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Exploring the Determinants of Aspects of Rotational Grazing in the U.S. Great Plains

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EXPLORING THE DETERMINANTS OF ASPECTS OF ROTATIONAL GRAZING IN THE U.S. GREAT PLAINS

BY

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THESIS ACCEPTANCE PAGE

Iftekhar Uddin Ahmed Chowdhury

This thesis is approved as a creditable and independent investigation by a candidate for the master's degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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This dissertation is dedicated to my mother.

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ABBREVIATIONS

BMP	best management practices
CSP	conservation stewardship program
CV	contingent valuation
DC	dichotomous choice
EQIP	environmental quality incentives program
GHG	greenhouse gas
ME	marginal effect
MIG	management intensive grazing
PO	proportional odds
PPO	partial proportional odds
RG	rotational grazing
Std	standard deviation
SE	standard error
WTA	willingness to accept

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ABSTRACT

EXPLORING THE DETERMINANTS OF ASPECTS OF ROTATIONAL GRAZING IN THE U.S. GREAT PLAINS

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Pasture and rangeland make up about 45 percent of the agricultural land in the U.S. Great Plains and one of the most common form of mismanagement of this pasture is overgrazing. Which results in many detrimental effects on environment. Many practitioners endorsed Rotational grazing (RG) as an improved grazing management practice over season-long continuous grazing. The overall goal of the current study is to assess the certain aspects of using RG in the U.S. Great Plains. Using mail survey data of the of 874 beef cattle producers of North Dakota, South Dakota, and Texas, the study found that neighborhood practice, government agencies, education, and slope of a land significantly affect nonadopters perceived benefits of RG practices. The results of the study further reveal that adopters with a higher proportion of grassland, less liability ratio, a lower share of leased land, and located relatively less steep sloped land generally perceive higher benefits from RG practices. The results of the study also indicate that the RG adopters who received cost share generally have higher proportion of grassland, higher ranch income ratio, fewer adoption years, put higher importance to the university extensions as information source, operate an increased proportion of land with LCC I and II, and located further north to the study region. The results from ordered logistic regression model further indicate that producers are more willing to adopt RG practices in the future with different subsidy amounts those who had more farming experiences, had less grassland acreage, and more liability ratio, emphasize the importance of university extensions, neighboring farms adopted the practices in their region. Furthermore, those who perceive lower initial investment and maintenance costs, and located further west/arid region of the study region are more likely to accept subsidy amount to adopt the practices. Our findings suggest that perceived benefits of RG could vary for producers with different ranch characteristics and regional factors and non-adopters with the aforementioned characteristics may be a suitable target group for public fund investment. Therefore, ranch characteristics, regional factors, non-adopters' characteristics should be considered in future research and outreach programs formulate the incentive levels required to successfully promote the adoption of RG practices in the U.S. Great Plains.

Keywords: Perceived benefit, cost-sharing, neighborhood practice, producer survey, rotational grazing

CHAPTER 1

ABSTRACT

EXPLORING THE DETERMINANTS OF PERCEIVED BENEFITS OF ROTATIONAL GRAZING IN THE U.S. GREAT PLAINS

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This paper examines the factors affecting the perceived benefits of using rotational grazing (RG) practice. A proportional odds/partial proportional odds model is estimated using mail survey data of 874 beef producers of North Dakota, South Dakota, and Texas to identify the key factors that affect the perceived benefits of non-adopters and adopters' RG practices. The results of the study indicate that neighborhood practice and government agencies play a positive role on the non-adopters perceived benefits of RG. More educated farmers and ranchers located on the flatter landscapes also perceive higher levels of benefits of RG. These findings also suggest that educated farmers operating on relatively more flat landscape, those who put higher ranking on importance of government agencies as information source, and whose neighborhood practices RG maybe a suitable target group for more effective outreach effort to promote RG practices in the U.S. Great Plains. The findings of the study further indicate that several farm characteristics, including adopters with more percentage of grassland in the operation, relatively less proportion of leased land and less liability ratio, generally perceive higher benefits from RG practices, while higher ranking on importance of government agencies and more percentages of farm located on flatter plains are two other significant variables that affect adopters perceived benefits of RG. These findings further suggest that operating on relatively less proportion of cropland on more owned and flat landscape could be beneficial (specifically, more grass-related, livestock-related, and off-farm environmental benefits) for RG adopters. In the longer term, adopters can also work with government agencies and other grazing specialists to get more technical guidelines and attend training programs to build their confidence and knowledge base to further realize the benefits of the RG and continue the practices in the future.

Keywords: Beef producer, neighborhood practice; perceived benefit, producer survey; rotational grazing

INTRODUCTION

Pastures represent an unexploited resource for ranchers. Pasture and rangeland make up about 44.5 percent of the agricultural land in the U.S. Great Plains (USDA-NASS, 2020). Overgrazing is one of the most common forms of mismanagement (Xu et al., 2018), which results in many deleterious effects on the environment such as soil erosion, runoff, weed problems, loss of wildlife habitat, poor-quality forages, increased greenhouse gas (GHG) emissions, and water pollution (Delgado et al., 2011; Teague et al., 2016). Traditionally, the most common form of grazing management on pastures with livestock is continuous season-long grazing, where livestock have continuous and unrestricted access to a single pasture throughout the season (Holechek et al., 2004; Teague et al., 2011; Vallentine, 2001). The season-long continuous grazing results in lower pasture yield or/and grassland degradation since forage is not allowed to rest and regrow between grazing (Undersander et al., 2002) and make it inefficient, however experimental evidence from arid and semi-arid rangeland studies do not support these observations (Briske et al., 2008). So to overcome these adverse effects of grazing on the environment, better grazing management is required to utilize the available forage efficiently on pasture and to exploit resources associated with it (Norton 1998).

Rotational grazing (RG) also known as management intensive grazing or multi-paddock grazing, is an improved pastureland management practice where the pasture is divided into small blocks and livestock allowed to remain in a single paddock for a short period of time (Teague et al., 2013). Rotational grazing systems were first introduced by the US Forest Service in the early 1900s to overcome the adverse effects of overgrazing on the environment (Holechek et al., 2004). Since then, RG systems have expanded in complexity, have been adopted by progressive producers, and are advocated by resource personnel (Briske et al., 2008; 2011).

RG has been shown to offer numerous environmental and economic benefits to the producer (Wang et al., 2018). For instance, RG practices offers more forage quantity and quality for livestock when tested at ranch scales (Teague et al., 2015). In addition, the practice could bring other benefits such as increasing desirable grass percentage (Wang et al., 2016), decreasing erosion and runoff (Gilley et al., 1996; Wilson et al., 2014; Park et al., 2017), increasing ground cover (Sanjari et al., 2010), increasing soil infiltration (Park et al., 2017; Wood & Blackburn, 1981), faster drought recovery, extended grazing days, increasing stocking rate capacity, reducing hay feeding cost, and provide long-term economic profit (Park et al., 2017; Wang et al., 2016, 2018). In their study McGinty et al., (1979) showed that the RG system had a 136% higher infiltration rate than that of continuous grazing systems, even though both having similar vegetation composition, cattle types, stocking rate, and study region.

Nevertheless, there is an overwhelming body of scientific literature that contradicts the claims made by RG strategies in preserving and improving the natural and agricultural resources on pasture (Briske et al., 2008, 2011; Roches et al., 2015; Savory, 2013). In their studies, Briske et al. (2008; 2011) concluded that RG practice does not provide any unique environmental or agricultural benefits compared to continuous grazing systems. These syntheses also conflict with the experiential perceptions of the benefits of RG practices (Norton et al., 2013; Teague et al., 2011, 2013). Therefore, a considerable gap between the experimental and experiential perceptions about the benefits of the rotational grazing strategies still exists in the literature.

Quite a few studies showed that farmers perceived benefits play an important role on selecting a certain conservation practice (Arbuckle & Roesch-McNally, 2015; Bergtold et al. 2012; Napier et al. 1984; Reimer & Prokopy 2012; Pannell et al. 2006; Singer et al., 2007). For instance, Singer et al. (2007) found that the perceived yield benefits, conservation program participation, and education level are the significant factors in deciding farmers choice of cover crop adoption in the USA corn belt. In addition, the farmers those who consider off-farm environmental benefits, for example, soil and water benefits, during their adoption decision were found to be more likely to adopt soil conservation practices than those who were not (Napier et al. 1984; Reimer and Prokopy 2012). Other similar studies also indicated that perceived soil health benefit could lead to higher likelihood of a soil conservation practice adoption, such as cover crops (Bergtold et al. 2012; Pannell et al. 2006). In general, producer adopts and continue a conservation practice as long as the perceived net benefit of using the practice is positive (Bergtold et al. 2008; Prokopy et al. 2019). However, these perceived benefits depend upon the types of conservation practices and may vary depending on how they are managed.

Despite all these benefits and current research and educational efforts, the adoption rate of RG practices (i.e., best management practices) among the beef producers are still lower than anticipated (Prokopy et al., 2008). To successfully promote/increase participation of the beef producers through best management practices (BMP) in the U.S. Great Plains, a better understanding of the factors influencing producers perceived benefits is required. Early literature on BMPs widely researched the link between different factors and farmers' adoption decision of conservation practices/BMP such as, cover crops, conservation tillage, rotational grazing, etc. (Baumgart-Getz et al., 2012; Brunson & Burritt 2009; Burnett 2014; Carlisle, 2016; Featherstone & Goodwin. 1993; Foltz & Lang, 2005; Gillespie et al., 2008; Jensen et al., 2015; Kim et al., 2005, 2008; Knowler and Bradshaw, 2007; Liu et al., 2018; Napier et al., 1984; Soule et al., 2000; Singh et al., 2017; Prokopy et al., 2008, 2019; Wang et al., 2019), a very few studies have addressed the determinants of farmers' perceived benefits of conservation practices (Bergtold et al., 2012). Specifically, to best of my knowledge, earlier literature on grazing practices did not address the drivers that determine producers perceived benefits of RG practices. Consequently, this study is an attempt to fulfill this ascertain research gap.

This study contributes to the existing literature in two ways. First, it fills the literature gap by identifying factors that influences beef cattle producers' perceived benefits of RG practices. From this understanding we can get more insight about the producers decision-making process in deciding to adopt and/or retain the use of RG practices on their rangeland. Finally, by using the producers' perceptions on benefit, we can predict producer's future likelihood of choosing the practice. This finding is also could enable us to fulfill the current research gap by potentially explaining why the RG practices adoption is lower than the expected.

RESEARCH OBJECTIVES

This study intended to increase our understanding on producers' rotational grazing adoption behavior and their perception about the RG practice. Therefore, the aim of this study is to examine the factors that influence cattle producers' perceived benefits to adopt RG practices in the northern and southern U.S. Great Plains. Specifically, this study explores:

What are the key factors that influencing perceived benefits for RG among the beef producers in the U.S. Great Plains?

Findings of the study will be helpful for cattle producers, policymakers, and academics in the following ways:

(i) improve the understanding of drivers of perceived benefits of conservation practices such as rotational grazing.

(ii) more effectively promote the rotational grazing practice by better connecting to potential producers with their adoption interest, their values, and perceptions.

(iii) better insights for policymakers to frame policies for the target people with positive perception about the RG practice.

LITERATURE REVIEW

This section reviews the existing research on producers perceived benefits of adopting rotational grazing or RG practices and other conservation practices. While several studies has been conducted to explain the factors that influence farmer adoption behavior regarding a new conservation practices, there seems to be growing concern that suggesting that more focus should be tailored on farmers perceptions and the factors that drives their perceptions. To get more insight about the farmers decision making process regarding RG we need to analyze more about their perceptions about the conservation practice. This section reviews this literature regarding farmers perceived benefits, different factors that influences their perceptions, and also how perceptions are linked to their adoption behavior.

Farmers' perceived benefits play a vital role in deciding whether to adopt a new technology or not. These perceived benefits of conservation practices could be influenced by farmer and farm characteristics such as education level, farming experience, farm size, liability ratio, rental ratio, exterior factors such neighboring farm practices, government information sources, location variables such latitude, longitude, slope of the land, etc.

Education level is found to have a positive effect on perceived benefit of farmers (Prokopy et al. 2008; Baumgart-Getz et al. 2012), for instance, in their study of Nebraska farmers, Hoover and Wiitala (1980) showed the more educated a farmer is, the more he/she likely to realize the soil erosion as problem, therefore perceive higher benefits from using conservation practices. On the other hand, farming experience had an adverse impact on perceived benefit from using a conservation practice (Bergtold et al. 2007). More farming experience may increase the likelihood of negative experiences with previous conservation efforts, make farmers more risks averse, and increase the opportunity costs of changing operation, therefore lower the perceive benefits of the conservation practice and farmers become less likely to adopt the conservation practice such as rotational grazing, cover crops, etc. in the future (Ghadim and Pannell, 1999; Kim et al. 2008; Winsten et al., 2011; Prokopy 2011).

Liability ratio in ranching operation is another important factor of producers perceived benefit. High liabilities (e.g., land mortgages) enforced to choose less intensive grazing practice and producers cannot afford to invest in more intensive grazing management practice, especially, infrastructures (such as fencing installation and water system improvement costs). Therefore, producers with relatively low liability ratio perceive more benefit from RG practice. Kim et al. (2008) in their study on 200 Louisiana beef cattle producers, found that producer with lower liability: asset ratio (with greater solvency), are more likely to adopt the rotational grazing practice due to their positive perception on benefits of the practice. Higher income of the farm could influence the farm investment decision. Which usually, lead to increased adoption since producers can afford to invest in new technologies and they are more likely to benefit from tax incentives than low-income producers (Gould et al. 1989; Norris and Batie 1987). Therefore, producers with higher income perceive higher benefits from the adoption of RG practices (Kim et al., 2008; Prokopy et al., 2008).

Neighboring farm practice found to have a positive influence on the farmers' perceived benefits and could increase the likelihood of future practice. For instance, Turinawe et al. (2015) showed that farmers adoption rate of conservation practice can be increased by 45% if their neighbors implement the conservation technologies. The similar findings also reported by Wollni and Andersson (2014), who have conducted a study of the spatial patterns of organic farming adoption in response to several influential factors. Their results indicate that farmers are more likely to adopt conservation practices (i.e., organic farming) when their neighbors also implement the practice.

Different exterior information sources such as government agencies (e.g., NRCS), associations, university extension, and independent consultants are key in disseminating new information and facilitating the adoption of new technologies (Lubell and Fulton, 2008; Lubell et al., 2013; Marshall et al., 2011). All these institutional factors positively contribute to the producers perceived benefits of adopting rotational grazing practices.

Rogers (2010) also shows that information sources play an influential role on farmers perceptions and their management decision. Another study by McBride and Daberkow (2003) showed that government information source positively influences farmers conservation decision.

Earlier literature also indicates, for instance, when farmers operate less rented land (more own land), the study noticed that there is an increase in the level of adoption of conservation practices such as soil management practices and nutrient management due to their positive perception on conservation practices (Bosch et al. 1995; Lichtenberg 2004; Khanna 2001). More grassland acreage in a farm operation is also an indicator of positive perception about that farming practice. Land characteristics such as slope of the land, land quality (e.g., LCC I, II, etc.), geographical location (i.e., latitude and longitude) also determine the producers perceive net benefit of adopting a conservation practice. Conant et al. (2003) in their study found that land characteristics influence the producer's perceived benefit.

A bunch of research indicated that perceived benefit plays a significant role on certain conservation practices. For example, a study of Arbuckle and Roesch-McNally (2015) conducted on Iowa farmers reported that perceived benefits of cover crops contribute to adopting soil management practices, i.e., cover crops. In general, producer adopts and continue a conservation practice as long as the perceived net benefit of using the practice is positive (Bergtold et al. 2008; Prokopy et al. 2019). The farmers who emphasize on the importance of off-farm environmental benefits, for example, soil and water benefits, are found to have higher likelihood of adopt the soil conservation practices (Napier et al. 1984; Reimer and Prokopy 2012).

Regarding the empirical model, earlier literature showed a range of different models were used to analyze the relationship among the factors and perceived benefits of a conservation practice. Arbuckle & Roesch-McNally (2015) used binary logistic regression to model factors that influence the cover corps in Iowa. Specifically, the study examines the association between the farmers' perceptions (benefits, risks, and facilitating factors) of cover crops and their cover adoption. A binary logistic regression is a suitable approach when a dependent variable is a dichotomous nature and here the study considered the value 1 for cover crop adopters and value 0 for nonadopters. In their study Ramsey et al., (2016) employed a bivariate probit model to estimate the farmers risk perceptions of conservation practice. An advantage of using this model is that no additional model modifications are needed to account for the endogeneity (Greene, 2012). Following Khanna (2001) and Tunali (1986), Bergtold et al. (2012) used a two-stage approach: first estimated the bivariate sequential probit model and then the estimate of the model was used as instruments in the Tobit model to identify the demographic and management factors that affects the adoption and perceived yield benefit of winter cover crops in the Southeast using survey data of Alabama farmers. However, several studies used an ordered logit model (also known as ordered logistic regression or proportional odds model) to estimate the influence of the different factors on perceived benefits of a conservation practice (Kim et al., 2008; Tosakana et al., 2010; Wang et al., 2019).

Earlier literature on best management practices widely researched the link between different factors and farmers' adoption decision of conservation practices or BMP such as, cover crops, conservation tillage, rotational grazing, etc. (Baumgart-Getz et al., 2012; Brunson & Burritt 2009; Burnett 2014; Carlisle, 2016; Featherstone &

Goodwin. 1993; Foltz & Lang, 2005; Gillespie et al., 2008; Jensen et al., 2015; Kim et al., 2005, 2008; Knowler and Bradshaw, 2007; Liu et al., 2018; Napier et al., 1984; Soule et al., 2000; Singh et al., 2017; Prokopy et al., 2008, 2019; Wang et al., 2019), a very few studies have addressed the different factors that affect farmers' perceived benefits of conservation practices (Bergtold et al., 2012). This study is an attempt to fulfill the research gap by providing valuable information and guidance for conservation practice through better understanding of the producers perceived benefits of RG practices and the factors that shape these perceptions.

MATERIAL AND METHODS

CONCEPTUAL FRAMEWORK

Producers' perception of the benefits of any new conservation practice is a complex system. It may be difficult to isolate certain psychological uncertainties associated to how farmer formulate their perceptions and to predict how the entire system will respond (Mankad, 2016). For example, there may involve uncertainties for non-adopters with the installation and adaptation and management skills require to a new conservation practice (USDA-NRCS, 2011). For adopter, on the other hand, uncertainties associated with macro factors such as geographic region, policies, markets, business also could play a role in shaping their perceptions (Knowler et al., 2007; Prokopy et al., 2008).

The producers benefit perceptions are assumed to be a function of an individual's experiences and personal background; location specific variables; farm size; and external variables. As indicated in Figure 1.1, farmer perceived benefits of RG practices likely to be a function of four dimensions: operator characteristics, farm characteristics, external variables, and geographic characteristics.

'Operator characteristics' dimension included the variables that capture their cultural background, for instance, years of operation and education. Earlier research indicates that higher socioeconomic status, i.e., a higher level of education lead to increased levels of perceived benefit of conservation practice for the farmers, ceteris paribus (Prokopy et al., 2008; Baumgart-Getz et al., 2012). On the other hand, Bergtold et al. (2012) notes that farming experience had an adverse impact on perceived benefit from using a conservation practice. Here the intuition is that more farming experience may increase the likelihood of negative experiences with previous conservation efforts, make farmers more risks averse, and increase the opportunity costs of changing the operation, therefore lower the perceived benefits of the conservation practice and farmers become less likely to adopt the conservation practice such as rotational grazing, cover crops, etc. in the future (Ghadim and Pannell, 1999; Kim et al. 2008).

'Farm characteristics' dimension comprised the variables that intend to describe the farmer's level of exposure to grazing practice benefits. Four variables were considered in this group: liability ratio, rented land ratio in the operation, total grassland acreage managed by each farm, and the percentage of grassland in their operation. Farmers with more rented land in their operation are more likely to perceive lower grazing benefits, ceteris paribus. The intuition is that the farmers with more rented land in their operation have less incentives for sustainable grassland management practice since they may not expect long-term benefits from those grasslands. Earlier literature indicates, for instance, when farmers operate less rented land (more own land), the study noticed that there is an increase in the level of adoption of conservation practices such as soil management practices (Lichtenberg 2004) and nutrient management (Bosch et al. 1995;

Khanna 2001) due to their positive perception about the practice. I addition, a farm operating more grassland acres (less cropland) may perceive more grass related benefits due to their specialization practice, ceteris paribus. While a farm with more liability ratio might perceive lower benefit from these practices may be due to their limited financial capabilities, they cannot switch their current practice or face financial challenges to expand the business in future, ceteris paribus. The intuition about the grassland percentage is that the more percentage of grassland (less cropland) farm operate the more likely they perceive an increased benefit from the practice due to their more focus on livestock production. This positive perception about the practice also leads adoption of different types of conservation practices such as cover crops, rotational grazing, etc. (Caswell et al. 2001; Gillespie et al. 2007; Dunn et al. 2016).

‘External information source’ intended to capture the effects of different agents on farmers’ perceived benefits. This dimension includes two important variables, such as neighboring farm practice and the government agencies. Neighboring farms practice capture the impact of conservation practice adoption in the neighboring area. The study hypothesized that neighborhood practice has a positive influence on the farmers’ perceived benefits and the likelihood of future adoption of conservation practices (Turinawe et al., 2015; Wollni and Andersson, 2014). The intuition behind this positive perceived benefit is that when a neighboring farm adopts a new conservation practice, it impacts the knowledge base of his neighbors too, since some of their successes or failures are observable. Increased usage of a new conservation practice may provide a signal to the non-adopters that the perceived benefits are higher than they originally thought.

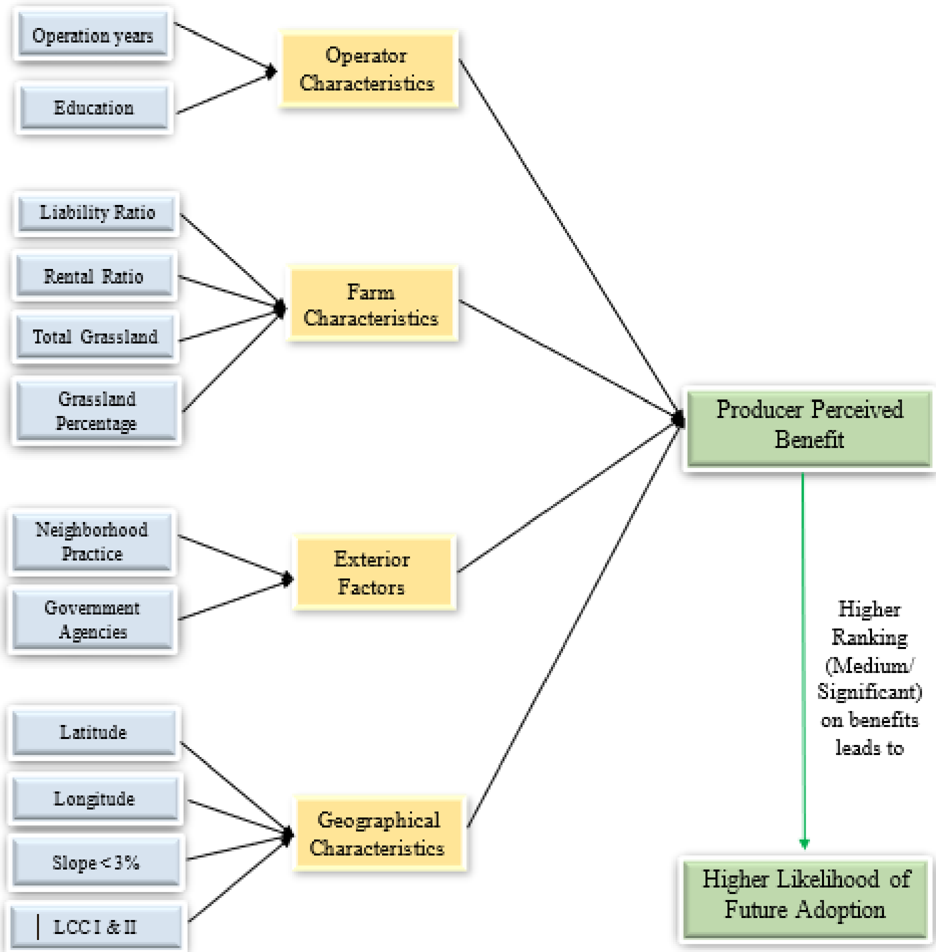

Figure 1.1. Perceived benefit conceptual framework

The study also hypothesized that providing importance to the information source from government agencies helps develop the perceived benefit of the RG practices, ceteris paribus. If a farmer receives more timely and adequate information from government agencies about a new conservation practice it may lead to positive perception about the practice, and they are more likely to adopt the practice in the future. In his study Rogers (2010) shows that information sources could shape farmers' initial knowledge of issues related to a conservation practice and can play a persuasive role in determining the adoption decision or reject a given conservation practice. Other studies on conservation practices, also verify that farmers' engagement with government agencies such as NRCS, USDA, etc., positively associated with the adoption of the practice (McBride and Daberkow 2003; Gillespie et al. 2007).

The final group 'geographic characteristics', includes variables that captures the impact of local environment and physical locations on perceived benefits of RG practices. The first two of these are latitude and longitude, that could greatly influence the farmers perceived benefits, specifically, the grass-related and off-farm benefits. For instance, the farms located more wet area may perceive more grass benefits than those located in the dry/arid area, ceteris paribus. Slope of the land is also an important factor that could shape farmers perceived benefit. A farm located on the flatter land perceive more grass-related, livestock-related, and off-farm benefits than those which located on higher sloped land (add literature). Furthermore, a higher percentage of high-quality land (LCC I and II) also increase producer perception on grass-related benefits from MIG adoption. Thus, the relationship between the perceived benefits and the influential factors that affect their perception can be modeled as a process where farmers decision on adopting or not adopting the practice in the future leads to an updated perception on benefits (see Figure 1.1).

The above discussion on conceptual framework suggests that there are several factors that might explain producer perceived benefits of RG or MIG and why there is a perception difference between adopter and non-adopter in the northern and southern U.S. Great Plains. Those factors conceptually involve (1) farmer characteristics; (2) farm characteristics; (3) external information sources; and (4) geographic characteristics.

The following hypotheses are proposed to assess the influence of different factors has on producers perceived benefit in RG/MIG practices:

H1: Non-adopters, those who have neighborhood practicing rotational grazing, perceive higher farm environmental benefits) than those who have no neighboring farm adopted the practices, *ceteris paribus*.

H2: Adopters, those who reported more percentage of grassland (less cropland) in their operation are more likely to perceive higher benefits in certain categories (such as grass-related benefits, livestock-related benefits, and off-farm environmental benefits), *ceteris paribus*.

SURVEY DESCRIPTION

To represent the physio-graphic and socioeconomic settings of these regions, the study selected beef producers from different counties in three states: North Dakota, South Dakota, and Texas, where a large proportion of cattle operation takes place compared to Central Plains (Wang et al., 2020). These three states also account for 27 percent of beef cattle in the U.S. (Livestock Market Information Center, 2020). The survey questionnaire was developed by a multidisciplinary team and modified and finalized based on the feedback received from the RG practitioners, NRCS conservationists (Wang et a., 2020). The overall purpose of the survey was to examine the economic, environmental, and land-use consequences of RG practice adoption, as well as identify the barriers for non-adoption and incentives to overcome those barriers. The survey questionnaire included a total of 42 questions encompassing a range of topics such as farmers' background information and demographics, past and current management practices, producer perception about RG practices, other RG related questions.

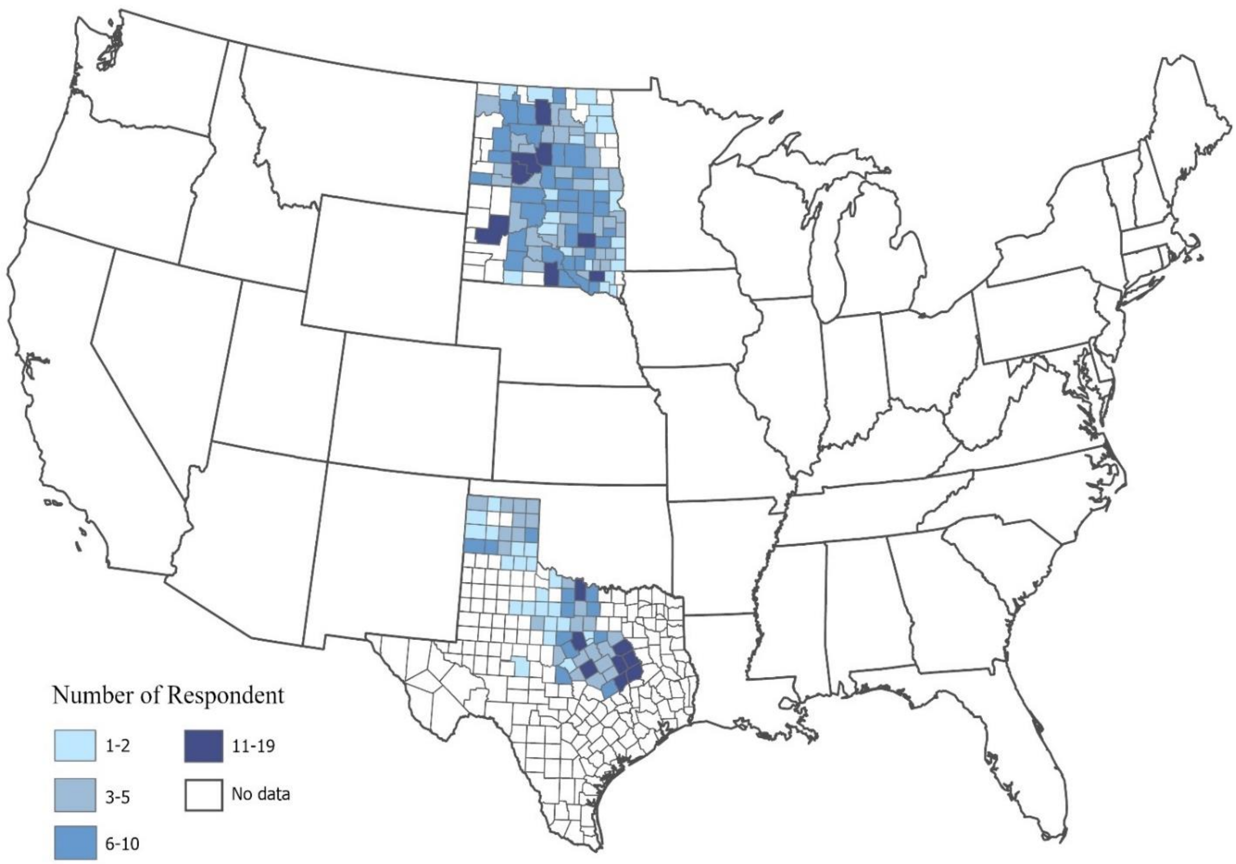

Figure 1.2. Distribution of the overall eligible surveys received by county (Beef Producer Survey, 2018)

The mail survey was sent to 4500 beef producers located in different counties in three states using a three-wave mailing process (Dillman, 2014). After eliminating the incomplete responses, producers who are no longer farming, and deceased, we had 875 usable surveys with an overall response rate of 20.6%. Out of total responses received 26.8 percent are from North Dakota, 36 percent are from South Dakota, and the rest of the 37.2 percent are from Texas. Additionally, about 59.5 percent of the survey respondents are adopters and the rest of the 40.5 percent are non-adopters of the RG practices (Wang et al., 2020). Note that the survey respondents were presented a short definition and pictures about different grazing management practices prior to being asked about their adoption status and perceptions in the rotational grazing practice. About 98.4 percent of the adopters and 91% of the non-adopters answered the perceived benefits-related questions. Later the probability of answering one of four response categories (none, slight, medium, and significant) for perceived benefits is estimated using an appropriate model. The spatial distribution of the respondents from different states is presented in Figure 1.2.

DATA DESCRIPTION

STUDY DEPENDENT VARIABLES

To answer the key research question of the study, I used the survey questions that asked farmer about their perceived benefits of rotational grazing practices.

The study included seven dependent variables in the empirical models. The set of dependent variables include: (1) increased grass percentage, (2) prolonged grazing, (3) faster drought recovery, (4) increased stocking rate, (5) increased weight gain, (6) improved livestock health, and (7) decreased soil erosion. These are identified as perceived benefits generated from the RG practices. Producer perceived benefits were categorized into three categories, grass-related, livestock-related, and off-farm environmental benefits. Here the first set of dependent variables (from 1-3) summarizes the perception on grass benefits reported by the respondents. The second set of dependent variables (from 4-6) represents respondents’ perception on livestock related benefits and the last dependent variable ‘decreased soil erosion’ show their perceptions on off-farm environmental benefits. The survey respondents were asked to rank their perceived benefits of the practice ordinally, therefore, provided same four options namely, 'none', 'slight', 'medium', and 'significant', respectively, for each benefit category, denoted as 1, 2, 3, and 4.

STUDY INDEPENDENT VARIABLES

Based on the existing literature, the study used a list of explanatory variables that are assumed to influence the perceived benefits of intensive grazing practice. These independent variables are grouped into four different categories such as operator characteristics, farm characteristics, external factors, and geographical characteristics.

The first set of explanatory variables 'operator characteristics' include two variables education level and operation years (farming experience). The variable "education level" have five categories denoted by 1 through 5, meaning 'less than high school', 'high school', 'some college or technical school', '4-year college degree' and 'Advanced degree', respectively. Variable "operation years" shows how long been they are involved in farming operation (in years). The average length of operation of the survey respondents were reported as about 38 years, which refers that most of them have been in farming operation for a long time. Additional 'farm-level characteristics' includes four variables such as liability ratio, rental ratio, total grassland in acres (farm size), and grassland percentage. Perceived benefits can be influenced by some external factors such as neighborhood farming practice and information from government agencies. In this study, I have included "neighborhood practice" as a dummy variable. Here the dummy variable takes a value 1 if neighborhood of the respondents is involved in RG or MIG practices or 0 if otherwise. Regarding the information sources, respondents were provided questions with five options to choose from for the variable “government agencies”, namely, “not important”, “slightly important”, “somewhat important”, “quite important”, and “very important”, respectively denoted by 1 to 5. The survey also contained information regarding geographical variables, thus I have included data on slope of land, latitude, longitude, and land capability classifications (type I and II). The study hypothesized that the non-adopters, those who have neighborhood practicing RG, perceive higher benefits in certain categories (such as, increased grass percentage, faster drought recovery, decreased erosion, etc.), ceteris paribus. The list of explanatory variables used in this study and a brief explanation of how each variable were coded in the analysis along with their mean responses and mean significant differences are shown in Table 1.1.

EMPIRICAL MODEL

The modeling objective of the study to examine the key research question of the study, i.e., what are the key factors that influence the potential benefits of RG or MIG practices? The response variable ‘perceived benefit’ used in this study is ordinal in nature and classified in terms of the degree of perceived benefits, where 1= ‘none’, 2 =‘slight’, 3 = ‘medium’, and 4 = ‘significant’ benefits, respectively. For the analysis of this type of categorical dependent variables an appropriate method is the ordered logistic regression model (Greene, 2012; Fullerton, 2009). Therefore, an ordered logistic regression model, also known as the cumulative odds model (Walker and Duncan, 1967) or proportional odds model (McCullagh,1980) will be used to identify the factors that affect the perceived benefits of rotational grazing/MIG practices. Following Kim et al. (2008) and Tosakana et al. (2010) the perceived benefit model of the study is defined as:

$$Y_i^* = x_i\beta_i + \varepsilon_i \;;\; Y_i = j \;\text{ if }\; \delta_{j-1} \leq Y_i^* < \delta_j, \quad \text{where } j = 1,2,3,4 \tag{1}$$

Where Y_i^* is the latent variable that denotes the level of perceived benefits ranging from $-\infty$ to $+\infty$, and 'ε_i' is the random errors of the respective models. The vector of explanatory variables under the study is denoted by the term x_i. Here, β_i is the slope coefficients and δ_j is the threshold of the model.

A dependent variable with four-category outcome will have three binary logit equations also are known as proportional odds model (McCullagh,1980) and can be expressed as probability models as follows:

$$P(Y_i > j) = f(X\beta_j) = \frac{\exp(\alpha_j + X_i\beta_j)}{1+\exp(\alpha_j + X_i\beta_j)}; \quad j = 1,2,...,J-1 \tag{2}$$

Where, X_i is the vectors of independent variables in the model, α_j is the intercepts of the models, and J is the number of categories of the ordinal dependent variable. Here in the model, $J = 4$. Therefore, the ordinal model has three set of coefficients, can be denoted as $\beta_j\left(j \in \{1,2,3\}\right)$.

One of the underlying assumptions of the above ordered logistic regression model (OLM) is that the association between each pair of outcome groups is identical. This is also known as the proportional odds (PO) or the parallel regression assumption. Violations of the parallel lines/proportional odds assumption might result in inconsistent estimates of the model variables.

When the PO assumption holds then I have used the proportional odds (PO) model which is specified as:

$$P(Y_i > j) = f(X\beta) = \frac{\exp(\alpha_j + X_i\beta)}{1 + \exp(\alpha_j + X_i\beta)}; \quad j = 1, 2, 3 \tag{3}$$

Here, the PO model estimates only 12 coefficients for each benefit models, which is more easily interpretable than the generalized ordered logit model.

Some of the alternative models can be used if PO assumption is violated by one or more explanatory variables, namely, unconstrained generalized ordinal logit (gologit) model (Clogg and Shihadeh, 1994), partial proportional odds model (Peterson and Harrell, 1990), or multinomial logit model (MNLM) proposed by (Luce, 1959). Following Williams (2016) and Wang et al. (2020), I have used partial proportional odds (PPO) models when PO assumptions were violated by one or more variables in the model. One of the advantages of using PPO model is that it helps to estimate a smaller number of coefficients than the gologit model. The Brant test (Brant, 1990) is conducted to check the models satisfy the PO assumption or not. The PPO model is specified as:

$$P(Y_i > j) = \frac{\exp(\alpha_j + X_i\beta + Z_i\beta_j)}{1 + \exp(\alpha_j + X_i\beta + Z_i\beta_j}; \quad j = 1, 2, 3 \tag{4}$$

Where, X_i is the vectors of independent variables that meet the PO assumption for benefit i in the PPO model, therefore, have the same coefficient β for the three different values of j, Z_i represents the explanatory variables that violate the PO assumptions for the benefit i and have different coefficient values with the changes in the value of j.

The parameters of the PO and PPO models for non-adopters and adopters perceived benefits were estimated using Statistical Software package STATA (version 14.0, StataCorp LLC, College Station, Texas, USA). For the benefit models where the PO assumption does not satisfy for one or more explanatory variables, marginal effects for those models were also calculated to further interpretation of the PPO models.

RESULTS AND DISCUSSION

OVERVIEW OF PERCEIVED BENEFITS

Table 1.1 provides the descriptive statistics of the benefit variables for non-adopter and adopter respondents along with their mean significant difference. Like prior empirical studies, the current study also divided producers into two groups —'adopters' and 'non-adopters' (Cary and Wilkinson, 1997; Cornejo et al., 1994) to analyze and identify the factors that significantly influence their perceived benefits of RG practice. As indicated in Table 1.1, all the benefit variables in three categories are significantly different for adopter and non-adopter, respectively. However, for the off-farm environmental benefits (i.e., reduced soil erosion benefits) category, the mean difference between adopters and non-adopters is the highest among the other perceived benefits, this indicates that on average non-adopters perceived lower soil erosion benefits than that of adopters.

Figure 2.0 provides a comparison of each of the seven benefit variables under three different benefit categories for RG adopters and non-adopters. For the grass-related benefit category, the average perceived benefits differed substantially between RG adopters and non-adopters. The average ranking of adopters perceived benefits regarding grass-related benefits is slightly higher than the 'medium', while the average ranking for the non-adopters perceived benefits in this category is reported as slightly lower than the 'medium'.

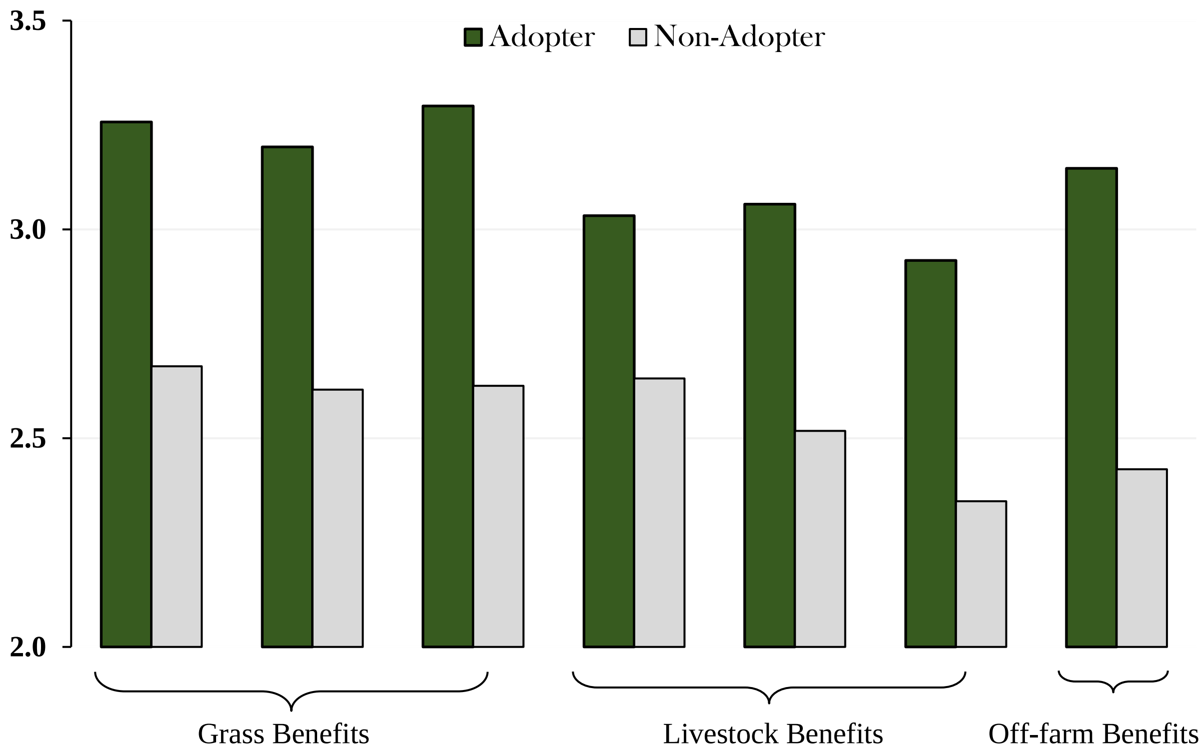

Figure 2.0 Average ranking for perceived benefits of intensive grazing practice for adopters and non-adopters. Here, ranking scale 1 = 'None'; 2 = 'Slight'; 3 = Medium'; 4 = 'Significant

A similar ranking is also reported for the adopters and non-adopters perceived benefits for the off-farm environmental benefit category. However, the difference between the adopters and non-adopters perceived benefits is less consistent for the livestock-related benefit category, where on average adopters and non-adopters perceive about 'medium' benefits and a little higher than 'slight' benefits from RG adoption.

The producers' positive perception of benefits can lead to a higher probability of adoption of the practice in the future.

Figure 3 (a)

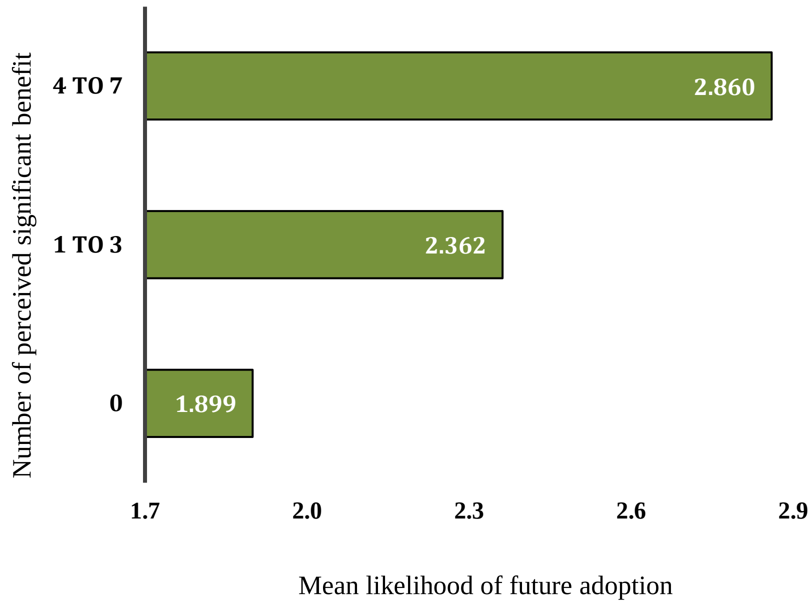

Figure 3 (b)

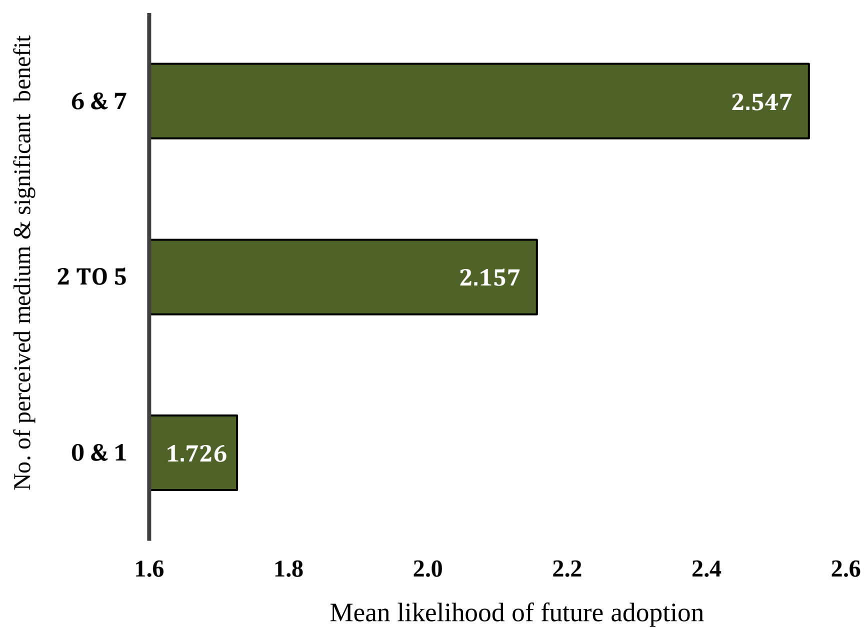

Figure 3.(a).(b). Average of likelihood of future adoption of rotational grazing reported by the non-users who perceived medium and significant benefits of the practice.

As displayed in Figure 3(a), the average of the likelihood of future adoption is the highest (2.860) for the non-adopter with higher-ranked group who perceived at least 4 to

7 significant benefits out of seven benefit categories. Similarly, about 34 percent of the non-adopter who ranked both medium and significant benefits between 6 and 7 out of 7 perceived benefits, had the highest average likelihood of future adoption, 2.547 (Figure 3(b)). This finding suggests that non-adopters' future adoption decisions substantially influenced by their higher level of perceived benefits of the practice.

PROPORTIONAL/PARTIAL PROPORTIONAL ODDS MODEL ESTIMATION RESULTS

Summary statistics of the motive variables (both response and explanatory variables) used in the proportional odds/partial proportional odd models are reported in Table 1.1. As indicated in Table 1.1, the average operation years of the non-adopters is about 38 years which is significantly higher than adopter's average operation years of 35. Furthermore, both non-adopters' and adopters hold on average some college/technical school or slightly higher education level and there are no significant differences between their mean education level. The mean liability ratio for both groups of respondents are slightly lower than the range of 21%-40%. There is a significant difference between the mean grassland percentage between non-adopters (69%) and adopters (70%). The average grazing land for non-adopters is 2420 acres which is significantly different than the adopters average grazing land 3040 acres. On average government information source is believed somewhat important by adopters, while non-adopters ranked the importance of government information source slightly lower than 'somewhat important' and statistically different. On average 95% of the adopters reported that their neighborhood also adopted the RG practice and in the case of non-adopters this average is 37%. The average latitude of the non-adopters and adopters ranges from 39.74 to 41.66-degree

North, while the average longitude of those two groups falls in the ranges between -99.02 to -99.47 degree West and mean location variables are statistically different. On average 48.5 percent of the non-adopters operate on an area that had slopes less than 3%, while in the case of adopters this rate is 43.5 percent on average. Within a 1-mile radius of the farm location on average 45.7% and 44.6% of the soil is reported as LCC I and II for the non-adopters and adopters, respectively.

Table 1.2 through 1.4 represents the PO and/or PPO model estimation results for the explanatory variables included in the non-adopters and adopters' benefit models. A positive coefficient sign in the PO model indicates the increase in the probability of being higher benefit categories as the corresponding value of the explanatory variables also increases, while a negative coefficient sign indicates the probability being lower. To check whether the PO assumptions are holds for all the models used for non-adopters and adopters, the study used the Brant test (Brant, 1990) available in STATA package 14.0. The Brant test results showed that all the models for non-adopters satisfy the PO assumption except for four benefit models for adopters such as the grazing period, drought recovery, stocking rate, and livestock health benefits models. More specifically, the study found liability ratio, rental ratio, government agencies, latitude, and longitude variables in the grazing period model, liability ratio, grassland percentage, government agencies, latitude, and slope less than 3% variables in the drought recovery model, liability ratio, rental ratio, grassland percentage, neighborhood practice, and government agencies variables in the stocking rate model, and liability ratio, total grassland acreage, government agencies, and latitude variables in the livestock health model violated the parallel line assumptions. For the variables violated the PO assumption in the model the study estimated the PPO models for those models, where superscript 'a' through 'c' indicates to coefficients for comparisons of various orders of response options (see Table 1.3 and Table 1.4). To further interpret the four PPO models, the marginal effects along with their respective standard errors are reported in Table 1.5.1 through Table 1.5.4 in the appendix section of the paper.

FACTORS AFFECTING NON-ADOPTERS PERCEIVED BENEFITS

Table 1.2 shows the estimation results of PO models of the non-adopters' perceptions on the benefits of the seven perceived benefits individually with each column shows results for each perceived benefit. Missing values for the explanatory variables reduced the sample size to 262 for the regression models under the grass-related benefits category and off-farm environmental benefits category and to 261 for the benefit models under the livestock-related benefits category.

Results in Table 1.2 reveals that exterior factors such as 'neighborhood practice' play a positive role in non-adopters' perceived benefits of RG practices. As indicated in Table 1.2, neighborhood adoption status is significantly affected five of the seven benefit models. This corroborated the hypothesis that with neighborhood practicing RG non-adopters' perceive more grass-related benefits such as increased grass percentage and drought resilience, more livestock-related benefits such as increased livestock weight gain and improved livestock health and off-farm environmental benefits (i.e., reduced soil erosion). This finding points to a promising avenue for the non-adopters' who could be motivated by their peer's success to adopt the RG practice. Earlier studies also verified that neighborhood practice has a positive influence on the farmers' perceptions and attitude which drive their likelihood of future adoption of the conservation practices in their local area (Manson et al., 2014; Rosset et al., 2011; Wollni and Andersson, 2014; Turinawe et al., 2015; Guo, 2018).

‘Government agencies’ was found significant in all benefit models and positively influence the non-adopters’ perceptions of benefits of the RG practice. This finding implies that emphasizing more importance to the government agencies allow farmers to get more authentic and technical information from exterior information source such as NRCS. This could help to shape their perceptions on benefits of the RG practices and increase the likelihood of the future adoption of the conservation practices. In this regard, the findings are consistent with the previous studies that shown farmers’ engagement with government agencies such as NRCS contributes to the adoption rate of conservation practices (McBride and Daberkow 2003; Gillespie et al., 2007, Rogers, 2010).

Not surprisingly, ‘operator characteristics’ that capture farmers’ cultural background, as indicated by ‘education level’ significantly influence the non-adopters’ perceived benefits of RG practices in all seven benefit models. Specifically, non-adopter with higher level of formal education (e.g., high school degree or college degree) were more likely to perceive higher benefits in all three benefits categories (Table 1.2). Ervin & Ervin (1982) and Prokopy et al. (2008) also verify that higher socioeconomic status, i.e., a higher level of formal education leads to increased levels of perceived soil benefits of the conservation practices. The results suggest that more educated farmers are exposed to more ideas regarding the benefits of conservation practices and making their adoption decisions. In this regards, prior works showed that formal education level had a positive effect on the use of conservation practices (Featherstone and Goodwin, 1993; Caswell et al., 2001; McBride & Daberkow, 2003; Prokopy et al., 2008; Barbercheck et al., 2012).

Slope was found significant four out of seven benefit models (Table 1.2), suggesting that non-adopters with ranches located on more sloped landscape are more likely to perceive more grass-related and livestock-related benefits than those located on flatter landscape. This is likely because more sloped lands are more prone to nutrient losses and have more soil and water-related issues. Therefore, adopting a rotational grazing system on a more sloped landscape could provide greater agricultural conservation practice benefits related to soil, grass, and livestock (High, 2011; Ranjan, 2019).

"Total grassland acres" and "longitude" are the two other significant factors that affect the non-adopters' perceived benefits in one benefit model (Table 1.2). We also found that non-adopters' operating on fewer grassland acreages are more likely to perceive higher livestock health benefits, which may increase the likelihood to adopt the RG practices in the future. It could be speculated that when farms operate less grassland acreage, they can closely monitor their cattle's health improvement which they may not notice when they operate higher grassland acreages. Operating in large grassland acreage also not well suited for livestock health. For instance, mortality rate increases and health status decreases in US cow herds with herd size increases (Shahid et al., 2015). The positive longitude indicates that farm located further east of the study region perceives higher grass-related benefits, specifically, an increased percentage of desirable grass.

FACTORS AFFECTING ADOPTERS PERCEIVED BENEFITS

Tables 1.3 and 1.4 represents the PO/PPO model estimation results of the seven benefits models for adopters of the RG practices. Here, a positive coefficient sign in a PO/PPO model refers to a higher value of the associated explanatory variables increases the probability of being in the higher benefit levels, whereas the negative signs before the model coefficient imply a decrease in probability. Since many farmers skip quite a few relevant questions, therefore, the number of observations decreases from 520 to 454 and 453, respectively for the regression models under the grass-related benefits category and off-farm environmental benefits category and models under the livestock-related benefits category.

The results reported in Tables 1.3 and 1.4 indicate that several farm characteristics including the proportion of grassland, rented land ratio, and liability ratio were significant in five out of seven benefit models for adopters. We found that adopter with a higher proportion of grassland in their operation perceives higher benefits in all three benefit categories. This is perhaps because with grazing land share increases farm can more focus on their cattle operation and closely observe the grass-related benefits, soil benefits, and livestock health benefits, therefore, perceive higher benefits of RG. Benefits research also suggests that pastureland usually has limited leaching and soil erosion (Speir, 2009; DeVore, 2016). By contrast, those who lease less proportion of grassland acres for grazing livestock were more likely to perceive higher soil erosion benefits, grass-related benefits (such as longer grazing period and increased drought recovery benefits), and livestock-related benefits (i.e., higher stocking rate and improved livestock health benefits). This is likely because due to the limited lease period and/or uncertainty about the duration of the operation in the rented land they may not plan to adopt a sustainable and well-designed long-term conservation practices. Furthermore, many renters don't realize the benefits in the short run because the benefits of conservation practice are generally seen in the long-term (Soule et al., 2000; Sklenicka et al., 2015). Earlier literature indicates, for instance, when farmers operate less rented land, the study noticed that there is an increase in the level of adoption of conservation practices such as soil management practices (Lichtenberg 2004) and nutrient management (Bosch et al. 1995; Khanna 2001) due to their positive perception about the soil-related benefits of the practice. The results also indicated that adopters with more liability ratio in their operation are less likely to perceive higher grass-related (i.e., grazing period and drought recovery) and livestock-related benefits from the RG practices than those who have lower liability ratios (Tables 1.3, 1.4). Consequently, higher liability farms those who are facing financial difficulties are more likely to perceive lower benefits from the RG practices. This finding also suggests that with lower liability ratio adapters tend to increase the degree of operating efficiency in their cattle production, hence, perceived more benefits into the foreseeable future.

Exterior factors such as information sources from ‘government agencies’ significantly affect the adopters’ perceived benefits of RG practices in all seven benefit models. As indicated in Tables 1.3 and 1.4, adopters who emphasize more importance on government agencies (e.g., NRCS) as information source had a higher likelihood to perceive higher benefits in all three benefit categories, for example, grass, livestock, and soil erosion benefits from the RG practice. Other studies on conservation practices have cited that agricultural information from the government agencies help farmers to understand the nature of farming, erosion process and the seriousness of erosion problem and contribute to the increased perceptions of benefits of the conservation practices (Liu et al.; 2018; Prokopy et al., 2019). Thus, it is reasonable that in the long-term adopters more engagement with government agencies can help them to get more technical and timely information and training programs that can build their confidence and knowledge base to further realize the benefits of the RG and continue the practice in the future.

For rangeland in the Northern and Southern Great Plains of U.S., the results of the study in Tables 1.3 and 1.4 indicated that adopters' ranch located on relatively sloped landscape perceive higher grass-related benefits such as longer grazing period and draught recovery benefits, livestock benefits such as increased weight gain and off-farm environmental such as reduced soil erosion benefits from RG practice. For example, farm that operate on more sloped grassland perceive higher livestock weight gain benefits since the RG system allows farmers to better utilize the higher sloped land in terms of a more uniform distribution of cattle grazing and efficient use of the pasture. In addition, in RG system, ranchers can also successfully avoid cattle grazing preference, for instance, research has demonstrated that cattle prefer grazing pastures with lower slopes and generally avoid grazing when slopes greater than 20 percent (Cook 1966; Ganskopp & Vavra, 1987; Mueggler,1965). Moreover, with an increase of each degree of the slope also rises the chance of surface soil carried away with the water that moves downhill into valleys and streams (Pimentel & Burgess, 2013) and a landscape with relatively higher slope also susceptible to drought injury (Schild, 2018).

Other factors such as 'latitude' and 'total grassland acreage' also found significant in three and two benefit models, respectively. As indicated in Table 1.3 and 1.4, adopters located further northeast of the study area perceive higher grass-related benefits such as longer grazing period and drought recovery benefits and reduced soil erosion benefits from the RG practice than those who located on further southwest. By contrast, adopters who operate less grazing land acres are more likely to perceive higher benefits in certain categories such as higher stocking rate and improved livestock health benefits.

FACTORS AFFECTING THE PERCEIVED BENEFITS OF RG ADOPTERS VS. NON-ADOPTERS

Similar to prior empirical studies, the current study also divided producers into two homogeneous groups —'adopters' and 'non-adopters' (Cary and Wilkinson, 1997; Cornejo et al., 1994) to analyze and identify the factors that significantly influence their perceived benefits of RG/MIG practices using PO/PPO models. This approach provides least discrimination on the factors that determines benefit and could separately capture their effects on the adopters and non-adopter's perception on benefits of these practices.

Taken overall, the results in Tables 1.2, 1.3, and 1.4, suggest several interesting patterns. One key finding is the consistent positive effect of information sources from government agencies on non-adopters' and adopters perceived benefits of RG/MIG practices. This variable is an important predictor in this model, having significant effects on the producers' perceived benefits in all three benefit categories. This effect is as expected given higher importance, how timely and more adequate information's from the government agencies could shape the knowledge base of both non-adopters' and adopters' perceived benefits of the RG/MIG practices. This positive perception on benefits also may lead to non-adopters' higher likelihood of future adoption of the practices. Another exterior factor, for instance, neighborhood adoption status has a significant and positive effect on non-adopters perceived benefits on RG/MIG practices in all three benefit categories, although it has no significant influence on adopters perceived benefits. This result suggests that non-adopters' perceptions on benefits is more likely to influence by the neighboring farming practice, as they can observe some of their peer’s success and failure story, therefore perceive higher benefits in certain categories such as increased grass percentage, drought recovery benefits, increased weight gain and livestock health benefits, and reduced soil erosion benefits.

Education has a significant effect on non-adopters’ perceived benefits in all three benefit categories, as anticipated, but was not significant for determining the adopters perceived benefits except in one case where it is found to be significantly affect the perceived soil erosion benefit. This finding aligns with prior work showing even though having higher levels of education adopters don’t see the grass-related and livestock-related benefits in the short-run, since some of the benefits of the conservation practice can be seen in the long-term (Soule et al., 2000; Sklenicka et al., 2015).

Several farm characteristics including grassland percentage, rented grassland ratio, and liability ratio were shown to affect perceived benefits of adopters, however, these farm characteristics was not significant for non-adopters’ perceived benefits of the RG/MIG practices. Interestingly, we found that adopters operating on higher proportion of grazing land (less cropland) and has lower liability ratio in their operation are more likely to perceive higher grass-related, livestock-related, and off-farm environmental benefits. More grassland share in the operation also suggests adopters more emphasize on the current cattle operations leads to higher perceived benefits of the practices in all three benefit categories. Meanwhile, operating on more own grassland had a positive effect on adopters perceived benefits, specifically, higher perceptions on grass-related and livestock-related benefits.

When we consider geographic characteristics, we see that slope of the land significantly affect both non-adopters and adopters perceived benefits of RG/MIG practices. Relatively more non-adopters' located on relatively flatter landscape were more likely to perceive higher benefits in certain categories, such as grass-related and livestock related benefits, so does the adopters located on more flatter land who perceive higher benefits in all three benefit categories. In addition, non-adopters located further east of the study region were more likely to perceive more increased desirable grass benefits, which is likely because those areas were basically more wet region that receive plenty of rainfall throughout the year. In comparison, adopters located further northeast of the study region are more likely to perceive more longer grazing period benefits and improved livestock health benefits, while farm located further southwest of the study region perceive more soil erosion benefits than that of the farms located further northeast.

Land class has no significant effect on both non-adopters and adopters perceived benefits, as Land I & II was found non-significant for all seven benefit models. Producers' years of operation also found to have no significant effect on perceived benefits of both groups of farmers.

At least three general conclusions maybe drawn from these results. First, there are important similarities in predictors of both non-adopters' and adopter' perceived benefits. Particularly, information from the government agencies and slope of the landscape related to the higher perceived benefits of the non-adopters and adopters in all three benefit categories. Second, some individual attributes, such as neighborhood adoption status and farmers education, significantly affect non-adopters perceived benefits of RG/MIG practices in all three benefit categories. Being a non-adopter' those who have their neighboring farm adopted the practices are more likely to perceive greater benefits compared to non-adopters whose peers did not yet adopt the RG practices. Compared to counterparts with less year of education, non-adopters' with more years of education more likely to perceive higher benefits of RG practices. Third, some unexpected differences in the farm characteristics were revealed. For example, several farm characteristics such as grassland percentage, lease ratio, and liability ratio significantly affected the perceived benefits of the adopters of RG practices but has no significant effect on non-adopters' perceived benefits concerning those practices.

SUMMARY AND CONCLUSION

The study is conducted to determine the key factors that affect non-adopters' and adopters' perceived benefits of RG adoption in the northern and southern U.S. Great Plains. The results of the PO/PPO logit regression analysis provide insight into the roles of perceived benefits play in decision making process in deciding to adopt and/or retain the use of rotational grazing practices on their operation among the beef producers of the study region.

The results of the study indicate that neighborhood practice and information from government agencies play a positive role on the non-adopters perceived benefits of RG. More educated farmers and ranchers located on the flatter landscapes also perceive higher levels of benefits of RG. These findings suggest that educated farmers operating on relatively more flat landscape, those provide more importance to the government agencies as information source, and whose neighborhood practices RG maybe a suitable target group for more effective outreach effort to promote RG practices in the Northern and Southern Great Plains of the USA.

The findings of the study further indicate that several farm characteristics, including adopters with more grassland percentage, relatively less proportion of leased land, and less liability ratio, generally perceive higher benefits of RG practices. While emphasizing more importance to the government information source and more percentages of farms located on the sloped landscape are two other significant variables that affect adopters perceived benefits of RG. These findings further suggest that farmers operating on a higher proportion of grassland on more owned and sloped land perceive higher benefits specifically, more grass-related, livestock-related and off-farm environmental benefits from RG practice In the longer term, adopters can also work with government agencies and other grazing specialists to get more technical guidelines and attend training programs to build their confidence and knowledge base to further realize the benefits of the RG and continue the practice in the future.

Considered together, the findings of the study will be helpful to determine the key factors that shape farmers' perceived benefits and their conservation behavior. However, simply explaining the benefits and identifying the determinants of such practice will not be as effective as demonstrating how they work. More outreach and exhibition efforts could be done so that it may allow farmers, especially among the non-adopters with favorite opinions towards RG to test the practice in their own farms, providing direct opportunities to experience about the benefits of the practice. On top of that there still exists a wide perception gap/differences of conservation practice benefits between users and non-users. Therefore, more research and education/training are still required to help expand the understanding of rotational grazing benefits for both farm profitability and the environment.

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APPENDIX

Table 1.1. Summary and descriptive statistics for the motive variables

Category	Variable	Variable description/coding	Non-Adopter Mean	Adopter Mean	Mean Difference
Perceived Benefits	Grass Percentage	Perceptions on possible benefits associated with intensive grazing practice (1 = None; 2 = Slight; 3 = Medium; 4 = Significant)	2.67	3.26	-0.59^{***}
	Prolonged Grazing		2.62	3.19	-0.58^{***}
	Drought Recovery		2.62	3.30	-0.68^{***}
	Stocking Rate		2.65	3.03	-0.38^{***}
	Weight Gain		2.52	3.06	-0.54^{***}
	Livestock Health		2.34	2.93	-0.58^{***}
	Soil Erosion		2.42	3.15	-0.73^{***}
Operator Characteristics	Operation Years	Number of years in farming as primary operator	37.66	35.30	2.36^{**}
	Education Level	Highest level of formal education completed (1 = less than high school; 2 = high school; 3 = some college/technical school; 4 = 4-year college degree; 5 = Advanced degree (Masters, PhD etc.)	3.19	3.27	-0.09
Farm Characteristics	Liability ratio	Ranchers' ratio of total liability ratio to total assets (1 = 0%; 2 = 1-20%; 3 = 21-40%; 4 = 41-60% ; and 5 = 61- 80%; 6 = 80% or above)	2.57	2.65	-0.08
	Rental ratio	Ratio of rented grassland acres to total grassland acres	0.29	0.35	-0.06^{**}
	Grassland Percentage	Percentage of total grassland acres in each farm	69.42	70.18	-0.76^{***}
	Total Grassland	Total grassland acres managed by each farm (in 10^3 acre	2.42	3.04	-0.62^{*}
Exterior Factors	Neighborhood Practice	Percentage of all ranchers with in a 20-mile radius of the farm practices RG (1 = Neighboring farm practice RG, 0 = otherwise).	0.37	0.95	-0.58^{***}
	Government Agencies	Importance of government information sources (1 = Not important; 2 = Slightly important; 3 = Somewhat important; 4 = Quite important; 5 = Very important)	2.67	3.08	-0.40^{***}
Geographic Characteristics	Latitude	Latitude of the farm exact location	39.74	41.66	-1.92^{***}
	Longitude	Longitude of the farm exact location	-99.02	-99.47	0.45^{***}
	Slope < 3%	Share of the slope of the land less than or equal to 3%	48.50	43.48	5.02^{*}
	LCC I & II	Share of the land with LCC equals I and II	45.65	44.57	1.08

Note: *** p<0.01, **p<0.05, *p<0.1

Table 1.2. Ordered logit regression model results for Non-adopters' Perceived Benefits

	Grass Benefits			**Livestock Benefits**			**Off-farm Benefits**
Variables	Grass Percentage	Grazing Period	Drought Recovery	Stocking Rate	Weight Gain	Livestock Health	Soil Erosion
Operation Years	0.002	0.009	-0.000	0.003	0.009	0.010	0.006
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
Education Level	0.376***	0.178	0.243**	0.242**	0.200*	0.269**	0.241**
	(0.124)	(0.121)	(0.119)	(0.121)	(0.121)	(0.124)	(0.122)
Liability Ratio	0.036	0.124	0.066	0.069	0.045	0.119	0.120
	(0.096)	(0.094)	(0.095)	(0.093)	(0.094)	(0.096)	(0.093)
Rental Ratio	0.121	0.098	0.088	0.227	0.175	0.241	0.099
	(0.357)	(0.356)	(0.352)	(0.348)	(0.355)	(0.357)	(0.351)
Grassland Percentage	-0.003	0.005	0.006	-0.004	0.002	0.004	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Total Grassland	0.051	-0.026	-0.040	0.048	-0.018	-0.049*	0.006
	(0.035)	(0.029)	(0.032)	(0.033)	(0.028)	(0.028)	(0.032)
Neighborhood Practice	0.607**	0.378	0.417*	0.292	0.619**	0.690***	0.519**
	(0.252)	(0.246)	(0.248)	(0.247)	(0.251)	(0.248)	(0.245)
Government Agencies	0.590***	0.520***	0.465***	0.506***	0.451***	0.466***	0.408***
	(0.099)	(0.096)	(0.095)	(0.095)	(0.095)	(0.096)	(0.096)
Latitude	0.022	0.027	0.030	0.001	-0.004	-0.023	-0.007
	(0.028)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Longitude	0.193**	0.096	0.090	0.083	0.072	0.057	0.096
	(0.076)	(0.077)	(0.076)	(0.077)	(0.077)	(0.076)	(0.076)
Slope < 3%	-0.005*	-0.007**	-0.003	-0.006*	-0.007**	-0.004	-0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
LCC I & II	-0.003	0.001	-0.002	-0.001	0.000	0.001	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant1	-17.596**	-7.597	-7.158	-7.942	-6.749	-4.685	-9.081
	(7.107)	(7.196)	(7.083)	(7.177)	(7.176)	(7.068)	(7.082)
Constant2	-15.953**	-6.019	-5.665	-6.432	-5.093	-3.257	-7.538
	(7.098)	(7.192)	(7.080)	(7.173)	(7.170)	(7.066)	(7.078)
Constant3	-14.024**	-4.327	-3.995	-4.975	-3.381	-1.814	-5.856
	(7.080)	(7.189)	(7.077)	(7.168)	(7.166)	(7.065)	(7.070)
Observations	262	262	262	261	261	261	262

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, *p<0.1

Table 1.3. Model Estimates for Adopters Potential Grass-related benefits

Variables	Grass Benefits					
	Grass Percentage		Grazing Period		Drought Recovery	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Operation Years	-0.002	0.008	-0.018**	0.008	-0.009	0.007
Education Level	0.051	0.106	0.046	0.107	0.006	0.109
Liability Ratio	-0.072	0.071	[a] -0.446**	0.206	[a] -0.117	0.212
			[b] 0.127	0.099	[b] -0.199*	0.106
			[c] 0.123*	0.076	[c] 0.078	0.077
Rental Ratio	-0.230	0.273	-0.541**	0.277	-0.512*	0.279
Grassland Percentage	1.320***	0.410	[a] 4.881***	1.251	[a] 3.147***	1.158
			[b] 1.334**	0.595	[b] 0.428	0.611
			[c] 0.252	0.448	[c] 0.310	0.458
Total Grassland	-0.016	0.019	-0.001	0.018	0.016	0.020
Neighborhood Practice	-0.114	0.454	0.007	0.474	-0.622	0.494
Government Agencies	0.151**	0.074	[a] 0.179***	0.074	[a] 1.022***	0.295
			[b] 0.278***	0.108	[b] 0.551***	0.120
			[c] 0.109	0.079	[c] 0.218***	0.079
Latitude	-0.010	0.023	[a] 0.266***	0.061	[a] 0.016	0.069
			[b] 0.037	0.032	[b] 0.008	0.031
			[c] -0.028	0.025	-0.067***	0.026
Longitude	-0.002	0.065	[a] 0.651***	0.156	-0.152**	0.069
			[b] 0.215**	0.087		
			[c] -0.083	0.068		
Slope < 3%	-0.003	0.002	-0.004*	0.002	[a] -0.019**	0.009
					[b] -0.013***	0.003
					[c] -0.006	0.002
LCC I & II	0.001	0.002	0.004	0.002	0.006	0.004
Adopter MIG (1,0)	-0.017	0.304	0.450	0.303	0.393	0.311
Constant	[a] -3.590		[a] 3.919		[a] 6.208	
	[b] -0.927		[b] 2.480		[b] 8.107	
	[c] 1.065		[c] -2.814		[c] 9.890	
Model Fit	LR χ^2 (12) = 22.16		LR χ^2 (19) = 63.01		LR χ^2 (22) = 67.27	
	Prob > χ^2 (12) = 0.035		Prob > χ^2 (19) = 0.000		Prob > χ^2 (22) = 0.000	
Observations	454		454		454	

Note: *** p<0.01, **p<0.05, *p<0.1;
For variables that meet proportional odds assumption there is one coefficient;
For variables violating proportional odds assumption there are three coefficients, superscript ‘a’ refers to coefficients for responses of 2, 3, 4 vs. 1; superscript ‘b’ refers to coefficients for responses of 3, 4 vs. 1,2; and superscript ‘c’ refers to coefficients for responses of 4 vs. 1, 2, 3, where 1 = ‘None’; 2 = ‘Slight’; 3 = ‘Medium’; 4 =‘Significant’

Table 1.4. Model Estimates for Adopters Potential Livestock-related benefits and Off-farm benefits

Variables	**Livestock Benefits**						**Off-farm Benefits**	
	Stocking Rate		Weight Gain		Livestock Health		Soil Erosion	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Operation Years	-0.010	0.008	0.008	0.008	0.012	0.008	0.003	0.008
Education Level	0.086	0.105	-0.040	0.104	0.027	0.103	0.304***	0.107
Liability Ratio	^{a} -0.339***	0.154	0.134*	0.071	^{a} -0.244*	0.142	-0.026	0.071
	^{b} -0.055	0.084			^{b} 0.180**	0.086		
	^{c} -0.125*	0.076			^{c} 0.216***	0.078		
Rental Ratio	^{a} -0.430	0.266	-0.352	0.272	-0.423*	0.267	-0.562**	0.272
	^{b} 0.093	0.332						
	^{c} -0.719**	0.307						
Grassland Percentage	0.083	0.405	0.434	0.404	0.963**	0.410	0.706*	0.415
Total Grassland	^{a} -0.066**	0.026	-0.015	0.019	^{a} -0.159***	0.033	-0.007	0.018
	^{b} 0.004	0.027			^{b} -0.049**	0.025		
	^{c} 0.021	0.024			^{c} -0.003	0.020		
Neighborhood Practice	^{a} -0.304	0.471	-0.444	0.443	0.288	0.444	-0.644	0.489
	^{b} 0.217	0.503						
	^{c} -0.788	0.486						
Government Agencies	^{a} 0.268*	0.072	0.219***	0.074	^{a} 0.057	0.141	0.295***	0.075
	^{b} 0.423***	0.093			^{b} 0.273***	0.090		
	^{c} 0.187**	0.080			^{c} -0.039	0.086		
Latitude	-0.012	0.022	-0.008	0.023	^{a} 0.110***	0.036	-0.044**	0.024
					^{b} 0.034	0.024		
					^{c} -0.001	0.024		
Longitude	-0.001	0.063	-0.054	0.064	-0.003	0.064	-0.159***	0.066
Slope < 3%	-0.001	0.002	-0.004*	0.002	-0.000	0.002	-0.004*	0.002
LCC I & II	0.003	0.002	-0.001	0.002	-0.001	0.002	0.000	0.002
Adopter MIG (1,0)	0.004	0.290	0.078	0.289	0.117	0.288	0.202	0.296
Constant	^{a} 3.061		^{a} 2.395		^{a} -2.305		^{a} 12.341**	
Constant	^{b} 0.953		^{b} 4.671		^{b} -3.318		^{b} 14.007**	
Constant	^{c} -0.718		6.681		-2.826		^{c} 15.840***	
Model Fit	LR χ^2(15) = 31.19		LR χ^2(16) = 42.81		LR χ^2(21) = 65.18		LR χ^2(14) = 57.67	
	Prob > χ^2(15) = 0.001		Prob > χ^2(16) = 0.000		Prob > χ^2(21) = 0.000		Prob > χ^2(14) = 0.000	
Observations	453		453		453		454	

Note: *** p<0.01, **p<0.05, *p<0.1

For variables that meet proportional odds assumption there is one coefficient; For variables violating proportional odds assumption there are three coefficients, superscript ‘a’ refers to coefficients for responses of 2, 3, 4 vs. 1; superscript ‘b’ refers to coefficients for responses of 3, 4 vs. 1, 2; and superscript ‘c’ refers to coefficients for responses of 4 vs. 1, 2, 3, where 1 = ‘None’; 2 = ‘Slight’; 3 = ‘Medium’; 4 = ‘Significant’

Table 1.5.1. Marginal effects (ME) and standard errors (SE) for adopter perceived grazing period benefits model:

Variables	None		Slight		Medium		Significant	
	ME	SE	ME	SE	ME	SE	ME	SE
Operation Years	0.000	0.000	0.002**	0.001	0.002*	0.001	-0.004**	0.002
Education Level	-0.001	0.001	-0.005	0.012	-0.005	0.013	0.011	0.026
Liability Ratio	0.006**	0.003	-0.009	0.011	-0.038**	0.017	0.043**	0.019
Rental Ratio	0.007	0.005	0.060*	0.031	0.066*	0.035	-0.132*	0.068
Grassland Percentage	-0.063***	0.023	-0.098	0.069	0.104	0.104	0.057	0.110
Total Grassland (x 10^3)	0.000	0.000	0.000	0.002	0.000	0.002	-0.000	0.004
Neighborhood Practice (1,0)	0.000	0.006	0.002	0.051	0.003	0.058	-0.005	0.116
Government Agencies	-0.007**	0.003)	-0.037***	0.012	0.016	0.019	0.027	0.019
Latitude	-0.004***	0.001	0.001	0.004	0.011**	0.005	-0.007	0.006
Longitude	-0.011***	0.004	-0.015	0.010	0.047***	0.014	-0.021	0.017
Slope < 3%	0.000	0.000	0.000*	0.000	0.000*	0.000	-0.001*	0.001
LCC I & II	-0.000	0.000	-0.000	0.000	-0.000	0.000	0.001	0.001
Adopter MIG (1,0)	-0.005	0.003	-0.046*	0.026	-0.066	0.047	0.117	0.075

Note: *** p<0.01, **p<0.05, *p<0.1

Table 1.5.2. Marginal effects (ME) and standard errors (SE) for adopter perceived drought recovery benefits model:

Variables	None		Slight		Medium		Significant	
	ME	SE	ME	SE	ME	SE	ME	SE
Operation Years	0.000	0.000	0.001	0.001	0.001	0.001	-0.002	0.002
Education Level	-0.000	0.001	-0.001	0.011	-0.001	0.015	0.001	0.027
Liability Ratio	0.001	0.003	0.021*	0.011	-0.042**	0.017	0.019	0.019
Rental Ratio	0.006	0.004	0.052*	0.029	0.070*	0.039	-0.128*	0.070
Grassland Percentage	-0.036**	0.015	-0.030	0.058	-0.001	0.096	0.067	0.112
Total Grassland (x 10^3)	-0.000	0.000	-0.002	0.002	-0.002	0.003	0.004	0.005
Neighborhood Practice (1,0)	0.005	0.004	0.051	0.033	0.095	0.079	-0.152	0.114
Government Agencies	-0.011***	0.004	-0.050***	0.012	0.005	0.018	0.056***	0.020
Latitude	-0.000	0.001	0.001	0.003	0.015***	0.005	-0.016***	0.006
Longitude	0.001	0.001	0.012*	0.007	0.017**	0.009	-0.031*	0.017
Slope < 3%	0.000*	0.000	0.001***	0.000	-0.000	0.001	-0.001	0.001
LCC I & II	-0.000	0.000	-0.000	0.000	-0.000	0.000	0.000	0.001
Adopter MIG (1,0)	-0.000	0.000	-0.000	0.000	-0.000	0.000	0.001	0.001

Note: *** p<0.01, **p<0.05, *p<0.1

Table 1.5.3. Marginal effects (ME) and standard errors (SE) for adopter perceived stocking rate benefits model:

Variables	None		Slight		Medium		Significant	
	ME	SE	ME	SE	ME	SE	ME	SE
Operation Years	0.000	0.000	0.001	0.001	0.001	0.000	-0.002	0.002
Education Level	-0.003	0.004	-0.011	0.015	-0.004	0.005	0.019	0.025
Liability Ratio	0.014**	0.006	-0.004	0.014	-0.039**	0.016	0.029*	0.018
Rental Ratio	0.024	0.022	-0.041	0.053	0.201***	0.070	-0.184**	0.072
Grassland Percentage	-0.004	0.016	-0.013	0.058	-0.005	0.021	0.022	0.096
Total Grassland (x 10^3)	0.002*	0.001	-0.005	0.004	-0.003	0.005	0.006	0.006
Neighborhood Practice (1,0)	0.014	0.030	-0.057	0.097	0.226***	0.087	-0.184	0.120
Government Agencies	-0.015*	0.008	-0.062***	0.016	0.033*	0.018	0.043**	0.019
Latitude	0.000	0.001	0.002	0.003	0.001	0.001	-0.003	0.005
Longitude	-0.000	0.003	-0.000	0.009	-0.000	0.003	0.001	0.015
Slope < 3%	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.001
LCC I & II	-0.000	0.000	-0.000	0.000	-0.000	0.000	0.001	0.001
Adopter MIG (1,0)	-0.000	0.012	-0.001	0.042	-0.000	0.015	0.001	0.069

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.5.4. Marginal effects (ME) and standard errors (SE) for adopter perceived livestock health benefits model:

Variables	None		Slight		Medium		Significant	
	ME	SE	ME	SE	ME	SE	ME	SE
Operation Years	0.001	0.000	-0.002	0.001	-0.000	0.000	0.003	0.002
Education Level	-0.001	0.001	-0.004	0.016	-0.000	0.000	0.006	0.022
Liability Ratio	0.012*	0.007	-0.049***	0.015	-0.009	0.017	0.046***	0.017
Rental Ratio	0.021	0.014	0.066	0.042	0.0040	0.007	-0.091	0.057
Grassland Percentage	-0.047**	0.022	-0.150**	0.065	-0.009	0.015	0.206**	0.088
Total Grassland (x 10^3)	0.008***	0.002	0.002	0.004	-0.009**	0.005	-0.001	0.004
Neighborhood Practice (1,0)	-0.016	0.028	-0.046	0.073	0.004	0.016	0.058	0.085
Government Agencies	-0.003	0.007	-0.053***	0.016	0.064***	0.019	-0.009	0.018
Latitude	-0.005***	0.002	-0.002	0.004	0.007**	0.004	-0.000	0.005
Longitude	0.000	0.003	0.001	0.010	0.000	0.001	-0.001	0.014
Slope < 3%	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.000
LCC I & II	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.001
Adopter MIG (1,0)	-0.006	0.013	-0.018	0.044	-0.002	0.007	0.026	0.064

Note: *** $p<0.01$, ** $p<0.05$, * p<

CHAPTER 2

ABSTRACT

DETERMINANTS OF COST SHARE FOR ROTATIONAL GRAZING: EVIDENCE FROM U.S. GREAT PLAINS

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This study evaluates the key factors that affect the adopters cost share and non-adopters' choice of different incentive payments for adopting the rotational or management intensive grazing practices. Using 874 beef producers survey data in North Dakota, South Dakota, and Texas, the study estimates a probit model and ordered logistic model to determine the key factors that influence producers' cost share/subsidy levels to implement the rotational grazing (RG) or management intensive grazing (MIG) practices. The results from the probit model show that, adopters of rotational grazing who received cost share had more proportion of grassland in their operation, higher ranch income ratio, fewer adoption years, provide more importance to the university extensions as information source, operate an increased proportion of land with LCC I and II, and located further north to the study region. These findings also suggest the type of producers who required cost share to implement the rotational grazing on their ranch. The empirical results from ordered logistic regression model further indicate that farmers are more willing to adopt RG/MIG practices in the future with different subsidy amounts those who had more years of farming experiences, had less grassland acreage, and more liability ratio, emphasize the importance of university extensions, had neighboring farms adopted the practices in their region. Furthermore, those who perceive lower initial investment and maintenance costs, and located further west/arid region of the study region are more likely to accept subsidy amount to adopt the practices. The above findings further suggest that non-adopters with the aforementioned characteristics may be a suitable target group for public fund investment and formulate the incentive levels needed to successfully promote the adoption of these two grazing management practices in the U.S. Great Plains.

Keywords: cost-sharing, rotational grazing, cattle producer, willingness to accept.

INTRODUCTION

It is widely recognized that agricultural production often places significant pressure on the utilization of natural resources and have direct and indirect effects on the environment. This pressure leads to increased social concern for environmentally friendly use of agricultural practices such as best management practices (BMPs) and the call for sustainable agriculture. Sustainable agriculture seeks to increase farm profitability, promote environmental stewardship, improve farm families and community's quality of life, and increase the earth's natural resource base (NIFA, 2020).

Agriculture contributes 9% of all U.S. greenhouse gas (GHG) emissions (USEPA, 2019), with about 26 % of these GHG emissions coming from beef cattle production (Li et al., 2016; USEPA, 2015). Through proper pasture management GHG emissions from beef cattle production some of these emissions could be mitigated. Rotational grazing (RG) practices also known as Management intensive grazing (MIG) can be classified as best management practices that exhibited to have both environmental and economic benefits (Park et al., 2017; Wang et al., 2016; 2018). About one-third of the U.S. land area still consists of grazing land (Nickerson et al., 2011) and those lands area already stockpiled large amounts of carbon dioxide (CO_2) from the environment (Follett & Reed, 2010) and could sequester more carbon with improved grazing management practices (Ma & Coppock, 2012; Morgan et al., 2010). Beyond these environmental benefits, ranchers may also be benefited from improved forage production and better quality on pasture, better manure distribution that act as source of soil nutrients and getting higher stocking rates from RG/MIG practices.

Various agri-environmental policies have been implemented to spur producers for environment-friendly agricultural practices. Two prominent examples are the Environmental Quality Incentives Program (EQIP) initiated in 1996 and the Conservation Stewardship Program (CSP) initiated in 2008. The EQIP and CSP are collectively referred as ‘working land programs’ that provides economic/financial incentives of 50% to 75% of costs of installing or maintaining conservation practices on farmland to producers in their ongoing conservation efforts and who adopt a new conservation practice. The focus of these programmes is to promote conservation practices on agricultural lands to mitigate GHG emissions, restrict negative externalities, such as soil erosion and nutrient runoff, improve water quality, and increase biodiversity (USDA 2019). However, governmental, and non-governmental conservation entities are still facing challenges to promote the RG/MIG practices. Even though USDA adopted number of strides to support BMPs (such as RG or MIG) through rental payments and cost-sharing subsidies for fencing and water system infrastructure, the use of RG/MIG practices has been following a declining trend (USDA, 2015). So, to promote these best management practices, it is important to examine the type of producer willing to adopt the RG or MIG practices, the motivation behind their current practices.

Government cost-sharing/financial incentive programs could play a vital role in promoting adoption of conservation practices (Lichtenberg, 2004; Uri 1999; Wang et al. 2019). However, these cost sharing/incentives programs are designed to adopt the conservation practice as voluntary and the success of these programmes depends on producer’s willingness to adopt the conservation practices. If they are, the next question is what type of producers’ want to participate and how much? Prior literature suggest that producers have shown interest to mitigate GHG emissions from cattle production through the adoption of management intensive grazing practices (Jensen et al., 2015). These interests could be utilized by successfully promoting the RG/MIG practices among the beef cattle producers. Current findings provide excellent information and guidance for adoption of best management practices. However, there still exists a gap in the literature on the type of producers who have implemented the current BMPs, and the profile of the producers who are more willing to adopt the BMPs with or without cost-share/incentive payments. This gap in the literature could also potentially explain why the BMP adoption rate is still lower than anticipated.

The prior literature regarding cost share and the adoption of conservation practices examined the effect of cost-share/incentive payments as one of many determinants of conservation practice adoption (Prokopy et al., 2019; Wang et al., 2019; Rolfe et al. 2006). A few of the studies used stated preference methods to estimate farmers willingness to adopt conservation practices (Cooper & Keim 1996; Cooper 2003; Ma et al., 2012) and several studies also conducted to identify the producers' willingness to adopt a conservation practice under a cost-share agreement/offer (Kim et al., 2008; Jensen et al., 2015). Furthermore, outside of this limited study, to my knowledge no other research has analyzed and compared the determinants of cost share for non-adopters and current producers of the RG/MIG practices.

Using results from a 2018 survey of northern and southern U.S. Great Plains beef cattle producers, this study investigated the determinants that affect ranchers' willingness to accept a certain hypothetical monetary incentive offer to adopt RG or MIG practices and address the adopter's motivation behind their current adoption by identifying the factors that influence their adoption of the rotational grazing practices with/without cost share. Understanding farmers' decision-making processes is an essential precondition for designing efficient agricultural cost-share programmes. In addition, it is also crucial to know the type of farmers who are more likely to adopt the practice with or without cost-share. An understanding of the factors that determine the adopters cost share and shape the non-adopter's choice of different levels of subsidy to adopt the practice will fulfill the existing literature gap. Essentially, this could guide policymakers to best decide how to allocate the program budget or design new cost-share programs to incentivize the use of RG or MIG practices in the U.S. Great Plain.

RESEARCH OBJECTIVES

There are two primary research objectives in this study:

(i) To identify the factors that affect adopters' cost-share of rotational grazing practices adoption.

(ii) To identify the factors that affect non-adopter's choice of subsidy levels for adopting the RG or MIG practices.

LITERATURE REVIEW

This section discusses the prior empirical studies on producer's willingness to participate on conservation practices with or without cost share or incentives payments.

Numerous studies on cost-share examined the effect of incentive payments as one of the many drivers of conservation practice adoption (Prokopy et al., 2008; Wang et al., 2019). For instance, Wang et al. (2019) in their study on northern Great Plains producers showed that financial incentives are important determinants that influence the adoption of soil conservation practices such as diversified crop rotation and integrated cropping and livestock system. Using survey data from Nebraska, South Dakota, and North Dakota producers, they estimated a probit bivariate model to identify the factors that affect their adoption decisions. The study found that producers requirements for monetary payments and value on soil health are influential determinants of their adoption behavior. Using telephone survey data of 592 Maryland producers conduced in 1995, Lichtenberg (2004) showed that cost-sharing had a substantial effect on the adoption of several conservation practices.

A few of the studies used stated preference methods to estimate farmers willingness to accept an amount to enroll in a certain conservation practices (Cooper & Keim, 1996; Cooper, 2003; Ma et al., 2012). Cooper and Keim (1996), used data from a survey conducted on 1000 farmers regarding their cropping practices in four watersheds in Eastern Iowa and Illinois Basin area, drainage area in Virginia and North Carolina, the Georgia-Florida Coastal Plain, and Upper Snake River Basin area to predict their adoption of the practice as a function of the payment offer ($2, $4, $7, $10, $15, and $20). Using both bivariate probit model and a double hurdle model, they concluded that farmers can be encouraged to adopt conservation practices through the incentive payments/subsidies. However, their study failed to explain the required level of incentive payments needed to achieve expected levels of participation.

In his study Cooper (2003), estimated farmers’ decisions to accept incentive payments in return for adopting five environmentally sound best management practices. Using the results of a multinomial Probit analysis of surveys of over 1,000 farmers facing five adoption decisions in a voluntary program, the study showed how the farmers' perceptions of the desirability of various bundles change with the offer amounts and with which practices are offered in the bundle. The study also demonstrated an estimator for the mean minimum willingness to accept for the adoption of a practice conditional on the cost share offers for other practices.

Ma et al. (2012) uses survey data of 1700 farmers in Michigan to model farmers' willingness to participate in payment-for-environmental-service programs. Their findings showed that farmers first-stage willingness-to-adopt decision depends mainly on farm and farmer characteristics such as education, experience in conservation programmes, environmental attitude, etc., while their second-round enrolment decision depends more on payment-driven benefit–cost criteria such as the per-acre payment offer, total cropland area, etc.

Bastos and Lichtenberg (2001) used reveal preference method to estimate the implicit decision criteria regarding allocation of federal cost sharing funds in Maryland farmers to adopt soil and water conservation practices. The results indicate that cost share awards in Maryland during the study period is inconsistent with sated environmental quality priorities. Their study failed to examine efficiency of cost sharing fund allocations to meet the environmental quality goals in Maryland.

A reveal preference was also used by Lichtenberg (2004) in his study to determine the influence of cost share in determining famers conservation decision for selected seven conservation practices. Using farmers survey data, the study concluded that all the seven practices showed traditional downward-sloping demand. The findings also suggest that cost sharing has a significant effect on adoption for several practices.

Kim et al. (2008) investigated the effects of cost-share levels and producer demographic variables on the willingness to adopt rotational grazing on 200 Louisiana cattle producers. Their findings showed that environmental attitude and increasing government cost-share have significant positive impact on adoption decision. The results of the study also showed that 63–71 percent of cattle producers were uncertain about the adoption with a government cost-share. That is uncertainty play a big role in their adoption decision with cost-share.

Fleming et al. (2017) examined the impact of agricultural cost sharing for cover crops on the acres of three conservation practices using survey data of Maryland farmers. Using a two-stage simultaneous equation approach the study found that large cover crop cost sharing effort in the region had a significant effect on cover crop acreage adoption.

Jensen et al. (2015) conducted a study on 2258 random sample of beef cattle producers from eight USDA Economic Research Service regions east of 100th meridian to estimate cattle producer's willingness to adopt or expand prescribed in the United States under a hypothetical incentive program. Using a triple hurdle model, the study found that producer's attitude towards stewardship, current farm management practices, farm location, and education were the main factors that influenced producers' willingness to participate in the hypothetical incentive program to adopt or expand prescribed grazing practices in the U.S.

Several studies examined producer's willingness to adopt conservation practices without cost share/incentive payments. For instance, using a multinomial logit model, Wu & Babocock (1998) estimated joint decisions of eight possible combinations of conservation practices as a mutually exclusive alternative. They found that there exists a positive correlation in the adoption of crop rotation and conservation tillage, along with a corresponding reduction in soil erosion. Khanna (2001) used a modified bivariate probit model to identify the sequential adoption of tow conservation practices- soil testing and precision fertilizer application. The author found that bivariate method is preferable in comparison to estimating interrelated conversation decisions. Using survey data of Alabama farmers, Bergtold et al. (2012) examined the effect of demographic and management factors on the adoption of winter cover crops. The result of the study indicated that adoption of cover crops was significantly affected by the rented land percentage, irrigation of crops, and perceived number of environmental benefits.

The previous findings provide considerable information about the factors affecting the adoption of conservation practices. Few studies also discussed the producers BMPs adoption possibilities with monetary incentives. However, a gap in this literature is understandably why producer implemented their current BMPs (whether cost-share matters for the adoption of the practice or not) and what factors affect their level of subsidy choices to adopt the BMPs. This knowledge gap could also explain why the BMPs adoption rate has been lower than anticipated.

MATERIALS AND METHODS

DATA DESCRIPTION AND SOURCES

A mail survey was designed and conducted using the Dillman mail survey administration method (Dillman et al., 2014) between January 2018 to early April 2018. The sampling frame for this producers' survey includes the beef cattle producers of different counties in three states (North Dakota, South Dakota, and Texas) in northern and southern U.S. Great Plains. From the total 1167 responses received, 145 responses were dismissed from the survey for answering 'no' (do not operate) to qualifying questions, 'Do you have any of the following cattle enterprises (such as cow-calf, stocker, grass-finishing, or custom graze)?'. Another 148 responses were removed due to producer refusal to participate, undelivered, and deceased leaving 874 usable responses providing a 20.6 % response rate from the total delivered mails (Wang et al., 2020). Of the total 874 usable surveys, about 26.8 percent respondents were from North Dakota, 36 percent from South Dakota, and the rest of the 37.2 percent respondents were from Texas.

The survey asked beef producers questions about basic their ranch operation and ranch management practices, current adoption status and producer perceptions about rotational or management intensive grazing practices, separate sections dedicated to adopters and non-adopters of RG or MIG practices, and demographic information. In addition, with the adoption of RG or MIG practices, the beef producers are assumed to incur additional initial investment costs in the form of fencing installation and water system improvement. Therefore, the respondents (adopters) were asked for each of the two practices whether they received cost share from the government. The respondents were asked to give the percentage of cost share provided by the government in two categories: fencing and improve water system and write zero as a response if they did not receive any cost share or subsidy.

Furthermore, the willingness to accept (WTA) question was framed as a hypothetical incentives package where the survey respondents were offered a same one-time subsidy amount per acre of either \$10, \$30, \$50, or \$70 to adopt the two types of management practices in their rangeland. For each subsidy level, the respondent was then given three answer choices: YES, NO, and NOT SURE. These represent dichotomous choice (DC) contingent valuation (CV) questions that include a middle response (not sure or uncertain option) in addition to the 'yes' and 'no' answer categories (Kim et al., 2008). The advantage of offering a 'middle response' is that it does not force to accept a value (WTA) to an uncertain survey respondent when they answer a DC question (Groothuis and Whitehead, 2002). According to Payne (1951), a question that include middle response should be offered if a study wants to obtain only a stronger opinion on the issue.

Since the survey questionnaire included separate sections for the adopters and non-adopters, therefore, the current study analyzed distinct models to determine the key factors that affect adopters cost share and non-adopters WTA a subsidy level to adopt the RG or MIG practices. In addition, for comparison purposes most of the explanatory variables for all the subsidy models for non-adopters remained the same except two variables (perceived labor and perceived profit) that only deals with RG and MIG related questions only. The summary statistics of the variables used in this study are presented in Table 2.2 and Table 2.4, respectively. The study hypothesized that:

H1. Adopters of rotational grazing are more likely to implement the practice even without cost share, *ceteris paribus.*

H2. Perceived initial investment is a significant factor in deciding non-adopters' choice of subsidy amount to adopt the rotational or management intensive grazing practices, *ceteris paribus.*

While dealing with cost share related questions in the survey that asked "Please indicate the cost share percentage (or dollar subsidy amount received) in the following two categories: fencing costs and water system improvement costs, when you started rotational grazing or MIG. If you did not receive cost share or subsidy, please write zero.", there are 17 observations for fencing cost share and 14 observations for water system improvement cost share percentage values have been adjusted/added. Those cost shares percentage have been calculated based on the following formula: *Cost Share = Subsidy amount in $/ (per acre cost $* X *total acres involved in the cost estimation).* After this adjustment we have total of 393 and 388 observations for the percentages of fencing cost share and water system improvement cost share, respectively, where the initial number of responses for those two categories were 376 and 374, respectively.

Regarding per acre initial investment costs in the form of fencing installation and improved water system, 299 and 297 responses were received, respectively. Per acre fencing installation and water system improvement costs ($) that were too large are adjusted by dividing with the corresponding total acres involved in the cost estimation information. Costs per acre values ($) that are unrealistic (too high e.g., 100, 500, 1000, etc.) are deleted. Wang et al. (2018) mentioned this initial investment cost ranges falls from

$30 to $70 per acre. Undersander et al. (2002) reported that costs for new fencing range from $1.18 per acre for mobile electric fencing with fiberglass posts to $18.37 per acre for high-tensile electric fencing. Setting up the whole system (using new fencing, fencers, and water systems) costs from $30 to $70 per acre. Probert (2013) provided an estimated range of mean cost/acre for a 140-acre grazing unit with typical fence and water system development costs, where he showed it costs $12.64/acre for permanent fencing, $34.64/acre for subdivision fencing, $2.63/acre, $33.21 and $74 per acre for water system costs depending on permanent and subdivision fencing, respectively. Following the literature, the study considered maximum initial investment cost per acre $75 as upper bound and the lower bound was set as $0.

For fencing installation, there are 21 observations were converted to $ per acre and the range of the values that are converted falls between $200 and $20,000. There were 42 observations that were not possible to convert hence deleted/ dropped for either the corresponding total acre value was missing, or the values were unrealistic (too high). The range of the values that are dropped falls between $100 and $50,000. About 21.07% of the respondents (63 respondents) provided over valued numbers who answered this question.

For water system improvement costs, 25 observations were converted to $ per acre and the value of the converted $ per acre costs falls between $100 and $75,000. There were 29 observations that were dropped/deleted from the dataset either for the corresponding total acre value was missing, or the values were too unrealistic and those values that were dropped fall between $80 and $100,000. A total of 54 respondents (almost 18%) provided over valued number who answered this question. After those adjustments, the total number of observations for fencing installment cost share and water improvement cost-share were found to be 257 and 268, respectively.

THEORETICAL FRAMEWORK

The study is rooted on the anticipated utility maximization theory. This theory posits that an individual's choice to adopt a particular technology (in this case RG/MIG) is a function of the anticipated maximum utility he/she would derive from the adoption. An individual will adopt the practice if and only if he/she would derive more utility compared to the non-adoption. This is expressed as:

$$U^{*} = U_1 > U_0 \qquad (1)$$

Where; U_1 denotes the expected utility of adopting RG/MIG practices, U_0 = the expected utility of non-adopting, and U^{*} represents the net utility of adopting the RG/MIG practices.

EMPIRICAL MODEL

The first objective of the study is to determine the key factors that affect the adopters cost share to implement the rotational grazing or management intensive grazing practices in their rangeland. The adopters' enrolment in these practices with cost share in the form of fencing installation cost share and water system improvement cost share can be expressed as binary values. If the adopter indicates that he/she received cost share then the dependent variable, $CostShare$ take the value of 1, and 0 if cost share is not offered to them. The binary sample rule uses a probit model to estimate the factors that determine adopters' cost share to implement the practices. The specification of the probit model, in this case can be expressed as:

$$CostShare^{*} = \beta' x + \varepsilon \qquad (2)$$

where x is a vector of explanatory variables including farm characteristics, producer characteristics, exterior factors, producer attributes, and geographic characteristics; β is a vector of parameters; and ε represent a random error term. The observed indicator '$CostShare^{*}$' is whether the respondent stated he or she received the cost share to adopt the practice where:

$$CostShare^{*} = \begin{cases} 1, & \beta' x + \varepsilon > 0 \\ 0, & \beta' x + \varepsilon \leq 0 \end{cases} \qquad (3)$$

Here, the coefficient estimate, β does not denote the marginal effects of the explanatory variables, x on adopters' cost share probabilities, rather it measures keeping other variables unchanged, how a unit change in any explanatory variable affect the expected values of the adopters' cost share. Following Greene (2012), the study used coefficients scaled by a probability density function (pdf), $\Phi(\beta' x)$ to compute the marginal effects of explanatory variables, x on the adopters' expected cost share.

The second model of the study aims to analyze the second objective of the study: to determine the key factors that affect the non-adopters' WTA a subsidy amount to adopt RG or MIG practices? Here the responses to the latent variables/choice of subsidy level variables take three ordinal categories (0 = 'no'; 1 = 'not sure' and 2 = 'yes'). For these types of response categories, an ordered logit regression model (Greene, 2012; Fullerton, 2009) also known as proportional odds (PO) model (William, 2016) is a suitable modeling choice. Here before we run ordered logistic regression model the response categories were arranged so that the 'NOT SURE' response is assumed to be a middle response. For each of the two conservation practices (i.e., RG or MIG), non-adopters were offered four subsidy levels: \$10/acre, \$30/acre, \$50/acre, and \$70/acre to adopt the practices. Thus, four separate ordinal logistic regression models for each conservation (RG or MIG) practices were estimated to determine the influence of farm characteristics, operator demographics, exterior factors, producer perceptions, and geographical characteristics on non-adopters' willingness to adopt these practices for each of the subsidy amount offered. Following McCullagh (1980), the subsidy model is defined as,

$$(Subsidy)_i^* = x_i\beta_i + \varepsilon_i; \;\; (Subsidy)_i = j \;\text{ if }\; \delta_{j-1} \le (Subsidy)_i^* < \delta_j, \;\text{ where }\; j = 0,1,2 \quad (4)$$

Where $(Subsidy)_i^*$ is the latent variable that denotes the level of subsidy amount ranging from $-\infty$ to $+\infty$, and 'ε_i' is the random errors of the respective models. The vector of the explanatory variables under the study is denoted by the term x_i. Here, β_i is the slope coefficients, δ_j is the threshold of the model.

A dependent variable with three-category outcome will have two binary logit equations also are known as proportional odds models (McCullagh,1980) and can be expressed as probability models as follows:

$$\ln\left[\frac{\Pr\left(Subsidy_i \le j \mid x\right)}{\Pr\left(Subsidy_i > j \mid x\right)}\right] = \delta_j - x_i\beta_i; \qquad j = 0,1,\ldots,J-1 \qquad (5)$$

Where, x_i is the vectors of independent variables in the model, δ_j is the thresholds, β_i is the vector of logit coefficients. J is the number of categories of the ordinal dependent variable. Here in the model, $J = 3$. The negative sign on the vector of logit coefficients facilitates an OLS regression-type interpretation of the coefficients. A positive coefficient indicates that a unit increase in x leads to a higher level of $Subsidy$. When all explanatory variables are considered as 0, then δ_1 represents the log odds of choosing 0 instead of 1 and 3 (0 vs. 1-2); while δ_2 represents the log odds of choosing 0 and 1 instead of 2 (0-1 vs. 2). When the latent variable crosses a threshold (δ_j) the category of the outcome variables also changes.

Previous literature suggest that the assumptions of the ordered logit model are frequently violated (Long & Freese, 2014). If the assumptions of the ordered logit model are met by each explanatory variable, then all the corresponding coefficients (except the intercepts) should be the same across the different logistic regressions, other than differences caused by sampling variability. Therefore, assumptions of the ordered logit/proportional odd model are sometimes referred to as the parallel lines or parallel regressions assumptions (Williams, 2006). The study used a test devised by Brant (1990) to identify whether the observed deviations from the proportional odds model predicts larger than what could be attributed to chance alone (the parallel lines assumptions were met or not). If the proportional odds (PO)/parallel lines assumption is perfectly met, then the proportional odds (PO) model will be used. When one or more explanatory variables violate PO assumption, then the study will use partial proportional odds (PPO) models, with this model it is possible to relax the parallel lines/proportional odds assumption only for those variables where it is violated, and it also help to avoid estimation of more unnecessary coefficients in the model.

RESULTS AND DISCUSSION

The study aimed to determine the key factors that influence the cost share of rotational grazing or management intensive grazing practices. The estimated coefficients for equation (1) along with the estimated marginal effects for the exogenous variables on adopters' cost share were reported in (Table 2.3), and the estimated coefficients for equation (2) on non-adopters' choice of different subsidy levels were reported in Table 2.4 and Table 2.5.

FACTORS AFFECTING THE ADOPTERS COST SHARE

The estimation results from the Probit models are furnished in Table 2.3. The models are estimated with 208 observations as 312 observations have missing values for some variables. The study also tests the Pearson's correlation coefficients among the explanatory variables used in the models to check possible multicollinearity in the model. All coefficients except for three cases (0.44, 0.41, & 0.40) are found below 0.25, which indicate that multicollinearity was not problematic in the Probit specification.

Results in Table 2.3 indicate that farm characteristics such as grassland percentage and ranching income ratio influence adopters' cost share to implement the rotational grazing practice. For instance, more grassland percentage in farms operation positively influence the adoption of the practice with both fencing and water system improvement cost shares at the 1% significance level. *Ceteris paribus*, a 1-unit increase in grassland percentage increases the probability of adoption with both fencing and water system improvement cost shares by 72.2% and 66.4%, respectively. Similarly, a 1-unit increase in ranching income ratio increases the probability of adoption with both fencing and water system improvement cost shares by 5.7%, while other conditions remain the same. This means that cost share is very important to those adopters who operate on higher grassland percentage (less cropland) and rely highly on cattle farming for their income. This is likely because farms that mainly focused on cattle operation (i.e., having more grassland percentage and receive more percentage of income from cattle operation) found it critical to get cost share that focuses on fencing installation and improving water quality. In addition to grassland percentage and ranch income ratio, the existence of some form of previous internal fencing is significant in the fencing cost-share model. Ceteris paribus, farmers who had some form of internal or cross fencing are 15.8 percent less likely to adopt the practice with fencing cost share compared their peers with no fences available.

Exterior information sources, such as information from university extension also positively affected the adopters' cost share to implement the RG practice at the 5% significance level. Specifically, when importance on information from university extension increases by 1-unit, the probability of adopting the practice with both type of cost shares increases by 6.9% and 8.4%, respectively, ceteris paribus (Table 2.3).

Among the operator characteristics, only years of rotational grazing adoption is significant in both cost share models at 1% significance level. This indicates that with an additional 1-year adoption of RG, the probability of rotational grazing adoption with cost share decreases by 1% and 7%, respectively (Table 2.3). This is likely because the government cost share program (Environmental Quality Incentives Program) that aims to focus on improving water system and fencing installation were provided to the new adopters who had started the practice after the year 1996, therefore, adopters before the year 1996 did not receive any cost share to adopt the practice. It also implies that cost share is not important to the adopters who already adopted this beneficial conservation practice before the declaration of the government cost share assistance program (USDA 2019).

Other important factors such as initial investment costs (i.e., fencing installation and improved water system costs) and economic profit also significantly affect the adopters cost share. Specifically, when the initial investment increase by $1/acre, the probability of adoption with cost share increases by about 5-7%. It also suggests the importance of cost share while the initial investment cost is significantly higher. In contrast, an additional level higher profit decreases the probability of adoption of the practice with cost share (i.e., water system improvement cost share) by 11.7%. This is likely because cost share is less important to the producers' who found the practice economically profitable.

The study also incorporated the location/geographical variables in the model to check the difference in adoption status across the study regions. The findings showed that farms located further located north and west/arid region of the study area were (1-5) % more likely to adopt the rotational grazing practice with cost share (Table 2.3). That is location has a significant effect on adoption with or without cost share. The result also implies that an increase in RG adoption rate with cost share is evident while moving further northwest in the study region (See Figure 1). Which is consistent with the Wang et al. (2020) findings, they indicated that cattle producer located further east of the study regions faced less challenges, therefore more likely to adopt rotational grazing practices without cost share.

Furthermore, the farm operated on more proportion of higher quality land, indicated by LCC I & II were more likely to implement the practice with cost-share (i.e., water system improvement cost share). Wang et al. (2020) showed that producers who operate on high-quality land tends to consider fewer challenges such as weather/climate condition, therefore more likely to adopt the practice with cost-share.

FACTORS AFFECTING THE NON-ADOPTERS CHOICE OF SUBSIDY LEVEL

Tables 2.5 and 2.6 shows the ordered logit modeling results for non-adopters' choice of different level of subsidies to adopt the RG and MIG practices, respectively. The same set of explanatory variables were included in the analysis of both subsidy models for rotational grazing and management intensive grazing practices. Out of a total 354 non-adopters, the models were estimated based on observations 183 and 151, respectively, since there are quite a few missing values for some variables in this section. The Pearson's correlation coefficients among the explanatory variables used in the models confirmed that there was no multicollinearity bias in the ordered logit regression specification.

The results in Table 2.5 and 2.6 indicate that, exterior factors such as university extension and neighborhood practice play a positive role in non-adopters' choice of subsidy amount they are willing to accept to adopt the RG/MIG practices. Non-adopters who emphasize more importance on information source from the university extensions are more likely to consider adopting the rotational grazing/MIG practices with given (low/high) subsidy amounts, *ceteris paribus*. This result suggests that although farmers receive information from various sources, valued information from the university extension is highly trusted based on their personal experiences, relationship with extension network, quality of the information received and the opportunity to get instant feedback from the extension specialist/agents. In contrast, non-adopters with more neighboring farm practicing in their region are more likely to adopt the RG practice with a high subsidy amount ($50/$70 per acre) and MIG practice with low ($30/acre)/high subsidy amount ($50/$70/acre). The results further indicate that neighborhood farming practice has a positive effect on non-adopters' choice of subsidy levels to adopt the RG/MIG practices.

The farm characteristics such as liability ratio and total grassland acreage have expected signs and significant in determining non-adopters' choice of subsidy amount. The study found that non-adopters with higher liability ratios in their ranching operation tends to choose a higher subsidy amount (i.e., $50 or $70/acre) to adopt RG/MIG practices. This is likely because the higher liability ratio lowers their borrowing capacity further (Winsten et al., 2010), therefore, they seek for higher subsidy amounts to implement the RG/MIG practices. By contrast, non-adopters operated less rangeland/grassland acres are more likely to adopt the RG/MIG practices even with lower subsidy amounts ($10/$30/acre). This implies that non-adopters' find it easier to manage the pasture when they operate less grassland acreage, therefore, more likely to accept lower subsidy amount to adopt the RG/MIG practices.

Rather surprisingly, farming experience positively influence the non-adopters' choice of subsidy amount to adopt the RG/MIG practices. The study found that as cattle producer gains more years of farming experience, they are more likely to adopt the practices even with lower subsidy amount such as $10/acre or $30/acre. This finding is contrast with the previous findings, which showed that experienced farmers were less likely to adopt a best management practice even with cost-share (Rahelizatovo & Gillespie, 2004; Kim et al., 2008; Smith 2014; Jensen et al., 2015). The finding is however congruent but align with the finding of the Gillespie et al. (2007) which showed with years of experiences the probability of adopting several best management practices also increases. Producers with education beyond some college/technical school/college degree or higher are less likely to adopt the practices with low subsidy amount such as $10/acre.

Results reveal that a number of farmer perception variables such as initial investment, maintenance costs, profit also influence non-adopters' choice of subsidy levels to adopt the practices. For instance, non-adopters who perceive lower initial investment costs are more likely to adopt the MIG practice even with both lower ($10 or $30/acre) subsidy amount. Similarly, those who perceive a lower maintenance costs per acre per year are significantly more likely to adopt the rotational grazing practice with low/high subsidy amounts. Therefore, initial investment and maintenance costs are important factors in deciding whether non-adopters enroll in RG/MIG practices with given/offered subsidy amounts. By contrast, farmers' positive perception of economic profits increases the likelihood of rotational grazing practice adoption with a higher subsidy amount. One possible explanation for this result could be that farmers believe that rotational grazing would afford them the opportunity to gain more economic profits, therefore, they motive to adopt the practice with a high subsidy amount ($50/$70/acre). Early literature also suggests that a decline or rise in profitability both discouraged and motivated the adoption of conservation practices (Ranjan et al., 2019).

Geographical differences are also evident, cattle operations located further eastern side to the study regions are less likely to adopt the RG/MIG practices with subsidy amount offered relative to the farms located in the west, which are more likely to adopt the MIG practice even with lower subsidy amount ($10/acre). It is known that the eastern half of a longitudinal line along the 100^{th} meridian, records plenty of precipitation, while in the western half of it the weather is relatively arid (having little or no rain). Our results indicate that producers in the dry area (arid region) are more favorable to adopt the RG/MIG practices with different subsidy amounts than those in the eastern half of the study region. In other words, the hypothetical one-time incentives/subsidies would be widely accepted in some regions than others.

SUMMARY AND CONCLUSION

This study examined how different factors may affect the adopters cost share and non-adopters' willingness to accept a subsidy amount to adopt the RG/MIG practices. An understanding of the beef producers' motivations to adopt such practices can guide extension specialists', policymakers, and academics in leading discussion of adopting more environmentally and economically friendly grazing management practices in the U.S. Great Plains. An increased adoption of such practice can also significantly lower the contribution of GHG emissions that generates from the beef cattle production (Balafoutis et al., 2017).

The survey of northern and southern U.S. Great Plains shows that beef cattle producer who adopted the rotational grazing with cost share generally had more proportion of grassland in their operation, had higher ranch income ratio, fewer adoption years, and provide more importance on the information from the university extensions.

The findings of the study also indicate that geographical characteristics such as increased proportion of land with LCC I and II, and farm located further northern side of the study regions adopted the rotational grazing practices with cost share (see Figure 1). These findings suggest the type of producers who usually require cost-share to implement the rotational/ management intensive grazing in their ranch. By understanding the profile of the producers who adopted the practices with little or no cost share, extension educator can develop more targeted programs to increase the level of participation in the beneficial rotational grazing or management intensive grazing practices.

A profile of the non-adopter farmers who are more likely to adopt the practices with different subsidy amounts include those who had more farming experiences, focus more importance on university extensions information source, and had neighboring farms adopted the practices in their region. Farm characteristics variables such as having less grassland acreage, more liability ratio, and producer those who perceived lower initial investment and maintenance cost, positively influenced the willingness to adopt the RG/MIG practices. Results from this study further indicate that located further western/arid areas of the study regions are more favorable to adopt these practices with offered various incentive amounts. These results further suggest that an annual incentives program would enhance the adoption of these beneficial grazing management practices.

The non-adopters with one or more of the above characteristics may be a suitable target group for public fund investment (PIFA) and formulate the proper incentive levels needed to successfully promote the adoption of these two environmentally friendly and beneficial grazing management practices in the U.S. Great Plains. An understanding of the profile of the non-adopters' and the optimal amount of subsidy that motivates them to adopt the RG/MIG practice could help in this effort. Once they realized the potential benefits of this practice, they could also serve as ambassadors in their region/community to influence other producers to adopt the practice with little or no cost share.

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APPENDIX

Table 2.1. Grazing management practice adoption, cost-share enrollment, and percent of operating acres by practice type by in the unweighted sample.

Practice type	Number of farms			Average percent acres	
	No adoption	Adoption without cost share	Adoption with cost share	Adoption without cost share	Adoption with cost share
RG	354	200	149	81.2%	77.9%
MIG	354	24	26	58.6%	66.5%

Table 2.2. Descriptive statistics of the variables in Probit Models for adoption the practice with Cost Share

Variable Name	Obs.	Mean	Std. Dev.	Minimum	Maximum
Dependent variable					
Fencing Cost Share	393	0.338	0.474	0	1
Water Improve Cost Share	388	0.438	0.497	0	1
Independent variable					
Internal Fencing	479	0.689	0.463	0	1
Liability ratio	483	2.656	1.335	1	6
Ranch income ratio	508	3.720	1.359	1	5
Total grassland (x 10^3 acre)	496	3.034	5.064	0	65
Grassland %	494	0.702	0.263	0	1
Adoption years (RG)	450	19.597	13.910	1	125
Education	514	0.411	0.492	0	1
University Extension	512	2.809	1.180	1	5
Neighborhood Practice	512	0.918	0.275	0	1
Installation Cost	257	16.026	15.949	0	75
Water Improvement Cost	268	17.744	18.179	0	75
Labor (RG)	460	3.578	0.781	1	5
Profit (RG)	449	3.829	0.691	1	5
Latitude	515	41.682	6.152	27.257	48.984
Longitude	515	-99.471	1.911	-103.899	-95.778
Slope < 3%	515	43.370	43.319	0	100
LCC I & II	515	44.608	44.258	0	100

Table 2.3. Probit model estimation results on adopters' costs share

	Fencing Cost Share			Water System Improvement Cost Share		
Variables	Coefficient	Marginal Effect	Pr > |z|	Coefficient	Marginal Effect	Pr > |z|
Internal Fencing	-0.412*	-0.158	0.060	-0.141	-0.056	0.512
Liability ratio	-0.035	-0.013	0.674	-0.011	-0.004	0894
Ranch income ratio	0.150*	0.057	0.080	0.143*	0.057	0.078
Total grassland (x 10^3 acre)	-0.024	-0.009	0.220	-0.007	-0.003	0.690
Grassland %	1.903***	0.722	0.000	1.673***	0.664	0.000
Adoption Years (RG)	-0.026***	-0.010	0.004	-0.018**	-0.007	0.028
Education	-0.151	-0.057	0.477	0.157	0.062	0.440
University Extension	0.183**	0.069	0.040	0.212**	0.084	0.018
Neighborhood practice	0.062	0.023	0.884	-0.448	-0.17091	0.220
Fencing Costs	0.012*	0.005	0.065			
Water System Costs				0.017***	0.007	0.004
Labor (RG)	-0.089	-0.034	0.512	-0.011	-0.004	0.937
Profit (RG)	-0.144	-0.054	0.376	-0.294*	-0.117	0.058
Latitude	0.044*	0.017	0.068	0.026*	0.010	0.061
Longitude	-0.100	-0.038	0.156	-0.133*	-0.053	0.055
Slope < 3%	0.002	0.001	0.395	-0.000	-0.000	0.963
LCC I & II	0.004	0.002	0.127	0.007***	0.003	0.008
Adopter MIG (1, 0)	-0.400	-0.142	0.186	-0.378	-0.150	0.285
Intercept	-13.300***			-15.190**		
Observations	200			208		

Asterisks (***) = significant at α = 0.01; ** = significant at α = 0.05; * = significant at α = 0.10.

Table 2.4. Descriptive statistics of the variables in Ordered Logit Model for Non-adopters' Choice of Subsidy Amount

Variable	N	Mean	Std. Dev.	Min	Max
Subsidy offered to implement RG Practice					
$10/Acre	267	0.532	0.602	0	2
$30/Acre	266	0.733	0.690	0	2
$50/Acre	267	1.071	0.740	0	2
$70/Acre	266	1.256	0.764	0	2
Subsidy offered to implement MIG Practice					
$10/Acre	235	0.362	0.540	0	2
$30/Acre	236	0.424	0.575	0	2
$50/Acre	235	0.587	0.682	0	2
$70/Acre	237	0.772	0.791	0	2
Farm Characteristics					
Internal fencing	301	0.661	0.474	0	1
Liability ratio	308	2.568	1.242	1	6
Ranch income ratio	337	3.475	1.402	1	5
Total Grassland (x 10^3 acre)	330	2.426	4.421	0	41
Grassland %	330	69.513	28.619	0	100
Farmer Characteristics					
Farming Experience	342	37.687	13.675	0	75
Education	336	0.405	0.492	0	1
Perception					
Initial Investment	237	3.460	1.173	1	5
Maintenance costs	233	2.996	1.069	1	5
Labor (RG)	288	0.295	0.457	0	1
Labor (MIG)	252	0.591	0.493	0	1
Profit (RG)	286	0.577	0.495	0	1
Profit (MIG)	258	0.477	0.500	0	1
External factors					
University Extension	319	2.480	1.194	1	5
Neighborhood practice	354	0.370	0.484	0	1
Geographical factors					
Latitude	350	39.724	6.350	30.338	48.746
Longitude	350	-99.022	1.826	-103.492	-95.773
Slope < 3%	350	48.646	43.350	0	100
LCC I & II	350	45.587	45.358	0	100

Table 2.5. Ordered Logit Model regression results on Subsidy Level to Adopt Rotational Grazing

VARIABLES	Amount of Subsidy Offered											
	$10/Acre			$30/Acre			$50/Acre			$70/Acre		
	Coeffi-cient	Odds Ratio	Standard Error	Coeffi-cient	Odds Ratio	Standard Error	Coeffi-cient	Odds Ratio	Standard Error	Coeffi-cient	Odds Ratio	Standard Error
Internal Fencing	0.130	1.139	0.404	0.483	1.622	0.558	0.636*	1.889	0.654	0.284	1.328	0.476
Liability ratio	0.001	1.001	0.135	0.095	1.099	0.147	0.185	1.204	0.156	0.139*	1.270	0.172
Ranch income ratio	0.191	1.201	0.143	0.187	1.206	0.139	0.170	1.185	0.137	0.058	1.059	0.128
Total grassland (x 10^3 acre)	-0.116*	0.891	0.057	-0.057*	0.945	0.039	-0.062	0.940	0.035	-0.007	0.993	0.049
Grassland %	0.003	1.002	0.007	0.004	1.004	0.007	-0.006	0.993	0.007	0.002	1.002	0.007
Farming Experience (years)	0.020*	1.020	0.013	0.006	1.006	0.012	-0.015	0.985	0.012	-0.023*	0.977	0.012
Education	-0.416*	0.660	0.234	-0.048	0.953	0.321	0.008	1.008	0.338	0.398	1.635	0.579
Initial Investment	-0.200	0.819	0.150	-0.117	0.890	0.156	0.213	1.237	0.226	0.331*	1.488	0.514
Maintenance costs	-0.172	0.842	0.169	-0.476**	0.621	0.122	-0.534***	0.586	0.116	0.381**	1.464	0.271
Labor	0.164	1.179	0.415	-0.323	0.724	0.243	-0.032	0.969	0.322	-0.429	1.535	0.546
Profit	0.520	1.682	0.597	0.522	1.685	0.580	0.926***	2.525	0.864	1.018***	2.769	0.960
University Extension	0.098	1.103	0.163	0.290**	1.336	0.192	0.430***	1.537	0.220	0.416***	1.516	0.225
Neighborhood practice	0.334	1.396	0.469	0.459	1.582	0.509	0.661**	1.936	0.630	0.484	1.623	0.618
Latitude	-0.048	0.953	0.037	-0.030	0.971	0.036	-0.064*	0.938	0.034	-0.002	0.998	0.037
Longitude	-0.149	0.862	0.089	-0.230**	0.794	0.082	-0.265***	0.767	0.078	-0.229**	0.795	0.082
Slope <3%	-0.002	0.998	0.004	0.000	1.000	0.004	-0.004	0.996	0.004	0.002	1.002	0.004
LCC & II	0.005	1.005	0.004	0.005	1.005	0.004	0.002	1.002	0.004	0.004	1.005	0.004
Observations	183			182			182			184		

Asterisks (***) = significant at $\alpha = 0.01$; ** = significant at $\alpha = 0.05$; * = significant at $\alpha = 0.10$.

Table 2.6. Ordered logit model regression results on Subsidy Level to Adopt Management Intensive Grazing

VARIABLES	Amount of Subsidy Offered											
	$10/Acre			$30/Acre			$50/Acre			$70/Acre		
	Coeffi-cient	Odds Ratio	Standard Error	Coeffi-cient	Odds Ratio	Standard Error	Coeffi-cient	Odds Ratio	Standard Error	Coeffi-cient	Odds Ratio	Standard Error
Internal Fencing	0.034	1.035	0.510	0.377	1.457	0.697	0.337	1.401	0.587	0.239	1.270	0.497
Liability ratio	0.142	1.153	0.193	0.181	1.198	0.193	0.338**	1.402	0.212	0.346**	1.414	0.198
Ranch income ratio	0.207	1.230	0.204	0.215	1.240	0.194	0.088	1.092	0.148	-0.067	0.936	0.119
Total grassland (x 10^3 acre)	-0.132	0.877	0.080	-0.187*	0.830	0.080	-0.068	0.935	0.043	-0.013	0.998	0.035
Grassland %	0.006	1.006	0.009	0.009	1.009	0.009	-0.003	0.997	0.008	-0.003	0.997	0.007
Farming Experience (years)	0.053***	1.054	0.019	0.042**	1.043	0.018	0.029**	1.030	0.015	0.017	1.017	0.013
Education	-0.965**	0.381	0.182	-0.599	0.549	0.239	-0.524	0.592	0.230	0.035	1.036	0.365
Initial Investment	-0.388	0.678	0.172	-0.494**	0.610	0.147	-0.398**	0.672	0.147	-0.141	0.869	0.170
Maintenance costs	0.065	1.067	0.270	0.036	1.036	0.253	0.002	1.002	0.220	0.048	1.049	0.212
Labor	-0.558	0.573	0.255	-0.720**	0.487	0.206	-0.032	0.968	0.382	-0.175	0.840	0.303
Profit	-0.191	0.826	0.374	-0.118	0.889	0.379	0.395	1.484	0.571	0.276	1.318	0.458
University Extension	0.366*	1.443	0.286	0.416**	1.516	0.292	0.404**	1.498	0.254	0.464***	1.590	0.255
Neighborhood practice	0.573	1.774	0.822	0.780**	2.182	0.939	1.276***	3.582	1.422	0.909***	2.481	0.906
Latitude	-0.078	0.925	0.047	-0.078	0.925	0.045	-0.101**	0.904	0.039	-0.012	0.988	0.037
Longitude	-0.259*	0.772	0.105	-0.358***	0.699	0.093	-0.208*	0.812	0.095	-0.072	0.930	0.097
Slope <3%	-0.005	0.995	0.005	-0.002	0.998	0.005	-0.003	0.997	0.004	0.002	1.002	0.004
LCC & II	0.001	1.001	0.006	0.005	1.005	0.005	0.003	1.003	0.005	0.001	1.001	0.004
Observations	151			153			151			154		

Asterisks (***) = significant at $\alpha = 0.01$; ** = significant at $\alpha = 0.05$; * = significant at $\alpha = 0.10$.

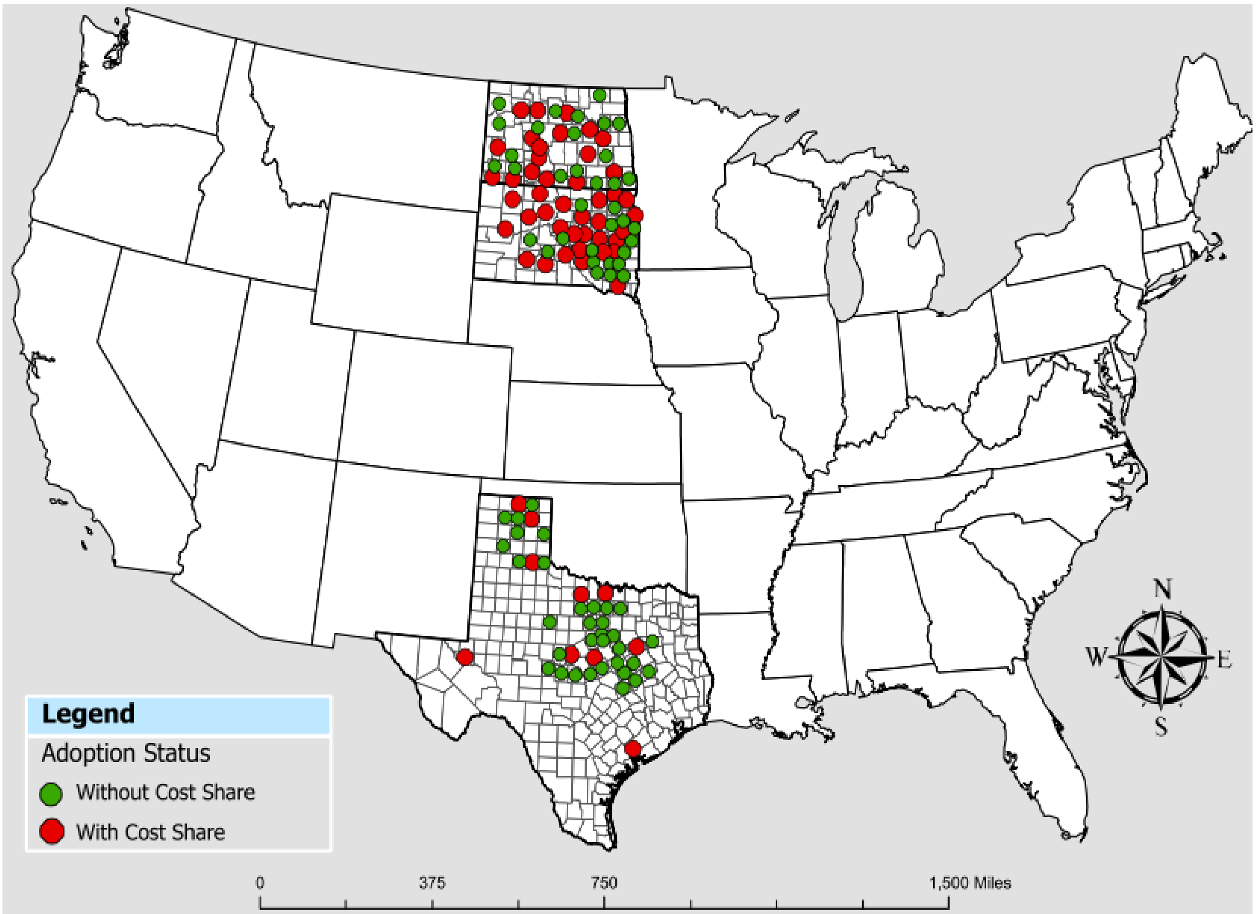

Figure 1. Adoption status of RG with or without cost share by counties in 2018

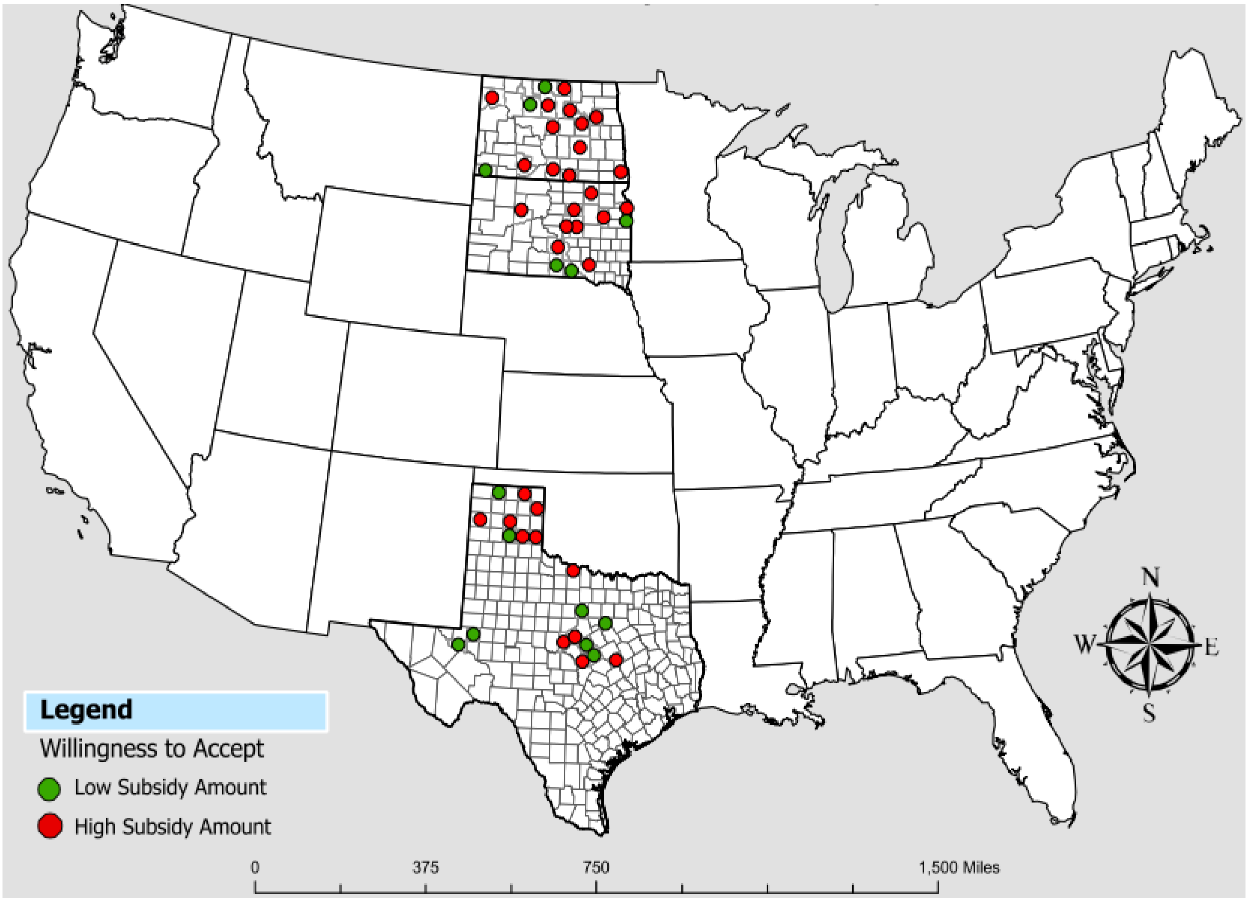

Figure 2. Non-adpters WTA for RG or MIG by counties in 2018

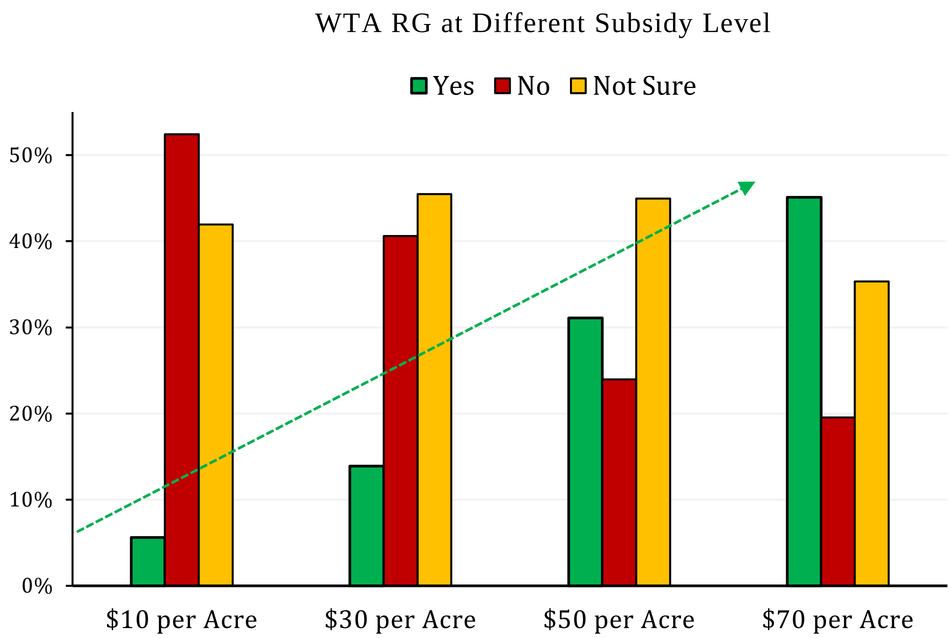

Figure 3.1. Non-adopter respondent who provided 'Yes', 'No' and 'Not Sure' response at different subsidy level to adopt RG

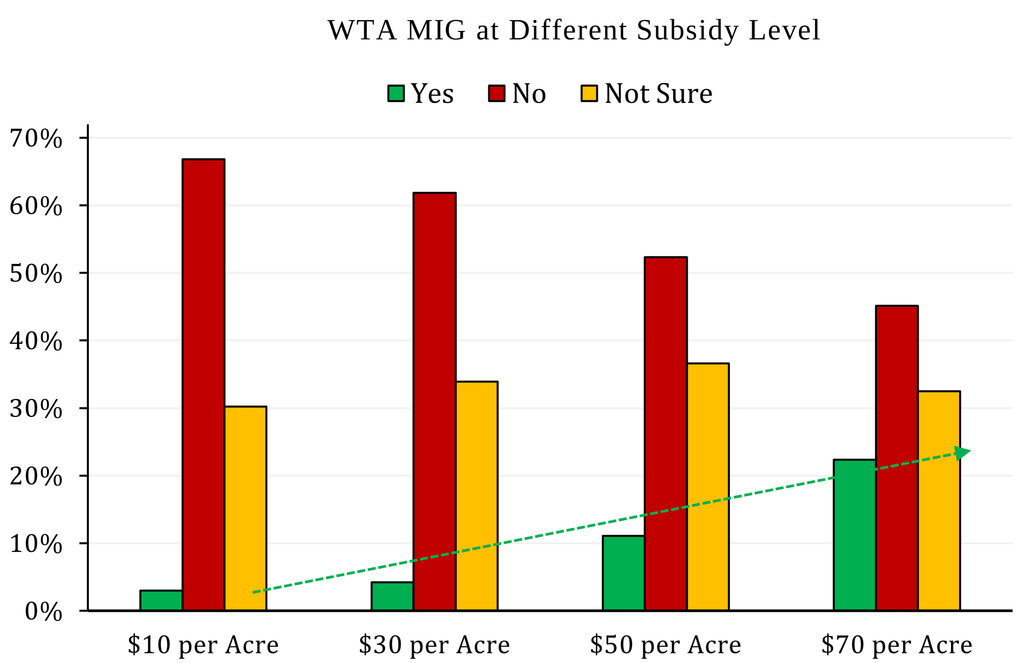

Figure 3.2. Non-adopter respondent who provided 'Yes', 'No' and 'Not Sure' response at different subsidy level to adopt MIG