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The interconnectedness between landowner knowledge, value, belief, attitude, and willingness to act: Policy implications for carbon sequestration on private rangelands

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ABSTRACT

Rangelands can be managed to increase soil carbon and help mitigate emissions of carbon dioxide. This study assessed Utah rangeland owner's 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 promoting carbon sequestration on private rangelands. Potential strategies for overcoming these challenges include emphasizing the ecological benefits associated with sequestering carbon to appeal to landowners with ecologically oriented management objectives, enhancing the cooperation between private agricultural organizations and government agencies, and funneling resources for promoting carbon sequestration into existing land management and conservation programs that may produce carbon benefits.

1. 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 (CO_2) and stores it as soil inorganic carbon (SIC), soil organic carbon (SOC), above-ground biomass, or below-ground biomass (Izaurralde 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).

1.1. 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 (Schuman et al., 2002; Lal et al., 2003). Given that more than half of U.S. rangelands and 21% 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

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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 prevent erosion and land degradation and protect soil carbon (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 influence 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 sequestration (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.

1.2. Mechanisms for promoting carbon sequestration on U.S. rangelands

There has been a strong interest internationally in evaluating various private, public and trading schemes for developing and implementing payments for ecosystem services (De Groot et al., 2010; FAO, 2011; Zander et al., 2013; Zander and Garnett, 2011), including greenhouse gas emission reduction and carbon sequestration. In the U.S., private or public policy mechanisms have been 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 CO_2 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 climatic 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 or fire. More importantly, this kind of cap-and-trade approach targeting vegetation management for enhanced carbon uptake may not be sufficient for addressing localized environmental conditions that can easily destabilize carbon storage, particularly on semi-arid and arid U.S. rangelands (Booker et al., 2013).

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 the 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.

1.3. 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