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CARBON SEQUESTRATION ON UTAH RANGELANDS:
A LANDOWNER PERSPECTIVE

by

Seth L. Cook

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

of

MASTER OF SCIENCE

in

Human Dimensions of Ecosystem Science and Management

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2012

ABSTRACT

Carbon Sequestration on Utah Rangelands: A Landowner Perspective

by

Seth Cook, Master of Science

Utah State University, 2012

Major Professor: Dr. Zhao Ma
Department: Environment and Society

Rangelands have significant potential to sequester carbon and contribute to the mitigation of climate change. This research aimed at better understanding the beliefs, attitudes, and perceptions of Utah rangeland owners concerning carbon sequestration and climate change, examining their current grazing management practices in relation to soil carbon sequestration, and exploring factors influencing their likelihood of participating in future programs. Data were collected through interviews of Utah rangeland owners and range management professionals and a statewide rangeland owner survey. About two-thirds of respondents thought the climate had been changing over the last 30 years, were aware of carbon sequestration, and viewed it positively. Forty-one percent considered it an important management objective. Having positive attitudes was associated with having “biocentric” environmental value and believing climate change and its anthropogenic nature. Respondents valued the potential ecological benefits of carbon sequestration, indicated a preference for educational programs over financial incentives, and preferred working with private agricultural organizations over non-profit or

government entities on carbon management. Thirty-seven percent of respondents reported likely to participate in a carbon sequestration program. Higher likelihood was associated with dependence on livestock production, considering carbon sequestration an important management objective, being interested in learning more about it, and placing high importance on the economic and climate benefits of participating in relevant programs. These results suggest potential challenges for developing technically sound and socially acceptable policies and programs for promoting carbon sequestration on private rangelands. Rangeland owners' attitudes towards carbon sequestration may play a strong role in their participation in future programs. Although education and outreach are considered important, innovative strategies are needed to communicate the concept and processes of carbon sequestration with rangeland owners without politicizing the issue. One approach is to tailor education and outreach messages to focus on the ecological benefits of carbon sequestration. Efforts are also needed to enhance the cooperation between private agricultural organizations and government agencies to promote carbon management on private rangelands. Instead of developing new programs, funneling resources to improve the carbon sequestration potential of existing conservation programs and attract wider participation among rangeland owners may be another cost effective policy strategy.

PUBLIC ABSTRACT

Carbon Sequestration on Utah Rangelands: A Landowner Perspective

Seth Cook

Carbon sequestration is the removal of carbon dioxide from the air and storing it in plants and soil through natural processes. Rangelands can be managed to sequester carbon and mitigate climate change. Supported by the Utah Agricultural Experiment Station, this study assessed Utah rangeland owners' perceptions of carbon sequestration and explored factors influencing their likelihood of participation in relevant programs. Data were collected through interviews and a statewide survey of Utah rangeland owners. Over two-thirds of respondents were aware of carbon sequestration and viewed it positively. Those who thought the climate had been changing over the past 30 years tended to have positive views. Respondents valued the potential ecological benefits of carbon sequestration, considered education and outreach more appealing than financial incentives, and preferred working with private agricultural organizations over non-profit or government entities. Thirty-seven percent reported they were likely to participate in relevant programs. Respondents who depended on livestock production, valued carbon sequestration and its potential economic and climate benefits, and were interested in learning more about it were more likely to participate. To promote carbon sequestration on private rangelands, outreach messages should focus on potential ecological benefits, cooperation between private agricultural organizations and government agencies needs to be enhanced, and resources could be funneled into existing conservation programs to improve carbon sequestration potential and attract wider participation among landowners.

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CHAPTER 1

INTRODUCTION

Climate change has been consistently at the forefront of environmental issues during the past few decades and is expected to have profound impacts on the world's biological and social systems (IPCC, 2007). Terrestrial carbon sequestration is a strategy that can be used to mitigate the human impact on climate change by removing carbon dioxide (CO₂) from the atmosphere and sequestering it in soils and above and below ground biomass (Izaurrealde et al., 2001; Lal et al., 2003). Rangelands can be managed in ways that enhance carbon sequestration in the soil (Lal et al., 2003). The management of private rangelands plays an important role in the overall potential of rangelands to sequester CO₂. Understanding private rangeland owners' beliefs, attitudes, and perceptions of climate change and carbon sequestration, as well as factors influencing their decisions to potentially engage in carbon sequestration activities, are important steps in determining the most effective ways to increase carbon sequestration on private rangelands. This information will further the understanding of rangeland owner decision making in the western U.S. and may also provide insight into the role of environmental attitudes in decision making which is useful for academics and land managers alike.

Carbon Sequestration on Rangelands as a Climate Change Mitigation Strategy

Terrestrial carbon sequestration is an attractive option for mitigating emissions of CO₂ because the technology is readily available, can be implemented without delay and can act as a bridge until further CO₂ offsets and reductions can be put in place (Post et al.,

2004). The literature suggests that although rangelands have a low per acre potential to sequester CO₂ in the soil, the vast area they cover increases the significance of their potential as a whole (Follett et al., 2001). More specifically, rangelands cover about 50% of the world's land surface (Svejcar et al., 2008), 31% of the U.S. (Sobecki et al., 2001), and 80% of Utah (Leydsman-McGinty, 2009).

Private land ownership plays an important role in rangeland management. About one third of the rangelands in the U.S. (SRR, 2011) and more than one fifth of the land in Utah are privately owned (Leydsman-McGinty, 2009). Rangeland management practices influence soil carbon levels and can be harnessed to improve carbon sequestration on private lands (Derner and Schuman, 2007). The amount of land in private ownership and the potential influence of land management practices on soil carbon make private rangeland owners an important player in determining the overall ability of U.S. rangelands to sequester carbon and mitigate CO₂ emissions.

Several policy options have been suggested in the literature to promote carbon sequestration on private rangelands. Market-based mechanisms have gained the most attention and have even been attempted in the U.S. For example, the Chicago Climate Exchange (CCX) was a voluntary market that operated from 2003 until 2010 as a platform for industries to pay for carbon offsets, which included terrestrial carbon sequestration projects. The CCX created the first and, as of yet, only carbon offset protocol for rangelands in the U.S (Western Climate Initiative, 2010). There are, however, several problems with measuring and quantifying soil carbon levels on rangelands which complicate their inclusion into these market-based options (Brown et al., 2010; White, 2010). Other policy options include local-level markets, government

payments for landowners to meet voluntary goals, or modification of existing conservation programs to include or focus on carbon management (Derner and Schuman, 2007; White, 2010). Although the biophysical and policy aspects of carbon sequestration are very important, the human dimensions surrounding management decisions by private rangeland owners to engage in carbon sequestration are crucial. These human dimensions are complex and can have profound implications for land managers in how they pursue carbon sequestration on private rangelands. Even though it is of great importance, very little research has been done to address the human dimensions of carbon sequestration on private rangelands, particularly in the western U.S.

The research presented in this thesis attempts to address this gap by looking at the following research questions: 1) What are Utah rangeland owners' beliefs, attitudes, and perceptions concerning carbon sequestration and climate change? 2) What are the factors driving Utah rangeland owners' decisions to engage in carbon sequestration activities? and 3) What policy mechanisms would be appealing to Utah rangeland owners for promoting carbon sequestration on private rangelands?

Environmental Beliefs, Attitudes and Rangeland Owner Decision Making

One lens used to guide this research is that of environmental attitudes. Environmental attitudes are complex and are associated with an individual's behavior in regards to an environmental action or goal (Larson, 2010). It is suggested that such attitudes are influenced, in part, by beliefs, values, value orientations, and social norms (Stern, 2000; Stern and Dietz, 1994; Vaske and Donnelly, 1999; Whitaker et al., 2006). Research on environmental attitudes and perceptions has been used in many natural

resource management settings and is useful for making informed management decisions (Larson, 2009; Morton et al., 2010; Vaske et al., 2001; Whitaker et al., 2001, 2006). In the case of this thesis, the environmental action or goal is carbon sequestration, which is in response to climate change. Within this context, the objective is to assess the relationships between ecological value orientations, climate change beliefs, attitudes towards carbon sequestration, the likelihood that rangeland owners will engage in carbon sequestration, and the preferred strategies and entities for promoting carbon sequestration.

Another lens that is used to guide this research is that of previous research on rangeland owner or rancher decision making. Previous studies have looked to understand factors that influence rangeland owners or ranchers decisions to implement recommended or innovative range management practices, to invest in range improvements, or to participate in conservation programs. A variety of factors have been identified that influence their management decisions including demographics, land ownership characteristics, economics, a variety of non-monetary values, and attitudinal factors (Coppock and Birkenfeld, 1999; Didier and Brunson, 2004; Ma and Coppock, 2012; Peterson and Coppock, 2001). Managing to increase carbon sequestration on rangelands has similar benefits as other conservation-oriented management goals such as reducing soil erosion, increasing water filtration, and increasing forage quality. Therefore, previous lessons learned about conservation and land management decisions on private rangelands are applicable for this research concerning carbon sequestration.

Thesis Structure

This thesis is prepared in a multi-paper format. There are two main chapters that are prepared for publication, which together describe the human dimensions of carbon sequestration on private rangelands in Utah. The data used in this research was collected during the summer of 2011 and the winter of 2012.

Chapter 2 discusses, on a more descriptive level, Utah rangeland owners' knowledge, beliefs, attitudes, and perceptions of carbon sequestration and climate change. Bivariate analyses are used to assess meaningful relationships among these variables in order to address research questions 1 and 3. Additionally, policy preferences are analyzed to determine the types of programs, incentives, and actors that are the most appealing to rangeland owners in Utah.

Chapter 3 focuses on the second research question by assessing factors that influence the self-reported likelihood of rangeland owner participation in a carbon sequestration program in the future. A logistic regression model is applied to isolate factors that influence potential behavior while holding all other variables constant. The model combines the information gained from the previous rangeland owner decision making literature as well as the environmental attitudes framework as discussed by Larson (2010). In Chapter 4, the conclusions from the research as a whole are discussed and implications for policy makers and land managers are explored.

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CHAPTER 2

PROMOTING CARBON SEQUESTRATION ON UTAH RANGELANDS:
LANDOWNER BELIEFS AND ATTITUDES¹**Abstract**

Rangelands can be managed to increase soil carbon and help mitigate emissions of carbon dioxide. This study assessed Utah rangeland owners' environmental values, beliefs about climate change, and awareness of and attitudes towards carbon sequestration, as well as their perceptions of potential policy strategies for promoting carbon sequestration on private rangelands. Data were collected from semi-structured interviews and a statewide survey of Utah rangeland owners, and were analyzed using descriptive and bivariate statistics. Over two-thirds of respondents reported some level of awareness of carbon sequestration and a generally positive attitude towards it, contrasting to their lack of interest in participating in a relevant program in the future. Having a positive attitude was statistically significantly associated with having more "biocentric" environmental values, believing the climate had been changing over the past 30 years, and having a stronger belief of human activities influencing the climate. Respondents valued the potential ecological benefits of carbon sequestration more than the potential financial or climate change benefits. Additionally, respondents indicated a preference for educational approaches over financial incentives. They also preferred to work with a private agricultural entity over a non-profit or government entity on improving land management practices to sequester carbon. These results suggest potential challenges for developing technically sound and socially acceptable policies and programs for

¹ This manuscript is co-authored by Seth L. Cook and Dr. Zhao Ma

promoting carbon sequestration on rangelands. Potential strategies for overcoming these challenges include emphasizing the ecological benefits associated with sequestering carbon to appeal to rangeland owners with ecologically oriented management objectives, enhancing the cooperation between private ranching organizations and government agencies, and funneling resources for promoting carbon sequestration into existing rangeland conservation programs that may produce carbon benefits.

Introduction

Climate change is expected to have detrimental impacts on humans and the environment (e.g., increased temperatures, droughts, and floods) and these impacts will vary both geographically and socially (IPCC, 2007). Two approaches to addressing impacts of climate change are adaptation, and mitigation through reducing greenhouse gases or enhancing carbon sinks (Klein et al., 2007). Terrestrial carbon sequestration is a mitigation strategy that removes atmospheric carbon dioxide (CO₂) and stores it as soil inorganic carbon (SIC), soil organic carbon (SOC), above-ground biomass, or below-ground biomass (Izaurrealde et al., 2001; Lal et al., 2003). Rangelands have the potential to play an important role in terrestrial carbon sequestration by storing soil carbon (Follett et al., 2001).

The role of privately owned rangelands in sequestering carbon

Rangelands cover about one third of the land in the U.S. (Sobecki et al., 2001) and 80% in Utah (USU Cooperative Extension, 2012). By implementing improved land management practices that increase soil carbon levels, rangelands can act as carbon sinks

(Lal et al., 2003; Schuman et al., 2002). Given that more than half of the U.S. rangelands and 21 percent of Utah rangelands are privately owned (Leydsman-McGinty, 2009; SRR, 2011), the management of private lands affects the overall potential for rangelands to sequester soil carbon (Conant et al., 2001; Derner and Schuman, 2007; Jones and - Donnelly, 2004).

Results from research on the effects of land management practices on soil carbon are varied and inconclusive (De Steiguer, 2008; Schuman et al., 2001). Although it may be uncertain how specific practices affect carbon sequestration, general practices that reduce soil erosion, increase forage production, increase drought-tolerant forage, and reduce invasive woody vegetation can significantly contribute to carbon management given the right environmental conditions (Derner and Schuman, 2007; Lal, 2001; Schuman et al., 2001). For example, overstocking and intensive grazing can lead to soil erosion, which has negative impacts on soil carbon. Thus, lowering stocking rates and utilization rates to maximize plant production can protect soil carbon by preventing land degradation and erosion (Lal, 2001). In fact, research has suggested that reduced stocking rates have the greatest effect on soil carbon levels compared to other management practices (Follett et al., 2001), such as inter-sowing grasses and legumes, fertilization, irrigation, and introducing earthworms (Conant et al., 2001; Lal, 1997, 2004; Ma et al., 2000).

The ability of rangelands to sequester carbon is also dependent upon environmental conditions. Climate and weather variation have been shown to be influential on whether rangelands act as carbon sources or sinks over time (Svejcar et al., 2008). In particular, drought can cause rangelands to be carbon sources while higher

precipitation levels can contribute to carbon sequestration. Knapp et al. (2002) reported that the timing of precipitation may be more important than the total annual amount of precipitation in terms of annual carbon fluctuations. The quality of soil, particularly the amount of soil organic matter, also has a direct influence on soil carbon (Bird et al., 2002). Jobbágy and Jackson (2000) found that the distribution of soil carbon is related to vegetation type. Gibbens et al. (1983) and Schuman et al. (2001) argued that increased shrub presence on rangelands may lead to overall carbon loss due to increased soil erosion across the landscape. Thus, it is important to take into account localized environmental conditions when exploring opportunities for sequestering carbon on private rangelands.

Mechanisms for promoting carbon sequestration on U.S. rangelands

Private or public policy mechanisms may be used to promote terrestrial carbon sequestration on private rangelands, including voluntary carbon markets, compliance carbon markets, government payments for meeting voluntary carbon sequestration goals, and modification of existing land conservation programs with carbon benefits. Among these mechanisms, carbon offset projects within voluntary (e.g., Chicago Climate Exchange) and compliance markets (i.e., cap and trade) have gained the most attention among researchers. A number of studies have been conducted to examine these market approaches and the economic aspects of selling or trading carbon credits (Bonnie et al., 2002; Campbell et al., 2004; De Steiguer, 2008; De Steiguer et al., 2008; Diaz et al., 2009; Ritten et al., 2012; Sandor et al., 2002). These studies generally concluded that carbon markets could be an effective way to mitigate CO₂ emissions and a viable option

for rangeland owners, particularly if carbon prices increase in the future. However, some technical and logistic difficulties need to be addressed.

The Chicago Climate Exchange (CCX) provided an example of the challenges facing a carbon market that included carbon sequestration activities on private rangelands. The CCX was a voluntary market that operated from 2003 until 2010 as a platform for industries to pay for carbon offsets, which included terrestrial carbon sequestration projects. The CCX created the first and, as of yet, only carbon offset protocol for rangelands in the U.S (Western Climate Initiative, 2010a). According to the protocol, landowners were required to sign contracts stating a five-year commitment to a set of required management practices (CCX, 2009), including developing and following a formal grazing plan that meets the Natural Resource Conservation Service (NRCS) standards, utilizing light to moderate stocking rates, and using rotational and seasonal use grazing. Documentation of the adopted management practices using photographs, stocking rate and grazing rotation records, and third party monitoring was mandatory.

The CCX protocol limited the geographic range of rangeland offset projects due to environmental factors. Because of Utah's climate and environmental conditions (mainly low precipitation), only nine of the 29 counties in Utah were eligible for rangeland carbon offset projects: Cache, Carbon, Daggett, Duchesne, Morgan, Rich, Summit, Utah, and Wasatch (CCX, 2009). This covered about 16% of the land area in the state. In addition to the geographic limitations imposed by the CCX, additionality, quantification, and permanence are also issues that complicate the inclusion of private rangelands in carbon markets. Additionality refers to the requirement that landowners must implement a new practice or change their current practices because offset projects

are defined as greenhouse gas reductions that are realized from a decision or practice designed specifically for that purpose (Bonnie et al., 2002; Western Climate Initiative, 2010b). This puts good land managers at a disadvantage because there is little more they can do to increase carbon storage by implementing additional measures (De Steiguer et al., 2008). A significant amount of carbon can remain sequestered through continued conservation practices, which may not meet the standard of additionality and be eligible for trading (Schuman et al., 2002). Monitoring and quantifying carbon levels in rangeland soils are also difficult and often expensive because rangelands cover a lot of ground and have high spatial and temporal variability (Bird et al., 2002; Brown et al., 2010; White, 2010). Fluctuations of soil carbon over time can cause problems with the permanence of terrestrial offset projects. Carbon sequestered in terrestrial ecosystems can be released back into the atmosphere after a change in management practices once a contract is over or simply from unexpected environmental conditions, such as drought.

In summary, the existing literature has identified several barriers to promoting carbon sequestration on private rangelands through various market mechanisms. Lacking is a comprehensive assessment of this market approach and other non-market mechanisms from the perspectives of private landowners. Understanding how they view and may act towards these mechanisms will help inform the improvement of existing programs and the development of future policy.

The role of environmental attitudes in carbon sequestration on private rangelands

Understanding private rangeland owners' attitudes towards carbon sequestration can lend insight into the likelihood they will engage in relevant management practices or

participate in a future program. Theoretically, attitudes are closely related to behavioral intentions, which are a precursor to an actual behavior (Fishbein and Ajzen, 2010; Stern, 2000). Various studies have supported the relationship between attitudes and intended behavior, particularly in the context of wildlife management and conservation (e.g., Vaske and Donnelly, 1999; Whittaker et al., 2001, 2006). A recent study explored Utah beef cattle producers' attitudes towards carbon sequestration and also found that their attitudes were associated with their self-reported likelihood of engaging in carbon sequestration activities (Ma and Coppock, 2012). Thus, a better understanding of landowners' attitudes is important for assessing the potential of carbon sequestration on private rangelands.

Environmental attitudes are built on a complex structure of core values, factual beliefs about the world, and cultural and social norms (Larson, 2010; Stern, 2000; Stern and Dietz, 1994). Core value can be defined as “an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite mode of conduct or end-state of existence” (Rokeach, 1973). Core values are abstract and underlie value orientations which are patterns of basic beliefs (Fulton et al., 1996; Homer and Kahle, 1988; Vaske and Donnelly, 1999). Environmental value orientations can be assessed by seeing how an individual views and compares the importance of the well-being of humans and of the environment – some individuals may have more “anthropocentric” value orientations and others may have more “biocentric” value orientations (Larson, 2010; Thompson and Barton, 1994). Previous research has used a single continuum, for example 1 to 10, from 1 being entirely anthropocentric to 10 being entirely biocentric, to examine the relationship between value orientations and attitudes

towards particular natural resource management actions (Shindler et al., 1993; Steel et al., 1994; Vaske and Donnelly, 1999; Vaske et al., 2001). Different from core values and value orientations, the beliefs that people have about the natural world encompass their knowledge and perceptions of how the natural world works (Heidmets and Raudsepp, 2001). Individuals may filter their beliefs through their value systems (Stern and Dietz, 1994). Leiserowitz (2006) provided an example of measuring beliefs by assessing how Americans perceived the risks of climate change in a nationwide survey, which led to a better understanding of their beliefs about the nature and processes of climate change. Finally, cultural and social norms refer to “standards that individuals use for evaluating behavior, activities, environments, or management proposals as good or bad, better or worse” (Shelby et al., 1996). Descriptive norms are one major type of norms which generates social expectations and people tend to conform to these norms in order to fit in (Minato et al., 2010). Norms can be measured by assessing what behaviors are appropriate under which circumstances and what course of action should or should not occur (Labovitz and Hagedorn, 1973). This approach has been used extensively in the recreation literature to determine encounter and impact norms (Shelby et al., 1996).

Generally speaking, core values, beliefs, and norms influence people’s attitudes towards an environmental action. Such attitudes can be positive or negative, and can also be measured by the importance people place on that particular action (Larson, 2010; Stern and Dietz, 1994; Whittaker et al., 2006). Furthermore, core values, beliefs and norms can influence people’s preferred policy options concerning environmental management (e.g., what types of climate change mitigation policies are acceptable) (Larson, 2010). An example was provided by Leiserowitz (2006), who conducted a

survey of the American public regarding climate change risk perceptions. The survey respondents who did not think the climate had changed and those who attributed the changing climate to natural causes were less likely to support adopting policies to mitigate climate change.

The majority of research concerning carbon sequestration on rangelands has focused on the biophysical effects of land management on soil carbon and market mechanisms for promoting carbon sequestration. Lacking is a comprehensive assessment of the human dimensions of carbon sequestration and how such an assessment may contribute to a better understanding of various policy opportunities (including both market and non-market mechanisms) for promoting relevant practices on private rangelands. Building upon previous research suggesting that people's values, value orientations, beliefs and norms influence their environmental attitudes, policy preference and behavior intention, this study focused on Utah rangeland owners and aimed at better understanding: 1) the relationship between their awareness of and attitudes towards carbon sequestration and their environmental value orientations, beliefs about climate change, and perceived norms about carbon sequestration; and 2) their perceptions of potential policy options for promoting carbon sequestration on private rangelands.

Several hypotheses were tested. First, more awareness of carbon sequestration was expected among younger, more educated individuals and among those who were dependent on on-ranch income or already participants of government conservation programs. Due to the technical nature of the subject, younger, more educated individuals may have received more information from school curricula and the media. Individuals relying on on-ranch income may be proactive in learning ways to diversify their income

from on-ranch activities and thus may have more awareness of carbon sequestration. Those involved in government conservation programs may have heard about carbon sequestration through their interactions with extension or outreach personnel.

Second, individuals who thought the climate had changed and had a stronger belief that human activities influence climate change were expected to be more aware of carbon sequestration, have more positive attitudes towards it, and have a higher likelihood to participate in a carbon sequestration program. Carbon sequestration has been considered a viable strategy to mitigate climate change. As previously discussed, the beliefs an individual holds towards the natural world (in this case climate change) are expected to, in part, influence the individual's attitude towards a relevant environmental action (in this case carbon sequestration), which may in turn influence the behavioral intention of that individual (in this case his/her likelihood to participate in a carbon sequestration program).

Finally, individuals with stronger "biocentric" environmental value orientations, recognizing the climate had changed, and having a stronger belief that human activities influence the climate were expected to be more open to various policy options to promote carbon sequestration on private rangelands (Larson, 2010).

Methods

The data for this study were gathered in two phases. The first phase consisted of qualitative key informant interviews, completed in the summer of 2011. Results from this qualitative phase were used to inform the development of the quantitative phase, a statewide mail/phone survey. Both the interview and survey instruments were approved

by the Utah State University (USU) Institutional Review Board to ensure that this research does not put participants at risk.

Interviews

One-on-one, key informant interviews were conducted with seven range and natural resource professionals and eight rangeland owners using a pre-determined interview guide (Patton, 1990). The professionals interviewed included NRCS range specialists, USU range extension specialists, county extension agents, and range specialists from the Utah Department of Agriculture and Food. They were identified by searching federal and state agency websites and talking to other researchers who worked on rangeland management issues at USU. The rangeland owners interviewed were chosen based on recommendations from range professionals and researchers at USU, the professionals interviewed, and other rangeland owners. The interviews were conducted during the summer months which were a busy time for rangeland owners who raise livestock and led to difficulty in scheduling interviews. Although consideration was given to spreading the rangeland owner interviews across different counties in Utah, all who were willing to take the time were included and they were from five counties in northern Utah: Cache, Box Elder, Rich, Uintah, and Tooele. Interviews of these northern Utah rangeland owners were very informative due to the higher precipitation of that part of the state and better ecological potential for carbon sequestration.

For both the professional and rangeland owner interviews, open-ended questions were asked concerning factors influencing rangeland owner decision making with respect to determining stocking rates, implementing grazing systems, making structural

improvements, and managing invasive species. Questions were also asked with respect to their general views towards government conservation programs and their specific reactions to a government approach versus a market approach to carbon sequestration. These general questions were important for understanding the technical and attitudinal potential of range landowners to adopt carbon sequestration practices. More specifically, stocking rates and grazing systems were part of the CCX protocol and have been shown to influence soil carbon on rangelands; structural improvements such as fencing or watering sources, allow for better grazing management and control over livestock; managing invasive species, particularly woody shrubs, can alter vegetation structure and influence soil carbon; and rangeland owners' views on existing government conservation programs may reflect their preferences for or aversion to various policy mechanisms that can be used to promote carbon sequestration in the future. The protocols for the rangeland owner and professional interviews can be found in Appendix A and Appendix B, respectively.

Survey

The second phase of data collection was a statewide mail/phone survey. The sampling frame included all known farmers and ranchers in Utah who owned private grazing land and some kind of livestock (e.g., cattle, sheep, horse, llama, alpaca). The survey was administered with the assistance of the Utah Field Office of the USDA National Agricultural Statistics Service (NASS) in January and February of 2012, by using a modified total design method (Dillman et al., 2009). A questionnaire with a cover letter was mailed to each rangeland owner. In the cover letter, each rangeland

owner was offered a five-dollar gift card to the Intermountain Farmers Association (IFA) stores if they would complete and return the survey questionnaire. Additional follow-up phone calls were made after two weeks to contact rangeland owners who had not responded through mail in order to achieve a target response rate of 70%.

The survey questionnaire was designed to take about 30 minutes to complete. All questions were pre-tested and revised with the help of NASS. The survey protocol can be found in Appendix C. A simple random sample of 1,000 Utah rangeland owners was drawn from a database maintained by NASS. This database contains the owners of all known farms and ranches in Utah, defined as any operation that has at least \$1,000 of agricultural sales in a normal year. Of the 1,000 initial individuals contacted, 282 were screened out by the previously mentioned target population parameters (i.e., owning private rangeland in Utah and some kind of livestock) and 120 had inaccurate or unreachable addresses or phone numbers, reducing the actual sample size to 598. Among these 598 rangeland owners, 37 refused to complete the survey, 126 did not respond, and 435 completed the survey questionnaire either via mail or on the phone, representing a response rate of 73%. Of those 37 who refused to complete the survey, many were known by NASS to chronically refuse to participate in any survey.

Information collected from the survey included demographics; general management practices and trends concerning grazing, stocking rates, and woody shrub management; involvement in conservation programs; factors contributing to rangeland management decision making; information sources used for land management; environmental value orientations; beliefs about climate change; awareness of and attitudes towards carbon sequestration; and perceptions of various policy mechanisms for

promoting carbon sequestration. One question was used to characterize respondents' environmental value orientations on a 10-point scale, from 1 being entirely "anthropocentric" to 10 being entirely "biocentric," as defined in Morton et al. (2010). To measure beliefs about climate change, respondents were asked whether they thought the climate had been changing over the last 30 years. Those who responded "yes" were then asked their perceived level of human influence on the climate. Possible responses were on a 4-point Likert scale ranging from "no influence" to "strong influence." Respondents were also asked to report any general trends in weather events they had observed over the past 30 years (e.g., precipitation, temperature, drought). All questions about carbon sequestration were prefaced with a one-sentence definition in lay terms, stating that "Carbon sequestration is the removal of carbon dioxide from the air and storing it in plants and soils through natural processes." Respondents were asked to report their level of awareness with respect to carbon sequestration on a 4-point scale, from 1 being "not aware" to 4 being "very aware." They were then asked to report their general attitude towards carbon sequestration on a four-point scale, from 1 being "very negative" to 4 being "very positive." Additional questions were asked about the importance they placed on carbon sequestration as a management objective (on a four-point scale, from 1 being "not important" to 4 being "very important") and whether they were interested in learning more about carbon sequestration (binary responses).

To assess respondents' policy preferences, they were asked a series of questions concerning the importance they placed on various potential benefits of participating in a carbon sequestration program, how appealing various potential program characteristics/attributes were to them, and their aversion to a number of potential policy

strategies and entities for promoting carbon sequestration. Fourteen items were used to represent potential benefits documented in the literature and/or mentioned by rangeland owners and professionals interviewed in this study. Six items were used to represent program characteristics/attributes discussed in the literature and/or used in previous/current carbon sequestration programs (e.g., CCX). Of the items concerning potential policy strategies, three were education and outreach oriented and three were incentive oriented, including government payments or subsidies, a voluntary market approach, and a compliance market approach. Four items were used to assess respondents' preference with respect to the types of entities administering a carbon sequestration program: a private farmer or rancher entity (e.g., Farm Bureau), a private non-profit or conservation organization, a state-level government agency, or a federal government agency.

Statistical analyses

Univariate descriptive statistics were computed for all variables to assess their distributions and determine if any outliers existed. Bivariate relationships were examined using ANOVA and Pearson chi-square tests. ANOVA was used to determine the associations between continuous and categorical variables, while chi-square tests were used to determine the associations among categorical variables. These statistical analyses were used to understand the relationships between individuals' environmental values, beliefs about climate change, perceived social norms with respect to carbon sequestration, and their attitudes towards carbon sequestration and behavioral intention to engage in relevant activities. The software package used for the statistical analyses was

Stata 12.0.

Results

Profile of private rangeland owners in Utah

All 29 counties in Utah were represented by the survey respondents. The average age of respondents was 61 years (SD=12.2; Min=18; Max=94) and on average, respondents had 15 years of formal education (SD=2.9; Min=5; Max=28). Thirty-nine percent of respondents reported an annual income of less than \$50,000 and on average, 25% of the reported annual income was from on-ranch sources. The amount of grazing land owned in Utah varied widely with an average of 458 acres (SD=1,330; Min=1; Max=15,000), of which an average of 90% was used for grazing livestock (SD=21; Min=4; Max=100). Eighteen percent of respondents had a public grazing permit. Eleven percent had a written grazing management plan and 27% had participated in a government conservation program administered by a state or federal entity.

Beliefs and observations about climate change

Sixty-four percent of respondents thought that in general the climate had been changing over the last 30 years, although 16% of these respondents thought that human activities had no influence on the climate. Fig. 2-1 shows the perceived changes in precipitation (spring/summer rainfall and winter snowfall) and temperature (average annual temperature, summer temperature, winter temperature) over the last 30 years in the county where respondents resided. The majority of respondents perceived no change in precipitation and temperature. However, among those who perceived change, the

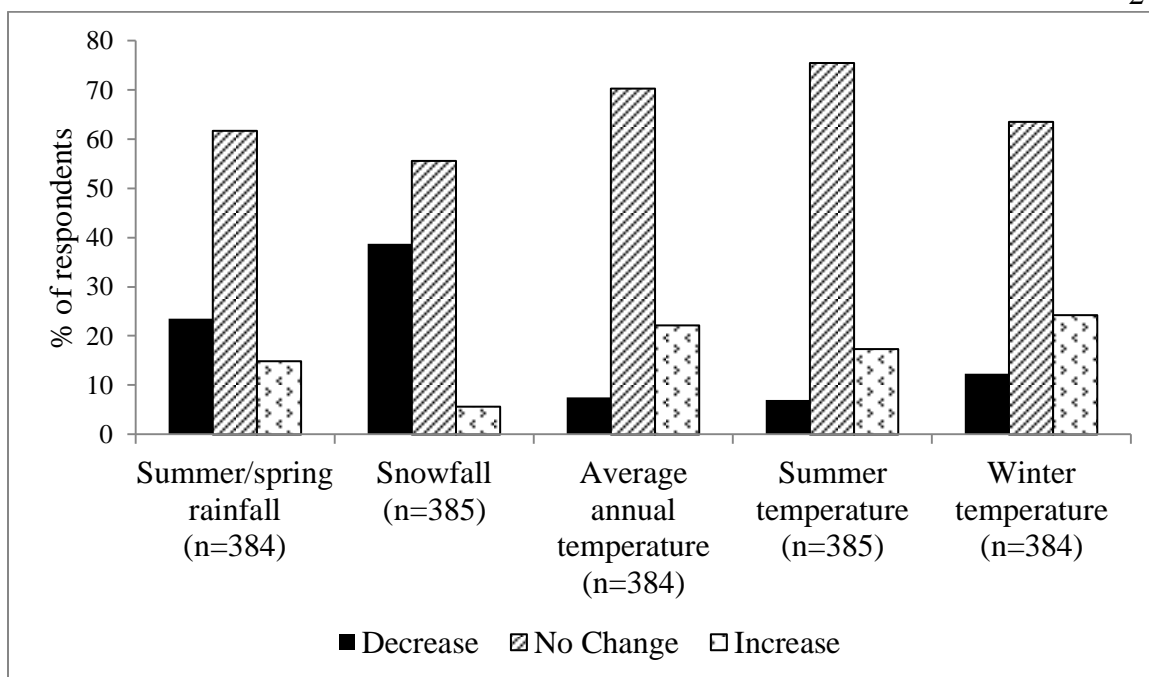


Fig. 2-1. Climate change perceptions of Utah rangeland owner respondents with respect to spring/summer rainfall, snowfall, average annual temperature, summer temperature, and winter temperature in the county they resided over the last 30 years.

majority reported a decrease in precipitation and an increase in temperature. With respect to drought, the majority of respondents perceived no change in the frequency and severity of drought, as well as the length of each drought, over the last 30 years in the county where they resided (Fig. 2-2). However, among those who perceived change, more reported an increase in the frequency, severity, and length of drought than those who reported otherwise. Perceived changes in local weather patterns did not always match up with general climate change beliefs. Ten percent of respondents who reported that they thought the climate had been changing did not perceive changes in any of the aforementioned weather events, while 56% of respondents who reported that they did not think the climate had been changing did perceive changes in at least one of the weather events.

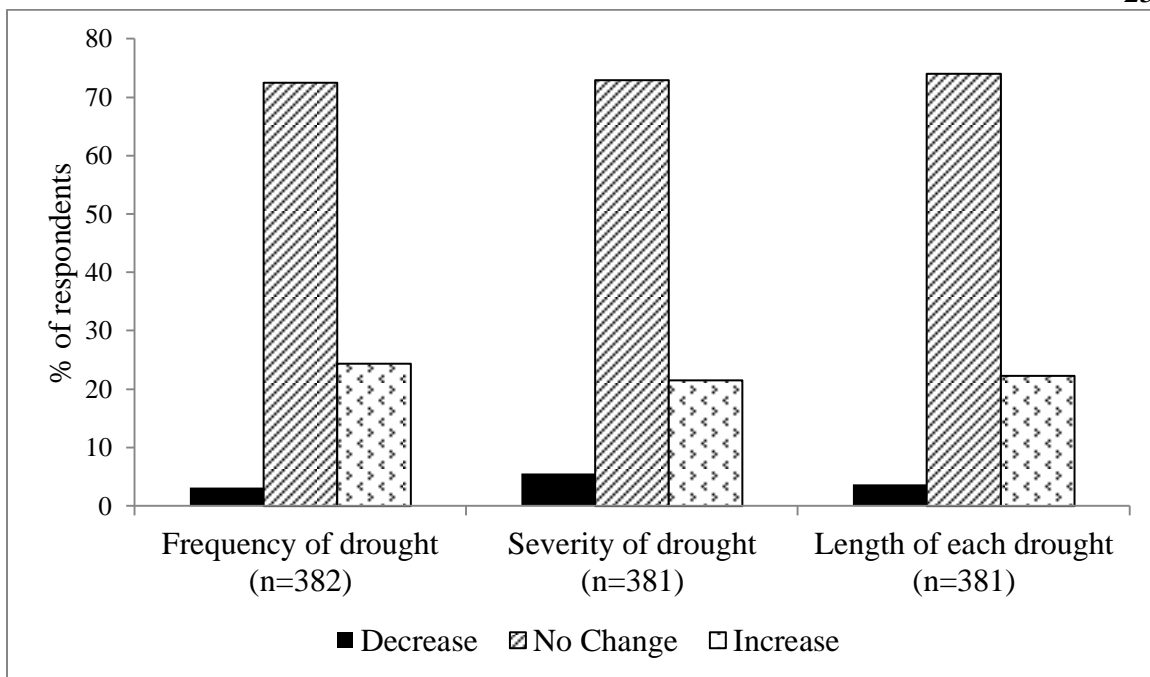


Fig. 2-2. Climate change perceptions of Utah rangeland owner respondents with respect to the frequency of drought, the severity of drought, and the length of each drought in the county they resided in over the last 30 years.

Awareness, attitudes, and likelihood to engage in carbon sequestration

Over two-thirds of respondents reported some level of awareness of carbon sequestration and a positive attitude towards it (Fig. 2-3; Fig. 2-4). Over half were interested in learning more about it and 63% of 161 respondents thought that other rangeland owners in their community would be interested in learning about it. Forty-one percent reported that carbon sequestration was moderately or very important to them as a management objective based on their current understanding of the concept. When being asked about the likelihood that they would participate in a carbon sequestration program in the future, 37% of respondents reported somewhat or very likely.

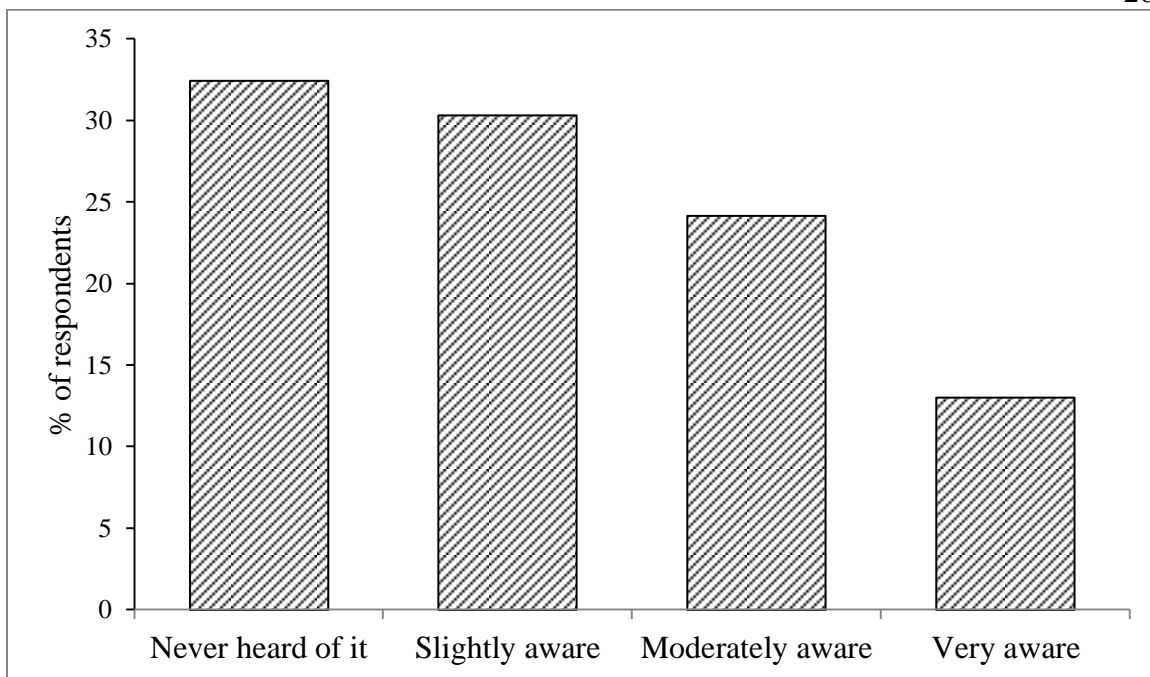


Fig. 2-3. Utah rangeland owner respondents' self-reported awareness of carbon sequestration (n=422).

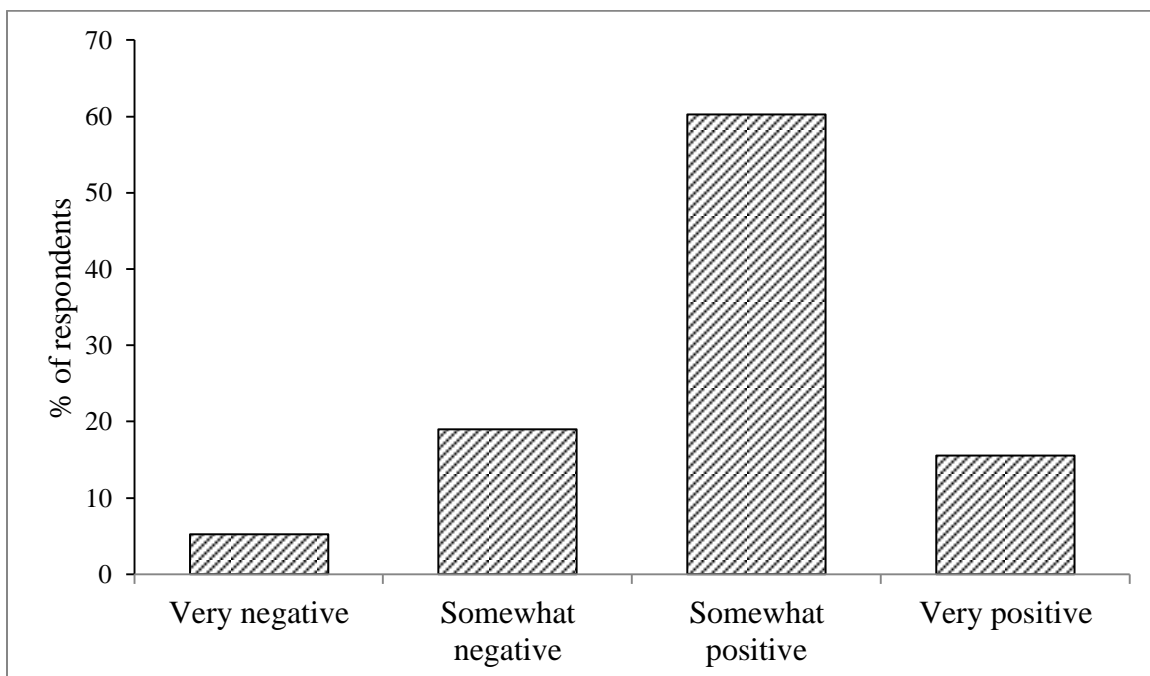


Fig. 2-4. Utah rangeland owner respondents' general attitudes towards carbon sequestration (n=405).

Self-reported awareness of carbon sequestration was positively associated with education level ($F=7.12$, $p<0.01$), income ($\chi^2=26.44$, $p=0.03$), percent of income from on-ranch sources ($F=3.70$, $p=0.01$), and having an interest in learning more about the concept ($\chi^2=9.83$, $p=0.02$). It was not, however, associated with age ($F=0.55$, $p=0.65$) or prior participation in government conservation programs ($\chi^2=0.69$, $p=0.88$). Positive attitudes towards carbon sequestration and higher importance placed on it as a management objective were significantly associated ($\chi^2=219.83$, $p<0.01$), and both were also associated with higher self-reported awareness ($\chi^2=76.79$, $p<0.01$ and $\chi^2=75.83$, $p<0.01$, respectively). Finally, respondents who were more aware of carbon sequestration ($\chi^2=12.34$, $p<0.01$), had a more positive attitude towards it ($\chi^2=59.29$, $p<0.01$), and placed a higher importance on it as a management objective ($\chi^2=83.40$, $p<0.01$) were more likely to participate in a carbon sequestration program in the future.

The relationships between values, beliefs, attitudes, and intentions to act

Generally speaking, respondents with more “biocentric” environmental value orientations were more likely to think that the climate had been changing over the last 30 years ($F=7.23$, $p<0.01$) and to believe that human activities had some level of influence on the climate ($F=17.86$, $p<0.01$). In addition, those with more “biocentric” value orientations tended to have more positive attitudes towards carbon sequestration ($F=11.30$, $p<0.01$) and to place more importance on it as a management objective ($F=3.46$, $p=0.02$). They were also more likely to be interested in learning more about carbon sequestration ($F=7.26$, $p<0.01$) and tended to report a higher likelihood of engaging in a future carbon sequestration program ($F=5.26$, $p<0.01$). Bivariate

relationships were observed between respondents' beliefs about climate change and their attitudes towards carbon sequestration. Those who thought the climate had been changing over the last 30 years tended to have a more positive attitude towards carbon sequestration ($\chi^2=23.15, p<0.01$) and to place a higher importance on it as a management objective ($\chi^2=12.10, p<0.01$). In particular, respondents who perceived a stronger human influence on the climate felt more positive about carbon sequestration ($\chi^2=41.99, p<0.01$). In addition, respondents who thought that others in their community would be interested in learning more about carbon sequestration were more likely to have a positive attitude towards it ($\chi^2=51.07, p<.01$). Finally, those who viewed carbon sequestration positively and who considered it an important management objective were more likely to be interested in learning more about it ($\chi^2=52.31, p<0.01$ and $\chi^2=31.66, p<0.01$, respectively) and to participate in a relevant program in the future ($\chi^2=59.29, p<0.01$ and $\chi^2=83.40, p<0.01$, respectively).

Policy preferences for carbon sequestration

Of the 14 items representing the potential benefits of carbon sequestration, the ecological benefits were generally perceived as the most important (Fig. 2-5). These ecological benefits included improved forage quantity and quality, increased drought resistance, improved soil quality, increased water storage and filtration, restoration of degraded rangeland, implementing environmentally sound management practices, and improved wildlife habitat. Over three quarters of respondents considered these ecological benefits “moderately important” or “very important.” In contrast, fewer respondents considered the economic and climate change mitigation benefits important. More

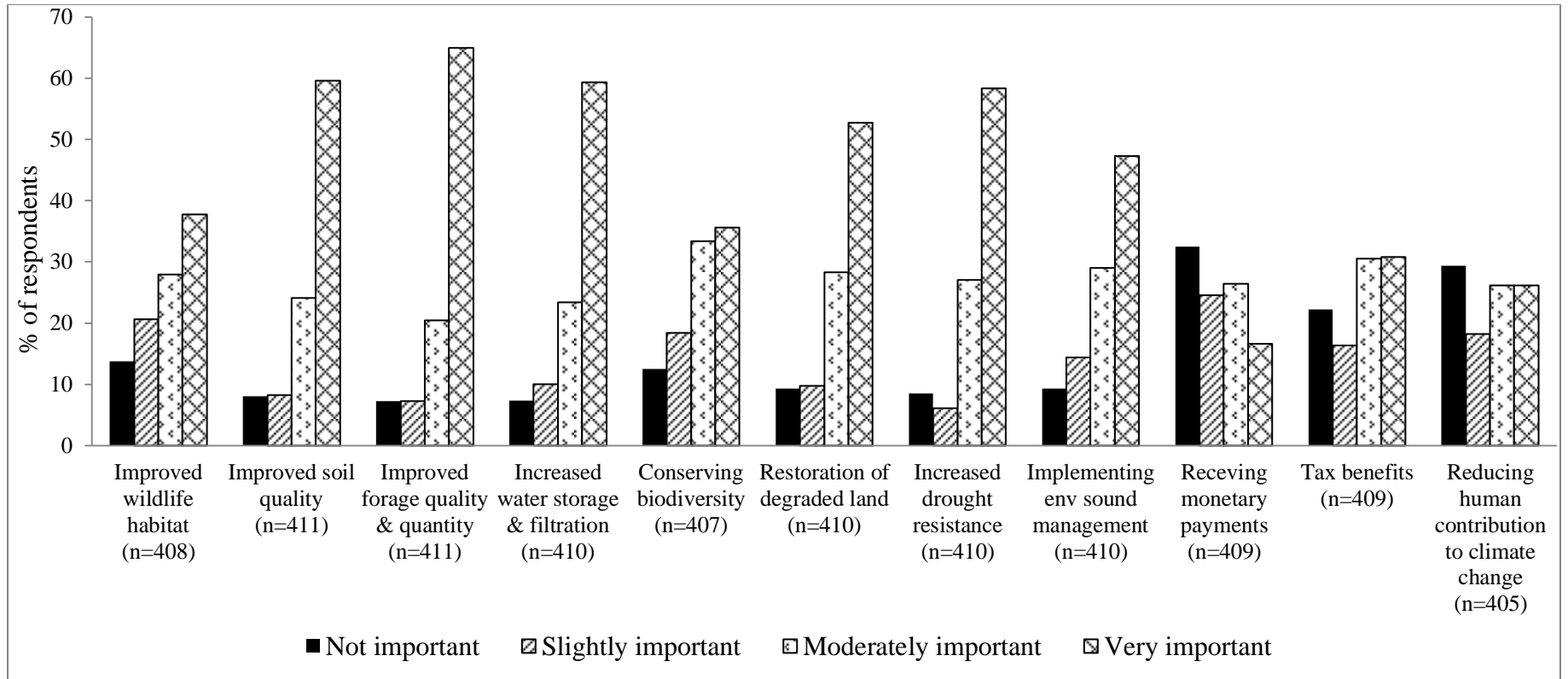


Fig. 2-5. The level of importance Utah rangeland owner respondents placed on the potential benefits of participating in a carbon sequestration program.

specifically, 61% of respondents considered tax benefits “moderately important” or “very important” and 43% valued receiving income/monetary payments from carbon sequestration. Only half of respondents considered reducing human contribution to climate change an important benefit of participating in a carbon sequestration program.

With respect to the six potential policy strategies for promoting carbon sequestration, respondents seemed to prefer educational programs over incentive programs (Fig. 2-6). More specifically, about three quarters of respondents found the following three ideas to be at least “slightly appealing:” increased education and outreach

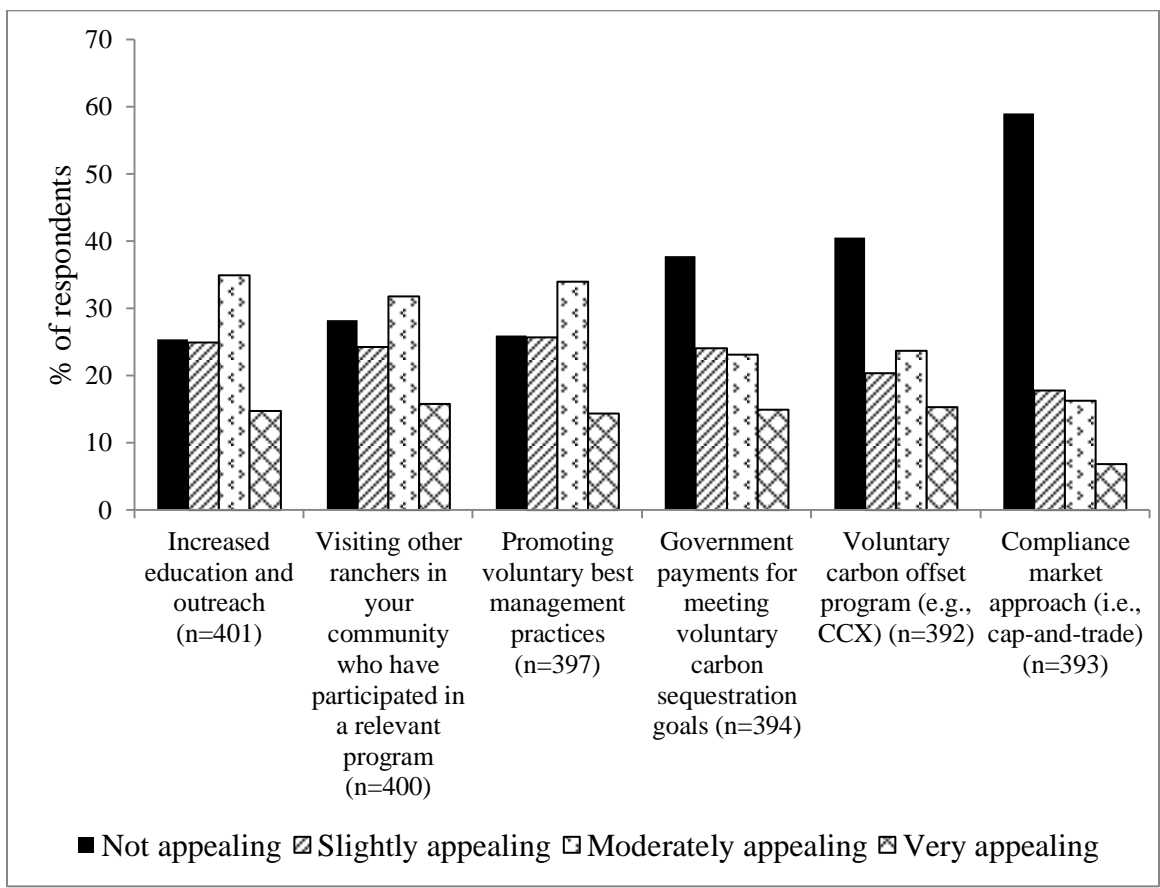


Fig. 2-6. Utah rangeland owner respondents reporting the level of appeal of various policy strategies for promoting carbon sequestration on private rangelands.

efforts regarding carbon sequestration, visiting other ranchers in their community who have participated in a carbon sequestration program, and promoting voluntary best management practices to increase carbon sequestration. In contrast, about 40% of respondents found government payments for meeting voluntary carbon sequestration goals and a voluntary carbon offset program (e.g., CCX) not appealing at all. The compliance market approach (i.e., a cap-and-trade program) was the least favorable among respondents, as nearly 70% considered it not appealing at all. Regardless of the type of potential carbon sequestration programs, 41% of respondents did not want to be one of the first few from their community to participate in any program.

With respect to program characteristics/attributes, the majority of respondents viewed all six potential requirements as barriers that would make them not at all or less interested in participating in a carbon sequestration program (Fig. 2-7). More specifically, being required to meet compliance or contract requirements was the least desirable attribute and over 80% of respondents considered it to be a barrier to participation. Interestingly, the most desirable attributes were having a private party or government agency annually measure soil carbon on their land and carbon emissions from their operation. Nearly 40% of respondents did not view these two requirements as barriers at all.

Finally, with respect to the types of entities administering a carbon sequestration program, respondents reported preference to work with a private agricultural entity, such as the Farm Bureau or Utah Cattlemen's Association over a non-profit conservation organization or a government agency (Fig. 2-8). In particular, government agencies were viewed as the least favorable. Between state and federal agencies, a state agency, such as

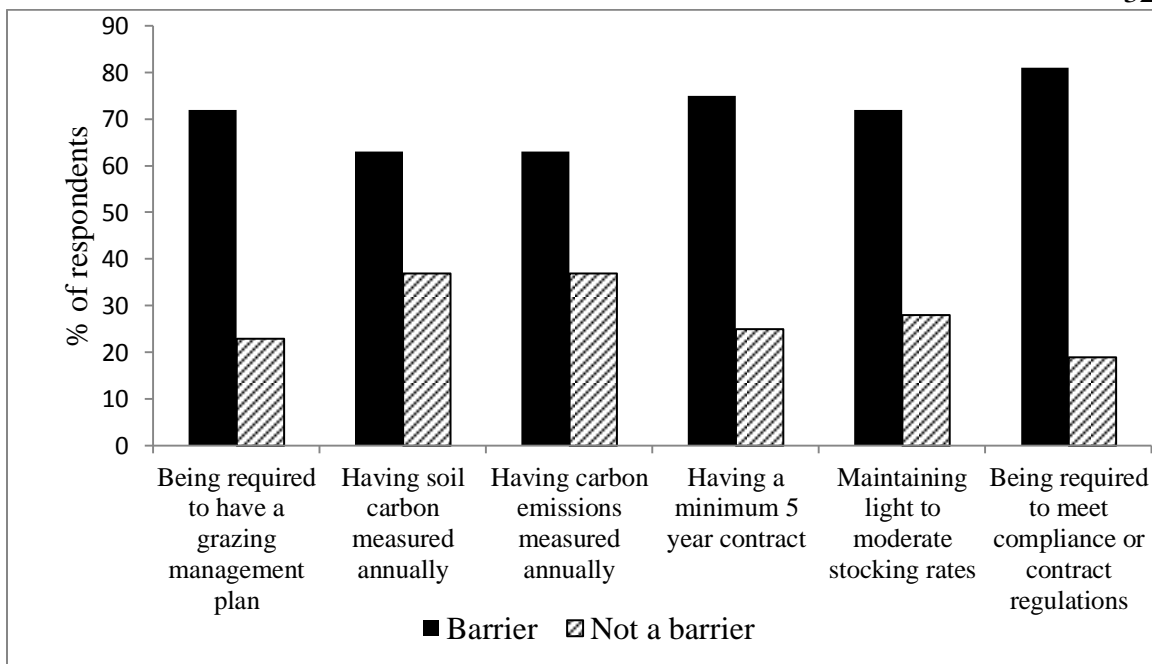


Fig. 2-7. Utah rangeland owner respondents reporting barriers that would make them not interested or less interested in participating in a carbon sequestration program (n=402).

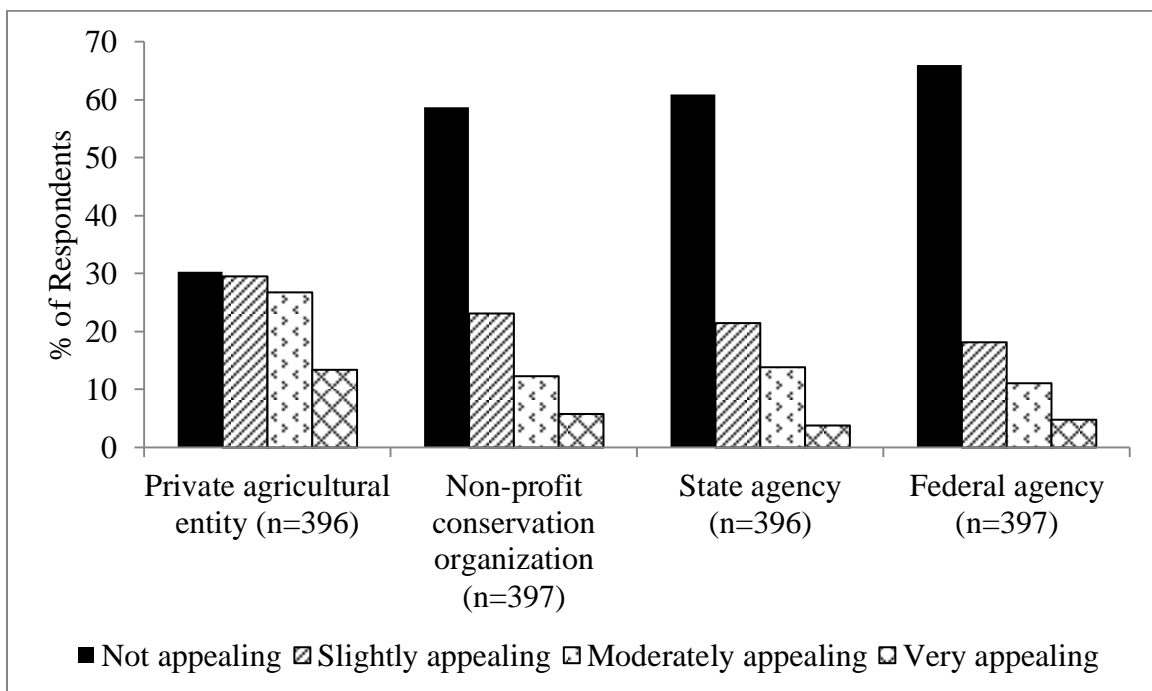


Fig. 2-8. Utah rangeland owner respondents reporting the level of appeal of various types of entities that may administer a program for promoting carbon sequestration on private rangelands.

the Utah Department of Agriculture and Food or Utah Department of Natural Resources was considered slightly more appealing to respondents.

Several relationships were observed between respondents' policy preferences and their environmental value orientations, beliefs about climate change, and attitudes towards carbon sequestration. Those who thought that the climate had been changing over the last 30 years were more likely to consider reducing human contribution to climate change an important benefit of participating in a carbon sequestration program ($\chi^2=26.46, p<0.01$). In particular, those who perceived a stronger influence of human activities on the climate were more likely to value this benefit ($\chi^2=79.24, p<0.01$).

In addition, these "climate change believers" tended to be more open to various policy strategies and to working with different entities to promote carbon sequestration. For example, respondents who perceived a stronger influence of human activities on the climate were more likely to find both education and outreach programs ($\chi^2=29.30, p<0.01$) and the compliance market approach ($\chi^2=17.78, p=0.04$) appealing. Those who thought the climate had been changing over the last 30 years were more willing to work with state ($\chi^2=9.32, p=0.03$) and federal agencies ($\chi^2=10.26, p=0.02$) to promote carbon sequestration. Furthermore, those who perceived a stronger influence of human activities on the climate were more willing to work with a non-profit conservation organization ($\chi^2=23.23, p<0.01$) than those who did not believe the anthropogenic nature of climate change. Finally, respondents with positive attitudes toward carbon sequestration tended to find each of the six potential policy strategies more appealing than those with negative attitudes. They also tended to be more open to working with the four types of entities presented to them as potential administrators of a carbon sequestration program.

Discussion

The demographic and rangeland ownership information obtained generally agrees with previous survey results in Utah (Brunson and Huntsinger, 2008; Coppock and Birkenfeld, 1999; Ma and Coppock, 2012) with two exceptions. Fewer individuals in this study had a public grazing permit or had participated in a government-sponsored conservation program. In addition, they tended to be less dependent on on-ranch income than participants of previous studies. This may be explained by the slight difference in the population of interest between this study and previous studies. Previous studies have focused on beef cattle producers, who are likely to be more business-oriented, while this study focused on a broader population of private rangeland owners, who may or may not have a cattle operation.

The literature has suggested the interconnectedness between individuals' environmental values, beliefs about the natural world, cultural and social norms, and their attitudes towards environmental actions (Larson, 2010; Vaske and Donnelly, 1999). This study further explored this interconnectedness in the context of climate change and carbon sequestration. More specifically, the study results show that having "biocentric" environmental values, holding a strong belief about climate change and its anthropocentric nature, and perceiving an interest in carbon sequestration among other community members were all statistically significantly associated with having positive attitudes towards carbon sequestration as a strategy to mitigate climate change. The study results also provide supporting evidence for the suggested relationship between attitudes and behavioral intentions (Fishbein and Ajzen, 2010; Stern, 2000). More positive attitudes towards carbon sequestration and higher importance placed on it as a

management objective were both statistically significantly associated with respondents' interests in learning about it and a higher likelihood to participate in a relevant program.

One puzzling finding is that the majority of respondents thought that in general the climate had been changing over the last 30 years, yet some of them did not perceive any change in precipitation, temperature, and the frequency, severity, and length of drought over the same time period in the county where they resided. On the other hand, some respondents who did not think the climate had been changing in fact reported changes in local weather patterns. Two potential explanations may help understand this disconnect. First, respondents may have been influenced by outside opinions rather than their own experience within their county. Climate change has been widely discussed by various media, which may have led to respondents' overall assessment of the climate. Second, respondents may have relied on weather indicators other than the ones presented to them in the survey when assessing the general trend of climate change. For instance, farmers in South Africa have noticed changes in the timing of rainy season as a sign of climate change (Thomas et al., 2007) and farmers in Mali reported changes of rainy season for rice production and more temperature and precipitation variability within a year (Ebi et al., 2011).

This observed disconnect begs further research. A number of studies in developing countries have suggested that agricultural producers perceive climate change and their experiences generally correlate well with actual climate data. For instance, farmers in Northwest China generally perceived climate change and reported that temperatures and drought conditions had increased since the early 1980s, which corresponded with local weather station data (Ostwald and Chen, 2006). In Mexico,

Zoque farmers also perceived climate change in the form of higher temperatures and decreased rainfall in autumn and winter for the previous 10-, 20-, and 30-year periods, which were consistent with changes documented by local weather station (Sanchez-Cortes and Chavero, 2011). However, little work has been done to compare public perceptions of general climate trends and specific weather patterns with actual climate data in the U.S. Thus, further research is needed to better understand how rangeland owners in the U.S. are different from agricultural producers in developing countries, why their perceptions of general climate trends and specific weather patterns do not correlate, and what factors contribute to their assessment of climate change.

The study result shows a generally positive attitude towards carbon sequestration among Utah rangeland owners, differing from what was found in a recent study by Ma and Coppock (2012) suggesting the majority of Utah beef cattle producers had negative attitudes towards carbon sequestration. This may be due to the slight difference in the population of interest between these two studies, as this study focused private rangeland owners and Ma and Coppock (2012) focused on beef cattle producers. Although these two populations of interest overlap to a certain extent, some private rangeland owners may not own a cattle operation, may be less business-oriented, and may be more open to various ideas that are not directly related to livestock production. In addition, the study results show a positive relationship between higher levels of awareness of carbon sequestration and more positive attitudes towards it, while Ma and Coppock (2012) identified a disconnect between awareness and attitudes. As suggested by Ma and Coppock (2012), the disconnect they observed may be due to the fact that the self-reported knowledge may not reflect actual knowledge. This means that respondents in

that study were assessing their awareness and attitudes based on their own definition of carbon sequestration, which may or may not be accurate, and those who reported more knowledgeable may have less actual understanding of the concept. In contrast, this study prefaced all questions about carbon sequestration with a one-sentence definition in lay terms, contributing to a better assessment of respondents' actual awareness and attitudes.

Carbon sequestration has been applied to addressing climate change because of its ability to reduce atmospheric CO₂. In this study, awareness and attitudes were reported based on the definition provided which describes the natural process of carbon sequestration without framing it as a climate change mitigation strategy. This definition may have contributed to depoliticizing the concept, which may also help explain why respondents in this study had more positive attitudes than the beef cattle producers in Ma and Coppock's (2012) study. In fact, among respondents with positive attitudes towards carbon sequestration, only half considered reducing human contribution to climate change a moderately or very important potential benefit of participating in a carbon sequestration program.

Another important finding is that the survey respondents preferred educational programs over monetary incentive programs. At the same time the majority of them considered the financial benefits of participating in a carbon sequestration program important. This may relate to Utah rangeland owners' general distrust of government (Coppock and Birkenfeld, 1999), which can be inculcated from rural conservatism and other value systems that underpin the "independent mentality" of ranching culture (Grigsby, 1980). More specifically, rangeland owners may value financial benefits, but still be wary about participating in a monetary incentive program, which often requires

compliance with government stipulations, such as signing a fixed-term contract or preparing a grazing management plan in order to receive the financial benefits. In comparison, educational programs are generally less intrusive and more voluntary-based.

Government agencies, particularly federal agencies, were seen as the least appealing entities for administering a carbon sequestration program; while the most preferred entities among the study participants were private agricultural organizations. These results are similar to findings in Elmore et al. (2007) where agricultural producers in southwestern Utah were more willing to work with the Farm Bureau or USU Extension than state or federal agencies or private conservation organizations concerning conflicts surrounding Utah prairie dog (an endangered species) on private lands. This kind of general preference presents a challenge for developing future carbon sequestration programs. In fact, many private agricultural organizations may not have the interest or ability to develop and implement a carbon sequestration program. However, because their involvement could potentially increase rangeland owners' trust in the program, some form of cooperation between government agencies and private agricultural organizations might be ideal for promoting conservation and environmental sustainability (Keough and Blahna, 2006; Wondolleck and Yaffee, 2000). One successful example of such cooperation is the Malpai Borderlands Group in Southeast Arizona and Southwest New Mexico, a partnership between private, public and non-profit sectors, whose mission is to protect land, promote innovative cooperative land management, support habitat restoration, and serve as a leader in public outreach (Curtin, 2002; Keough and Blahna, 2006; MBG, 2012; Sayre, 2005; Wondolleck and Yaffee, 2000). With respect to developing a carbon sequestration program, one possible strategy is for a government

agency to offer grants or financial incentives to a private agricultural organization so that they can work collaboratively and the private entity can serve as the marketer and administrator of the program.

Establishing carbon sequestration programs can be costly. It may be more efficient to put limited resources into existing conservation programs that have the potential to contribute to carbon sequestration on rangelands. Relevant programs at the federal level include but are not limited to the Conservation Innovation Grants (CIG) program, the Conservation of Private Grazing Lands (CPGL) initiative, the Conservation Reserve Program (CRP), the Conservation Stewardship Program (CSP), and the Environmental Quality Incentives Program (EQIP). Relevant programs at the state level include but are not limited to the Agriculture Resource Development Loans (ARDL) program and the Utah Grazing Improvement Program (UGIP). In fact, research has shown increases in carbon storage on land enrolled in the CRP (Gebhart et al., 1994; NRCS, 2003, 2010; Schuman et al., 2002). The NRCS has also published fact sheets acknowledging the carbon benefits associated with the CPGL initiative and the CIG program. Examples of strategies for promoting carbon sequestration through existing programs include providing additional financial incentives to participants of UGIP to encourage adoption of carbon-oriented management practices or reducing the length of CRP contracts among participants who can demonstrate carbon benefits. Such arrangements may attract additional participants, thus benefiting existing conservation programs.

This study also sheds light on the potential characteristics/attributes of carbon sequestration programs that deserve attention in future policy development. Several

requirements that were part of the CCX rangeland management protocol and are still part of many existing rangeland conservation programs were viewed as barriers to participation in a carbon sequestration program by the majority of respondents. More specifically, respondents did not like restrictive policies (e.g., having a management plan, maintaining light to moderate stocking rates, signing a contract, complying with contract requirements). In fact, only about a quarter of respondents had previously participated in a government-sponsored conservation program and only 11% had developed a grazing management plan. This poses challenges for developing policies and programs that are acceptable by rangeland owners but still effective for promoting carbon sequestration. Policy innovations are needed so that future programs can be flexible enough to encourage participation but still provide sufficient oversight and have enough teeth to ensure protocols are being followed and the benefits of carbon sequestration are being produced. The aforementioned barriers and need for policy innovation may also be relevant to rangeland owners' involvement in conservation programs in general.

Finally, respondents seemed to value the ecological benefits of carbon sequestration more than the economic or climate change benefits. This was observed among both respondents who reported likely to participate in a carbon sequestration program and those who reported unlikely. Although changing people's underlying beliefs about climate change could influence their attitudes towards carbon sequestration and make them more likely to support a relevant program, it is often very different to reverse people's values and beliefs. To garner support among those who were not interested in carbon sequestration, one strategy may be to promote the ecological benefits of carbon sequestration, such as improved soil quality, water retention, and forage

quality. In addition, outreach messages need to be tailored to reflect rangeland owners' management objectives, instead of marketing carbon sequestration as a climate change mitigation strategy.

Conclusion

Terrestrial carbon sequestration on private rangelands has important implications for mitigating climate change. Environmental values, beliefs about climate change, and perceptions of community norm all affected how Utah rangeland owners viewed carbon sequestration and their intentions to take relevant actions. Generally speaking, Utah rangeland owners seemed to be aware of carbon sequestration and have generally positive attitudes towards it, although relatively few showed interest in participating in a future program based on their current understanding of the issue. This suggests potential challenges for developing technically sound and socially acceptable policies and programs for promoting carbon sequestration on rangelands. One possible strategy is to emphasize the broad range of ecological benefits associated with sequestering carbon thereby increasing interest among rangeland owners with ecologically oriented management objectives. Another potential strategy is to enhance the cooperation between private ranching organizations and government agencies, which has been documented as a successful approach for achieving conservation. A third strategy may be to pool the resources for promoting carbon sequestration and put them into existing rangeland conservation programs that may produce carbon benefits.

As climate change becomes more challenging over time, the interest in mitigating climate change through improved rangeland management will likely grow. More

research is needed to further examine private rangeland owners' perceptions of climate change, attitudes towards carbon sequestrations, and willingness to take actions. It is also important to recognize that rangeland owners in the U.S. have their own characteristics and ways of operating, which may be different from agriculturalists and landowners elsewhere, particularly in developing countries. Understanding the human dimensions of carbon sequestration on rangelands is necessary for developing sensible and effective policies and programs in the U.S. and beyond.

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CHAPTER 3

POTENTIAL ENGAGEMENT OF UTAH RANGELAND OWNERS IN CARBON
SEQUESTRATION ACTIVITIES²**Abstract**

The management of private rangelands is important to the overall potential of terrestrial carbon sequestration in the U.S. Previous research has focused on the adoption of innovative range management and conservation practices, but little is known about rangeland owner decision making with respect to carbon sequestration. This study examined Utah rangeland owners' current management practices in relation to soil carbon management and explored factors influencing their likelihood of participating in a carbon sequestration program. Data were collected from a statewide survey of Utah rangeland owners to assess the relationships between their demographics, land ownership characteristics, awareness of and attitudes towards carbon sequestration, beliefs about climate change, and reported likelihood to participate in a relevant program. Thirty-seven percent of respondents were considered potential participants. Higher likelihood of participation was associated with dependence on livestock production, considering it a moderately or very important management objective, having an interest in learning more about it, and valuing its potential economic and climate benefits. Although education and outreach are generally considered important policy tools for promoting conservation, special efforts are needed in the case of carbon sequestration to develop innovative strategies to communicate its concept and related processes with Utah rangeland owners without politicizing the issue. One approach is to tailor education and outreach messages

² This manuscript is co-authored by Seth L. Cook and Dr. Zhao Ma

to focus on the ecological benefits of carbon sequestration that are valued by many rangeland owners. Instead of developing new programs, carbon management can also be incorporated into existing conservation programs at both federal and state levels. Research is needed to further examine the perceived differences between carbon sequestration and other conventional conservation practices in order to improve the carbon sequestration potential of existing conservation programs and attract wider participation among rangeland owners.

Introduction

Climate change is expected to have detrimental impacts on humans and the environment (e.g., increased temperatures, droughts, floods) and these impacts will vary both geographically and socially (IPCC, 2007). Mitigation is one approach to addressing climate change through reducing emissions of greenhouse gases (such as CO₂) or enhancing carbon sinks (Klein et al., 2007). Terrestrial carbon sequestration is a mitigation strategy which stores atmospheric CO₂ in the soil and in the above and below ground biomass (Izaurralde et al., 2001; Lal et al., 2003). Rangelands can act as carbon sinks and soil carbon levels can be increased through the implementation of improved land management practices (Schuman et al., 2002; Lal et al., 2003).

Carbon sequestration on rangelands

Although rangelands have a low per acre potential to sequester carbon, they cover about half of the world (Svejcar et al., 2008), one third of the U.S. (Sobecki et al., 2001) and 80% of Utah (USU Cooperative Extension, 2012). This vast amount of rangelands as a whole has great potential for sequestering carbon (Follett et al., 2001). In particular,

over half of the rangelands in the nation and one fifth in Utah are privately owned (Leydsman-McGinty, 2009; SRR, 2011). Schuman et al. (2001) estimated that with improved management practices public and private rangelands in the U.S. could sequester 11 metric tons of carbon per year (MMTC/yr), while 8 MMTC/yr could be accumulated through keeping private rangelands in the Conservation Reserve Program (CRP) and 43 MMTC/yr could be prevented from loss by maintaining current conservation practices. The overall carbon sequestration potential of these private rangelands is equivalent to five percent of the U.S. annual CO₂ emissions (Follet et al., 2001).

Previous research on the effects of rangeland management practices on soil carbon are varied and inconclusive (Derner and Schuman, 2007). However, it has been recognized that general management practices that reduce soil erosion, prevent land degradation, or restore degraded land have the biggest impacts on soil carbon (Lal, 2001). More specifically, management practices such as lowering stocking and forage utilization rates, using nitrogen fertilization, removing woody vegetation, and inter-sowing grasses and legumes are potentially beneficial for soil carbon (Gibbens et al., 1983; Conant et al., 2001; Lal, 2004; Derner and Schuman, 2007). The current literature on the biophysical aspects of carbon sequestration on rangelands raises two questions: 1) What management practices are private rangeland owners currently using which produce carbon benefits? 2) What are the most effective ways to promote further adoption of management practices to enhance carbon sequestration on private rangelands?

Carbon sequestration policy

Although no program is currently focused on carbon sequestration on private rangelands in the U.S., a variety of policy options have been discussed in the literature. Of these policy options, a voluntary market-based approach has been the main focus of research (e.g., Bonnie et al., 2002; Sandor et al., 2002; Antle et al., 2003; Campbell et al., 2004; De Steiguer et al., 2008; Diaz et al., 2009). The Chicago Climate Exchange (CCX), operated from 2003 to 2010, is an example of a voluntary market-based approach. The CCX developed the only protocol for carbon sequestration offset projects on private rangelands in the U.S. Even though rangelands can be competitive in a market setting (Campbell et al., 2004), there are many challenges related to additionality, quantification, verification and permanence for promoting carbon sequestration on private rangelands through such an approach (Bird et al., 2002; Schuman et al., 2002; De Steiguer et al., 2008; Brown et al., 2010; White, 2010). The CCX also imposed geographic limitations on eligible rangelands due to environmental factors, which excluded 84% of Utah.

Other policy options discussed in the literature include a compliance market-based approach (e.g., a cap-and-trade program), government payments for landowners to meet voluntary carbon sequestration goals, or modification of existing land conservation programs to include carbon management (Derner and Schuman, 2007; White, 2010). This last option has started gaining attention among researchers and policy makers, as evident by Schuman et al.'s (2002) study on lands enrolled in the CRP and facts sheets published by the Conservation Innovation Grant program and the Conservation of Private Grazing Land initiative (Gebhart et al., 1994; NRCS, 2003, 2010). The ecological

benefits of carbon sequestration are generally consistent with those achieved through land conservation programs (e.g., improved soil and water quality, improved grazing management, improved wildlife habitat). Therefore, it is important to examine strategies for incorporating carbon sequestration into existing land conservation programs. Understanding why rangeland owners implement conservation practices and participate in existing conservation programs may be beneficial for identifying factors that influence rangeland owners' interest in carbon sequestration.

Decision making by private rangeland owners

The diffusion of innovations theory (Rogers, 2003) has been widely used to study rancher management decisions. It provides a good basis for understanding why and how innovative range management practices may be adopted. For instance, it suggests that adoption is influenced by characteristics of the innovation, including whether the innovation has a clear advantage for the adopter, whether it is compatible with the adopter's management objectives, how complex the innovation is, whether the adopter can try it out, and whether the results are readily observable to the adopter. Rogers' theory also suggests that social networks can influence the adoption of innovations by facilitating the spread of information among connected individuals. Didier and Brunson (2004) interviewed Utah ranchers who adopted innovative range management practices. These interviewees reported extensive social interactions with ranching organizations and university extension professionals, contributing to their obtaining information from outside sources about the innovation of interest. Similar results were also observed in Kennedy and Brunson (2007).

Previous research has conceptualized the relationships between environmental value orientations, beliefs, attitudes and actions. In particular, individuals' environmental value orientations and beliefs influence their attitudes towards an environmental action, which in turn influence their decisions about whether or not to take that action (Stern and Dietz, 1994; Stern, 2000; Fishbein and Ajzen, 2010; Larson, 2010). Following this line of thought, rangeland owners' value orientations and beliefs about the environment would influence their rangeland management decisions, such as adopting an innovative practice or participating in a conservation program.

Demographics and ranch structure have been shown to predict rancher decision making. Coppock and Birkenfeld (1999) examined factors influencing the adoption of recommended livestock and range management practices by Utah livestock producers. They found that low education levels and advanced age were associated with low rates of adoption. Peterson and Coppock (2001) examined the differences in management styles between ranchers with public grazing permits and those who relied on private rangelands. They found that investment in ranching operations in Utah was affected by ranchers' old age. Although it is unclear whether the average age of ranchers has actually been increasing over the years, the old age of the current ranching community in Utah and other western states could have profound implications on private land management and conservation policy in the future (Brunson and Huntsinger, 2008). Higher income has also been shown to be a predictor of innovation adoption (Coppock and Birkenfeld, 1999; Peterson and Coppock, 2001; Didier and Brunson, 2004). Dependence on ranch income seemed to influence Utah and Texas ranchers' decisions to invest in range improvement projects and to adopt conservation practices (Rowan and White, 1994; Didier and

Brunson, 2004; Kreuter et al., 2004; Olenick et al., 2005). Furthermore, Utah ranchers who owned smaller operations, did not have a public grazing permit, mainly relied on private lands for livestock production, and had higher off-ranch incomes tended to fall under the category of “private hobbyists” and were generally less likely to adopt rangeland management innovations (Coppock and Birkenfeld, 1999).

Ranchers are also motivated by a variety of non-monetary values. For example, Smith and Martin (1972) found that intrinsic values of and personal ties to their land was the most significant factor in explaining why Arizona ranchers did not sell their ranches when the prices were high. Grigsby (1980) found that a large portion of ranchers in southeastern Oregon viewed ranching as a way of life rather than a business. A need to preserve a sense of tradition, culture, and lifestyle has been evident in other studies as well (Rowe et al., 2001; Didier and Brunson, 2004). Ranchers have been shown to forgo opportunities that allow them to adopt innovative practices with economic benefits to keep the traditional lifestyle of ranching and livestock production (Grigsby, 1980). To motivate ranchers to adopt conservation practices, one needs to take these factors into account and be sensitive to ranchers’ motivations outside of financial incentives.

In addition, previous research has examined rangeland owners’ attitudes towards social responsibility and how such attitudes may influence their management decision making. Jackson-Smith et al. (2005) found that a large majority of Utah and Texas landowners they sampled thought they had some level of responsibility to their neighbors, communities, and society in general. Most landowners also felt an obligation to be a good steward of their land because of their individual moral values. Kreuter et al. (2006) suggested that landowners in Utah, Colorado and Texas who believed they had a

social responsibility were more open to the idea of providing ecosystem services without financial compensation.

In summary, many factors have been found to influence rangeland owner decisions about adopting conservation practices or participating in a relevant program. Characteristics of an innovation are important in predicting adoption behavior (Rogers, 2003; Didier and Brunson, 2004) and large social networks seem to have a positive influence on the adoption of innovations (Didier and Brunson, 2004). Younger, more educated individuals with public grazing permits and who are dependent on ranch income are more likely to invest in rangeland improvements (Coppock and Birkenfeld, 1999; Peterson and Coppock, 2001; Didier and Brunson, 2004). Non-monetary values, such as a deep sense of ranching tradition and culture, also influence rancher decision making (Smith and Martin, 1972; Rowe et al., 2001; Didier and Brunson, 2004). Although not explicitly addressing carbon sequestration, these general findings about innovation adoption are important for identifying factors influencing carbon management practices on private rangelands.

In contrast to the number of studies on general rangeland management issues, only one study was found examining rancher decision making with respect to carbon sequestration. Ma and Coppock (2012) studied beef cattle producers in Utah and found that producers with a large operation, relying on income from grazing, but lacking public grazing access were more likely to be interested in carbon sequestration activities. Valuing the environmental benefits of carbon sequestration was also associated with higher likelihood of engagement. While being informative, Ma and Coppock (2012) did not explore some of the aforementioned factors affecting rancher decision making. Also

needed is a more comprehensive discussion about various potential benefits of carbon sequestration, specific policy mechanisms that may be used to promote carbon sequestration, and program attributes that may determine the attractiveness and effectiveness of future programs.

Building upon the existing literature on rancher decision making, this study expands on Ma and Coppock (2012) by providing a comprehensive assessment of Utah rangeland owners' interests in carbon sequestration. Specifically, this study will (1) determine factors influencing the likelihood of private rangeland owners to participate in a carbon sequestration program in the future; (2) assess the current management practices used by private rangeland owners in relation to soil carbon management; and, (3) identify potential outreach and policy strategies that may help promote carbon sequestration on private rangelands.

Methods

There were two phases of data collection. Open-ended, qualitative interviews were conducted in the summer of 2011. The interview data were analyzed and used to inform the development of a statewide mail/phone survey (Johnson and Onwuegbuzie, 2004). Both the interview protocol and survey instrument received approval by the Utah State University (USU) Institutional Review Board to ensure that this research did not put participants at risk.

Interviews

Seven range and natural resource professionals and eight Utah rangeland owners were interviewed in a one-on-one setting using pre-determined interview guides (Patton,

1990). The professional interviewees were identified through government websites and recommendations from researchers at USU and included Natural Resources Conservation Service (NRCS) range specialists, USU range extension specialists, county extension agents, and range specialists from the Utah Department of Agriculture and Food. The rangeland owner interviewees were recommended by the professional interviewees, researchers at USU, and other rangeland owners. The rangeland owner interviews were conducted during the summer months, a busy time for livestock producers, leading to difficulty in scheduling. Although consideration was given to spreading the rangeland owner interviews across different counties in Utah, all who were willing to take the time to participate were included. The final set of rangeland owner interviewees were from five counties in northern Utah: Cache, Box Elder, Rich, Uintah, and Tooele. Interviews of these northern Utah rangeland owners were very informative due to the higher precipitation in that part of the state and better ecological potential for carbon sequestration. For both the professional and rangeland owner interviews, open-ended questions were asked concerning factors influencing rangeland owner decision making with respect to determining stocking rates, implementing grazing systems, making structural improvements, and managing invasive species (see Appendix A and Appendix B for the interview protocols). Questions were also asked about their general views towards government conservation programs and specific reactions to a government approach versus a market approach to carbon sequestration. This broad range of questions was used to get a sense of general factors influencing management decisions that have the potential to affect soil carbon. For instance, grazing management was part of the CCX rangeland management protocol for carbon sequestration offset projects. The

management of invasive species, particularly woody species, affects rangeland degradation and restoration, which also influences soil carbon. Interviewees' views towards government conservation programs may be helpful for assessing their potential attitudes towards future carbon sequestration programs, which may be designed and implemented in a similar way as existing programs.

Survey

The second phase of data collection was a statewide mail/phone survey. The sampling frame included all known Utah farmers and ranchers who owned private grazing land and some kind of livestock (e.g., cattle, sheep, horse, llama, alpaca). The survey was administered with the assistance of the Utah Field Office of the USDA National Agricultural Statistics Service (NASS) in January and February of 2012 following a modified total design method (Dillman et al., 2009). The first contact was made through mail in which a survey questionnaire and cover letter were sent to each individual in the sample. A five-dollar gift card to the Intermountain Farmers Association (IFA) stores was offered as an incentive to complete and return the questionnaire. If an individual had not returned the survey within two weeks of the initial mail-out, weekly follow-up phone calls were made to contact him/her for three weeks in order to achieve a target response rate of 70%.

The survey questionnaire was designed to take about 30 minutes to complete. All questions were pre-tested and revised with the help of NASS (see Appendix C for the survey instrument). Data collected in the survey included information on demographics (e.g., age, education, income), rangeland ownership characteristics (e.g., size of land

holding, length of landownership, public permittee status), general management practices concerning grazing intensity, stocking rates, and woody shrub management, previous involvement in rangeland conservation programs, factors contributing to management decision making, information sources used for making management decisions, environmental value orientations, awareness of and attitudes towards carbon sequestration, beliefs about climate change, and the likelihood of participation in a carbon sequestration program in the future.

A simple random sample of 1,000 Utah rangeland owners was drawn from a database maintained by NASS, containing all known farms and ranches in Utah. A farm or ranch is defined as any operation that has \$1,000 of agricultural sales in a normal year. Of the 1,000 initial individuals contacted, 282 were screened out by two questions asked at the beginning of the questionnaire about the target population parameters (i.e., owning private grazing land in Utah and some kind of livestock) and 120 had inaccurate or unreachable addresses or phone numbers, reducing the actual sample size to 598. Among these 598 eligible individuals, 37 refused to complete the survey, 126 did not respond, and 435 completed the survey questionnaire either via mail or on the phone, representing a response rate of 73%. Most of the 37 individuals who refused to participate in this study were considered “chronic refusers” and have not responded to any surveys administered by NASS.

Statistical analyses

Responses were examined using univariate descriptive statistics and bivariate analyses. ANOVA was used to determine associations among continuous and nominal

variables, t-tests were used to determine differences in two group means, and Pearson chi-squared tests were used to assess relationships among nominal variables. These analyses helped assess the bivariate relationships between rangeland owner demographics, landownership characteristics, environmental value orientations, beliefs about climate change, attitudes towards carbon sequestration, and interests in carbon sequestration.

An empirical model was further developed to examine factors influencing the likelihood of respondents to participate in future carbon sequestration programs. The response variable (LPART) took value 1 if a respondent reported “somewhat” or “very” likely to participate in a carbon sequestration program based on his or her current understanding of the issue, and 0 otherwise. LPART was modeled as a function of 23 explanatory variables, described in detail in Table 3-1. The empirical model was not able to include a variable indicating whether or not an individual had participated in any government conservation program because too few responses were given to the corresponding question in the survey.

A binary logistic regression procedure was used to estimate the empirical model and assess the influences of the explanatory variables on LPART. In binary logistic regression each of the two possible outcomes is assigned a probability. Where Y is the binary response variable and X is a vector of explanatory variables, the probabilities are calculated as follows: $P(Y_i = 1) = P_i = e^{\beta X_i} / (1 + e^{\beta X_i})$ and $P(Y_i = 0) = 1 - P_i = 1 - [e^{\beta X_i} / (1 + e^{\beta X_i})] = 1 / (1 + e^{\beta X_i})$. In the above equation, P_i represents the probability of a rangeland owner responding likely to participate in a carbon sequestration program in the future, β is a vector of regression coefficients, and βX_i is a standard regression notation

Table 3-1 Explanatory variables used in the empirical model for estimating private rangeland owners' likelihood to participate in a future carbon sequestration program.

Variable name	Description
AGE	Continuous (years)
EDUCATION	Continuous (years of formal education completed)
INCOME	Binary – 1 if a respondent's self-reported annual net household income over the past five years was over the median for Utah residents (\$50,000), 0 if otherwise
INCGRZ	Binary – 1 if livestock production was a major source of income for a respondent (>50%), 0 if otherwise
LTOTGRZLND	Continuous – log of the amount of private grazing land owned (acres)
ABSENTEE	Binary – 1 if a respondent lived more than a mile away from his/her private grazing land, 0 if otherwise
LENGOWN	Continuous – length of time a respondent's family had owned the private grazing land (years)
LSELL	Nominal – a respondent's self-reported likelihood to sell or give away his or her private grazing land in the next five years; four categories: 1 if very unlikely, 2 if unlikely, 3 if likely, 4 if very likely; three dummy variables were created to be included in the logistic regression model
PERMIT	Binary – 1 if a respondent had a permit to graze on public land, 0 if otherwise
MGMTPLN	Binary – 1 if a respondent had a grazing management plan, 0 if otherwise
PRIORITY	Nominal – a respondent's environmental value measured by the self-reported rating of the extent to which society should prioritize economic versus environmental considerations when managing natural resources; 1 to 10 scale with 1 being "economic considerations should have the highest priority" and 10 being "environmental considerations should have the highest priority"
AWARE	Nominal – self-reported awareness of carbon sequestration; four categories: 1 if never heard of it, 2 if slightly aware, 3 if moderately aware, 4 if very aware; three dummy variables were created to be included in the logistic regression model
INTEREST	Binary – 1 if a respondent reported an interest in learning more about carbon sequestration, 0 if otherwise
IMPCS	Nominal – the importance a respondent placed on carbon sequestration as a management objective; four categories: 1 if not important, 2 if slightly important, 3 if moderately important, 4 if very important; three dummy variables were created to be included in the logistic regression model
THINKCC	Binary – 1 if a respondent thought the climate had been changing over the last 30 years, 0 if otherwise

Variable name	Description
MD_RESCONS	Continuous – the importance of resource conservation for a respondent when deciding how to manage his or her private grazing land (principal component loadings, see Table 3-2)
MD_PROD	Continuous – the importance of agricultural production for a respondent when deciding how to manage his or her private grazing land (principal component loadings, see Table 3-2)
MD_WLDFL	Continuous – the importance of wildlife and recreation for a respondent when deciding how to manage his or her private grazing land (principal component loadings, see Table 3-2)
MD_LNDVAL	Continuous – the importance of land investment for a respondent when deciding how to manage his or her private grazing land (principal component loadings, see Table 3-2)
IMPGOVINC	Nominal – the importance of receiving income from participating in government programs for a respondent when deciding how to manage his or her private grazing land; four categories: 1 if not important, 2 if slightly important, 3 if moderately important, 4 if very important; three dummy variables were created to be included in the logistic regression model
PB_ECOL	Continuous – the importance a respondent placed on the potential ecological benefits of participating in a carbon sequestration program (principal component loadings, see Table 3-3)
PB_ECON	Continuous – the importance a respondent placed on the potential economic benefits of participating in a carbon sequestration program (principal component loadings, see Table 3-3)
REDCC	Nominal – the importance a respondent placed on reducing human contribution to climate change as a potential benefit of participating in a carbon sequestration program; four categories: 1 if not important, 2 if slightly important, 3 if moderately important, 4 if very important; three dummy variables were created to be included in the logistic regression model

representing the right hand side of a regression model. Because the logistic regression coefficients cannot be interpreted on a per unit basis, the marginal effect for each explanatory variable was calculated using the following equation: $dP_i/dX_i = P_i(1 - P_i)\beta$.

Pair-wise correlations were calculated to check for multicollinearity among explanatory variables included in the empirical model. The variable measuring the

general attitude towards carbon sequestration and the variable measuring the importance placed on carbon sequestration as a management objective were highly correlated ($\rho=.60$). Therefore, only the latter was included in the final model. The remaining pairwise correlations ranged from 0.001 to 0.560, all below 0.6, therefore, did not raise any concern. Variance inflation factor (VIF) was calculated for the regression. The commonly given rule of thumb is that a VIF of 10 or greater may be a sign of multicollinearity. The final VIF for the empirical model was 1.45.

In the logistic regression model, four continuous explanatory variables (MD_RESCONS, MD_PROD, MD_WLDF, MD_LNDVAL) measured the importance of various factors in rangeland owners' management decision making and two continuous variables (PB_ECOL and PB_ECON) measured the importance of various potential benefits of participating in a carbon sequestration program. These variables are composite variables and were obtained through principal component analysis (PCA), a statistical technique that reduces multiple correlated variables down to fewer uncorrelated principal components (PCs). The results of a PCA are usually discussed in terms of PC loadings. A PC loading represents the correlation between the survey items and the PC, and is used to define and name each PC. PC loadings of 0.50 or higher are considered significant (Finely et al., 2006).

In this study, PCA was applied to two sets of original survey questions. The first set of questions asked respondents to indicate the importance of 14 items when deciding how to manage their grazing land. Table 3-2 shows the original 14 items and how they loaded onto four PCs. Based on the associated item themes, the first PC, MD_RESCONS, was defined as making management decisions based on resource

Table 3-2 Description of survey items measuring the importance of various factors for Utah rangeland owner respondents when deciding how to manage their private grazing land.

Survey items: factors influencing decisions about how to manage grazing land ^a	Mean (Std. Dev.)	Rotated principal component loading ^b				Cronbach's Alpha
		PC_1 ^c	PC_2 ^d	PC_3 ^e	PC_4 ^f	
Protecting water resources	3.80 (0.50)	0.70				0.73
Reducing soil erosion	3.67 (0.69)	0.62				
Controlling invasive species	3.77 (0.54)	0.67				0.54
Reducing impacts of drought or lack of water	3.64 (0.69)	0.61				
Maintaining or enhancing forage quality and quantity	3.69 (0.61)	0.57				0.55
Hay production	2.77 (1.30)		0.60			
Livestock production	3.39 (0.97)		0.79			0.50
Maintaining family farming/ranching tradition & lifestyle	3.66 (0.74)		0.55			
Protecting wildlife habitat	3.28 (0.90)			0.74		0.55
Providing recreation opportunities (including hunting)	2.79 (1.17)			0.84		
Viewing land as an investment	3.15 (1.06)				0.63	0.50
Reducing property taxes	3.30 (1.02)				0.66	
Development of nearby land	2.55 (1.23)				0.63	
Income from participating in government programs	1.74 (1.10)					

^a Item scale: 1=not important, 2=slight important, 3=moderately important, 4=very important

^b Rotated principal component loadings smaller than 0.50 are left blank

^c PC_1 (MD_RESCONS) was defined as the importance of resource conservation when deciding how to manage private grazing land.

^d PC_2 (MD_PROD) was defined as the importance of agricultural production when deciding how to manage private grazing land.

^e PC_3 (MD_WLDLF) was defined as the importance of wildlife and recreation when deciding how to manage private grazing land.

^f PC_4 (MD_LNDVAL) was defined as the importance of land investment when deciding how to manage private grazing land.

conservation considerations; the second PC, MD_PROD, was defined as making management decisions based on agricultural production considerations; the third PC, MD_WLDF, was defined as making management decisions based on wildlife and recreation considerations; and the final PC, MD_LANDVAL, was defined as making management decisions based on land investment considerations. As a measure of scale reliability, Cronbach's Alpha was calculated for each PC (Cronbach, 1951). Because the last three PCs did not meet the suggested Cronbach's Alpha minimum of 0.70 (Nunnally, 1978), caution is needed when interpreting results related to these PCs. One of the original survey items measuring the importance of receiving income from participating in government programs (IMPGOVINC) did not load significantly onto any derived PCs, and therefore was left as a standalone variable in the logistic regression.

The same PCA process was applied to a different set of questions asking respondents to indicate the level of importance they placed on potential benefits of participating in a carbon sequestration program. The original 11 survey items were reduced down to two PCs, shown in Table 3-3. Based on the associated item themes, the first PC, PB_ECOL, was defined as valuing the ecological benefits of carbon sequestration; and the second PC, PB_ECON, was defined as valuing the economic benefits of carbon sequestration. Both PCs met the suggested Cronbach's Alpha minimum of 0.70 (Nunnally, 1978), indicating a strong scale reliability. The variable measuring the perceived importance of reducing human contribution to climate change, REDCC, did not load significantly onto either PC, and was therefore left in the logistic regression model as a standalone variable.

Table 3-3 Description of survey items measuring the importance of various potential benefits of participating in a carbon sequestration program for Utah rangeland owner respondents.

Survey items: potential benefits of participating in a carbon sequestration program ^a	Mean (Std. Dev.)	Rotated principal component loading ^b		Cronbach's Alpha
		PC_1 ^c	PC_2 ^d	
Improved wildlife habitat	2.90 (1.06)	0.69		0.93
Improved soil quality and organic matter	3.35 (0.94)	0.82		
Improved forage quantity and quality	3.43 (0.91)	0.81		
Increased water storage and filtration	3.35 (0.93)	0.81		
Conserving biodiversity	2.92 (1.02)	0.79		
Restoration of degraded land	3.24 (0.97)	0.79		
Increased drought resistance	3.35 (0.93)	0.83		
Implementing environmentally sound management practices	3.14 (0.98)	0.79		
Income/receiving monetary payments	2.27 (1.09)		0.90	
Tax benefits	2.70 (1.13)		0.87	
Reducing human contribution to climate change	2.49 (1.17)			

^a Item scale: 1=not important, 2=slight important, 3=moderately important, 4=very important

^b Rotated principal component loadings smaller than 0.50 are left blank

^c PC_1 (PB_ECOL) was defined as the importance of potential ecological benefits of participating in a carbon sequestration program.

^d PC_2 (PB_ECON) was defined as the importance of potential economic benefits of participating in a carbon sequestration program.

Results

Description of Utah rangeland owners

All 29 counties in Utah were represented by the survey respondents. Great variations were observed with respect to the characteristics of landowners and landownership. Respondents averaged 61 years of age (SD=12.2; Min=18; Max=94) and had, on average, 15 years of formal education (SD=2.9; Min=5; Max=28). Of the 384 respondents who reported their income, 64% had an annual income below the median income for the general population of Utah (\$50,000). The major source of income for respondents was off-ranch activities, including other jobs, investments, and retirement plans. On average, respondents reported receiving 25% of their income from on-ranch sources (SD=34; Min=0; Max=100) with 18% from livestock production and 7% from other on-ranch sources such as dairy production.

The amount of private grazing land owned by respondents also varied. The average acreage owned was 458 acres (SD=1330; Min=1; Max=15,000) and the average acreage used for grazing was 448 acres (SD=1336; Min=0; Max=15,000). Thirty-eight percent of respondents owned grazing land in one of the nine counties in Utah that the CCX included in their rangeland offset protocol (Cache, Carbon, Daggett, Duchesne, Morgan, Rich, Summit, Utah, Wasatch). Seventeen percent of respondents reported having a public grazing permit.

By far the most common way through which respondents acquired their land was purchasing. Specifically, 70% of respondents reported purchasing their land, while 19% reported inheriting it and 8% reported a combination of the two. The average length of time that respondent's family had owned the grazing land was 45 years (SD=38; Min=1;

Max=165). The family ownership length was strongly correlated with whether or not respondents inherited their land ($F=250.12, p<0.01$). The majority of respondents (70%) reported living on or within one mile of their grazing land, while 30% were considered absentee landowners. When asked about the likelihood that they would sell or give away their grazing land in the next five years, 87% responded “very unlikely” or “unlikely.” Of the 13% who responded “likely” or “very likely,” over a third indicated the reason for their plan was because they were ready to retire. Sixty-four percent of respondents reported being the sole decision maker concerning their grazing land, while 34% reported making management decisions with family members and the remaining 2% relied on a hired ranch manager or a tenant operator.

Current management practices on private grazing lands

With respect to current grazing management practices, 48% of respondents reported using rotational grazing, 34% using seasonal or yearlong rest, 14% using continuous grazing, and 4% using management-intensive techniques. Eleven percent of respondents reported having a written grazing management plan. When asked how they had been managing woody plants and shrubs on their property over the past five years, 26% reported having decreased the amount of such plants, 25% maintained the same amount, and 8% increased the amount, while 17% did not manage woody plants and shrubs at all and 24% said they did not have such plants on their property.

Respondents were also asked to report changes in their stocking rate over that last five years. Nineteen percent reported having decreased their stocking rate, 61% maintained the same, and 20% increased their rate. With respect to perceived level of

forage utilization, over half of respondents reported having, on average, more than 60% of forage grazed off over the last five years.

Of the 299 respondents who reported on their awareness of and participation in various rangeland conservation programs, 27% had participated in at least one of the six programs: CRP, Conservation Stewardship Program (CSP), Environmental Quality Incentives Program (EQIP), Utah Grazing Improvement Program (UGIP), Agriculture Resources Development Loans (ARDL) program, or a conservation easement program. More respondents were aware of the CRP and had participated in it than in any other programs.

Respondents were asked about various factors affecting their management decisions concerning private grazing lands. Controlling invasive species, protecting water resources, maintaining or enhancing forage quantity and quality, reducing soil erosion, reducing impacts of drought, and maintaining ranching tradition and lifestyle were considered “moderately” or “very” important by over 90% of respondents. Livestock production and protecting wildlife habitat were seen as “moderately” or “very” important by 83% of respondents. Between 60% and 80% of respondents reported reducing property taxes, viewing land as an investment, hay production, and recreation as “moderately important” or “very important” factors in their decision making. The least influential factors were development of nearby land and income from participating in government programs – 53% and 24% of respondents, respectively, reported these two factors as being “moderately important” or “very important.”

Finally, respondents were asked to assess themselves on a scale from 1 to 10 concerning how they thought society should prioritize economic versus environmental

considerations when managing natural resources, with 1 being “economic considerations should have the highest priority” and 10 being “environmental considerations should have the highest priority.” The average response was 4.9 (SD=2.4; Min=1; Max=10). The distribution of responses is reported in Fig. 3-1.

Awareness, attitudes, and perceptions of carbon sequestration and climate change

Before asking respondents any questions about carbon sequestration, the following definition was provided: Carbon sequestration is the removal of carbon dioxide from the air and storing it in plants and soil through natural processes. The majority of

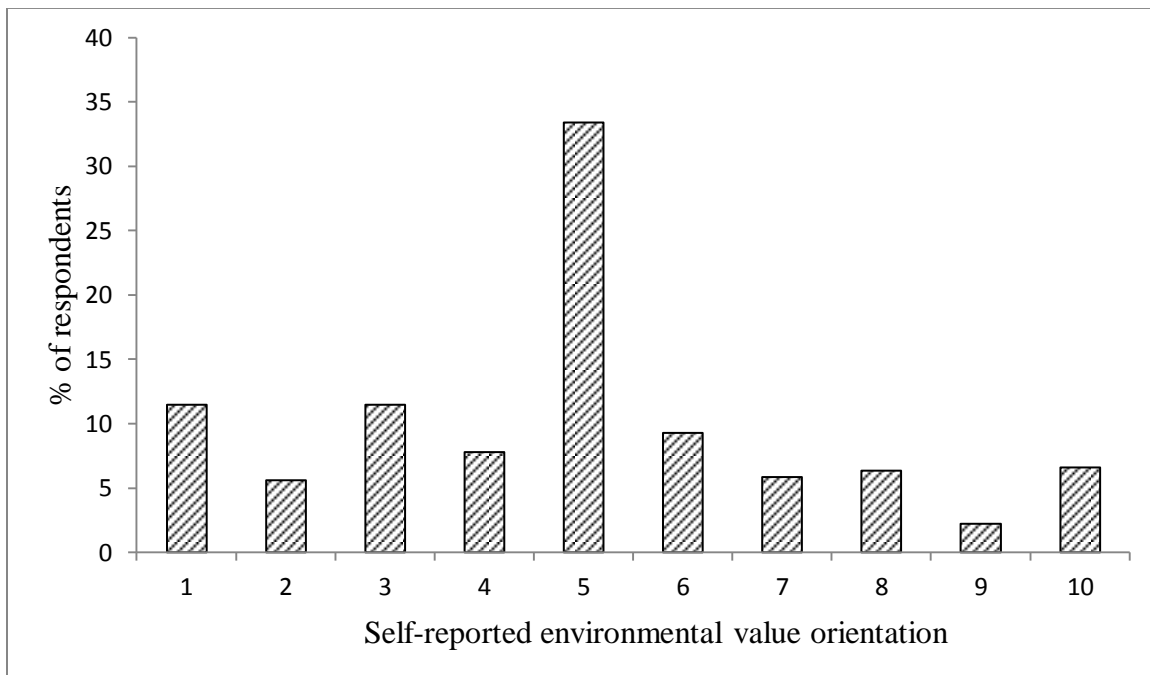


Fig. 3-1. The environmental value orientation of Utah rangeland owner respondents, measured by the self-reported rating of the extent to which society should prioritize economic versus environmental considerations when managing natural resources using a 10-point scale, from 1 being “economic considerations should have the highest priority” to 10 being “environmental considerations should have the highest priority” (n=410).

respondents (63%) indicated that they had no or little awareness of carbon sequestration prior to the survey. Seventy-six percent of respondents reported a “positive” or “very positive” attitude towards carbon sequestration and 41% considered it a “moderately important” or “very important” management objective to them personally. Over half of respondents were interested in learning more about carbon sequestration and of the 161 respondents who answered this question, 63% believed that other ranchers in their community would be interested in learning about it as well. More awareness was associated with a more positive attitude towards carbon sequestration ($\chi^2=76.79, p<0.01$) and a higher importance placed on it as a management objective ($\chi^2=75.83, p<0.01$).

With respect to the potential benefits of carbon sequestration, 66% to 85% of respondents found improved forage quantity and quality, increased drought resistance, improved soil quality, increased water storage and filtration, restoration of degraded rangeland, implementing environmentally sound management practices, and improved wildlife habitat to be “moderately important” or “very important” benefits (Fig. 3-2). The economic and climate change benefits were seen as the least important as 43% to 61% reported that receiving tax benefits, receiving monetary payments, and reducing human contribution to climate change were “moderately important” or “very important.”

Sixty-four percent of respondents thought the climate had been changing over the past 30 years, among which over half believed that human activities had a moderate or strong influence on the climate. Statistically significant relationships were observed between respondents’ beliefs about climate change and their attitudes towards carbon sequestration. Those who thought the climate had been changing over the past 30 years,

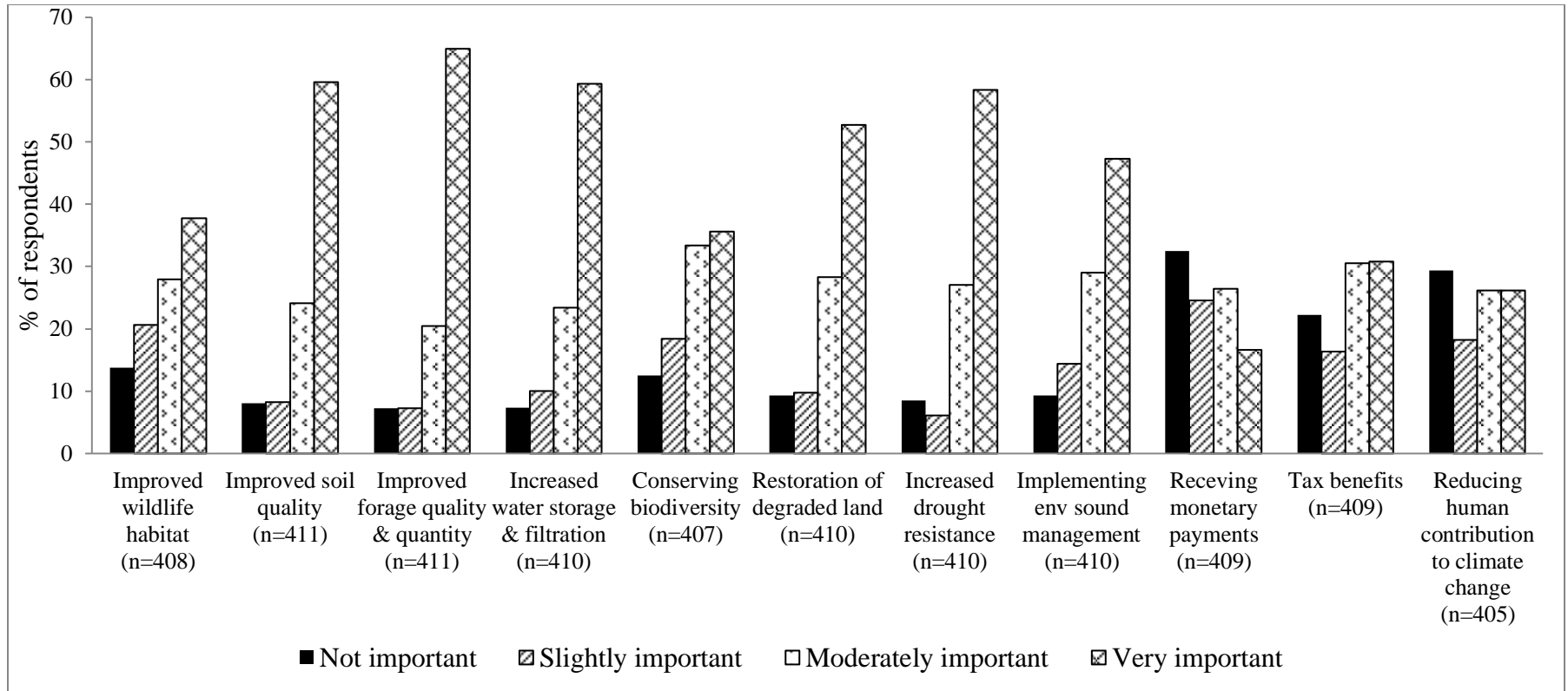


Fig. 3-2. The level of importance Utah rangeland owner respondents placed on the potential benefits of participating in a carbon sequestration program.

particularly those who believed the anthropogenic nature of climate change, were more likely to have positive attitudes towards carbon sequestration ($\chi^2=23.15$, $p<0.01$ and $\chi^2=41.99$, $p<0.01$, respectively) and to place a higher importance on carbon sequestration as a management objective ($\chi^2=12.10$, $p<0.01$ and $\chi^2=26.64$, $p<0.01$, respectively).

Rangeland owners' reported likelihood to engage in carbon sequestration

Respondents were asked to report the likelihood that they would participate in a carbon sequestration program in the future based on their current understanding of the issue and 63% reported “very unlikely” or “unlikely,” while 37% reported “likely” or “very likely.” Only one statistically significant difference was observed between potential participants and non-participants with respect to their demographics and landownership characteristics (Table 3-4). Potential participants had slightly more education (less than one year of formal schooling) than their counterparts ($p=0.03$).

Additional comparisons were made between potential participants and non-participants with respect to their awareness, attitudes, and perceptions of carbon sequestration and climate change (Table 3-4). Specifically, potential participants were more likely to be aware of carbon sequestration ($\chi^2=12.34$, $p<0.01$) and have positive attitudes towards it ($\chi^2=59.29$, $p<0.01$). They also tended to place a higher importance on both the ecological ($p<0.01$) and economic ($p<0.01$) benefits of participating in a future program. With respect to their beliefs about climate change, potential participants and non-participants had similar views on whether or not the climate had been changing over the last 30 years ($\chi^2=1.20$, $p=0.27$) and the extent to which human activities had been influencing the climate ($\chi^2=4.06$, $p=0.26$).

Table 3-4 Comparisons between potential participants and non-participants of carbon sequestration programs with respect to their demographics, landownership characteristics, and awareness, attitudes, and perceptions of carbon sequestration and climate change.

	Potential non-participants ^a	Potential participants ^a
Age (years)	61	59
Education (years)*	14	15
Household income over Utah median (\$50,000) (% of respondents)	44	38
Income from on-ranch sources (% of total income)	23	30
Amount of private grazing land owned (acres)	497	423
Length of family ownership of private grazing land (years)	45	45
Absentee ownership of private grazing land (% of respondents)	33	26
Having a public land grazing permit (% of respondents)	16	22
Having a grazing management plan (% of respondents)	11	13
Awareness of carbon sequestration (on a four-point scale, from 1 being “never heard of it” to 4 being “very aware”)* ^b	2.07	2.42
Attitude towards carbon sequestration (on a four-point scale, from 1 being “very negative” to 4 being “very positive”)* ^b	2.65	3.22
Having an interest in learning more about carbon sequestration (% of respondents)*	36	84
The importance of carbon sequestration as a management objective (on a four-point scale, from 1 being “not important” to 4 being “very important”)* ^b	1.93	2.75
The importance potential ecological benefits of participating in a carbon sequestration program (score of composite variable PB_ECOL)*	-0.27	0.42
The importance potential economic benefits of participating in a carbon sequestration program (score of composite variable PB_ECON)*	-0.24	0.36
Thinking the climate had been changing over the last 30 years (% of respondents)	62	68
The extent to which human activities may be influencing the climate (on a four-point scale, from 1 being “no influence at all” to 4 being “strong influence”)	2.46	2.72
# of observations	261	154

^a Respondents who reported “very unlikely” or “somewhat unlikely” to participate in a future carbon sequestration program were classified as potential non-participants and those who reported “somewhat likely” or “very likely” as potential participants.

^b Means are reported but statistical significance was tested using Pearson’s chi-square.

* $p < 0.05$

Finally, the logistic regression model for assessing factors influencing respondents' likelihood of participation was significant overall ($\chi^2=153.84$, $p<0.01$; Table 3-5). Several factors were considered statistically significant at the five percent level. More specifically, respondents who were more dependent on ranch income reported a higher likelihood to participate. Having a positive attitude towards carbon sequestration and having an interest in learning more about it were both associated with higher likelihood to participate. Those who considered carbon sequestration a moderately or very important management objective were more likely to participate than those who placed little or no importance on it. Finally, those who valued the potential economic benefits of a carbon sequestration program or the benefit of reducing human contribution to climate change were more likely to participate.

Discussion

The profile of private rangeland owners in this study is similar to what has been observed in previous studies of ranchers in Utah (Peterson and Coppock, 2001; Coppock et al., 2009; Ma and Coppock, 2012). Concordance was observed with respect to respondents' age, education, income, absentee status, private land holding size, and length of family ownership, while differences were observed in terms of sources of income and public permittee status. This study also produced new data on the way rangeland owners acquired their land, which was mostly through purchasing, and their plan for the next five years. Generally speaking, private rangeland ownership will stay relatively stable in Utah, and only 13% of owners indicated a plan to sell or give away their land, mainly due to retirement and inter-generational transfer issues. About half of these individuals planned for their children to receive their land, while they may still be

Table 3-5 Logistic estimates of the empirical model for estimating private rangeland owners' likelihood to participate in a carbon sequestration program.

Explanatory variable	Coefficient ^{a, b}	Standard error
AGE	0.002	0.003
EDUCATION	0.021	0.014
INCOME	0.050	0.081
INCGRZ	0.256**	0.120
TOTGRZLND	-0.001	0.023
ABSENTEE	0.018	0.091
LENGOWN	-0.001	0.001
LSELL: Unlikely	-0.017	0.093
LSELL: Likely	0.026	0.138
LSELL: Very likely	-0.013	0.271
PERMIT	-0.032	0.101
MGMTPLN	-0.010	0.116
PRIORITY	-0.017	0.016
AWARE: Slightly aware	-0.001	0.096
AWARE: Moderately aware	0.063	0.103
AWARE: Very aware	0.103	0.133
INTEREST	0.314***	0.068
IMPCS: Slightly important	0.181	0.118
IMPCS: Moderately important	0.481***	0.103
IMPCS: Very important	0.308*	0.161
THINKCC	-0.062	0.083
MD_RESCONS	-0.021	0.045
MD_PROD	0.012	0.047
MD_WLDF	0.049	0.040
MD_LNDVAL	0.026	0.044
IMPGOVINC: Slightly important	-0.067	0.104
IMPGOVINC: Moderately important	0.100	0.136
IMPGOVINC: Very important	-0.028	0.129
PB_ECOL	0.097	0.060
PB_ECON	0.109**	0.042
REDCC: Slightly important	-0.026	0.113
REDCC: Moderately important	0.039	0.112
REDCC: Very important	0.278**	0.132
# of observations	313	
LR chi-squared	160.78***	
Pseudo R ²	0.381	

^a Coefficients are marginal effects.

^b * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

involved in the management of the ranch (Brunson and Huntsinger, 2008).

The aforementioned PCA results suggest that Utah rangeland owners generally have four major considerations when making management decisions, including resource conservation, agricultural production, wildlife and recreation, and land investment. Unexpectedly, maintaining family farming/ranching tradition and lifestyle appeared to be associated with the composite variable representing agricultural production. This may be explained by the fact that respondents who considered ranching a family tradition and lifestyle were more dependent on livestock production and other on-ranch activities. These results further extended previous research examining how rancher values affect their decision making. For instance, Rowe et al. (2001) found that ranchers who were dependent on income from ranching were more concerned with the profitability of their ranch. Rowan and White (1994) found that ranchers who were more dependent on ranch income, particularly income from livestock production, were more likely to implement weed/brush treatments, although production is not always the sole motivation of range improvements (Didier and Brunson, 2004).

With respect to current grazing management practices, this study shows that very few rangeland owners had a grazing management plan, which was a qualifying condition for landowners to participate in carbon offset projects under the CCX protocol and is often required for participation in many current government conservation programs. On the other hand, most respondents reported using some type of rotational grazing system. Although research has not been conclusive that rotational grazing contributes to carbon sequestration (Derner and Schuman, 2007), it was another requirement of the CCX. Furthermore, over 80% of respondents either maintained or decreased their stocking rate

over the last five years. Previous research has suggested that reduced stocking rate may have the biggest effect on soil carbon (Follett et al., 2001). Therefore, the current grazing management practices suggest both challenges and potential for carbon sequestration. For example, it is important to consider the implication of imposing grazing management plans as part of future carbon sequestration program eligibility requirements. The average rangeland owner in this study had a relatively small portion (18%) of income from livestock production, therefore may not be willing to put in the time and financial resources to develop a plan if his or her livelihood does not dependent on grazing. To motivate landowners, government agencies and range professionals need to better assess the extent to which a plan is necessary for promoting carbon management. If it is indeed necessary, efforts are needed to develop strategies and incentives to help more landowners prepare such plans. In addition, barriers may exist for promoting rotational grazing. Because many respondents made their living mostly from off-ranch sources, they may have little time available for implementing time-intensive practices, such as rotational grazing as evident by Didier and Brunson (2004). On the other hand, there may be opportunities for reducing stocking rates. Since many respondents were not dependent on grazing, they may be able to reduce their stocking rate without significant negative financial repercussions, particularly if a government agency is willing to provide incentives to compensate such practice.

The study results show that potential participants of future carbon sequestration programs had slightly higher education than potential non-participants. Although statistically significant, the difference between the two groups was less than one year of formal schooling, which seems to be insignificant from a practical perspective. Besides

this, no other statistically significant difference was observed between the two groups.

This suggests that landowners' demographics and landownership characteristics were not related to their likelihood of participation in a carbon sequestration program.

Associated with likelihood of participation was landowners' attitude towards carbon sequestration, which was in turn associated with their beliefs about climate change. These results support previous research suggesting that an individual's belief about the environment influences his or her attitude towards a relevant environmental action and intention of undertaking that action (Stern and Dietz, 1994; Stern, 2000; Fishbein and Ajzen, 2010; Larson, 2010). Although likelihood to participate may not always lead to actual participation, it is a behavioral intention and a precursor to making a decision (Fishbein and Ajzen, 2010). In fact, when an individual indicates a likelihood to undertake an action, he or she often has already made up his or her mind at an unconscious level even though he or she may consciously report being undecided (Galdi et al., 2008).

This study further suggests the importance of developing education and outreach strategies to address climate change beliefs among rangeland owners in order to influence their attitudes towards carbon sequestration and further increase their likelihood of participation in a relevant program. Education and outreach are generally considered important policy tools (Marynowski and Jacobson, 1999; Loomis et al., 2001; Ferranto et al., 2012), however, in the case of climate change it may be easier said than done. Climate change has received a lot of media attention, particularly in the U.S., and has been politicized to a great extent, potentially making it very difficult to change people's mind about it. Completely removing the political aspect of climate change may be

impossible; however, avoiding the use of buzz terms such as “global warming” or minimizing the discussion about causes of climate change when communicating with rangeland owners may help alleviate the problem (Schuldt et al., 2011). For example, the majority of respondents in this study appeared to think that the climate had been changing over the past 30 years, although many of them did not think it was due to human activities, and they may not agree to describe climate change using a seemingly unidirectional term “global warming.”

Individually, each of the ecological benefits associated with participating in a carbon sequestration program was considered more important by the study participants than any of the potential economic benefits. However, the logistic regression result suggests that rangeland owners’ likelihood to engage in carbon sequestration was influenced by their perceived importance of potential economic benefits rather than ecological benefits. Several factors may contribute to this result. As previously discussed, many rangeland owners value farming and ranching as a family tradition or lifestyle, however they tend to operate under tremendous financial constraints and pressure (Didier and Brunson, 2004). Therefore, they may be interested in seeking other sources of income to supplement their on-ranch production, such as potential income from sequestering carbon, in order to maintain their tradition or lifestyle.

Previous research also suggests that ranchers can be motivated by non-monetary values over financial incentives with respect to adopting innovative rangeland improvement practices or participating in conservation programs (Didier and Brunson, 2004). However, carbon sequestration may not fall under this umbrella of activities from the perspective of rangeland owners, especially given the fact that most respondents did

not value carbon sequestration as a potential strategy for reducing human contribution to climate change and therefore, may not feel the social responsibility to do anything about it (Kreuter et al., 2006). If carbon sequestration is not viewed as a rangeland improvement or conservation activity, ranchers may be unwilling to participate unless they receive compensation for the costs occurred from providing this public good that they do not necessarily value. This would be in line with findings concerning Texas landowner participation in weed brush management programs (Kreuter et al., 2004; Olenick et al., 2005). Regardless of the reason why rangeland owners placed high importance on the potential economic benefits of carbon sequestration, this study suggests a challenge for future policy and program development because profitability of carbon sequestration, particularly on rangelands, has been an issue of concern (White, 2010; Ritten et al., 2012), partly evident by the failed CCX. More research is needed to better understand rangeland owners' economic interests, which will help identify the right type and magnitude of incentives for developing future carbon sequestration programs.

Overall, few variables in this study were found to be significant in the empirical model for assessing factors that influence rangeland owner decision making with respect to carbon sequestration. This suggests the complex and unique nature of carbon sequestration, which may be viewed very differently by landowners from conventional rangeland management innovations or conservation practices. A carbon sequestration program may be considered more political than a regular conservation program because people may easily associate it with climate change mitigation. Carbon sequestration may also be viewed as more technical and abstract than other management practices that rangeland owners are familiar with, such as soil and water conservation and wildlife

habitat improvement. Future research is needed to look into the perceived differences between a carbon sequestration program and more conventional conservation programs, even though many of their ecological benefits may be similar. This will help develop better models to predict rangeland owner decision making with respect to carbon sequestration.

Conclusion

The management of private rangelands is important to the overall potential of U.S. rangelands to sequester carbon and mitigate climate change. Understanding private rangeland owner decision making process and factors influencing their likelihood to participate in a relevant program is critical for promoting carbon sequestration as a management objective and a policy goal. Attitudes towards carbon sequestration are important for determining rangeland owners' interest in a program. Education and outreach may be used to influence attitudes. However, because the strong association between attitudes towards carbon sequestration and beliefs about climate change, innovative strategies are needed to better communicate the nature of climate change with rangeland owners while avoiding as much as possible being trapped in current political debates about the issue. One approach is to tailor education and outreach messages to focus on the ecological benefits of carbon sequestration that are similar to the benefits of conventional rangeland improvement and conservation projects and are valued by many rangeland owners.

The potential economic benefits of participating in a carbon sequestration program were also important to Utah rangeland owners. However, creating sufficient

benefits has proven to be a challenge based on previous market experience in the U.S., namely the CCX. It may be more realistic to look at financial incentives outside of a market setting. Cost share, lower tax rates, and other incentives have been widely adopted to promote land stewardship and could be useful for promoting carbon sequestration as well. Finally, incorporating carbon management into existing conservation programs may be more cost effective than developing new programs specific for carbon sequestration. In fact, several federal and state programs are already in place focusing on sustainable grazing management and soil conservation, which are consistent with many carbon sequestration activities. The challenge is to develop strategies to improve the carbon sequestration potential of these existing programs and to attract wider participation among rangeland owners.

Although the geographic focus of this study was Utah, Utah rangeland owners are similar to those in other western states with respect to their demographics, values, and the economic and environmental challenges they face (Didier and Brunson, 2004; Kennedy and Brunson, 2007; Brunson and Huntsinger, 2008). Therefore, the results presented here can be informative for understanding rangeland management decisions in general and carbon sequestration decisions in particular in other western rangeland settings.

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CHAPTER 4

SUMMARY AND CONCLUSIONS

Carbon sequestration has become an important management objective for private forestland, cropland, and rangeland in the U.S. for its potential to aid in climate change mitigation. Although this is the most well-known purpose of carbon sequestration, it has a variety of other benefits. The research presented in this thesis dug into the perceptions held by Utah rangeland owners of carbon sequestration and their beliefs about climate change. It assessed how these perceptions were associated and how they influenced the likelihood of landowners to engage in carbon sequestration on their private rangelands. It also examined the drivers of management decisions made by these landowners and how perceptions fit into the decision making process. The two approaches used can be harmonized to focus on several key points and identify areas in need of further research.

First, the connection between carbon sequestration and climate change adds a dimension to this issue that poses a challenge for increasing support for carbon sequestration among those who have varying beliefs about climate change. This, coupled with the low profitability of carbon sequestration on rangelands (Ritten et al., 2012) creates a difficult task for developing policy to promote this abstract, yet important, management goal on private rangelands in the western U.S. Learning what aspects of carbon sequestration are valued by landowners and the role of potential economic benefits in decision making provides direction for a dual approach to policy formulation. Education and outreach programs are used to influence individual's attitudes towards some objective and have had success concerning natural resource issues (Loomis et al.,

2001; Marynowski and Jacobson, 1999). Emphasizing the ecological benefits to improve the popularity and perceived importance of carbon sequestration needs to be coupled with the ability for landowners to profit financially. Future policy and programs should implement this dual approach. This also opens up questions for future research. Understanding what is behind the importance of the economic benefits can help determine the types of incentives and financial benefits to offer.

Second, we found that not only did the purpose of a carbon sequestration program influence intended participation but also the characteristics of the policy or program did so. This includes the policy content as well as which entity was administering it. Restrictions, constraints, and rigidity were not seen as favorable traits of policy options and rangeland owners expressed more willingness to work with a private agricultural entity over a governmental or private conservation organization. This reveals a need for collaboration, cooperation, and flexibility in future policy development. A government agency is the most likely entity to implement a carbon sequestration program; however, a collaborative effort that includes private agricultural entities may be more effective. Collaborative management is a useful tool for conservation and has been successful in many cases such as the Malpai Borderlands Group (Sayre, 2005; Wondolleck and Yaffee, 2000). This group of ranchers, private organizations, scientists, and government entities in the southwestern U.S. has achieved amazing success in the conservation and improvement of rangelands with a variety of land ownership types. Although their success cannot be replicated exactly, lessons learned can be applied to other situations: lessons such as trust, flexibility, and focusing on process rather than specific results. Flexibility is important for managing rangelands with their variable moisture and forage

production and, in turn, carbon fluctuations. A lack of flexibility could be a barrier to landowner involvement in future programs and developing and following grazing management plans. Focusing on the processes that enhance carbon sequestration may be one way to improve flexibility while also focusing on multiple benefits rather than a single measurement such as metric tons of soil carbon. Not only does this approach address the flexibility issue but also the permanence, quantification, and additionality issues that were present in past carbon market approaches. Research is needed to help find a balance between flexibility of programs and contracts while still ensuring proper land management and ecological improvement.

Third, a low percentage reported they were likely to participate in a future carbon sequestration program. It is likely that the actual number who would end up participating is even lower (Fishbein and Ajzen, 2010). We also observed low participation in existing conservation or cost share programs. What is it about these existing programs that focus on conventional conservation issues that prevents participation? This could be a very fruitful area of research among rangeland owners in the western U.S. Understanding the barriers to participation in traditional conservation programs would help adjust existing programs to be more effective and widely used as well as direct future programs from the start.

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APPENDICES

APPENDIX A
RANGELAND OWNER INTERVIEW PROTOCOL

Interview Protocol: Range Management Professionals
Project: Utah rancher perceptions of climate and carbon sequestration

Date:
Time of interview:
Place:
Interviewer:
Interviewee:
Position of interviewee:

Introduction:

Thank you for taking the time to participate in this study. The objective of this study is to learn more about Utah rangeland and grazing land owner's perceptions towards carbon sequestration, climate uncertainty, and their needs and concerns regarding land management and conservation programs.

Informed Consent: *Your participation is voluntary. All of our research records will be kept confidential. This interview will be recorded with your consent.*

Definitions: *The following terms will be used during this interview:*

Carbon sequestration – The storage of CO₂ in the soil and plants as soil organic carbon (SOC) and plant above and below ground biomass (plant tissue and roots)

Incentive – Benefits provided by a program (financial assistance, technical assistance, social recognition, etc.) for implementing certain management practices

Technical Assistance – Information, data, guidance, conservation planning, etc. provided to aid the landowner in improving conservation and land management practices

Financial Assistance – Payments for a portion of costs associated with implementation of a practice (cost share)

Questions:**Section I: Land management decision making**

1. What are rancher's main considerations and concerns when making decisions about their grazing management practices?

2. Why do ranchers implement or choose not to implement a grazing system on their land?

3. What are rancher's main considerations and concerns when making decisions about managing invasive species?

4. How do ranchers weigh short term versus long term costs and benefits when making land management decisions on their ranch?

Probe: Why do they tend to place more emphasis on _____ (depends on the answer to 4)?

5. How do ranchers weigh ecological costs and benefits versus economical costs and benefits?

Probe: Why do they tend to place more emphasis on _____ (depends on the answer to 5)

Section II: Land management and conservation program characteristics and incentives

1. What structural characteristics (personnel, organization, application process, eligibility, contract lengths, monitoring, etc.) of land management and conservation programs that are in place do you think ranchers find the most appealing?

Probe: What structural characteristics do they find the least appealing?

2. How would ranchers prioritize program incentives such as social recognition, financial assistance, and technical assistance?

Probe: Is there a lack of or need for a particular incentive in current programs?

Section III: Attitudes and perceptions of carbon sequestration and climate change

1. How do you think ranchers would respond to a program focused on carbon sequestration?

2. What do you see as potential concerns ranchers might have about participating in a program with a focus on carbon sequestration?

Probe: How would you recommend such a program be structured?

3. Are ranchers observing any impacts of climate change on their land or livestock health?

Probe: What, if any, land management practices are ranchers implementing to reduce the impacts of climate change?

4. Do ranchers think there is a relationship between human activities and climate change?

Probe if yes: What is the nature of the relationship?

5. What other general observations do you have about the climate change issue and its relationship to ranching in the Intermountain West?

APPENDIX B

RANGE MANAGEMENT PROFESSIONAL INTERVIEW PROTOCOL

Interview Protocol: Private Landowner

Project: Utah rancher perceptions of climate change and carbon sequestration

Date:

Time of interview:

Place:

Interviewer:

Interviewee:

Position of interviewee:

Introduction:

Thank you for taking the time to participate in this study. Our objective is to learn more about attitudes of private landowners towards carbon sequestration and land management and conservation programs in general.

Definitions: *The following terms will be used during this interview:*

Carbon sequestration – The storage of CO₂ in the soil as soil organic carbon and in plants as above and below ground plant tissue and root biomass

Incentive – Offered for promoting the implementation of certain management practices, including:

- Technical assistance – Information, data, guidance, conservation planning provided to aid the landowner in improving conservation and land management practices.
- Financial assistance – Payments for a portion of costs associated with implementation of a practice or tax benefits.
- Social recognition – Public recognition or award for implementing conservation practices.

Questions:**Section I: Land management decision making**

1. What are your main considerations when making decisions about grazing management practices?

Probe: How did you come to the decision to use your current grazing management system?

2. What are your main considerations and concerns when deciding when and how to manage invasive species on your land?

3. How do you work through difficult management decisions that require you to weigh short terms costs and benefits versus long term costs and benefits?

4. How do you work through difficult management decisions that require you to weigh ecological costs and benefits versus economical costs and benefits?

Section II: Land management and conservation program characteristics and incentives

1. What do you like about the land management and conservation programs that are offered?

2. What do you dislike about them?

3. How do you prioritize these benefits?

4. Is there a lack of or need for more of any of them?

5. How can these programs be improved to better benefit you and other livestock producers?

Section III: Attitudes and perceptions

1. How familiar are you with carbon sequestration or storage?

2. Would you consider joining a land management program that was focused on promoting carbon sequestration?

3. What concerns do you have about participating in a carbon program?

4. What would make a carbon program more appealing to you?

5. Do you think there is a relationship between human activities and the atmosphere or

climate?

Probe if yes: What is the nature of the relationship?

Probe: Are you seeing any impacts of a changing climate on your ranch or way of life?

Probe: Have you implemented any management practices or made changes in your management to reduce impacts of a potential changing climate?

6. What other general observations do you have about the climate change issue and its relationship to ranching in the Intermountain West?

APPENDIX C
SURVEY INSTRUMENT

Project Code: 461

Survey of Utah Ranchers' Management Practices and Views on Carbon



Information requested in this survey will be used by researchers at Utah State University to study management practices and views on carbon. Facts concerning your operation are **confidential** and used only in combination with similar reports from other producers. Response is **voluntary**.

SECTION 1

For the purposes of this survey, grazing land includes permanent pasture and rangeland. This land use category encompasses grazable land that does not qualify as woodland pasture or cropland pasture. It may be irrigated or dry land. In some areas, it can be a high quality pasture that could not be cropped without improvements. In other areas, it is barely able to be grazed and is only marginally better than wasteland.

1. Do you own any private grazing land?

¹ Yes ³ No

100

2. Do you graze any livestock (e.g., cattle, sheep, horse, llama/alpaca) on your privately owned grazing land?

¹ Yes ³ No

101

If you answered "Yes" to both of the above questions, please fill out the rest of the questionnaire and return it in the enclosed, self-addressed, postage-paid business reply envelope.

If you answered "No" to either of the above questions, it won't be necessary for you to complete the questionnaire, but please return your incomplete questionnaire in the enclosed, self-addressed, postage-paid business reply envelope.

Survey of Utah Ranchers' Management Practices and Views on Carbon

SECTION 2 – Grazing Land Information

Please answer the following questions with respect to only the private grazing land you own. This does not include any public land you lease or use for grazing.

- | | |
|--|-----|
| 1. In which county do you live? _____ | 200 |
| 2. How much irrigated grazing land do you own in Utah?acres | 201 |
| a. How much of it is in the following counties: Cache, Carbon, Daggett, Duchesne, Morgan, Rich, Summit, Utah, Wasatch?.....acres | 202 |
| 3. How much non-irrigated grazing land do you own in Utah?.....acres | 203 |
| a. How much of it is in the following counties: Cache, Carbon, Daggett, Duchesne, Morgan, Rich, Summit, Utah, Wasatch?acres | 204 |
| 4. Of the irrigated and non-irrigated grazing land you own, how much do you use for livestock grazing?.....acres | 205 |
| 5. Is your home (or primary residence) on or within one mile of your grazing land? ¹ <input type="checkbox"/> Yes ³ <input type="checkbox"/> No | 206 |
| 6. Which of the following best describes the ownership of your grazing land? (check only one)
¹ <input type="checkbox"/> Individual ⁴ <input type="checkbox"/> Trust or estate
² <input type="checkbox"/> Joint, such as a husband and wife ⁵ <input type="checkbox"/> Corporation or business partnership
³ <input type="checkbox"/> Family partnership | 207 |
| 7. How did you get your grazing land in Utah? (check all that apply)
¹ <input type="checkbox"/> Purchased ⁴ <input type="checkbox"/> Received as a gift
² <input type="checkbox"/> Inherited ⁶ <input type="checkbox"/> Other (please specify): _____ | 208 |
| 8. How long has your <i>family</i> owned the grazing land?.....years | 209 |
| 9. What is your likelihood to sell or give away any of your grazing land in Utah in the next 5 years? (check only one)
¹ <input type="checkbox"/> Very unlikely ² <input type="checkbox"/> Unlikely ³ <input type="checkbox"/> Likely ⁴ <input type="checkbox"/> Very likely | 210 |

If likely or very likely, please answer a and b; otherwise, skip to question 10.

- | | |
|---|-----|
| a. Who will likely receive it? (check all that apply) | |
| ¹ <input type="checkbox"/> My childrenNumber of children: <input type="text"/> | 211 |
| ² <input type="checkbox"/> Other family members.....Number of family members: <input type="text"/> | 212 |
| ³ <input type="checkbox"/> Other individuals | 213 |
| ⁴ <input type="checkbox"/> A business | |
| ⁵ <input type="checkbox"/> A government agency | |
| ⁶ <input type="checkbox"/> Don't know | |

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b. Why are you planning to sell it or give it away? (check all that apply)

- ¹ I am ready to retire ² My children are ready to take over the farm/ranch
³ Too expensive to keep ⁴ Financial needs of the family
⁵ High market value ⁶ Development pressure
⁷ No longer interested in farming/ranching ⁸ Part of investment strategy
⁹ Other (please specify): _____

214

10. Who is the primary decision maker (i.e., the person who makes the day-to-day decisions) concerning your grazing land? (check only one)

- ¹ Myself alone ² Myself and others (e.g., family members, business partners)
³ A hired ranch manager ⁴ A tenant operator to whom I lease my land

215

11. Did you buy any hay for winter feed in the past 5 years? ¹ Yes ³ No

216

12. Do you have a public grazing permit? ¹ Yes, how many AUM's:

217

³ No

218

SECTION 3 – Current Management Practices on Deeded Grazing Land

13. Do you have a written grazing management plan? ¹ Yes ³ No

300

14. What grazing management practice do you currently use on your grazing land? (check only one)

- ¹ Continuous grazing ² Seasonal or yearlong rest
³ Rotational grazing ⁴ Management-intensive grazing

301

15. How have you managed the amount of woody plants and shrubs on your grazing land over the last 5 years (if you have had this land for less than 5 years, please report on the time of your ownership)? (check only one)

- ¹ Decreased the amount of woody plants and shrubs
² Maintained the same amount of woody plants and shrubs
³ Increased the amount of woody plants and shrubs
⁴ I have not managed woody plants and shrubs
⁵ I have not had any woody plants or shrubs on my land

302

16. How has the stocking rate on your grazing land changed over the last 5 years (if you have had this land for less than 5 years, please report on the time of your ownership)? (check only one)

- ¹ Decreased ² Maintained the same ³ Increased

303

17. What level of forage utilization (i.e., the percent of forage grazed off) would you say you have used on your grazing land over the past 5 years (if you have had this land for less than 5 years, please report on the time of your ownership)? (check only one)

- ¹ Less than 21% ⁴ 61 – 80%
² 21 – 40% ⁵ Over 80%
³ 41 – 60%

304

Survey of Utah Ranchers' Management Practices and Views on Carbon

18. Please indicate if you are aware of each of the following programs and if you are a participant:

	Administered by	I am aware	I am a participant	
Conservation Reserve Program (CRP)	Farm Service Agency	¹ <input type="checkbox"/>	² <input type="checkbox"/>	305
Conservation Stewardship Program (CSP)	NRCS	¹ <input type="checkbox"/>	² <input type="checkbox"/>	306
Environmental Quality Incentives Program (EQIP)	NRCS	¹ <input type="checkbox"/>	² <input type="checkbox"/>	307
Utah Grazing Improvement Program (UGIP)	UT Dept. of Agriculture and Food	¹ <input type="checkbox"/>	² <input type="checkbox"/>	308
Agricultural Resource Development Loan (ARDL)	UT Dept. of Agriculture and Food	¹ <input type="checkbox"/>	² <input type="checkbox"/>	309
Conservation Easement (whether through a government or private entity)	Federal, state, or private entity	¹ <input type="checkbox"/>	² <input type="checkbox"/>	310

19. To what extent do you think society should prioritize economic versus environmental considerations when managing natural resources? Please indicate your opinion on a scale of 1 to 10, 1 being "economic considerations should have the highest priority" and 10 being "environmental considerations should have the highest priority." (check only one)

1	2	3	4	5	6	7	8	9	10	311
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

20. What is the importance of each of the following when you decide how to manage your grazing land? (check one box for each line item)

	Not important	Slightly important	Moderately important	Very important	
Hay production	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	312
Livestock production	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	313
Income from participating in government programs	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	314
Viewing land as an investment	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	315
Reducing property taxes	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	316
Development of nearby land	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	317
Not subdividing my land	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	318
Being a good steward of my land	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	319
Increasing biodiversity	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	320
Protecting water resources	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	321
Reducing soil erosion	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	322
Controlling invasive species	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	323
Protecting wildlife habitat	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	324
Reducing impacts of drought or lack of water	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	325
Maintaining or enhancing forage quality and quantity	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	326
Maintaining family farming/ranching tradition & lifestyle	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	327
Protecting the privacy of my family	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	328
Providing recreation opportunities (including hunting)	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	329

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21. Please indicate if you have received grazing land management information from the following sources and the usefulness of these sources:

	Received information	Useful	Not useful	
Family members	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	330
Neighbors or other ranchers in my community	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	331
General Internet search (i.e., Google)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	332
Targeted internet search of websites of government agencies, ranching organizations, or conservation organizations	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	333
Television	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	334
Written materials (e.g., brochures, newsletters, emails, other publications)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	335
Conferences, workshops, classes	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	336
Federal agency employees (e.g., from NRCS, Forest Service, BLM)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	337
State agency employees (e.g., from UDAF, UDNR)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	338
Local government officials (e.g., county commissioners, planners)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	339
Extension agents (e.g., USU extension specialists, county agents)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	340
Ranching organizations (e.g., Farm Bureau, Utah Cattlemen's Association)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	341
Conservation organizations (e.g., Sierra Club, The Nature Conservancy, Rocky Mountain Elk Foundation)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	342

SECTION 4 – Landowner Attitudes and Perceptions of Carbon Sequestration

1. Prior to this survey, which of the following best describes your awareness of carbon sequestration? *Carbon sequestration is a natural process by which plants and soils remove carbon dioxide (CO₂) from the air and store it above and below ground.* (check only one)

1 Never heard of it 2 Slightly aware 3 Moderately aware 4 Very aware

400

2. Would you be interested in learning more about carbon sequestration? 1 Yes 3 No

401

3. Do you think ranchers in your community would be interested in learning about carbon sequestration?

1 Yes 2 No 3 Don't know

402

4. Regardless of your awareness level, what is your general attitude towards carbon sequestration? (check only one)

1 Very negative 2 Somewhat negative 3 Somewhat positive 4 Very positive

403

5. Based on your current understanding, what is the importance of carbon sequestration to you as a management objective? (check only one)

1 Not important 2 Slightly important 3 Moderately important 4 Very important

404

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6. Based on your current understanding, what is the likelihood that you will participate in a carbon sequestration program in the future? (check only one)

405

¹ Very unlikely ² Somewhat unlikely ³ Somewhat likely ⁴ Very likely

7. Please indicate the level of importance you place on the following potential benefits of participating in a carbon sequestration program: (check one box for each line item)

	Not important	Slightly important	Moderately important	Very important	
Income/receiving monetary payments	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	406
Tax benefits	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	407
Demonstrating good land stewardship to the public	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	408
Demonstrating good land stewardship to other ranchers/farmers	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	409
Improved wildlife habitat	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	410
Improved soil quality and organic matter	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	411
Improved forage quantity and quality	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	412
Increased water storage and filtration	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	413
Conserving biodiversity	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	414
Restoration of degraded grazing land	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	415
Increased drought resistance	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	416
Implementing environmentally sound management practices	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	417
Reducing human contribution to climate change	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	418
Demonstrating good land stewardship to federal/state agencies	¹ <input type="checkbox"/>	² <input type="checkbox"/>	³ <input type="checkbox"/>	⁴ <input type="checkbox"/>	419

8. Which of the following would make you not interested or less interested in participating in a carbon sequestration program? (check all that apply)

Being required to develop and follow a grazing management plan	¹ <input type="checkbox"/>	420
Having a private party or government agency annually measure carbon on your land	¹ <input type="checkbox"/>	421
Having a private party or government agency annually measure carbon emissions from your operation	¹ <input type="checkbox"/>	422
Being in a minimum 5-year contract	¹ <input type="checkbox"/>	423
Being required to maintain light to moderate stocking rates	¹ <input type="checkbox"/>	424
Being required to meet compliance or contract requirements	¹ <input type="checkbox"/>	425
Low financial return	¹ <input type="checkbox"/>	426
Not knowing enough about it	¹ <input type="checkbox"/>	427
Being one of the first few from your community to participate	¹ <input type="checkbox"/>	428

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9. Please indicate how appealing the following ideas are to you for promoting carbon sequestration on private grazing land: (check one box for each line item)

	Not appealing	Slightly appealing	Moderately appealing	Very appealing	
Increased education and outreach efforts regarding carbon sequestration	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	429
Visiting other ranchers in your community who have participated in a carbon sequestration program	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	430
Promoting voluntary best management practices to increase carbon sequestration	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	431
A carbon sequestration program run by a private farmer/rancher entity (e.g., Farm Bureau, Utah Cattlemen's Association)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	432
A carbon sequestration program run by a private conservation organization (e.g., The Nature Conservancy)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	433
A carbon sequestration program run by a state agency (e.g., UDAF, UDNR)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	434
A carbon sequestration program run by a federal agency (e.g., NRCS, Forest Service, BLM)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	435
Government payments for meeting voluntary carbon sequestration goals (i.e., similar to the conservation programs run by NRCS)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	436
No regulation of CO ₂ emissions, but if companies want to voluntarily offset their carbon emissions, they can pay private landowners to sequester carbon (i.e., a voluntary carbon offset program)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	437
Government regulates the total amount of CO ₂ that can be emitted by companies, and companies can offset their carbon emissions by paying private landowners to sequester carbon (i.e., a cap-and-trade program)	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	438

SECTION 5 – Landowner Beliefs and Perceptions of Climate Change

1. Do you think in general the climate has been changing over the last 30 years? 500

1 Yes 3 No *If no, skip to question 3.*

2. To what extent do you think human activities may be influencing the climate? (check only one) 501

1 No influence at all 2 Slight influence 3 Moderate influence 4 Strong influence

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3. Please indicate any general trends you have observed in the following climate and weather patterns in your county over the last 30 years or as long as you have lived in this county: (for each line item check one box in the first three columns, under predictability and one box in the next three columns, under change)

a. I have been living in my current county foryears

502

	Predictability			Change			Predictability	Change
	Less predictable	No change	More predictable	Decrease	No change	Increase		
Precipitation	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	503	504
				1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>		506
Temperature	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	505	508
				1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>		510
				1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>		512
Drought	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	507	514
				1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>		516
				1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>		518

SECTION 6 – Landowner Information

1. What is your age?.....years

600

2. How many years of formal education have you completed? (starting from the first grade).....years

601

3. On average, what is your annual net household income (after tax, on-ranch plus off-ranch) over the past 5 years (check only one)

602

- 1 \$25,000 or less
- 2 \$25,001 to \$50,000
- 3 \$50,001 to \$75,000
- 4 \$75,001 to \$100,000
- 5 \$100,001 to \$200,000
- 6 More than \$200,000

4. On average, what percentage of the above income comes from the following sources?

	Percent (%)
Livestock production (e.g., beef cattle, sheep, horses)	603
Other on-ranch activities (e.g., hay/crop production, dairy/poultry production, leasing land, providing recreation, income from participating in a conservation program)	604
Off-ranch sources (e.g., other jobs, investments, retirement plans)	605
	100%