy, management, and education (Osmond et al., 2010). All of Extension programming is rooted in science, much of which is conducted at land-grant universities. Research and education are the fundamental pillars of Extension
and their primary forms of work which is what makes them an excellent example of a niche organization during a socio-technical transition.

**Recommendations for Future Research**

My research contributes to socio-technical transition literature by offering a case-study style analysis on Extension as a niche innovator that has the potential to influence a socio-technical transition towards a low carbon society. There were limitations to the scope of my analysis that could be expanded upon in the future with more interviews with Extension leaders asking more directed questions relating to socio-technical frameworks.

The political complexities of Extension’s work with their audiences and the effects of politics on the funding opportunities for climate change programming could be explored more. These issues were prevalent throughout interviews and its effects as a potential barrier could be better understood with further inquiry into how local politics play a role in programming, how state and federal politics affects consistency of funding, and how political beliefs among Extension professionals and leaders affect climate programming.

Throughout this research, questions arose as to whether Extension is truly serving low-income and at-risk people in the US for climate change issues. The impact this could have on their programming and whether it is a persistent pattern rooted in funding or culture among Extension faculty is unclear. Future studies could obtain
information regarding Extension’s intentions in servicing more at-risk and low-income audiences that are not in the agricultural field.

The interviews with Extension professionals provided an in-depth understanding of the experiences of Extension professionals and the complexities of implementing climate programming. However, one important aspect that future research should incorporate is quantitative data. Taking a broad inventory of all programming that aims to address climate change and attempting to quantify how such programs affect emissions in the US over time would allow for a better understanding of the extent to which Extension is reducing emissions and increasing greenhouse gas sequestration in the US. I recognize that this data would be challenging to obtain given uncertainties in the extent to which Extension’s educational programs directly or indirectly influence on-the-ground practices. Nonetheless, a quantitative estimate could help determine the types of programs most likely to reduce emissions and/or sequester existing atmospheric carbon if they were scaled up. Having quantitative data could help raise the profile of Extension as an important organization that can be utilized by federal and state governments to address climate change, allowing for more funding opportunities for Extension climate programming.

Lastly, this research used a framework that is popular for analyzing socio-technical transitions. Future research could focus on other frameworks used for analyzing transitions or social-ecological systems and cross compare the findings, such as the diffusion of innovation framework (Sahin, 2006). This would create a more rich understanding of Extension and climate change in the US.
Conclusion

My research uses socio-technical literature to illustrate Extension’s potential to become a significant actor in a potential transition towards a low carbon society in the US. Through Extension’s connections to communities, municipal governments, state governments, and federal agencies as well as access to science-based solutions, it has the ability to lead efforts in the adoption of climate mitigation and adaptation in the US. According to this research, Extension is a niche organization as defined using the MLP that could help the US in reaching climate goals set by the Paris Agreement. My research highlighted Extension’s historic successes in increasing agricultural productivity while also identified some shortcomings and sources of resistance for Extension influencing a socio-technical change aimed at advancing climate solutions. Based on my research, I am optimistic that more Extension professionals will recognize the urgency of climate change and their individual and collective potential to bring their efforts and resources together as an institution to focus on addressing climate change.
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Appendix A: Letter of Information and Invitation

Oppportunities and Challenges for Climate Change Extension Programs

Dear [Participant’s Name],

You are invited to participate in a research study by Dr. Roslynn McCann, Dr. Sarah Klain and Dakoeta Pinto at Utah State University, Dr. Paul Lachapelle at Montana State University, and Jennison Kipp and Maria Dozier at the University of Florida.

The purpose of this research is to understand the scope and nature of your professional experience with Extension climate and/or extreme weather programming. Our goal is to compile climate change education and research program data from across the United States (U.S.) Cooperative Extension System and identify areas of greatest impact and gaps. Specifically, we are interested in learning about both opportunities and challenges you have encountered in your experiences with climate change and/or extreme weather programming. You are being asked to participate in this research because of your relevant experience with Extension.

Your participation in this study is voluntary and you may withdraw your participation at any time for any reason.

If you take part in this study, you will be asked to take a 20 to 45-minute interview with a member of our research team. In compliance with Utah State University COVID-19 research policies, interviews will be conducted by phone or computer videoconference, not in person.

The possible risks of participating in this study include loss of confidentiality due to the limited number of Extension professionals with experience in climate change related programming. The benefits of participating in this study may include having your opinions and perspectives anonymously shared in our publications and communications with project sponsors and collaborators, including The Extension Committee on Organization and Policy (ECOP). ECOP provided direction for this project and is the representative leadership and governing body of Cooperative Extension and Extension Foundation.

We will make every effort to ensure that the information you provide remains confidential. We will not reveal your identity or personally identifying information in any publications, presentations, or reports resulting from this research study. However, due to the nature of our study and focus on learning from people in Extension with climate programming experience, it may be possible for someone to recognize you through the specific opinions or perspectives that you share.

We will collect your information through interviews. We will audio record all phone and computer (Zoom) interviews. Online activities always carry a risk of a data breach, but we will use systems and processes that minimize breach opportunities. Recordings and transcriptions will be stored securely in a restricted-access USU box cloud storage folder. All data with personally identifying information, including audio and video recordings, will be deleted after four years.

You can decline to participate in any part of this study for any reason and can end your participation at any time.

If you have any questions about this study, you can contact Sarah Klain at sarah.klain@usu.edu.

Thank you again for your time and consideration. If you have any concerns about this study, please contact Utah State University’s Human Research Protection Office at (435) 797-0567 or irb@usu.edu.
If you would like to participate, please scan this QR code with your smartphone, which will take you to our consent form online, or you can go to this website: https://usu.co1.qualtrics.com/jfe/form/SV_2x40wvXz2Nn2wv.

Sincerely,

Sarah Klain, PhD
Assistant Professor
Environment & Society
Utah State University
Appendix B: Interview Protocol

Opportunities and Challenges for Climate Change Extension Programs

Interview Protocol

- Interviewer introduces themselves
- Be sure that interviewee has provided informed consent via the Qualtrics Survey
- Record interviewee name
- Introduce project

I am working with a team of researchers to better understand Extension climate and extreme weather programming. The goal of our research is to compile climate change education and research program data from across the Cooperative Extension System and identify areas of greatest impact and gaps.

You were identified by members of our research team as having experience with Extension regarding climate and/or extreme weather programming. The information you provide will be anonymous (you will not be identified in any way or tied to the results) and will be part of a sample of individuals from across the United States. We have received Institutional Review Board authorization (IRB #11352) from Utah State University and are happy to provide you with a copy of our final report upon request.

We would like to record this interview. We will transcribe the text verbatim, then share the transcript with you to ensure accuracy and to give you an opportunity to remove any text you would like us to exclude from our synthesis.

Let’s get started.

1. Please tell me about your background/experiences with Extension regarding climate and/or extreme weather programming (educational outreach, research, etc.).

2. Can you share any challenges related to these climate and/or extreme weather programs that you encountered from your extension colleagues and/or your program audiences/clientele?

3. Do you see opportunities to meet unmet needs in your community/state? If so, can you elaborate?

4. If more funding and staff time became available to you for Extension programs focused on climate change and/or extreme weather, where and in what ways would you invest these resources?

5. Is there anyone else—at your institution or others—with a background or experience with Extension climate/extreme weather programming and who you suggest we invite to contribute to this research?