Policy development to support ecosystem services on pasture systems in Saskatchewan

A Thesis Submitted to the

College of Graduate and Postdoctoral Studies

In Partial Fulfillment of the Requirements

For the Degree of Masters of Science

In the Department of Agricultural and Resource Economics

University of Saskatchewan

Saskatoon

By

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Abstract

The purpose of this research is to investigate acceptable and cost-effective policy tools to increase the provision of ecosystem services on Saskatchewan grasslands. Due to the voluntary nature of grassland conservation programs, these programs are only effective at increasing ecosystem services and environmental quality if private ranchers and landowners find the programs acceptable and opt-in to the programs. Therefore the goal of this thesis is to investigate acceptable policy parameters, including a cost-effective economic incentive to support producer participation, to aid in the development of potential grassland conservation programs. To accomplish this a survey was developed and administered to Saskatchewan ranchers to examine their opinions and attitudes regarding policy structures, ecosystem services, grassland management practices, and opportunity costs related to participating in conservation programs. An interval estimation approach was used to estimate the mean and median willingness-to-accept (WTA) of Saskatchewan ranchers for an acceptable participation incentive to compensate for a 10% loss in opportunity costs from participating in a conservation program. The results indicated that the mean WTA among the sample population for participating in a conservation program and incurring a 10% loss in opportunity costs was between $34.83 and $42.58 per acre. Extrapolating these results suggest that the mean WTA per 1% increase in opportunity costs incurred was between $3.48 and $4.26 per acre to participate in a conservation program. Additional results and findings from the survey that could also aid in policy development to increase ecosystem services on grasslands are also presented in the thesis.

Acknowledgements

I would like to thank my supervisors Ken Belcher and Hayley Hesseln for their invaluable guidance and assistance throughout the research process. I would also like to thank my advisory committee, Tristan Skolrud and John Patterson, for their input as well as Marianne Possberg and Kathy Larson for their help with contacting potential survey participants. Lastly, I would like to thank the Saskatchewan Cattlemen's Association for providing the financial assistance that made this research project possible.

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List of Abbreviations

AES	Agri-Environmental Schemes
BMP	Beneficial Management Practices
PES	Payments for Ecosystem Services
SODCAP	South of the Divide Conservation Action Program
WTA	Willingness-to-Accept
WTP	Willingness-to-Pay

1. Introduction

Grasslands provide a wide variety of benefits to private ranchers and the public including forage for livestock, carbon sequestration and climate regulation, biodiversity and wildlife habitat, water and air quality, pest and disease control, nutrient cycling, wetland preservation, and aesthetic value (Kroeger and Casey, 2007; Kulshreshtha et al., 2008). These public and private benefits are often related to the ecosystem services produced on grasslands. Ecosystem services represent the benefits people obtain from natural ecosystems or environments such as grasslands, and have been organized into four categories: provisioning services, which are the products obtained from ecosystems; regulating services, benefits such as water and air quality that society obtains from regulating ecosystem processes; cultural services that are typically non-market and non-material benefits such as aesthetic, spiritual, and historical values; and supporting services such as nutrient cycling and pollination that allow ecosystems to provide other services, for example food supply (Millennium Ecosystem Assessment, 2005). While measuring the economic value of ecosystem services in monetary terms can be difficult, society undoubtedly benefits greatly from these services. For example, a study by the Saskatchewan Forage Council (2010) found that the direct economic value of forages in Saskatchewan was approximately $740.4 million annually, while the indirect benefits, which include the value of ecosystem services, were valued between $894.5 million and $1.9 billion annually.

However, several ecosystem services provided by grasslands can be characterized as public goods, meaning they are non-rival and non-excludable in their use and consumption (Popescu and Hrestic, 2013). Non-rival implies that one individual's use or consumption of a good or service does not constrain the use of the good or service by others, and non-excludable means that once made available consumers cannot be prevented from accessing or enjoying the benefit of the good or service. An example in the context of grasslands could be air quality, as one individual breathing clean air does not prevent another from doing so (non-rival), and no one can exclude others from breathing the air (non-excludable). Consumers generally benefit freely from public goods because of these characteristics since it is difficult for the private sector to charge those who benefit and to exclude those who do not pay (Batina and Ihori, 2005). This is the case for many grassland ecosystem services: there are no representative markets for many of the ecosystem services so private landowners have limited financial incentives to produce them. Without these representative markets, grassland landowners might undersupply ecosystem services relative to the socially optimal level in favor of producing outputs that do have representative prices and contribute to their profits (Ribaudo et al., 2010).

When a market misallocates resources to a point that a good or service is under or oversupplied relative to its socially efficient level, there is a market failure and justification for some type of market intervention (Tietenberg and Lewis, 2014). It has been acknowledged that economic incentives or some form of government or market intervention could be required to increase the production of ecosystem services on private grasslands to reach a socially desired output (Gao et al., 2016; Kemp and Michalk, 2007; Kemp et al., 2013; Klimek et al., 2007; Kroeger and Casey, 2007; Narloch et al., 2011; Ribaudo et al., 2010). Therefore, the challenge facing policymakers is to design policies or programs that balance the environmental needs of the public with the needs of the landowner to generate income and make a living off the grassland (Kemp et al., 2013).

Several policy measures have been introduced to encourage private grassland landowners to adopt management practices that increase ecosystem services. The most common method is to offer landowners economic incentives for producing ecosystem services, therefore addressing the price signal problem and making producing ecosystem services a more financially viable option for landowners. For example, agri-environmental schemes (AES) are offered in Europe to encourage the production of ecosystem services. The European Commission (2017) describes AESs as, “payments to farmers who subscribe, on a voluntary basis, to environmental commitments related to the preservation of the environment and maintaining the countryside.” AES payments are therefore designed to encourage farmers to adopt agricultural practices or levels of production intensity that will result in desirable environmental outcomes, such as the increased production of ecosystem services, even though these management practices may not generate the most revenue for the farmer (European Commission, 2017).

AESs and other conservation programs have become an increasingly important policy tool as governments aim to boost the environmental quality of agricultural land amidst growing social concern regarding sustainability and climate change (Ruto and Garrod, 2009). This holds true in Canada, where Beneficial Management Practice (BMP) programs are available in all provinces as a shared federal-provincial initiative to encourage the adoption of BMPs and to support environmental quality. BMPs are defined as any agricultural management practice that ensures the long-term health of land resources for agricultural production, positively impacts the long-term economic and environmental viability of agricultural production, and/or minimizes negative impacts to the environment (Government of Saskatchewan, 2018a). In Saskatchewan the provincial government mostly uses cost-share programs to promote BMPs. In these programs the government covers a portion of approved costs farmers must undertake to voluntarily implement management practices that are designed to improve or maintain environmental quality and ecosystem services (Government of Saskatchewan, 2017a). Alberta has similar environmental programs that involve the government providing cost share support to farmers for implementing environmentally friendly management practices, while also offering extension programs designed to provide farmers with a better understanding of how certain management practices might improve ecosystem services and grassland productivity (Alberta Agriculture and Forestry, 2017). The Canadian government has also partnered with private stakeholders to form conservation organizations such as the South of the Divide Conservation Action Program (SODCAP) Inc. that support and develop conservation programs. For example, SODCAP Inc. delivers programs that provide funding to ranchers and farmers in Southwest Saskatchewan to adopt environmentally friendly management practices, and has also attempted to introduce other programs, including results-based agreements and grass banking, designed to increase ecosystem services (SODCAP Inc., 2015).

The 2016 Canadian Census of Agriculture reported over 4.8 million acres of tame or seeded pasture and over 11.2 million acres of native pastureland within Saskatchewan, totaling over 16 million acres of pastureland in the province (Statistics Canada, 2016). The typical ownership and management structure of Saskatchewan grasslands consists of titled lands that are privately owned and managed, land rented or leased from one private user to another, land leased from the Saskatchewan government to private users, and public pastures that are owned and managed by the provincial or federal government and rented out to pasture patrons. However the public pastures in Saskatchewan are undergoing significant changes in management structure, as these pastures will no longer be under government management and are being leased to former pasture patrons or other private users. For example, the Ministry of Agriculture is offering patrons of former provincially-owned pastures 15-year leases, and state that all pastures will be transitioned from government ownership to private leases by the 2020 grazing season (Government of Saskatchewan, 2017b). This means that there will be a large influx of privately-managed grasslands in Saskatchewan by 2020, and given the public goods nature of ecosystem services, these services could be undersupplied on these grasslands. Saskatchewan grasslands have also been noted to be one of the most significantly modified ecosystems in Canada due to changing agricultural practices as well as oil and natural gas extraction (Nasen et al., 2011). Considering the land use changes and management changes occurring on Saskatchewan grasslands, conservation programs could potentially be used to encourage ranchers to manage these grasslands in an environmentally friendly manner that can maintain sustainable grassland ecosystems into the future.

1.1 Problem Statement

There is a potential market failure involving the production of ecosystem services on Saskatchewan grasslands. The lack of economic incentives available to Saskatchewan ranchers to produce ecosystem services might result in the underproduction of ecosystem services relative to the socially optimal output. As previously discussed, several grassland ecosystem services are public goods for which there are no representative markets or prices, which could result in the underproduction of these services. Further considering how agricultural land uses and management practices impact grassland ecosystems, now is an important time to understand the public benefits provided by grasslands and how land use changes or changes in management practices could affect these benefits. These issues provide justification to investigate potential policy mechanisms to encourage ranchers to adopt management practices that will increase or maintain the production of ecosystem services on Saskatchewan grasslands.

1.2 Research Purpose and Objectives

The voluntary nature of conservation programs means that producer participation is integral to achieving policy objectives, namely maintaining or increasing ecosystem services and environmental conservation (Ruto and Garrod, 2009). Ranchers must choose to opt into the program, meaning that it is important to design a policy that is appealing and provides sufficient incentives to increase or maintain ecosystem services on grasslands (Sorice et al., 2013). If ranchers do not find the policy acceptable and choose not to participate, the policy will be ineffective and will not achieve its goals. The purpose of this research is to investigate acceptable policy parameters for voluntary conservation programs designed to encourage management practices that promote or maintain ecosystem services on private grasslands from the perspective of ranchers in Saskatchewan.

The primary objective of this research is to inform an acceptable voluntary conservation program structure that will effectively promote ecosystem services and environmental conservation on Saskatchewan grasslands. More specific research goals are to:

1. Identify existing policy instruments and grassland management practices that increase the provision of ecosystem services on grassland ecosystems. This includes identifying how management practices influence the degree of ecosystem services provided by grassland ecosystems.
2. Assess the relative acceptability of alternative policy instruments and key policy characteristics to ranchers in Saskatchewan.
3. Examine the opinions and attitudes of ranchers regarding ecosystem services and grassland management practices to aid in policy development.
4. Estimate an economic incentive, or price point, that would incentivize ranchers to participate in a conservation program.

5. Provide recommendations for policy design based on the acceptability and cost-effectiveness of conservation programs designed to improve or maintain environmental quality on Saskatchewan grasslands.

1.3 Research Methods

The research will begin with a thorough literature review of peer-reviewed articles, texts, and government reports relevant to grassland policy, alternative grassland management practices, and grassland ecosystems services. This preliminary research will help identify how conservation programs and alternative management practices can be used to preserve grasslands and increase ecosystem services. A theoretical model will then be developed to predict and explain when utility-maximizing ranchers will participate in conservation programs. To assess the relative acceptability of potential policy instruments and producer attitudes regarding ecosystem services, the next step will be to design and administer a survey directed towards ranchers in Saskatchewan. Literature on voluntary conservation programs will inform the design of the survey and provide background information on the main policy characteristics important to ranchers. The survey is used to estimate the willingness-to-accept (WTA) of Saskatchewan ranchers to participate in a conservation program that imposes opportunity costs on the program or policy participant. An individual's WTA is the minimum amount of money they are willing to receive to lose a good or incur some kind of negative impact, such as a loss in private benefits in the case of this survey. The survey will also ask ranchers their opinions regarding alternative conservation programs, policy characteristics, ecosystem services, and grassland management practices. The final methodological step is to interpret the quantitative and qualitative data gathered via the survey to make informed recommendations on policy structure that could increase or maintain grassland ecosystem services in Saskatchewan.

1.4 Thesis Organization

Chapter two of the thesis provides a literature review of grassland ecosystem services, how alternative grassland management practices impact the provision of ecosystem services, and grassland conservation policies. This review highlights the relationship between ecosystem services and management practices on grasslands, providing justification for investigating potential policies to encourage the adoption of alternative management practices to increase or maintain ecosystem services. Chapter three presents the theoretical framework of the thesis, including market failure in grassland management and develops an economic model to identify the circumstances under which a profit-maximizing rancher would choose to opt in to a conservation program. Chapter four outlines the analytical framework of how the research will be conducted. This includes an overview of the survey instrument and the econometric specifications used to estimate ranchers' WTA. Chapter five examines and discusses the quantitative and qualitative results of the survey, and chapter six serves as the conclusion of the thesis.

2. Background Literature

2.1 Introduction

Agricultural production has had to increase significantly over time to meet the growing food demands of an ever-expanding global population. The intensification of agricultural practices has largely allowed society to meet its growing demands for food and has led to substantial economic development as well, but at a significant cost. The Millennium Ecosystem Assessment (2005) found that over the past 50 years, humans have altered ecosystems more rapidly and extensively than in any other equivalent time period in human history. Bennett (2000) reviews how increases in agricultural production through changing land use patterns and intensifying land use have led to severe environmental consequences including the loss of genetic diversity, destruction of habitats, and a significant decrease in many lesser-used crop species. This human impact on ecosystems has also led to the degradation and loss of natural environments and ecosystem services and has caused a substantial, and in many cases irreversible, loss in biodiversity. Therefore it is important to maintain the remaining natural environments that provide the ecosystem services upon which society depends.

The pressure from increasing agricultural production has significantly impacted grassland ecosystems, many of which are under pressure from growing human populations and changing agricultural practices. However, even as grasslands are degraded or lost to changing land uses, they still cover 40% of the world's land surface excluding Antarctica and Greenland, making it one of the largest ecosystems in the world (Reynolds, 2005). These grasslands provide an abundance of ecosystem services including carbon sequestration, wildlife habitat, water quality, air quality, and pollination among an array of other ecosystem services (Table 2.1). As grasslands continue to be threatened from land use changes and growing populations, for example, maintaining current grasslands becomes increasingly important to ensure their long-term sustainability and production of the vital ecosystem services they provide.

Table 2.1: Grassland ecosystem services (Sources: Kroeger and Casey, 2007; Kulshreshtha et al., 2008).

Grassland Ecosystem Services	
Regulating Services	Cultural Services
Carbon sequestration Climate regulation Air quality maintenance Water quality maintenance Pest and disease control	Aesthetic value Historical value Heritage value Recreational services
Provisioning Services	Supporting Services
Food and forage Wildlife habitat Biodiversity Wetland preservation Pharmaceuticals	Soil quality and formation Soil conservation Nutrient cycling Pollination

Grassland management practices can have a significant impact on the viability of grasslands and the degree of ecosystem services produced. Appropriate ranching and grazing practices have been shown to enhance ecosystem services, provide significant conservation value, and increase forage production, making ranching a viable method for maintaining sustainable grassland ecosystems in the long-term (Brunson and Huntsinger, 2008; Kulshreshtha et al., 2008; Schönbach et al., 2011; Schuman et al., 2002). However grassland management practices can also negatively affect ecosystem services. For example, highly intensive grazing practices and exceedingly high livestock stocking rates can reduce ecosystem services and cause significant soil erosion, reduced vegetative cover, grassland degradation, and reductions in water quality (Gao et al., 2016; Kemp and Michalk, 2007; Schönbach et al., 2011; Ward et al., 2016). This suggests that there can be both positive and negative externalities associated with grassland management depending on the management practices adopted. Appropriate management practices can result in positive externalities by promoting ecosystem services and environmental benefits, whereas overgrazing can result in negative externalities by degrading environmental quality and decreasing the degree of ecosystem services provided.

The grassland management practices landowners and ranchers adopt have a clear impact on the provision of ecosystem services, many of which are outlined in Table 2.1. The following three sections of this chapter examine three essential ecosystem services provided by grasslands: carbon sequestration, biodiversity, and water quality. Each section illustrates the importance of ecosystem services and how alternative management practices can increase or decrease the provision of each service. The fifth section of this chapter provides a literature review of voluntary environmental conservation policies designed to increase ecosystem services on private grasslands, which serves as the background for the analytical framework and methodology for this research.

2.2 Carbon Sequestration

A key ecosystem service that grasslands provide is carbon sequestration and storage. Besides reducing fossil fuel use and developing low or non-carbon fuels, Srivastava et al. (2012) suggest carbon sequestration as a major strategy for mitigating climate change, one of the most urgent environmental challenges the world faces today. Grasslands act as a substantial long-term carbon sink by sequestering and storing atmospheric carbon in soil and plants, therefore aiding in mitigating climate change. According to Follett and Reed (2010), global estimates suggest that grazing lands account for 25% of the worldwide potential for carbon sequestration in soils. Grassland ecosystems have also been shown to have a greater capacity to sequester and store carbon compared to other agricultural land uses. For example, Guo and Gifford (2002) examined the effects of agricultural land use changes on carbon stocks in the soil, and found that carbon stocks generally decreased when the land use changed away from a pasture system and increased when the land use changed toward a pasture system. Burke et al. (1995) found similar results where native grasslands fields had significantly more soil organic matter and carbon when compared to cultivated fields, further illustrating the relative potential of grasslands to help mitigate climate change through carbon sequestration compared to other agricultural land uses.

While climate change mitigation is an important public benefit associated with carbon sequestration, there are several other benefits including increased forage production, the maintenance of surrounding water bodies, improved air quality and wildlife habitat, increased soil productivity, quality, and formation, and reduced soil erosion that are associated with increased levels of soil carbon (Follett and Reed, 2010; Srivastava et al., 2012). The numerous public and private benefits related to carbon sequestration and increased soil carbon emphasizes the importance of maintaining grassland ecosystems that effectively sequester and store carbon.

While grasslands are evidently effective at sequestering carbon, livestock grazing practices can impact the potential for carbon sequestration and storage on grasslands both positively and negatively. For example, when comparing the soil carbon levels between grazed and non-grazed grasslands, results have shown grazed grasslands often have higher soil carbon levels than non-grazed grasslands (Reeder and Schuman, 2002; Schuman et al., 2002). However, while grazing activity might have a positive effect on carbon sequestration and storage, overgrazing and high livestock stocking rates on pastures might diminish carbon stocks (Ward et al., 2016). A grassland pasture has been deemed overgrazed when consumption rates of desirable plants and grass species exceed the growth or recovery rate of those species resulting in ecosystem degradation, declining aboveground production over time, and reduced environmental values (Kemp and Michalk, 2007). Ward et al. (2016) detected less soil carbon in grasslands that were overgrazed and intensively managed relative to land that was lightly or intermediately grazed and extensively managed; such results suggest that carbon stocks could decrease as grazing intensity increases. For these reasons it is commonly recommended to adopt light to moderate grazing rates to support carbon sequestration and to maintain sustainable grassland ecosystems (Reeder and Schuman, 2002; Schönbach et al., 2011).

Alternative management practices have also been extensively researched to determine management practices that can effectively increase carbon sequestration and storage relative to other management practices. The use of nitrogen fertilizer has been shown to enhance grassland forage production, water-use efficiency, and carbon sequestration in soils, although the production and use of nitrogen fertilizer might negatively affect other ecosystem services (Kemp and Michalk, 2007; Schuman et al., 2002). Boehm et al. (2004) identify complementary and rotational grazing practices as management techniques that can potentially enhance carbon sequestration by reducing soil disturbance and increasing plant biomass carbon added to the soil. Conant et al. (2001)

reviewed results from over 100 studies that examined management practices intended to increase forage production that could potentially increase soil carbon as well. Management practices included fertilization, improved grazing management, conversion from cultivation to native grassland vegetation, inter-seeding legumes with grasses, introducing earthworms, and irrigation. They found that soil carbon content and concentration increased with one of these improved management practices in 74% of the studies reviewed. Mean soil carbon also increased under each type of management practice. This indicates that these practices might be suitable management options, paired with appropriate grazing practices, to increase carbon sequestration and storage in grassland soils.

Although grasslands have a large capacity to sequester and store carbon, it is important to note that grasslands might not act as a perpetual carbon sink. There is a finite limit to how much carbon can be stored in grassland soils and once the carbon stock reaches the upper limit of its storage capacity, the soil can only sequester as much carbon as it releases (Smith, 2014). However improved management practices can be adopted to increase the carbon sink capacity in grassland soils, therefore increasing the upper limit of carbon that can be sequestered and stored long-term. This illustrates the importance of ensuring ranchers adopt suitable grassland management practices to either increase carbon sequestration and storage on previously poorly managed land or maintain the carbon stocks in more well managed land (Smith, 2014).

Grasslands are one of the most effective agricultural land uses for sequestering and storing atmospheric carbon (Guo and Gifford, 2002; Burke et al., 1995). Improved grassland management practices and strategies can also be adopted to potentially increase carbon sequestration and storage capacity in grassland soils to an even greater degree. Increasing carbon sequestration in grassland soils provides an array of private and public benefits such as increased aboveground forage production, soil productivity and formation, climate change mitigation, and other enhanced environmental benefits, making it a win-win for both the private user and the public (Conant et al., 2001; Schuman et al., 2002). Overall, well-managed grassland ecosystems have been shown to be a reliable, effective, and sustainable method for sequestering and storing atmospheric carbon (Follett and Reed, 2010; Gebhart et al., 1994; Srivastava et al, 2012; Ward et al, 2016).

2.3 Biodiversity

As one of the largest ecosystems in the world, grasslands are the natural habitat of many animal, bird, insect, and plant species. Providing habitat to maintain viable populations of native grassland species, some of which are endangered or at risk, is essential to preserving a high degree of biodiversity. The management practices that ranchers adopt can impact the habitat of grassland species, and therefore the level of biodiversity present on grasslands. Biodiversity also produces substantial societal value by providing vital environmental services. Therefore maintaining and enhancing biodiversity through sustainable management practices is essential to maximizing public benefits.

Humans derive a substantial amount of value from biodiversity, both economically and environmentally. Pimentel et al. (1997) reviewed the many services that biodiversity provides or aids in and measured the economic and environmental benefits of several biodiversity functions including soil formation, organic waste disposal, nitrogen fixation, crop and livestock genetics, biological pest control, plant pollination, and pharmaceuticals. The authors estimated that the worldwide value of these biodiversity-related benefits was $2.928 trillion in the year of the study, or approximately equal to 11% of the total worldwide economy at the time, illustrating immense societal value. These findings indicate that preserving grassland ecosystems is of great importance to maintain the many benefits associated with high levels of biodiversity.

Similar to how livestock grazing impacts carbon sequestration and storage in grassland soils, livestock grazing practices can also impact biodiversity in grassland ecosystems. A variety of grazing or mowing management regimens can be adopted to maintain grasslands and support biodiversity, but affects biodiversity differently. Tälle et al. (2016) compared the effects of grazing and annual mowing practices on biodiversity conservation and found that grazing generally had a more positive effect, albeit small to moderate, suggesting that grazing should be the preferred management practice for conserving biodiversity in most cases. Klimek et al. (2007) came to similar conclusions analyzing the variety of plant species under different management practices and environmental conditions, finding that plant species richness was significantly greater on grazed pastures than on mown or mown then grazed pastures. Based on their results, Klimek et al. (2007) suggested that grazing at a low stocking rate might be the best management practice to help conserve biodiversity on grasslands. These results, in tandem with earlier findings, suggest that proper grazing practices can have a positive impact on both biodiversity and carbon sequestration on grasslands.

The literature also evaluates the effects of other management practices on grassland biodiversity and wildlife habitat. One such practice is fencing off stream banks and riparian areas. Livestock with free access to streams and other water bodies can destroy wildlife and fish habitat and increase soil erosion and sedimentation. By fencing stream banks and riparian areas, livestock can be excluded from environmentally sensitive areas and vegetative buffer zones can grow between the water body and fence, which can provide food and nesting areas for birds and small animals, while also enhancing water quality and habitat for aquatic species by reducing erosion and nutrient or chemical runoff (Brittingham and DeLong, 1998). Other management practices that have been suggested to enhance wildlife habitat and biodiversity include providing brush piles, controlling noxious and invasive plants, tree shelters, herbaceous forest openings, nest boxes or other nesting structures, and wetland restoration initiatives (Brittingham and DeLong, 1998).

Grassland ecosystems enhance biodiversity by providing wildlife habitat, including habitat for endangered and at risk species, and land for native vegetation to grow, thereby maintaining the population of animal and plant species (Kulshreshtha et al, 2008; Kroeger and Casey, 2007). Preserving biodiversity is essential for maintaining sustainable and functioning ecosystems that humans depend on, including grasslands (Pimentel et al., 1997). However the management practices that are adopted on grasslands can either enhance or degrade biodiversity and grassland ecosystems. There are significant public benefits associated with maintaining high levels of biodiversity, therefore adopting management practices that conserve grassland ecosystems and enhance biodiversity can effectively maintain or increase these benefits.

2.4 Water Quality

Grassland ecosystems play a large role in preserving the water quality of adjacent wetlands, streams, lakes, and groundwater stocks. Maintaining water quality is a vital ecosystem service as it provides drinking water, habitat for fish and aquatic species, and reduces the costs of treating contaminated or dirty water for public use (Kroeger and Casey, 2007). Non-market valuation studies have shown that society places significant value on maintaining high levels of water quality, including within grassland ecosystems. For example willingness-to-pay (WTP) experiments are commonly used to estimate the value society places on ecosystem services such as water quality and retention. WTP refers to the maximum amount of money that an individual would be willing to pay or give up to receive a good or prevent something undesirable from happening, such as pollution. Pattison et al. (2011) examined the WTP for wetland retention and restoration in Manitoba, finding that over a five-year period Manitobans, on average, were willing to pay between $296 and $326 per household per year depending on the level of wetland maintenance or improvement. Based on these estimates, the authors calculated the present value of aggregate payments in Manitoba for retaining wetlands at their current conditions to be $504 million. Dias and Belcher (2015) similarly estimated the WTP for wetland ecosystem services in Saskatchewan. The authors found that the Saskatchewan public values water quality the highest among wetland ecosystem services with a WTP of $104.68 per household to decrease the frequency of water boil advisories, resulting in a WTP of $42.9 million province wide. These results demonstrate the significant value the public places on wetland retention and restoration, a water quality service closely associated with grassland ecosystems as wetlands are commonly located within grasslands.

Management practices again play a large role in the provision of ecosystem services as grazing intensity has been shown to significantly impact water quality on grassland ecosystems. Intensively managed grasslands can contribute to soil erosion and diffuse pollution rates, which leads to sediment and nutrient losses in soils. This can pose a significant threat to receiving surface waters as suspended sediments and phosphorus concentrations have been found to greatly exceed water quality guidelines in surface waters near intensively managed grasslands (Peukert et al., 2014). Peukert et al. (2014) also estimated that annual erosion rates, total phosphorus losses, and total carbon losses on intensively managed grasslands were similar to or exceeded the losses of other grasslands, arable sites, or mixed-use land. Many of these nutrient and soil losses from erosion may carry pollutants and runoff into waterways and decrease water quality.

Proper grazing management is important to water quality preservation, but other management practices can aid in maintaining water quality by reducing erosion, runoff, and nutrient loss. For example, pasture renovation is a management tool that improves aeration in pastures by mechanically puncturing holes within the soil. De Koff et al. (2011) examined the effects of conducting pasture renovation before manure application on forage production, soil erosion, and nutrient runoff under different grassland soils and rainfall simulations. Their results indicated that there are significant and beneficial water retention changes from pasture renovation, as runoff volumes were 45% to 74% lower in seven of eight treatments and water infiltration rates increased in all renovated treatments compared to non-renovated treatments. Furthermore, they found that these positive impacts lasted up to three months, minimizing the nutrient runoff following manure application during this time period and reducing the adverse effects this runoff would have on water quality. However, de Koff et al. (2011) also noted that pasture renovation did not have a significant impact on forage yields, meaning that although the practice can increase public benefits by maintaining or increasing water quality, there may be little to no private benefits derived from adopting the practice.

Fencing off waterways and wetlands can benefit water quality by restricting livestock, which reduces erosion and decreases pollutants from entering the water, therefore maintaining water quality (Brittingham and DeLong, 1998). Livestock can be allowed limited access to waterways for drinking or crossing if necessary, but restricting livestock to a smaller section of a water body can help maintain the overall water quality of the stream or wetland.

Degradation and pollution of water sources can cause human health problems, lower environmental quality, damage fish habitat, and carry high economic costs to clean and treat polluted water. Therefore maintaining high levels of water quality is an important ecosystem service that carries significant societal value. Since grassland management practices can greatly impact water quality, the literature shows that the adoption of appropriate management practices can maintain and protect natural water bodies such as streams and wetlands. Preserving water quality on grasslands helps maintain a sustainable ecosystem and provides public benefits and value in the long-term.

2.5 Grassland Conservation Policy Review

Conservation programs such as payments for ecosystem services (PES) and cost-share programs have been developed to increase ecosystem services on grasslands by offering economic incentives to ranchers who adopt management practices that enhance environmental benefits. Voluntary, incentive-based conservation programs are commonly used to support the provision of ecosystem services rather than imposing regulatory policies that are mandatory and enforced by legal measures. Voluntary conservation programs have the advantage of being a consensual agreement between a landowner and governing group without unwanted costs or requirements being imposed on the landowner that would be under mandatory regulation (Segerson, 2013). Brunson and Huntsinger (2008) also note that while ranchers have historically been hostile towards any form of land control, regulation, or government involvement, many ranchers have found voluntary programs and payments to be acceptable practices. Segerson (2013) suggests that for a voluntary policy approach to be effective, it must provide a sufficiently strong participation incentive to the targeted population, in this case grassland landowners and ranchers. Likewise, Sorice et al. (2013) use agency theory to suggest the potential market failure regarding ecosystem services could be corrected if the principal, in this case the government or some conservation group, used incentives to align the goals of the agent, or landowners, with their own goals, namely increasing ecosystem services. Mettepenningen, Verspecht, and Huylenbroeck (2009) further illustrate this principal/agent exchange as the government offering landowners a compensation payment as an incentive to voluntarily produce environmental goods and services on their land.

Hanley et al. (2012) identify five policy design options for promoting ecosystem services on private land: 1) regulation; 2) uniform payment schemes; 3) conservation auctions; 4) conservation easements; and 5) creating markets for ecosystem services. All of the above policy mechanisms are designed based on the assumption that landowners are driven by profit maximization, although the authors also consider extension programs that assume landowners may voluntarily adopt environmentally friendly management practices, without compensation, if they are provided with information on these management practices. Hanley et al. (2012) also consider four key policy design challenges: 1) paying for environmental outcomes, not actions; 2) determining contract length and other dynamic considerations; 3) spatial coordination; and 4) transaction costs. These policy design challenges are further examined in the context of voluntary conservation programs, mainly uniform payment schemes.

The environmental effectiveness of voluntary conservation programs is highly dependent on the uptake of the program by eligible landowners, ranchers, and farmers (Mettepenningen et al., 2009). Therefore designing a program that landowners find acceptable and choose to participate in is integral to the success of any given conservation initiative. Sorice et al. (2013) examined how program structure can affect preferences for potential participation in conservation programs designed to protect at-risk species. The authors found programs that offered greater levels of compensation, supported landowners' autonomy to make land management decisions, and had shorter term contracts were more acceptable to landowners compared to programs that were highly controlling and inflexible, required permanent conservations easements, or put landowners at risk of further regulation. Their findings illustrated that autonomy is a highly important value held by landowners that influences their willingness to participate in conservation programs. They also suggest that there is a fundamental tradeoff to be made between maximizing participation and maximizing conservation benefits when designing a voluntary conservation incentive program. Narloch et al. (2011) examine the potential tradeoff between the ecological effectiveness and economic efficiency of conservation programs, finding that increased management flexibility or higher compensation could increase participation, although these incentives may decrease the conservation benefits realized through the program.

Ruto and Garrod (2009) found similar results investigating farmer preferences over four main program characteristics: level of compensation, flexibility over contract length, flexibility over land and management decisions, and level of transaction costs measured in terms of paperwork needed. On average, their results showed that farmers preferred shorter length contracts, had a positive preference for having flexibility over the land they entered in the program and over the management practices they must undertake, and preferred lower levels of paperwork. They also argue that "farmer factors", such as age, education, and farm size should be taken into consideration along with program or policy factors when examining farmer participation in conservation programs. The authors state that there is a general consensus that participation in conservation programs is positively influenced by farm size, education, and a farmer's interest in conservation, but negatively influenced by a farmer's age. However farmer factors may be of little interest to policymakers since they cannot control or change these factors.

Ruto and Garrod's (2009) results also indicated that higher levels of compensation could be offered to induce participation in programs that had longer contracts, offered less flexibility, or required more paperwork. However, offering greater compensation is neither cost-effective nor ideal for increasing program participation. While compensation payments serve as a strong participation incentive, conservation programs are typically constrained by a fixed budget. Therefore developing cost-effective programs is key to maximizing the environmental benefits derived from conservation programs under limited budgets. Suter et al. (2008) investigated landowner responsiveness to monetary incentives and found that one time payments offered at the time of sign up are a more cost-effective means of increasing enrollment than annual incentive payments. Ulber et al. (2011) argued that the cost-effectiveness of conservation programs increases if payments to participants compensate their opportunity costs, in terms of foregone production, and no more. Babcock et al. (1996) further stated that to maximize environmental benefits in a cost-effective manner, land with potentially high benefit-to-cost ratios should be targeted for conservation programs. If the potential environmental benefits are high relative to the private opportunity costs of the landowner, more social benefits can be realized relative to the compensation costs required to enter the land in a conservation program. Beyond benefit-cost targeting, Claasen et al. (2008) note that a clear environmental objective needs to be defined, as policy makers can then aim to maximize the extent to which the objective is met in a cost-effective manner. The environmental objective should be one that is highly important to both landowners and the government (and society), as landowners may be more willing to participate in a program if the program supports environmental benefits they value.

Babcock et al. (1996) discuss the importance of measuring environmental quality and the effects of management decisions at a highly disaggregate level, such as individual fields rather than large geographical areas. Management practices that benefit one area may not have as great of an impact in another, while environmental issues and opportunity costs can differ greatly from region to region. Weber (2015) further discussed how significant information deficiencies might exist with respect to environmental goods due to large heterogeneities in agricultural land and farm management practices, which can affect the quality of the desired environmental outcome and opportunity cost of reaching these objectives across regions. Therefore understanding how varying management practices, environmental benefits, and opportunity costs are related across heterogeneous regions is essential to maximizing environmental benefits relative to costs (Claasen et al., 2008).

Understanding the effects of transaction costs in environmental conservation programs is also a key factor for developing effective policies (Coggan et al., 2010). McCann et al. (2005, p. 530) define transaction costs in environmental policy as, "the resources used to define, establish, maintain, and transfer property rights." Policy makers must also consider both public and private transaction costs incurred by the government and program participant, respectively, when developing cost-effective conservation programs. McCann et al. (2005) list several public transaction costs associated with administrating environmental policies, including: 1) research, information gathering, and analysis to define the problem; 2) enactment of enabling legislation; 3) design and implementation of the policy; 4) support and administration of the program; 5) contracting costs such as additional information, bargaining, and decision costs; 6) monitoring and detection costs; and 7) conflict resolution costs if lack of compliance is found. Private transaction costs incurred from conservation programs fall under three major categories: 1) ex ante search costs, which includes looking for information on the program, comparing the program with alternatives, comparing compensation to expected costs, and deciding whether or not to participate in the program; 2) negotiation costs, including application costs, meeting necessary conditions to apply, administration costs of applying, and contacting program administrators; 3) and ex post monitoring/enforcement costs, which could include any monitoring costs required by the government after they opt in to the program (Mettepenningen et al., 2009).

Transaction costs have been shown to account for a significant portion of total policy costs and compensation payments in conservation programs. Mettepenningen et al. (2009) estimated that transaction costs represented approximately 15% of total program related costs and about 25% of the compensation payment in conservation programs. The authors also indicated that foregone income and production was the greatest cost factor landowners incurred from participating in a program as it accounted for more than 50% of total costs. Coggan, Whitten, and Bennett (2010) reviewed several studies on conservation programs and found that public and private transaction costs can account for anywhere between 21% and 50% of total policy costs. Transaction costs can evidently account for a large portion of the costs participants incur from opting into a program, and therefore may impact the likelihood of any given landowner participating in an environmental conservation program.

2.6 Conclusion

There is a clear relationship between management practices and the ecosystem services provided by grasslands. For example, adopting light to moderate grazing intensity practices can contribute to carbon sequestration, biodiversity, water quality, and the long-term sustainability of grasslands, while overgrazing can negatively impact these ecosystems services. This highlights how the adoption of certain management practices can maintain or increase the public benefits derived from ecosystem services. However, many grassland ecosystem services could be undersupplied relative to what is socially desired because private landowners receive little to no financial incentive to provide them. Therefore there is reason to explore policy mechanisms to increase the level of ecosystem services and public benefits produced through management practices within grassland ecosystems.

3. Theoretical Framework

3.1 Introduction

Chapter two demonstrated that ecosystem services could be increased through alternative grassland and ranching management practices, which can increase public benefits. However, adopting management practices to increase ecosystem service provision can often be a costly endeavor for a landowner, whether it is explicit costs from adopting a practice or opportunity costs from foregoing a more profitable land use or management option (Hanley et al., 2012). Additionally, some management practices that increase ecosystem services provide limited or possibly zero private benefits to the landowner or manager adopting the practices (e.g. de Koff et al., 2011). If a costly management practice offers little in the way of private benefits, it is unlikely that a profit maximizing individual will voluntarily adopt the practice even if it increases ecosystem services and public benefits. This section examines and illustrates decision making as supported by economic theory that occurs under private grassland management. A simple model is developed to demonstrate the conditions under which a rancher would agree to participate in a voluntary conservation program and adopt management practices that increase ecosystem services and environmental benefits.

3.2 Market Failure in Grassland Management

The private costs and limited rewards from producing ecosystem services can lead to landowners supplying fewer ecosystem services than are socially desired. Ecosystem services are commonly undersupplied by profit-maximizing individuals due to the lack of financial reward for doing so (Ferraro and Kiss, 2002). Without markets for ecosystem services, the supply of ecosystem services goes unrewarded and those producing ecosystem services receive no direct financial benefit for doing so even though society values these services. This results in an inefficient allocation of resources in that grassland landowners and managers will under produce ecosystem services relative to the amount that is socially desired (Ribaudo et al., 2010).

The underproduction of ecosystem services relative to the socially efficient output represents a market failure in grassland management. This market failure is illustrated with a market model (Figure 3.1), where $MC_{private}$ and $MB_{private}$ are the private marginal cost and private marginal benefit of providing ecosystem services for a grassland landowner or manager. The marginal cost is upward sloping since the costs of taking actions to increase the quantity of ecosystem service provision increase for any given landowner. For example, at low levels of ecosystem service provision the landowner can make low-cost changes to management or retire land that has low productivity for agricultural commodities, resulting in a low opportunity cost. At higher levels of ecosystem service provision the manager would need to adopt higher cost management changes or give up more highly productive land (Hanley et al., 2012). As a result the cost of providing marginal units of ecosystem services is relatively higher as more ecosystem services are provided.

Conversely, Private marginal benefit is downward sloping since the benefit of increasing the quantity of ecosystem service provision declines for private landowners as the quantity of ecosystem service provision increases. As noted by Follett and Reed (2010) and Srivastava et al. (2012), producing ecosystem services such as carbon sequestration can provide private benefits.

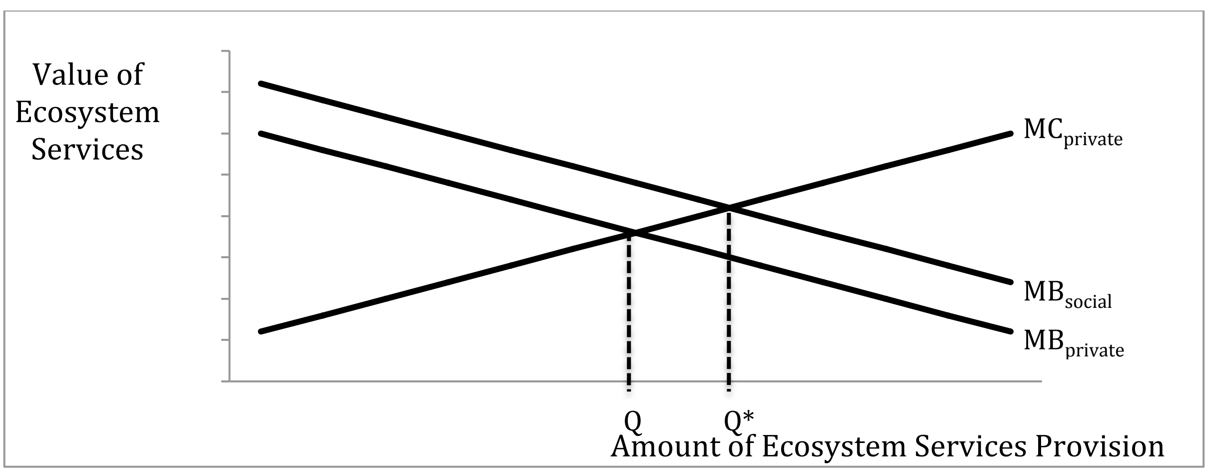

Figure 3.1: Graph illustrating the potential market failure in provision of ecosystem services on grasslands.

When there is a relatively low amount of ecosystem service provision, changes in management practices to increase provisions can have relatively large benefits, such as clean water and improved soil and forage productivity. However as ecosystem services provision continues to increase the private benefits become less significant. For example forage productivity and water quality might only be able to increase so much before a relative plateau in productivity and quality is reached. Therefore the marginal benefit of increasing ecosystem services decreases as the quantity of ecosystem services increases.

Combining the $MC_{private}$ and $MB_{private}$ functions in the economic model represents the private market supply and demand for ecosystem services in grassland management. A private landowner or rancher will supply ecosystem services to the point where the private marginal benefit of ecosystem service provision is equal to the private marginal cost. In Figure 3.1 this quantity of ecosystem service provision is denoted by Q. Beyond this point the private marginal cost of producing ecosystem services is greater than the private marginal benefit so a landowner would incur a net loss in welfare if they supplied ecosystem service provision beyond Q. For example, a landowner could fence a water body on their land to restrict access to livestock and create a riparian buffer zone. This management decision would increase the landowner's marginal cost due to labour, materials, and management, and decrease their marginal benefit as they lose potential grazing land to the riparian buffer zone. Although marginal benefit is decreasing and marginal cost is increasing, initially the marginal benefit would be greater than the marginal cost of the management decision as water quality could improve. The landowner would continue to fence the water body and expand the riparian zone until the marginal cost of doing so was equal to the marginal benefit they received. Additional fencing or expansion of the riparian zone beyond this point would result in a net welfare loss for the landowner.

While $MB_{private}$ and $MC_{private}$ represent the demand and supply of ecosystem service provision for a private landowner, MB_{social} depicts the full social demand for and marginal benefit of ecosystem service production on grasslands. MB_{social} is greater than $MB_{private}$ because many ecosystem services provide positive externalities for which the total benefits are not fully captured by the private user. These positive externalities are the public goods and services discussed by Batina and Ihori (2005) that often do not have private markets and that consumers generally benefit freely from, and therefore provide limited private benefits to the landowner. Assuming there are no external costs associated with the management change in the previous fencing and riparian buffer zone example, in addition to the private benefits society would also benefit from the increase in downstream water quality, the enhanced riparian zone serving as habitat for wildlife, a potential increase in biodiversity, and potentially improved aesthetic value. Therefore the social marginal benefits of ecosystem service provision are greater than the private marginal benefits.

From a social welfare standpoint, the socially optimal quantity of ecosystem service provision on private grasslands is the quantity where the social marginal benefit is equal to the private marginal cost. The optimal social quantity of ecosystem service provision is at point Q* in Figure 3.1. As Segerson (2013) notes, when there is a potential market failure unregulated behavior might not result in efficient resource allocations and socially desirable outcomes. Considering that the social marginal benefit is greater than the private marginal benefit of ecosystem service provision, it follows that society would desire a greater output of ecosystem services than provided by the private landowner given the same marginal cost of ecosystem service provision. This is evident in Figure 3.1 as Q* is greater than Q. The difference between Q* and Q illustrates that the level of ecosystem service provision by the private landowner is less than the socially desired amount, and that social welfare would increase if the quantity of ecosystem service provision were equal to Q*. Therefore there is clear potential for market failure in grassland management as ecosystem services could be undersupplied relative to the socially optimal output if there is no intervention.

3.3 Conceptual Model for Participating in a Voluntary Conservation Program

The conceptual model used for this research closely follows similar models developed by Roberts, Froud, and Fraser (1996) and Mewes et al. (2015). While there is literature that argues ranchers may not prototypically maximize profit (see Brunson and Huntsinger, 2008; Torell et al., 2001), I assume profit is the only variable in the rancher's utility function that changes whether they choose to participate in a conservation program or not. Rancher *i*'s goal is to maximize his or her utility function $U_i(\pi_i, X_i)$, where π_i is the rancher's profit and X_i denotes a vector of individual characteristics including their attitude towards conservation and lifestyle factors such as their way of life, ability to be their own boss and live in a rural area, and other characteristics related to ranching that rancher *i* might gain utility from. A rancher will participate in an environmental conservation program if their utility from doing so is greater than, or at least equal to, their status quo condition of non-participation. Subscript 1 is used to denote a rancher who participates in a conservation program, whereas nonparticipating ranchers are denoted by subscript 0. For example, rancher *i*'s utility from participating in the program is denoted as $U_{i1}(\pi_{i1},X_i)$, whereas their utility from not participating is denoted as $U_{i0}(\pi_{i0},X_i)$. Therefore, I assume rancher *i* will participate in a given conservation program if $U_{i1}(\pi_{i1},X_i) \geq U_{i0}(\pi_{i0},X_i)$.

The profit equations in the utility functions for a non-participating and participating rancher, respectively, are:

$$\pi_{i0} = p\theta_0 - c_0L \tag{3.1}$$

$$\pi_{i1} = p\theta_1 - c_1L - TC + PI \tag{3.2}$$

PI denotes a participation incentive, a compensation payment received by the rancher for adopting management practices to promote ecosystem services. Transaction costs (TC) are incurred by the rancher for participating in the policy, decreasing their total profits. Ranch revenue is a function of p, the price per pound for beef that is exogenous, and θ_0 or θ_1, the beef yield in pounds if they do not participate or do participate, respectively. It is assumed that $\theta_0 \geq \theta_1$ since the status quo management practices are assumed to maximize profit and beef production, and therefore participating in a conservation program and undertaking management changes would decrease or maintain beef production. A price premium or policy initiative could exist where p is greater for beef produced within a program, such as having "sustainably raised beef" labeling and marketing for beef raised in the program under given management practices. However for the purpose of this model, no price premium is assumed to exist or be offered to ranchers who participate in a policy and p remains equal whether the rancher participates in a program or not. L represents the total acres of land which is equal whether the rancher participates or not, and c_0 and c_1 are the costs of beef production per acre if they participate or do not participate, respectively. It is also assumed that $c_1 \geq c_0$, since production costs are expected to increase or remain the same for participating ranchers from adopting alternative management practices.

Rancher i will participate in a conservation program if $U_{i1}(\pi_{i1},X_i) \geq U_{i0}(\pi_{i0},X_i)$. Inserting the profit equations into the utility functions, rancher i's utility from non-participation and participation in a conservation program, respectively, are:

$$U_{i0}(\pi_{i0},X_i) = p\theta_0 - c_0L + X_i \tag{3.3}$$

$$U_{i1}(\pi_{i1},X_i) = p\theta_1 - c_1L - TC + PI + X_i \tag{3.4}$$

Assuming X_i remains the same if rancher i participates in a conservation program or not, this suggests rancher i will not participate in a conservation program that decreases their profit, but will participate if the policy leads to increases in, or at the very least maintains, their current profit level. Solving for PI in this equation will define a price point that would serve as a sufficient participation incentive for rancher i. Isolating PI in the inequality $U_{i1} \geq U_{i0}$ gives

$$PI \geq TC + p(\theta_0 - \theta_1) + L(c_1 - c_0). \tag{3.5}$$

$p(\theta_0 - \theta_1)$ represents the potential foregone or lost production from participating in the policy compared to their reference state of profit maximization without policy. $L(c_1 - c_0)$ represents the increase in costs a rancher could incur from adopting more costly management practices, which could include increased labor, materials, or input costs relative to their costs under profit maximization without policy participation. The total opportunity cost, denoted as δ, incurred by a rancher for participating in a conservation program is the sum of their foregone or lost production and increased costs, or $\delta = p(\theta_0 - \theta_1) + L(c_1 - c_0)$. Therefore, $PI \geq TC + \delta$ must hold for a rancher to participate in a conservation program. For any price point where $PI > TC + \delta$, it is more profitable and therefore more desirable for the rancher to participate in the policy than to not participate. The price point where $PI = TC + \delta$ is the indifference price where profits are equal for the rancher whether they opt in policy or not, so each scenario is equally desirable. Setting the participation incentive equal to the sum of transaction costs and opportunity costs is therefore the cost-effective price point to induce participation in a conservation program.

In reference to Figure 3.1, the goal of the participation incentive is to increase the private marginal benefit ($MB_{private}$) of ecosystem service provision to the point where it is equal to the social marginal benefit (MB_{social}). If a given landowner's private marginal benefits for providing ecosystem services increase to a point where it equals the social marginal benefits, they will increase their quantity of ecosystems service provision from Q to Q*. Therefore, if policymakers understand the value of the transaction costs and opportunity costs (TC + δ) landowners would incur to increase ecosystem service provisions to the socially optimal output, the participation incentive could be set equal to this value (Figure 3.2). From the conceptual model, a participation incentive equal to the sum of the opportunity costs and transaction costs of participating in a conservation program should effectively encourage landowners to increase ecosystem service provision to the socially optimal output.

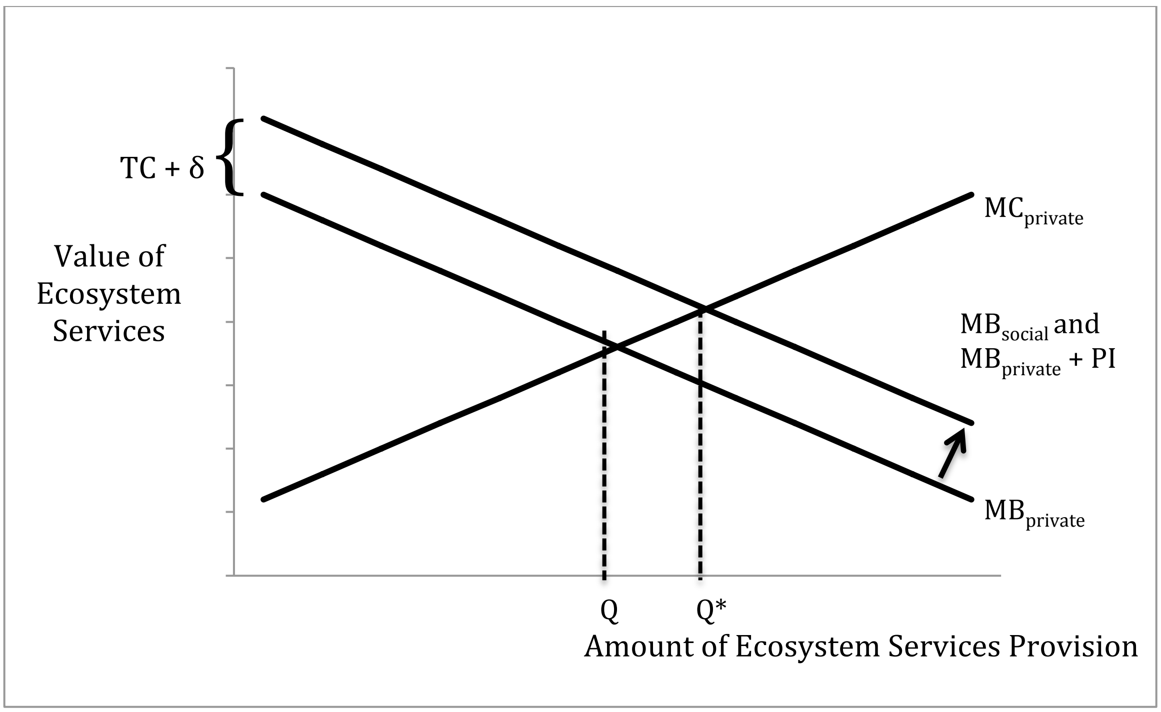

Figure 3.2: Graph illustrating how a participation incentive can shift the private marginal benefit of ecosystem service provision.

3.4 Conclusion

Many grassland ecosystem services are under-provided relative to the socially efficient and desired output due to a lack of private economic incentives available to the private land manager or rancher. To increase provision of ecosystem services, environmental policies and programs have been developed to introduce incentives, compensation, or rewards for ranchers and grassland landowners for voluntarily adopting management practices that promote ecosystem services. A rancher or landowner is more likely to participate in an environmental conservation program if the policy does not decrease their profits relative to their reference state of profit maximization without policy. Therefore it is necessary to evaluate the opportunity costs and transaction costs ranchers potentially face from participating in conservation programs in order to develop cost-effective policy tools that can effectively increase ecosystem services on grasslands.

4. Analytical Framework

4.1 Introduction

To develop cost-effective policy for increasing ecosystem services on grasslands, policymakers must understand the potential opportunity costs and transaction costs participants would incur from adopting alternative management practices. As demonstrated with the conceptual framework described in the previous chapter, a cost-effective participation incentive for an environmental conservation program should equal the sum of opportunity costs and transaction costs incurred by potential participants. By understanding these costs, policymakers can set participation incentives that landowners and ranchers will find acceptable to encourage the adoption of BMPs.

This chapter outlines the research methods used to conduct analysis for this project. This includes a description of the survey that was developed to gather data on the attitudes and opinions of Saskatchewan ranchers regarding conservation policy, ecosystem services, and grassland management practices. The survey was also used to assess the WTA of Saskatchewan ranchers for participating in a conservation program to inform an acceptable participation incentive. The survey area and targeted potential participants are also discussed, as well as potential survey issues. The econometric specifications that were used for the WTA estimation process are then outlined. The WTA estimation process serves as the base of the analysis for estimating a cost-effective participation incentive from the conceptual model discussed in the previous chapter.

4.2 Rancher Survey

To design and implement environmental conservation programs, policy makers require information on the potential environmental benefits expected and the minimum level of compensation potential participants would be willing to accept for adopting management practices to achieve these benefits (Claasen, Cattaneo, and Johansson, 2008).

While the ecosystem services literature review outlined potential environmental benefits associated with certain grassland management practices, I developed a survey to estimate Saskatchewan ranchers' WTA for potentially increasing production of ecosystem services on their land. The survey also aimed to identify rancher characteristics and examine ranchers' opinions on conservation programs, key policy components, ecosystem services, and grassland management practices.

4.2.1 Survey Description

The survey began with a general information section that provides details on policy structures and ecosystem services. The question portion of the survey is divided into four sections: i) policy; ii) ecosystem services; iii) willingness-to-accept; and iv) demographics. The complete survey instrument is provided in Appendix A.

Section i examined participants' policy preferences. Participants were asked to rank three policy designs (cost share programs, extension programs, and conservation easements), from most to least preferred. Participants were asked if there were any other policy structures they would like to have available to them to potentially increase ecosystem services on their land. Additionally, respondents were asked the minimum cost share percentage they would want the government to cover for them to adopt a given management practice. This was done via a payment card question where survey participants respond how likely they would participate at each given level of cost share. Additional policy related questions in section i include those designed to evaluate attitudes to transaction costs, how many additional hours of labor respondents would be willing to work to adopt a given management practice, and the maximum contract length they would agree to.

Section ii questions were designed to reveal survey respondents' attitudes towards specific ecosystem services including carbon sequestration, wildlife habitat, and water quality. Survey respondents were asked to rank the ecosystem services according to which ecosystem services they believed provided the most public benefits or were most beneficial to society. Survey respondents were also asked whether they believe they are effectively providing these ecosystem services with their current management practices. Additional questions regarding ecosystem services include whether respondents agree that landowners, both themselves and others, have a responsibility to manage their land in a manner that conserves or enhances ecosystem services, if they would change their management practices to enhance ecosystem services, and whether they believe the government should compensate landowners for providing ecosystem services.

Section iii of the survey estimated opportunity costs of participating in conservation programs by determining how much money per acre each survey respondent would be willing to accept to participate in a given program. A multiple-bounded payment card approach was used to estimate the WTA of ranchers for decreasing grazing intensity by 10% on their land to potentially increase ecosystem services (Figure 4.1). A 10% decrease in grazing intensity was chosen as the hypothetical management method to increase ecosystem services because low to moderate grazing intensities have been shown to support ecosystem services (see Klimek et al., 2007; Reeder and Schuman, 2002; Schönbach et al., 2011) while overgrazing has been shown to reduce ecosystem services (see Gao et al., 2016; Kemp and Michalk, 2007; Schönbach et al., 2011; Ward et al., 2016). This hypothetical policy structure would decrease the negative externalities associated with overgrazing and potentially increase the positive externalities associated with appropriate grazing practices discussed in chapter two. The 10% reduction in grazing intensity also provided a relatively clear way to express that opportunity costs would be incurred from participating in the program. Ruijs et al. (2017) researched the opportunity cost of increasing ecosystem services on agricultural land in Central and Eastern Europe, finding that a 10% increase in carbon sequestration only decreased agricultural revenues by 4%, while a 5% increase in biodiversity decreased agricultural revenues by 13%. By choosing 10% for the reduction in grazing intensity, each respondent's WTA is assumed to roughly represent an opportunity cost of 10% relative to their status quo conditions from undergoing a change in management practices and participating in the program. The multiple-bounded payment card approach presented participants with a list of dollar values per acre and asks if they would be willing to accept each amount in return for decreasing their grazing intensity by 10%. The respondent was then asked to provide the likelihood of acceptance for each value (Figure 4.1). After marking the payment card, respondents were then asked open-ended questions where they could indicate management practices that they would be willing to adopt to potentially increase each given ecosystem service.

Section iv is used to collect demographic information on the survey respondents and their individual ranch operations. The demographic information is used to quantify and examine the effects that different farm and farmer characteristics have on other aspects of the data collected in the survey. For example, demographic data are used to measure the impacts that different farmer and farm characteristics have on the amount each survey respondent is willing to accept to participate in a given conservation program.

It is important to note that all survey participant responses were completely and fully anonymous and voluntary, so respondents were under no obligation to provide information regarding themselves or their ranch. The survey developed for this research received an ethics exemption from the University of Saskatchewan Behavioural Research Ethics Board on September 18, 2017. The survey was administered from November 2017 through February 2018.

Payment Amount	Definitely Not	Probably Not	Probably	Definitely
$1/acre				
$5/acre				
$10/acre				
$20/acre				
$30/acre				
$40/acre				
$50/acre				
$60/acre				
$70/acre				
$80/acre				
$90/acre				
$100/acre				

Figure 4.1: Multiple-bounded payment card question format to determine ranchers' WTA.

4.2.2 Survey Study Area

While the majority of native grasslands in Saskatchewan are located in the southwest, the targeted study area covered all of Saskatchewan, as cattle are raised throughout the province on both native grasslands and tame or seeded pastures. There are over 11.2 million acres of native grassland and 4.8 million acres of tame or seeded pasture throughout Saskatchewan, totaling over 16 million acres of pastureland in the province (Statistics Canada, 2016).

4.2.3 Survey Participants

The survey targeted Saskatchewan cattle producers, although survey responses from producers outside Saskatchewan were also accepted. The only criteria used to identify and select potential survey participants were if they owned cattle and used pastureland. For example, a cattle producer who owned or operated a feedlot but did not own, rent, or lease pastureland would not be targeted. Survey respondents were asked how many acres of land they owned and rented or leased separately. Therefore the acres of grassland or pasture reported by survey respondents could be privately owned, rented or leased from other private landowners, or leased from the Saskatchewan government. According to Statistics Canada (2016) there are 13,497 cattle farms in Saskatchewan that reported a total of 2,592,277 cattle for an average of 192 cattle per farm. This represents a relatively large cattle industry as Saskatchewan farms the second most cattle provincially in Canada.

4.2.4 Survey Administration and Data Collection

Potential survey participants were identified through Saskatchewan cattle breeder directories that had cattle producers' contact information, and in person at cattle industry trade shows and conferences in Saskatchewan. Participants were typically informed about the survey either in person at the trade shows and conferences or by email if they were identified via a breeder directory. Surveys were conducted in person when possible, however several surveys were conducted by phone, mail, or email when in person meetings were not possible. When surveys were conducted in person or by phone, the interviewer recorded all survey responses and comments by the interviewee on paper. If the survey was sent out by mail or email, the participant was sent either a physical or electronic copy of the survey that they would send back after completing the survey. Participants were also provided with the researcher's contact information so if the survey was not conducted in person or by phone, they were still able to receive assistance.

4.3 Econometric Specifications for Estimating Ranchers' WTA

To estimate the mean and median WTA of Saskatchewan ranchers, I conducted an econometric estimation of WTA using data gathered from the survey. Following Broberg and Brännlund (2008) and Cameron and Huppert (1989), an interval estimation approach is applied to the WTA payment card data to estimate upper and lower bounds for mean and median WTA. Broberg and Brännlund's (2008) expansion method for estimating double bounded data is used where each respondent's WTA, the dependent variable, is bounded by the highest bid amount they responded "no" to and the lowest bid amount they responded "yes" to in the "definitely" column (see Figure 4.1). To estimate the upper and lower bounds of WTA, two regressions were run: the upper bound regression considers only "definitely yes" responses on the payment card as "yes" responses, and the lower bound regression considers both "definitely yes" and "probably yes" responses as "yes" responses. Therefore the WTA interval in the lower bound regression is bounded by the highest "probably not" response and lowest "definitely yes" response, while the upper bound regression is bounded by the highest "probably yes" and lowest "definitely yes" responses. This coding procedure accounts for uncertainty in survey participant's responses by widening their WTA interval over a larger range for the lower bound regression, whereas the upper bound regression reflects more certain responses. After estimating each regression, mean and median WTA for each regression can be calculated and serve as upper and lower boundaries where the average minimum WTA is expected to fall within the calculated interval.

Following Broberg and Brännlund (2008) and assuming that each value on the payment card represents a bid amount, A_i, the probability that survey respondent *i*'s WTA is higher than a given bid amount is:

$$\Pr(\text{"yes}_i\text{"}) = 1 - \Pr(\text{"no}_i\text{"}) = 1 - \Pr(WTA_i < A_i) \tag{4.1}$$

Each respondent's WTA is assumed to be an exponential function of a linear combination of observable individual characteristics, X_i, and a normally distributed stochastic error term, ε_i, with zero mean and standard deviation, σ, resulting in:

$$\text{WTA}_i = e^{BX_i+\varepsilon_i} \tag{4.2}$$

Where B is a vector of parameters. After substituting for WTA_i and manipulating the function, the probability that a survey respondent accepts bid A_i is then:

$$\Pr(\text{“yes}_i\text{”}) = 1 - \Pr(\ln(A_i) - BX_i > \varepsilon_i) \tag{4.3}$$

Following the interval estimation approach utilized by Broberg and Brännlund (2008) and Cameron and Huppert (1989), I define the WTA interval according to the highest "no" bid, A^L, and the lowest "definitely yes" bid, A^U, which serve as the lower and upper bounds of the interval, respectively. The minimum WTA of each participant then lies in the interval $A^L < \text{WTA} \leq A^U$. I then denote the cumulative distribution function of ε as F, and denote F(A) as the probability of saying "yes" to bid A and 1- F(A) as the probability of saying "no". The probability that the WTA lies between A^L and A^U is:

$$P(\text{WTA} > A^L) - P(\text{WTA} > A^U) = F(A^U) - F(A^L) \tag{4.4}$$

The log likelihood is then:

$$L = \sum_{i=1}^{N} \ln[F(A_i^U) - F(A_i^L)] \tag{4.5}$$

Where N is the number of survey respondents. Further assuming that the WTA function is distributed log-normally, the parameter vector B can be estimated and used to calculate the median and mean WTA of the survey sample according to the following equations (Cameron and Huppert, 1989):

$$\text{Median(WTA)} = e^{(X'B)} \tag{4.6}$$

$$\text{Mean(WTA)} = e^{\left((X'B)+\left(\frac{\sigma^2}{2}\right)\right)} \tag{4.7}$$

4.4 Applying the Data Analysis to the Conceptual Model

The econometric estimation process estimates the impact of rancher and farm characteristics on the expected WTA of individual ranchers within the sample. Estimates for mean and median WTA among survey respondents can also be calculated from the econometric estimates. In reference to the conceptual model discussed in chapter 3, the lower and upper bound mean and median WTA estimates suggest a potential range of values that could serve as a participation incentive for a grassland conservation program. The minimum dollar amount per acre that survey respondents say they are willing to accept is assumed to be approximately equal to the opportunity costs they would incur from participating in the conservation program. In the survey the opportunity costs incurred from participating in the hypothetical conservation program are 10% of the rancher's current production level. Furthermore, the WTA amount that each survey respondent reports is assumed to serve as an adequate participation incentive for that given respondent. Therefore the estimated mean and median WTA values among survey respondents are assumed to represent a participation incentive that the average rancher would accept to participate in a conservation program. While the survey assumes opportunity costs are 10% of the rancher's current production level, the WTA estimation results could potentially be extrapolated to predict acceptable participation incentives at other levels of opportunity cost as well.

The mean and median WTA estimates function as approximate estimates for an acceptable conservation program participation incentive as noted in the conceptual model in chapter three. The survey results will also reflect the opinions and attitudes of Saskatchewan ranchers regarding ecosystem services and key policy characteristics, ultimately informing policy recommendations based on the acceptability and cost-effectiveness of a potential conservation program.

4.5 Conclusion

The survey developed for this project was intended to gather qualitative and quantitative data to inform potential grassland conservation policy development in Saskatchewan. It also provided survey participants with an opportunity to voice their opinions regarding potential policies and the provision of ecosystem services that may further inform potential policy development. The stated preference question format of the survey offered a simple and straightforward method for evaluating rancher's policy opinions and valuations of non-market ecosystem services. The descriptive and econometric results from the survey provide insights for grassland conservation policy design and development, rancher attitudes regarding ecosystem services and grassland management practices, and estimates of WTA for potential economic incentives.

5. Results and Discussion

5.1 Introduction

This chapter summarizes and presents the results from the rancher survey described in chapter 4. Descriptive statistics from the survey are presented along with a review of common answers and comments to open-ended questions. Findings from the econometric analysis are then presented and examined followed by a discussion of the overall results.

5.2 Descriptive Statistics of Survey Responses

A total of 170 survey invitations were emailed to ranchers whose email information was retrieved from cattle breeder directories. Of the 170 invitations, 19 surveys were completed via email, mail, or over the phone. Eleven more surveys were conducted in person resulting in a 17.6% response rate and a total of 30 completed surveys.

The sample population average farm size and number of cattle is considerably higher than the Saskatchewan provincial farmer population. However the average farm size reported in the census of agriculture includes both crop and livestock farmers and counts all non-zero farm sizes, so farms with very little land are still reported and might suppress the provincial average. Ranchers with very few cattle who would be reported in the census are also less likely to have information or ads in breeder directories and therefore were less likely to be contacted for the survey. Both average farm size and number of cattle in the sample population are also influenced by a small number of significantly large farms. This is evident in Table 5.1 where the medians of both variables in the survey sample are more in line with the population averages.

T-tests on cattle and land ownership reveal that neither variable is statistically different from the population mean at the 1% significance level, while rented land has no statistical difference at any significance level. The percentage of survey participants with university degrees is also considerably higher than the percentage of Saskatchewan farmers with degrees (Table 5.1). Half of the survey sample has a university degree, whereas only 7.2% of Saskatchewan farmers have a university degree (Statistics Canada, 2016).

Table 5.1: Demographic information from the survey sample and Saskatchewan farmer population. Standard deviations in parentheses. N=30 unless otherwise stated.

Variable	**Survey Sample**	**Census Of Agriculture**
Cattle (N=29)	379.8 (378.1) Median=275	192
Farm Size[a] (Acres)		
Owned land	2282.7 (2346.8) Median=1630	1171
Rented or leased land	2182.3 (2356.3) Median= 1440	1391
Age[b] (%)		
Under 35	15.0%	6.9%
35 to 54	48.3%	36.8%
55 and over	36.7%	56.4%
Education (%)		
No university degree	50.0%	92.8%
University degree	50.0%	7.20%
Male (%)	70%	86%

[a] the census does not count farms that report zero acres when calculating average area. Therefore to be consistent with the census, the survey mean and median of rented or leased land does not count respondents who reported zero acres leased or rented, the mean is only among farms that reported renting land.

[b] survey respondents reported their age in intervals different from the intervals used in the census. Uniform distributions were assumed in survey age groups to redefine survey age intervals equal to those used in the census.

(Source: Statistics Canada, 2016)

There is a slight difference in age of the sample population as the survey respondents are skewed younger than the Saskatchewan farmer population, while a t-test for gender indicates that there is no statistical difference between the survey sample and population at the 5% significance level. The above information suggests that there are some statistical differences between the survey sample and the Saskatchewan rancher population that should be considered when interpreting and extrapolating the results beyond the sample population.

5.2.1 Summary Statistics of Survey Sample

Demographic information on the survey respondents suggests that the sample population contained ranchers with above average sized cattle operations who relied on cattle or other farming activities for their income. The average farm in the survey sample had nearly 380 cattle and 2,282.4 acres of owned land used for cattle production, while Statistics Canada (2016) reports the average Saskatchewan cattle farm has 192 acres and owns 1,171 acres (Table 5.1). Over 36% of the survey population derived 80% or more of their total income from cattle production, while 76.7% of respondents received 19% or less of their total income from off-farm employment (Table 5.2). This suggests that the majority of the survey population were full time farmers who received little to no income from working off-farm, and those who's cattle-based income accounted for less of their total income likely received their income through other farming activities such as crop production.

Grassland pastures in Saskatchewan that were formerly owned and managed by either the provincial and federal government will be leased to private users in the coming years, with all provincial pastures planning to be transitioned to private leases by 2020 (Government of Saskatchewan, 2017b). Given these changes in ownership and management, it could be valuable to examine the proportion of ranchers who used these pastures and the proportion of ranchers that plan to lease. As Table 5.2 shows, 43% of the survey population used government-managed pastures in the past, however only 33% plan to lease. While respondents did not state why they planned or did not plan to lease, a potential reason for the decrease could be an increase in private costs relative to when the pastures were government-managed. Ranchers who used government pastures but do no plan to lease will likely need to find some other means for feeding and grazing their cattle or undergo some form of change in their cattle operation or management practices.

Table 5.2 reports the additional labor hours per week respondents would be willing to work to adopt rotational grazing practices, and the maximum contract length respondents would be willing to agree to participate in a conservation program or to adopt certain management practices.

Table 5.2: Survey statistics. Standard deviations in parentheses.

Variable	Number of Observations	Survey Sample
Cattle Income (% of total income)	N=30	
0-19%		13.3%
20-39%		23.3%
40-59%		13.3%
60-79%		13.3%
80-100%		36.7%
Off-farm Income (% of total income)	N=30	
0-19%		76.7%
20-39%		10.0%
40-59%		6.7%
60-79%		6.7%
80-100%		0.0%
Former Government Pasture User (%)	N=30	43%
Plan to Lease Former Government Pastures (%)	N=30	33%
Government Program User (%)	N=30	60%
Respondents in Brown/Dark Brown Soil Zone	N=30	56.7%
Experience (years)	N=30	31.8 (14.34)
Additional Labor (hours/week)	N=27	5.2 (3.14)
Maximum Contract Length (Years)	N=29	7.7 (4.47)
Lower Bound Cost Share (%)[a]	N=29	38.3 (16.49)
Upper Bound Cost Share (%)[b]	N=28	61.8 (18.06)

[a] calclulated as the mean of the lowest cost share respondents said they'd probably participate in.

[b] calclulated as the mean of the lowest cost share respondents said they'd definitely participate in.

Survey respondents were willing to work an additional 5.2 hours per week on average to adopt rotational grazing practices to potentially increase ecosystem services. This could indicate that ranchers perceive rotational grazing practices to also have private benefits, or they value the increase in public benefits provided by increased ecosystem services. If there were no perceived benefits, ranchers would likely require economic incentives to adopt such practices.

The average maximum agreeable contract length was 7.7 years. Only 33% of respondents indicated that they planed to lease government pastures, which might shed light on why ranchers are resistant to leases equal to or greater than 15 years (Government of Saskatchewan, 2017b).

Cost-share programs are offered in Saskatchewan where the government covers a portion of the approved costs that farmers must undertake to implement management practices to improve or maintain environmental quality and ecosystem services on agricultural land (Government of Saskatchewan, 2017a). If offered a cost-share program to adopt management practices that increase ecosystem services rather than a uniform payment scheme, the average survey respondent would require between 38.3% and 61.8% of the costs to be covered (Table 5.2). For context, the Saskatchewan government offered an environmental solutions cost-share program that covered 20-50% of eligible costs up to $50,000 for projects that would provide environmental or public benefits, and another native rangeland grazing management cost-share program that would cover 50% of eligible costs up to $10,000 (Government of Saskatchewan, 2017a). This suggests that the cost-share programs offered in Saskatchewan likely provide enough compensation for ranchers to consider participating in a given program. In any case, the acceptable cost-share ranges could be useful to policymakers for comparing the potential costs relative to uniform payment schemes to possibly identify the most cost-effective means of maximizing both participation and the environmental benefits of a conservation program.

5.2.2 Statistical Differences Between Respondents Relative to Soil Zone

The majority of native grasslands in Saskatchewan are located in the southwest region of the province. Southwest Saskatchewan is also predominantly classified as having brown or dark brown soil zones, whereas other regions of the province are mostly black or grey soil zone classes. Since the majority of native grasslands are located in brown or dark brown soil zones, I compare summary statistics between survey respondents in the brown or dark brown soil zones to those outside these soil zones. Therefore any statistical differences between soil zones are not necessarily driven by the soil zone classes, but rather other factors such as land conditions, agricultural land use options, and the presence of more native grasslands in the brown soil zone. Native grasslands might offer a broader, or at least different range of ecosystem services than tame or seeded pastures found in other soil zones, and therefore could be a higher priority for conservation purposes to provide public ecosystem services.

The average survey participant's ranch in the brown or dark brown soil zones is considerably larger and has more cattle compared to ranches outside these soil zones within the sample population (Table 5.3). The native grasslands in the brown soil zone are likely not as suitable for crop production as the more arable land in the black and grey soil zones. Therefore the most productive use of native grasslands is often livestock production, leading to larger cattle operations in these regions, while the opportunity cost of having significantly large cattle operations in other soil zones might be greater because of potentially more profitable alternative land use options such as crop production.

Government of Saskatchewan (2018b) pasture maps show that there were a greater number of provincial pastures in non-brown soil zones, although the total pasture area and livestock capacity would differ between soil zones and individual pastures. However, a greater proportion of survey respondents in the brown soil zones used public, government owned pastures in the past and indicated a plan to lease these pastures in the future than respondents in other soil zones (Table 5.3). While the percentage of respondents in non-brown soil zones who used and plan to lease government pastures is constant at 30.8%, the percentage of respondents in brown soil zones who plan to lease former public pastures is 35.3%, 17.7% lower than the 52.9% of survey respondents in brown soil zones who used public pastures (Table 5.3). This further highlights the population of Saskatchewan ranchers who will no longer have access to the grazing and livestock management services the government pastures formerly provided. The producers in the brown soil zones who used a public pasture but do not plan to lease will likely have to find other options for feed or undergo changes within their cattle operations as previously mentioned. However it is important to note the small sample size when interpreting these results, as the sample might not accurately reflect how many Saskatchewan ranchers used these pastures or plan to lease them in the future.

Table 5.3: Comparative statistics between survey respondents relative to soil zone. Standard deviations in parentheses.

Variable	Brown/Dark Brown Soil Zone (N=17)	Black Soil and Other Soil Zones (N=13 unless otherwise stated)
Number of Cattle	498.5 (457.3)	(N=12) 211.7 (84.5)
Farm Size (Acres)		
Owned Land	3296.5 (2697)	957.1 (501.6)
Rented Land	2600 (2602.2)	460.9 (686.7)
Former Government Pasture Users (%)	52.9%	30.8%
Plan To Lease Former Government Pastures (%)	35.3%	30.8%
Participated in BMP Programs (%)	64.7%	53.9%

A greater proportion of respondents in the brown soil zones participated in BMP programs, with 64.7% of respondents participating compared to 53.9% in other soil zones (Table 5.3). While the rate of BMP participation across soil zones is similar, the disparity can possibly be explained by, or related to, average farm size and cattle income levels across soil zones. In the sample population, the larger ranches and more cattle in the brown soil zones appeared to be more dependent on their cattle operation for their income. As Figure 5.1 shows, 47% of respondents in brown soil zones derived 80% or more of their total income from cattle compared to 23% of respondents in other soil zones. This suggest that a greater proportion of ranchers surveyed in brown soil zones are dependent on ranching as their main source of income compared to ranchers surveyed in other soil zones who could earn a greater proportion of their income from other farming activities such as crop production. Therefore survey participants outside brown soil zones who are less dependent on cattle as their main source of income might be less inclined to participate in

BMP programs that assist their ranching practices and will instead focus on other farming activities. For ranchers in the brown soil zones, whose income is primarily cattle based, the benefits of participating in cattle based BMP programs might be greater and therefore a greater proportion of ranchers in these soil zones might participate in BMPs.

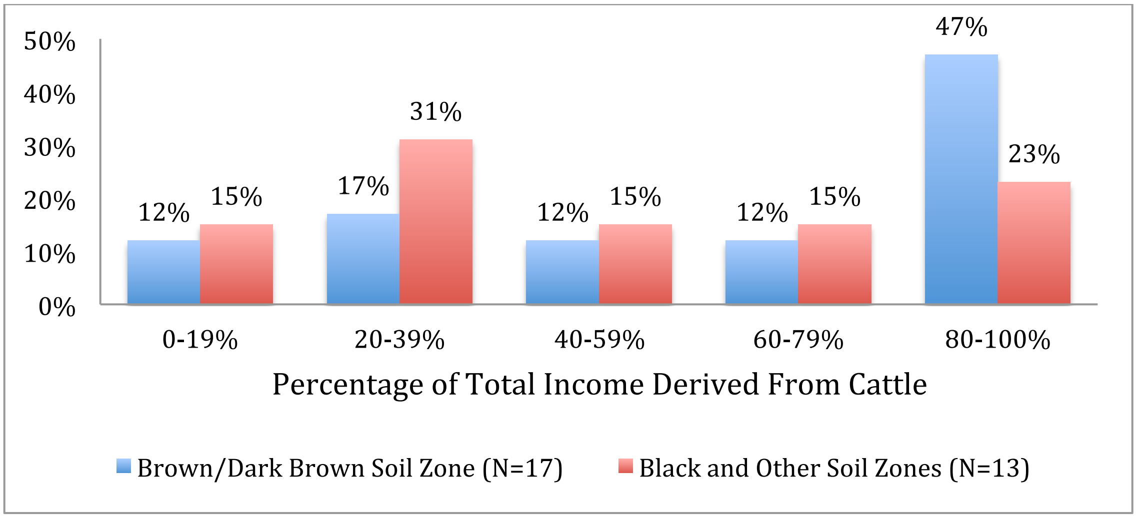

Figure 5.1: Comparing cattle income as percentage of total income between survey participants in different soil zones.

5.2.3 Policy Structure and Ecosystem Services Preferences

A primary objective of the survey was to examine Saskatchewan ranchers' opinions regarding policy preferences. Survey respondents were presented with three policy options and asked to rank them from most to least preferable. Cost-share programs were the most preferred policy option (79%), followed by extension programs and then conservation easements (Figure 5.2). The stated preference for cost-share programs suggests that monetary compensation for participation is important to ranchers. Extension programs, which leave management flexibility and decision-making to the rancher but offer no compensation, were preferable to conservation easements. Conservation easements, primarily characterized by permanent contract lengths, were the least preferred policy option, suggesting that shorter contracts or land management agreements are preferable to ranchers.

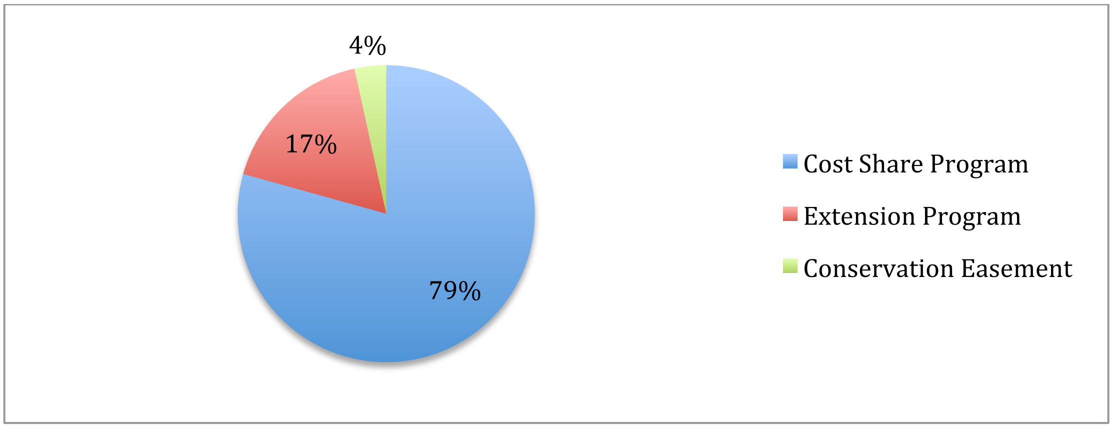

Figure 5.2: Most preferred policy structure among survey respondents (N=29).

Short-term contracts might be preferable to ranchers to maintain management flexibility into the future, as new management practices or potential opportunities could become available that might provide greater benefits. The policy preferences generally indicate that ranchers require some level of compensation, prefer to have management flexibility, and find short-term agreements preferable to long-term conservation arrangements. These results are consistent with findings from Sorice et al. (2013) and Ruto and Garrod (2009) that examined how program structure affects farmer preferences and participation in conservation programs.

The survey also aimed to assess ranchers' opinions and attitudes regarding the provision and benefits of ecosystem services on grasslands. Claasen et al. (2008) suggested that conservation programs require well-defined environmental goals, and aligning these goals with ecosystem services that ranchers value and find beneficial might increase participation in these programs. Survey respondents were presented with three ecosystem services, carbon sequestration, wildlife habitat, and water quality, and asked to rank the services from most to least beneficial to society. In this manner respondents would rank the ecosystem services according to which they believe provided the most public benefits.

Water quality was ranked the most socially beneficial ecosystem service by 57% of respondents, followed by wildlife and habitat conservation and carbon sequestration (Figure 5.3). The low importance ascribed to carbon sequestration, based on comments provided by the respondents, could possibly be explained by a lack of understanding or information on the benefits that increased soil carbon provides. While carbon sequestration provides several private and public benefits such as climate change mitigation, increased forage production, improved air quality, increased soil productivity, quality, and formation, and reduced soil erosion (Follett and Reed, 2010; Srivastava et al., 2012), ranchers might not know about these benefits, the benefits might not be as visible or clear to ranchers, or they may not value these benefits as highly as others. Higher water quality and enhanced wildlife habitats are visible, whereas carbon sequestration is not. Therefore the benefits of carbon sequestration might not be as noticeable or clear to ranchers as the private and public benefits gained from water quality and wildlife habitat. This could explain why ranchers in the sample population viewed water quality and wildlife habitat as more beneficial ecosystem services than carbon sequestration.

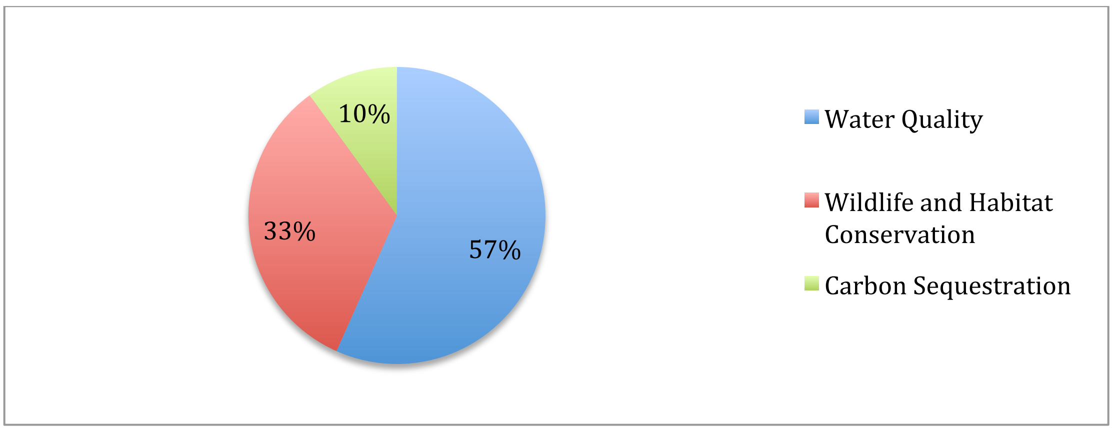

Figure 5.3: Most beneficial ecosystem service to society according to survey respondents (N=30).

5.2.4 Rancher Attitudes Towards Conservation Policies and Ecosystem Services

To assess survey participants' attitudes and opinions towards conservation policies and programs, respondents were asked to indicate whether they agreed, disagreed, strongly agreed, or strongly disagreed with a series of statements. Responses to these statements can provide insight on how respondents view features of conservation policy such as transaction costs, opportunity costs, and payments for ecosystem services. The mean responses, on a scale from one (strongly disagree) to four (strongly agree), to policy based opinion questions are shown in Table 5.4. The average survey respondent indicated that they would voluntarily adopt management practices that could increase ecosystem services if they had more information on the different types of management practices (mean = 3.03). This suggests that extension programs, the second most preferred policy structure behind cost-share programs as discussed earlier, could be effective at increasing ecosystem services by providing ranchers with information regarding alternative management practices. However, the average response towards the alternative of providing monetary compensation (mean=3.27) also demonstrates a somewhat strong opinion that the government should provide monetary compensation for production of ecosystem services on private land. As Gao et al. (2016), Kemp et al. (2013), and Klimek et al. (2013) have suggested, this supports the position that economic incentives might be necessary to encourage ranchers to adopt alternative management practices and participate in conservation programs.

Table 5.4: Opinion responses to survey questions related to policy where 1=strongly disagree, 4=strongly agree. Standard deviations in parentheses. N=30 unless otherwise stated.

Question	Sample Mean
If I had more information on grassland and grazing management practices that could potentially increase ecosystem services, I would adopt these management practices voluntarily.	3.03 (0.72)
The government should provide monetary compensation to grassland/pasture landowners and lessees for producing and conserving ecosystem services on their land.	3.27 (0.57)

Another two questions in the opinion response section of the survey dealt with attitudes towards program transaction costs. Transaction costs have been shown to have a significant impact on total policy costs in conservation programs. For example Coggan, Whitten, and Bennett (2010) found that public and private transaction costs accounted for anywhere between 21% and 50% of total costs after reviewing several conservation programs. Survey participants were asked questions regarding transaction costs to help reveal how transaction costs affect participation in conservation programs. The majority (56%) of survey participants agreed that it is easy to find and learn about existing conservation programs, suggesting that search costs are low and do not present a major barrier (Figure 5.4). However, the responses represented only a slight majority, indicating that an increase in outreach regarding the availability of conservation programs might aid in reaching a wider range of potential participants. A similar distribution was also revealed for negotiation costs, as 55% of respondents said they would be willing to take on additional administrative duties and paperwork to participate in a conservation program, whereas 41% responded that they were not willing to take on these duties (Figure 5.4). Respondents who are not willing to take on additional paperwork, administrative work, or other negotiation costs are less likely to participate in conservation programs. Therefore conservation programs that minimize private transaction costs can expect higher degrees of participation and therefore greater environmental impact.

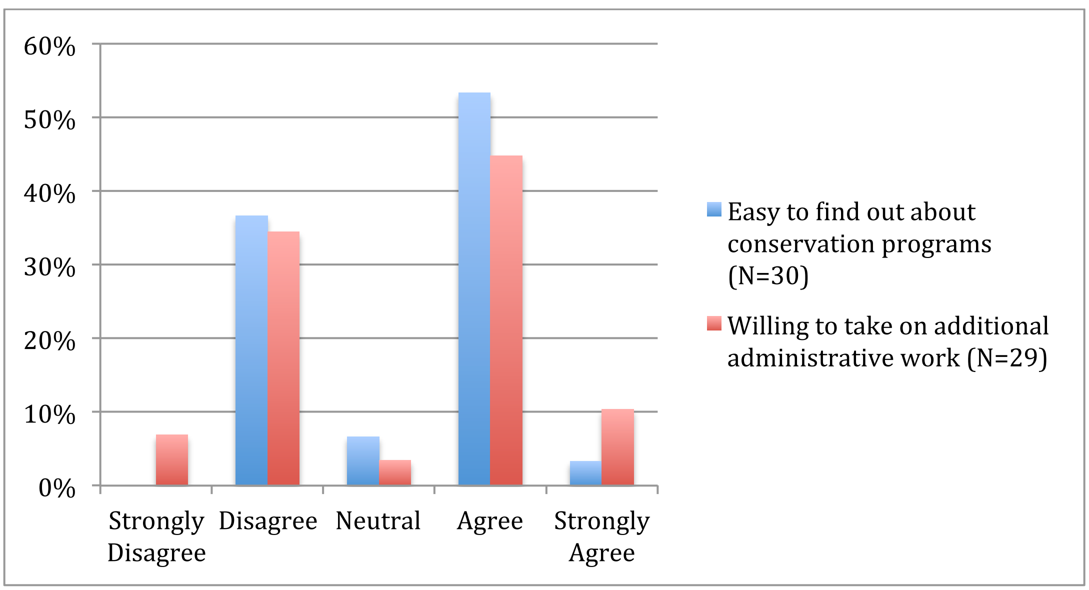

Figure 5.4: Survey responses to transaction cost questions.

Survey respondents were also asked opinion-based questions regarding ecosystem services to assess whether they believe landowners, including themselves, have a responsibility to conserve or enhance ecosystem services on their land, if respondents would be willing to reduce their cattle grazing stocking rate to increase ecosystem services, and whether they believe their current management practices effectively provide ecosystem services. These questions are presented in Table 5.5 and Figure 5.5. Survey respondents indicated that they strongly believe landowners have a responsibility to manage their land in a sustainable manner that conserves or enhances ecosystem services (mean=3.43, Table 5.5). However, when asked if they would reduce their cattle-stocking rate (animal units per acre) the mean was 2.37, representing a fairly neutral response and possibly indicating that the opportunity cost of doing so might be a deterrent. Responses to these questions suggest that ranchers in the sample population believe grasslands should be managed in a sustainable manner that provides ecosystem services, but if such management practices decrease their private benefits and revenue they would be less willing to adopt such practices. Therefore if the socially optimal production of ecosystem services comes at too great an opportunity cost to landowners, ranchers will require compensation.

Table 5.5: Opinion responses to survey questions related to ecosystem services where 1=strongly disagree, 4=strongly agree. Standard deviations in parentheses. N=30.

Question	**Sample Mean**
Pasture and grassland landowners and lessees have a responsibility to use management practices that conserve or enhance ecosystem services on their land.	3.43 (0.50)
I would be willing to reduce my cattle grazing stocking rate, meaning decrease the number of animal units per acre on my land, if it would increase ecosystem services on my land.	2.37 (0.72)

While the ranchers in the sample population indicated that they are open to increasing the production of ecosystem services on their land, they seem to believe they already effectively provide ecosystem services. For example, 90%, 97%, and 90% of survey respondents agreed or strongly agreed that their current management practices effectively provide carbon sequestration, wildlife and wildlife habitat, and water quality respectively (Figure 5.5). It is quite possible that several ranchers in Saskatchewan do provide an adequate amount of ecosystem services on their grasslands. However from a policy standpoint, if ranchers believe they already effectively produce an acceptable amount of ecosystem services they might not think an increase in ecosystem services is necessary, and therefore could be less likely to participate in a conservation program. Therefore if there is a societal motive to increase ecosystem services on private grasslands beyond the current levels, economic incentives could be required to persuade and encourage ranchers to increase ecosystem service provisions and offset the opportunity costs of doing so.

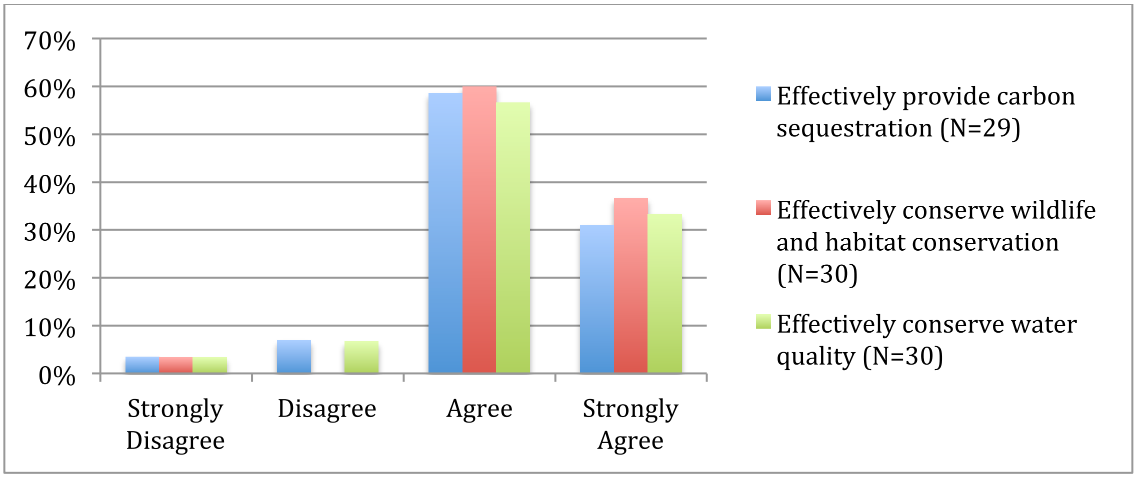

Figure 5.5: Survey responses to whether respondents' current management practices effectively provided or conserved ecosystem services.

5.3 Survey Comments

The survey instrument included an opportunity for participants to express their general attitudes through open-ended questions about conservation policies, grassland management, and ecosystem services. Such comments provide valuable information regarding the opinions of livestock producers who provide ecosystem services and therefore could be affected by policy. Some prevalent opinions, responses, and comments are outlined here, while a complete record of all survey comments are provided in Appendix B.

When asked about potential policy structure preferences, 20 of the 30 survey respondents provided a response. Seven respondents expressed preferences for varying types of incentive based programs such as cost-shares, a potential tax relief for meeting a given conservational criteria, “results-based” programs that only pay producers if they meet specific, measurable habitat or grassland quality parameters rather than just for implementing practices, or yearly payments on a per acre basis for providing wildlife habitat conservation such as wetlands or forested areas to encourage landowners to maintain these areas. Three respondents were in favor of creating a carbon-trading program whereby carbon credits or habitat credits could be bought and sold to incentivize grassland conservation. This suggests that there are ranchers who prefer a market-based approach to promoting ecosystem services. Two respondents also expressed that they were against policy or government involvement altogether.

The vast majority of survey participants (93%) indicated that they would consider changing management practices if it would increase ecosystem services. When asked a follow up question as to why they would consider changing management practices to increase ecosystem services, the reasons for doing so were quite similar. Respondents commonly cited sustainability, conservation, the environment, the good of future generations and everyone today, and just doing the right thing in general as reasons for possibly changing management practices to promote ecosystem services. Some also cited the relationship between positive environmental outcomes and personal benefits as healthy grasslands translate to increased productivity and profits for the rancher, so increasing ecosystem services is beneficial for both them personally and society as a whole. However it was noted that adopting management practices to increase ecosystem services would also depend on how the change would affect them financially, This could suggest that ranchers are willing to make management changes that could increase ecosystem services but both explicit private costs and implicit opportunity costs must be accounted for when considering these potential changes.

It is important to note that there were a number of respondents (20%) who commented on the management practices presented in the survey. While respondents were asked what management practices they would be willing to implement to increase ecosystem services, some questions framed an increase in ecosystem services as a result of reducing grazing intensity. Several respondents indicated that a simple overall reduction in grazing intensity is not a guaranteed method or the best way to increase ecosystem services. For example, a management practice that was suggested multiple times was a high intensity, short time interval rotational grazing system. The practice involves grazing livestock intensively on a plot of land for a relatively short duration, and then moving the livestock to another plot and letting the previous plot rest. Appropriate grazing practices are undoubtedly important for maintaining healthy, sustainable grasslands and supporting ecosystem services. However, the appropriate grazing practices and intensity can likely differ depending on the ecosystem service in question and the condition and location of any given grassland. Considering grassland bird habitat as an example, Askins et al. (2007) suggest that the varying climate and geographic conditions across the Canadian prairies and the individual needs and responses to grazing practices among grassland bird species makes it impossible to recommend any one optimal grazing practice to conserve habitat for grassland bird species across all prairie grasslands. An important takeaway is that there is no single management practice that is best at increasing all types of ecosystem services across all grasslands. The heterogeneity of grasslands, both native and seeded, can lead to alternative practices having greater or lesser effects in different regions based on the grassland conditions in a given area. While alternative methods might be more effective at increasing certain ecosystem services on grasslands than decreasing grazing intensity, suggesting it in the survey served the purpose of evaluating the opportunity costs ranchers face for participating in a potential conservation program.

5.4 Willingness-to-Accept Results

WTA intervals were estimated non-parametrically and econometrically to determine a price point that could serve as an economic incentive to encourage participation in a conservation program. The purpose of the non-parametric WTA estimates and WTA regression is to estimate a cost-effective economic incentive that would encourage ranchers to participate in a conservation program. The WTA interval is interpreted as the range in compensation needed for ranchers to incur a 10% reduction in grazing intensity, which is assumed to be the opportunity cost of a change in management practices to increase ecosystem services. A 10% reduction in grazing intensity was used so respondents would consider the lost production or opportunity costs they might incur from a change in management practices if they were to participate in an actual conservation program. For context, Ruijs et al. (2017) found that the opportunity cost of increasing biodiversity by 5% can be a 13% decrease in agricultural revenues, while increasing carbon sequestration by 10% resulted in a 4% decrease in agricultural revenues. Using the results of this survey, a 10% decrease in grazing intensity suggests that the opportunity cost of participating in the hypothetical program for the average survey respondent would be 38 fewer cattle that they could graze, based on the sample population mean for cattle numbers. The WTA estimation results could also be extrapolated to reflect WTA intervals at other levels of opportunity costs relative to current production levels among the survey population.

Non-parametric WTA estimates were calculated as the mean values of the lowest amount survey respondents indicated they would "probably" and "definitely" accept on the payment card. The lower bound WTA was estimated to be $33.25 per acre and the upper bound WTA estimate was $53.60 per acre (Table 5.6). These results suggest that a payment within this interval would be required for the average survey respondent to participate in a conservation program that has an opportunity cost of 10% of their current production level to increase ecosystem services.

Table 5.6: Non-parametric estimates for WTA. Standard deviations in parentheses.

Variable	Number of Observations	Survey Sample
Lower Bound WTA ($/acre)[a]	N=28	$33.25 (17.74)
Upper Bound WTA ($/acre)[b]	N=25	$53.60 (26.75)

[a] calclulated as the mean of the lowest amount respondents said they'd probably accept.

[b] calclulated as the mean of the lowest amount respondents said they'd definitely accept.

A double-bounded interval estimation approach was also used to estimate the mean and median WTA of survey participants econometrically. Variables used in the WTA regression were chosen to control for farm and farmer characteristics that past research suggests might influence rancher participation in voluntary conservation programs (Table 5.7). Farm and farmer characteristics that are believed to positively influence participation in conservation programs are expected to have a negative impact on WTA. Therefore variables that are expected to positively influence participation in conservation programs are expected to have negative coefficients. Conversely, variables that might negatively influence participation in conservation programs will increase WTA, representing a decrease in likelihood or aversion to participating in a conservation program, and are therefore expected to have positive coefficients. Overall ranchers who are more likely to participate in conservation programs will have lower WTAs than ranchers who are less likely to participate in a conservation program. Lower WTAs could signal that a rancher's opportunity cost of increasing ecosystem services is lower relative to other ranchers and therefore they are willing to accept less, or it could represent ideological beliefs that the rancher wants to increase ecosystem service provisions on their land and are willing to accept less compensation to do so. Higher WTAs could reflect higher opportunity costs of ecosystem service provision relative to other ranchers, or possibly an aversion to policy programs or government involvement and therefore they might only participate for a payment greater than their actual opportunity costs.

Table 5.7: Description of independent variables used in econometric analysis.

Variable	**Description**
Cattle	Continuous variable representing the number of cattle each survey participant reported.
Acres	Continuous variable representing the total number of acres, owned and rented, used for cattle production.
Cattle Income	Ordinal variable indicating percentage of total income derived from cattle operation. 1=0-19%, 2=20-39%, 3=40-59%, 4=60-79%, 4=80-100%.
Age	Ordinal variable indicating age range. 1=29 or less, 2=30-39, 3=40-49, 4=50-59, 5=60 and over.
Education	Binary variable indicating whether or not survey participants had a post-secondary degree. 1=yes.
Male	Binary variable. 1=male.
Paperwork	Binary variable indicating whether or not survey participants agreed or disagreed to take on additional paperwork and administrative duties to participate in a conservation program. 1=yes.
Agreed to Voluntarily Reduce Grazing Intensity	Binary variable indicating whether or not survey participants agreed to voluntarily reduce their cattle stocking rate or grazing intensity to increase ecosystem services. 1=yes.

Ruto and Garrod (2009) state that farm size, education, and farmer interest are all generally considered to positively influence participation in conservation programs, while age negatively influences the likelihood of an individual participating. Therefore the *a priori* expectations are for the cattle, acres, and education variables to have negative coefficients and for age to have a positive coefficient. Cattle income could also signal farm size as larger cattle operations likely generate more of their total income from cattle, which would suggest a negative coefficient expectation for the cattle income variable. However the more income one derives from their cattle operation the greater the opportunity cost of displacing cattle, which would suggest a positive coefficient could be expected as well. Therefore the *ex ante* expectation for the sign of the cattle income variable is indeterminate. The variables for paperwork and whether or not survey participants agreed to voluntarily reduce grazing intensity reflect survey participants' interest in conserving ecosystem services and conservation programs. The more interest a rancher has in grassland conservation and conservation programs, the more likely they are to participate in a program (Ruto and Garrod, 2009). For example, respondents who agreed that they would take on paperwork and administrative duties to participate in a conservation program are likely more interested in conservation programs. Likewise, agreeing to voluntarily reduce grazing intensity to increase ecosystem services indicates a greater level of interest in conservation and increasing ecosystem services. Therefore I expect both of these variables to have negative coefficients. There is no *ex ante* expectation for the sign of the gender coefficient as there is no reason to expect a significant difference in WTA or perceived opportunity costs among male and female ranchers.

For the WTA values the upper bound estimation has fewer observations due to some survey participants not responding "definitely" to any values, which results in right-censored data in the lower bound estimation but missing observations in the upper bound estimation. As expected the mean and median WTA estimates are lesser in the lower bound regression due to expanding the WTA interval and coding both "probably" and "definitely" responses as "yes" responses (Table 5.8). The mean WTA estimates from the econometric estimation can also be compared to the non-parametric mean WTA estimates in Table 5.2. The lower and upper bound non-parametric estimates of mean WTA were \$33.25 and \$53.60, compared to \$34.83 and \$42.58 from the econometric estimation.

Table 5.8: Lower and upper bound coefficient estimates of WTA function following Broberg and Brännlund (2008) expansion approach. Standard deviations in parentheses.

Variable	Lower Bound	Upper Bound
Constant	2.08 (0.765)***	2.25 (0.698)***
Cattle	0.003 (0.001)***	0.002 (0.001)**
Acres	-0.0002 (0.000085)**	-0.0001 (0.000081)
Cattle Income	-0.19 (0.095)**	-0.228 (0.092)**
Age	0.597 (0.169)***	0.604 (0.155)***
Education	0.585 (0.353)*	0.325 (0.327)
Male	-0.726 (0.3399)**	-0.274 (0.340)
Paperwork	-0.338 (0.2714)	-0.527 (0.252)**
Agreed to Voluntarily Reduce Grazing Intensity	-0.271 (0.263)	-0.237 (0.245)
Mean WTA (per acre)	34.83	42.58
Median WTA (per acre)	32.53	40.08
Number of Observations	27	24

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

The upper bound econometric estimate is considerably more conservative than the non-parametric estimate. This can be explained by the interval estimation approach setting the lower limit equal to the payment card value one interval less than the amount they "definitely" agreed to. In contrast, the non-parametric estimate is simply the mean of the higher limits used for the interval estimation approach. The lower bound estimates from each method are much closer, with the greater WTA value from the interval estimation approach likely due to the higher bound being greater than the values used to calculate the non-parametric measure, which was the lowest value survey participant's agreed they would "probably" participate. In general, the econometric estimates indicate that the average surveyed rancher's WTA, or opportunity cost, for decreasing their grazing intensity by 10% to participate in a conservation program and potentially increase ecosystem services lies between $34.83 and $42.58 per acre. Scaling these results suggests that ranchers could be willing to accept a payment between $3.48 and $4.26 per acre for every additional 1% loss in opportunity cost relative to their current production level. The estimated WTA interval could also be useful to policymakers for comparing the potential costs under a payment scheme such as this to a cost-share program, which survey respondents indicated needed to cover between 38.3% to 61.8% of costs (Table 5.2), to identify the most cost-effective means of maximizing both participation and the environmental benefits of a conservation program.

The estimated coefficients are interpreted as a percentage change in the expected WTA to decrease grazing intensity given a one-unit change of the independent variable. Using the lower bound estimates in Table 5.7 as an example, for every additional acre a rancher manages their estimated WTA decreases by 0.02%, while for every additional cow a rancher has their WTA increases by 0.3%. This suggests that for every 100 acres the average rancher manages, their WTA is predicted to decrease $0.70 per acre, and for every 10 cattle the average rancher owns their WTA is predicted to increase by $1.04 per acre. For an ordinal variable such as cattle income, the measured effect is for every level or group increase. Therefore if a rancher's income from cattle production rises from 0-19% to 20-39% of their total income, on average their WTA is predicted to decrease by 19%. However the magnitude of the coefficients should be interpreted carefully considering the small sample size and the limited observations that were usable for econometric analysis. Some variable report extreme affects or quite different estimates between the lower and upper bound estimates. For example each age group is predicted to have a WTA 60% higher than the age group immediately before it, while males are estimated to have a WTA 72.6% less than that of females in the lower bound regression and 27.4% less in the upper bound regression. Therefore some of the measured effects appear to be unreasonably large or less reliable. A larger, more representative sample of ranchers is recommended and likely necessary to accurately estimate the magnitude of the demographic and farm factor effects on one's WTA. Although the limited sample size detracts from the estimation and analysis, and the magnitude of the coefficients might not be reliable, this analysis still allows me to estimate the directional effect of each variable and calculate the mean and median WTA boundaries.

The coefficient signs are as expected for most variables while the cattle income and gender variables, for which I had no *ex ante* expectations, both had a negative impact on WTA. However the impact of the cattle and education variables are the opposite of my *ex* *ante* expectations. Farm size was expected to positively affect the likelihood of participation in conservation programs according to Ruto and Garrod (2009), and therefore have a negative coefficient. However the cattle coefficient is positive and statistically significant in both regressions. This could be due to the framing of the question, as the more cattle a rancher has, the larger the opportunity cost of decreasing grazing intensity. Acres has a negative coefficient since the payments were per acre, so farms with more land area might be willing to accept less per acre and still receive a large return. The 10% reduction in grazing could be roughly interpreted by ranchers as a 10% decrease in the number of cattle they are grazing on their current number of acres. Therefore the acres variable might capture the expected effect of farm size, whereas the number of cattle a rancher has might increase their opportunity cost of reducing their grazing intensity and therefore increases their WTA for doing so.

Education was also expected to positively influence participation in conservation programs according to Ruto and Garrod (2009) and therefore expected to negatively impact WTA. However the measured effect of education on WTA in the WTA regression was positive, although less statistically significant. A possible explanation is that ranchers with university degrees or diplomas could have an increased understanding of the opportunity costs they would incur from decreasing grazing intensity, and therefore have a higher WTA than those without a university degree. The unexpected sign, or at least the magnitude of the education effect, could also be due in part to the small sample size and limited observations used in the estimation process.

5.5 Discussion

Qualitative and quantitative results from this research provide useful insight regarding rancher preferences for conservation policy development and attitudes towards grassland management practices and ecosystem services. The results highlight trends and common opinions among ranchers within the sample that might reflect the broader rancher population. However with only 30 completed surveys, it is important to keep the sample size in mind before extrapolating the results beyond the sample population.

The results indicate that ranchers within the survey sample generally value and understand the public and private benefits associated with ecosystem services. The majority of survey participants are also open to increasing the provision and conservation of ecosystem services on their land. This is indicated by 93% of the survey sample agreeing that they would consider changing management practices if it would potentially increase ecosystem services, and the average respondent also agreed that if they were given information on management practices that could increase ecosystem services on their land, they would voluntarily adopt these management practices (mean=3.0 where 1=strongly disagree, 4=strongly agree, Table 5.4). However the barrier to adopting management practices that can potentially provide a greater degree of ecosystem services appears to be the private costs of doing so. Increasing ecosystem services provision comes at an opportunity cost to ranchers, either in the form of increased management costs or implicit opportunity costs related to lost or foregone production. For example the theoretical model used for this analysis assumes that ranchers choose the management practices that maximizes their profit. If a given management practice that produced an efficient amount of ecosystems services was also the profit maximizing option for a rancher, it is assumed they would already employ the management practice or voluntarily adopt it and therefore policy would not be needed. The results indicate that many ranchers believe their current management practices already effectively provide ecosystem services (Figure 5.5), and this could be true on several Saskatchewan grasslands. However if this is not the case or there is a social desire to increase ecosystem service provisions beyond the current level, it is argued that financial incentives could be required to encourage ranchers and landowners to adopt management practices that can potentially produce a greater degree of ecosystem services (Gao et al., 2016; Kemp et al., 2013; Klimek et al., 2013). The results seem to support this notion as survey participants were generally not willing to reduce their cattle grazing stocking rate to increase ecosystem services (mean=2.4, Table 5.5), with the reduction in stocking rate representing the opportunity cost of providing ecosystem services. One survey participant also commented that the profit margins in cattle production are too slim to make significant changes in management practices or to incur additional costs to increase ecosystem services. Therefore the results from the survey support the position that economic incentives can, and might be required to, increase provision of ecosystem services on private grasslands.

If policy initiatives can provide economic incentives for ranchers to adopt certain management practices and provide a greater degree of ecosystem services, the incentive offered should be cost-effective to maximize the potential environmental benefits. The WTA estimation procedure used in this analysis aims to identify cost-effective and acceptable compensation levels for ranchers to participate in a conservation program. Using an interval estimation approach suggested by Broberg and Brännlund (2008), a mean WTA interval of $34.83 to $42.58 per acre was estimated as the minimum amount the average rancher would accept to offset the opportunity cost of a 10% decrease in grazing intensity from participating in a hypothetical conservation policy. These results suggest that if a uniform payment scheme were implemented to increase ecosystem services but resulted in a 10% loss in opportunity costs relative to current production levels for the rancher, a participation incentive within this interval would be required for the average survey respondent to participate in the conservation program. For comparison, according to the Government of Saskatchewan (2017c) the average rental rate for cultivated land in Saskatchewan is $45.30 per acre while the median rental rate is $40.00 per acre. For pastureland rental agreements, the average rental rate for livestock grazing agreements on pasturelands in Saskatchewan is $0.86 per animal per day with an average grazing period of 4.9 months for cows (Government of Saskatchewan, 2017c). This could suggest that survey respondents aligned their WTA with land rental rates, as the estimated mean and median WTA are similar to the average rental rates for cultivated land in Saskatchewan. The econometric results also indicated that farms with greater land area, cattle based income, and interest in conservation had lower WTAs on average, while the rancher's age, education, and number of cattle increased WTA on average.

Beyond estimating the average WTA for participating in a conservation program, survey participants also suggested policy frameworks they would prefer. Among the given policy options, cost-share programs were the most preferred by a considerable margin with 79% of respondents indicating it was their most preferred policy structure. Non-parametric estimates from the survey suggest that 38.3% to 61.8% of costs would have to be covered for the average survey participant to adopt rotational grazing practices that could potentially increase ecosystem services. The estimates for acceptable cost-share percentages and ranchers' WTA for increasing ecosystem services can be compared to determine the most cost-effective means of maximizing participation in a conservation program and therefore maximizing the environmental benefits of the program.

Survey participants also suggested other policy structures including a market-based carbon credit-trading program, tax relief for providing ecosystem services, "results-based" programs that trigger incentives for providing measurable ecosystem services, and an expansion or continuation of previously offered cost-share programs. The comments given by survey respondents provided insights on policy frameworks ranchers would find acceptable, and might therefore effectively encourage management practices that increase ecosystem services. A common theme among the policy preferences and comments is that economic incentives would be a key component in the preferred policy frameworks. These results suggest that compensation is one of the most important components of any conservation program. Therefore economic incentives are integral to encouraging rancher participation in conservation programs.

As previously noted, the environmental impact and success of a program is highly dependent on producer uptake of the program. Along with economic incentives, additional survey results might indicate other policy components that could potentially increase participation in a conservation program. For example, Sorice et al. (2013) and Ruto and Garrod (2009) noted that landowners tend to prefer shorter contracts. Results from this survey indicated that the average maximum contract length survey participants would be willing to agree to where they would adopt management practices on their land to increase ecosystem services was 7.7 years. Leases for former government pastures are 15-year agreements, or roughly double what the average survey participant was willing to agree to. This suggests that shorter contracts or management agreements might increase participation or interest in these leases and other potential programs. Claasen, Cattaneo, and Johansson (2008) further note that conservation programs should have a clearly defined environmental objective. Aligning the environmental objective with landowner interests can potentially increase participation in a program, as landowners might be more willing to participate in a program that supports environmental benefits they value. Fifty seven percent of survey participants ranked water quality as the most socially beneficial ecosystem service from grasslands, followed by wildlife and wildlife habitat with 33% of respondents ranking it first, and only 10% of respondents ranked carbon sequestration the most beneficial ecosystem service among the three. These results suggest that conservation programs designed to promote water quality and wildlife habitat could be more appealing or acceptable to ranchers relative to programs promoting carbon sequestration.

6. Conclusion

6.1 Thesis Summary

Grasslands produce a wide array of ecosystem services including food and forage, carbon sequestration, air and water quality maintenance, biodiversity and wildlife habitat, nutrient cycling, and pollination (Kroeger and Casey, 2007; Kulshreshtha et al., 2008). However many of the benefits derived from grassland ecosystem services are public goods for which private landowners and ranchers receive limited or no economic incentive. Limited private benefits for producing ecosystem services could result in under production relative to the socially optimal output, as landowners will adopt management practices that maximize private gains but not social benefits (Ribaudo et al., 2010). Therefore there is a potential market failure in grassland management.

To address this, voluntary conservation policies and programs have been developed to encourage ranchers and landowners to adopt management practices that increase or maintain the provision of ecosystem services. The purpose of this research was to investigate policy parameters acceptable to landowners and ranchers to aid in the design and development of voluntary conservation programs, as they are only effective at increasing ecosystem services if producers opt in to a program (Ruto and Garrod, 2009; Sorice et al., 2013). A major objective was to estimate the WTA of Saskatchewan ranchers for participating in a conservation program and adopting alternative management practices. Adopting alternative management practices to increase ecosystem services imposes costs on the landowner relative to status quo management practices employed to maximize profit. These costs include both explicit adoption and management costs as well as opportunity costs related to foregone or lost production relative to profit maximizing output. It has been commonly suggested that economic incentives could be required to offset costs and encourage ranchers to adopt management practices that promote ecosystem services (Gao et al., 2016; Kemp and Michalk, 2007; Kemp et al., 2013; Klimek et al., 2007; Narloch, Drucker, and Pascual, 2011). Therefore estimating a WTA interval should aid in developing an acceptable and cost-effective participation incentive to produce greater ecosystem services.

A multi-bounded payment card approach was used for survey participants to report their WTA for participating in a hypothetical conservation program that would require a 10% decrease in grazing intensity. This reduction is equated to a 10% opportunity cost incurred by the rancher for participating in a given program, and therefore the WTA amount they report would offset a 10% loss in opportunity costs from the status quo. An interval estimation approach was then used to econometrically estimate a mean and median WTA interval for an acceptable and cost-effective participation incentive. The econometric estimates for the lower and upper bounds of the mean WTA interval among survey participants were \$34.83/acre and \$42.58/acre, respectively, while the median interval boundary estimates were \$32.53/acre and \$40.08/acre. The estimated WTA interval approaches the mean rental rate for cultivated land in Saskatchewan of \$45.30 per acre (Government of Saskatchewan, 2017c), which would indicate that it is a relatively large incentive payment for a conservation program. Extrapolating the results suggests that a participation incentive for a conservation program would have to increase by \$3.48/acre to \$4.29/acre for every additional 1% increase in opportunity costs incurred by the average survey participant for them to participate in a grassland conservation program.

Survey results were consistent with past suggestions and findings that economic incentives are an important component of conservation programs, highlighting the opportunity costs of ecosystem services. The minimum WTA to participate in grassland conservation programs can be used as a starting point to developing policy options to increase grassland ecosystem services.

6.2 Study Limitations

The research and analysis of this study was limited by a relatively small sample population compared to the total number of ranchers in Saskatchewan. As Table 5.1 showed, it was evident that the sample population was not entirely a representative sample of Saskatchewan ranchers. Therefore it is it important to keep the sample size, and sample population characteristics, in mind before drawing broad conclusions about the entirety of the Saskatchewan rancher population. However, the results presented in this research still provide useful insights and trends regarding rancher opinions and attitudes towards grassland conservation policy, ecosystem services, and WTA.

Selection bias might also be an issue with the survey given the method used to invite the majority of survey respondents. Potential survey participants were typically found in Saskatchewan cattle breeder directories and were then emailed a survey invitation. Larger ranches and cattle operations are more likely to advertise or have information in breeder directories, and therefore selection bias might occur in having larger ranches participate in the survey. The average survey respondent's ranch or farm was larger than the average Saskatchewan ranch, in both the number of cattle they had and acres of land they owned, rented, or leased, which might reflect this bias. Due to the content and purpose of the survey, self-selection bias might also be prevalent as ranchers who are more interested in ecosystem services and conservation policies might be more willing to participate in the survey. For example, 60% of survey respondents indicated they have participated in a government program in the past such as a BMP or other conservation program, suggesting that the majority of survey respondents look favorably towards conservation programs (Table 5.2). However this might not be a major issue as targeting and sampling ranchers who are favorable towards conservation programs will reflect the opinions of those who are more likely to participate in a conservation program.

6.3 Further Research

To expand on the research of this thesis, a similar study consisting of a larger sample could be helpful in estimating more accurate values for WTA and determining the opportunity costs of increasing ecosystem services on grasslands. An econometric analysis of rancher WTA would benefit from a larger sample as more consistent and accurate results could be obtained, both for the coefficients and calculated mean and median WTA. A larger sample would also more accurately reflect the opinions of Saskatchewan ranchers regarding their willingness to participate in grassland conservation policy, acceptable policy parameters to support participation in such programs, and effective management practices for increasing ecosystem services.

Different incentives for adopting BMPs to increase ecosystem services on private or government leased grasslands could also be investigated. For example, economic incentives besides direct monetary compensation, such as reduced lease or rental rates, could be explored for grassland lessees who adopt BMPs that would not apply or be relevant to privately owned and managed grasslands. Therefore a continuation of research directed toward Saskatchewan ranchers and grassland landowners/lessees could be beneficial to conservation policy development.

While this research focuses on the WTA of private ranchers and landowners to participate in conservation programs to increase ecosystem services, researching the public's opinion and value of ecosystem services could be beneficial to policy development as well. Understanding the public's WTP for increasing ecosystem services is a critical part of policy development, and balancing the WTA of private ranchers with the public's WTP for ecosystem services could be beneficial for developing effective grassland conservation policy. Research directed toward the public could also focus on determining the general public's knowledge of grassland ecosystem services and their expectations for ecosystem services provision on both private and government leased grasslands in Saskatchewan.

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Appendix A: Grassland Ecosystem Services Survey

Grassland Ecosystem Services Survey

Information Section

Ecosystem services refer to the many services provided by natural environments, including grassland and pasture ecosystems, from which society benefits. Since people benefit from ecosystem services, private landowners and lessees whose land produces ecosystem services are providing public benefits and contributing to societal welfare. Landowners and lessees can impact the total societal benefits derived from grasslands by adopting management practices that either increase or decrease ecosystem services.

Grazing practices maintain the ecosystem services that are essential to the long-term vitality, sustainability, and preservation of grassland ecosystems. Successful ranching management can also ensure that the public will continue to benefit from ecosystem services derived from grasslands in the future. Ranching is therefore integral to conserving grassland ecosystems that provide numerous benefits to society.

Temperate grasslands, which include Saskatchewan grasslands, are identified as the world's most endangered ecosystem by the Nature Conservancy of Canada, and are a priority for long-term conservation. To conserve grasslands and increase ecosystem services, policy tools have gained interest in recent years as a way to encourage agricultural landowners to adopt environmentally friendly management practices. These policies extend to grasslands, where they generally compensate landowners for adopting management practices that increase ecosystem services and conserve grassland ecosystems.

This survey will help identify policy measures designed to maintain or increase ecosystem services that are acceptable to Saskatchewan ranchers. The survey will also investigate key policy points from the perspective of ranchers as well as ranchers' attitudes towards ecosystem services.

Conservation policies that maintain or increase ecosystem services are usually voluntary and therefore only effective with producer participation. This means designing a policy that ranchers find acceptable is important for any potential policy development.

Ecosystem Services

The grassland ecosystem services that will be discussed in this survey include carbon sequestration, wildlife and habitat conservation, and water quality.

Carbon sequestration involves the storage of carbon in grassland soils and plants, which can contribute to the mitigation of climate change. This is achieved in grassland ecosystems by removing carbon from the atmosphere through plant photosynthesis and by maintaining the accumulation of carbon within plants and the soil. Carbon sequestration also increases soil functions such as water storage and nutrient cycling.

Wildlife and habitat conservation means sustaining the biodiversity of all the species of animals, birds, plants, insects, and microorganisms of a grassland ecosystem. This requires providing habitat and maintaining viable populations for all species, including those species listed as endangered or at risk.

Water quality in grassland ecosystems refers to grasslands and wetlands filtering and removing pollutants and excess nutrients from waterways, preventing the pollution of water sources such as wetlands, lakes, sloughs, and streams, maintaining water levels, and maintaining the supply and quality of groundwater to dugouts and flowing springs.

Policy Alternatives

The policy options designed to increase ecosystem services on grasslands include extension programs, cost share programs, and conservation easements. Each policy measure is designed to maintain or increase ecosystem services by encouraging conservation management practices such as fencing off environmentally sensitive areas from livestock or altering grazing practices. All policy options discussed in this survey are voluntary in that the landowner can choose whether or not to participate in the program.

Extension Programs – The government or a conservation organization provides free information about the benefits of grassland and grazing management practices that maintain or increase ecosystem services. Ranchers and grassland landowners may then choose whether or not to voluntarily implement the management practices.

Cost share programs – A subsidy where the government refunds participants a portion of the management costs they voluntarily undertake to maintain or increase ecosystem services. The cost-share would be a one-time payment to the participant for each approved management action or development the participant undertakes.

Conservation Easement – A voluntary legal agreement between a landowner and government or conservation agency that permanently limits how the land may be used, for example prohibiting any kind of development on the land, in order to protect its conservation values and provide ecosystem services. How landowners are compensated can vary based on the structure of the agreement, but landowners are most commonly compensated through tax benefits. Conservation easements can be personalized to each individual landowner to meet their needs while still meeting some conservation objective. The landowner still retains ownership and the right to use the land for ranching purposes. If the landowner were to choose to sell the land under the agreement, the conservation easement still holds for any new landowner.

Survey Questions

i. Policy Questions

1. Suppose the government wanted to encourage ranchers to adopt management practices that increase carbon sequestration on grasslands. Assume the government is going to implement some policy measure (no policy is not an option). How would you rank the following three policy options in order of which you prefer most or would most likely participate in, 1 being most preferable and 3 being least preferable?

   a) Extension Program: ____________
   b) Cost Share Program: ____________
   c) Conservation Easement: ________

2. Is there a type of policy or program not mentioned in question #1 that you would prefer to have available to you that would encourage management practices which would lead to increased ecosystem services on grasslands?

Please answer questions 3 through 5 from your own personal perspective.

3. If I had more information on grassland and grazing management practices that could potentially increase ecosystem services, I would adopt these management practices voluntarily.

   a) Strongly disagree
   b) Disagree
   c) Agree
   d) Strongly agree

4. It is easy to find out about current environmental and beneficial management practice (BMP) programs offered by the government or other conservation agencies.

   a) Strongly disagree
   b) Disagree
   c) Agree
   d) Strongly agree

5. I'm willing to take on additional paperwork and administrative duties, such as information gathering and recording, to participate in an ecosystem services conservation policy.

   a) Strongly disagree
   b) Disagree
   c) Agree
   d) Strongly agree

6. Suppose the government implemented a cost-share subsidy to encourage ranchers to install fencing so they could adopt rotational grazing practices to enhance ecosystem services on grasslands. By participating in the cost-share subsidy, you would incur private costs for fencing materials, installation, and labor, which the subsidy would cover a portion of. How would the following levels of compensation offered affect the likelihood of you participating in the cost-share subsidy and installing fencing to adopt rotational grazing practices?

Cost Percentage Covered by the Government	Definitely Not Participate	Probably Not Participate	Probably Participate	Definitely Participate
10% Cost Share				
20% Cost Share				
30% Cost Share				
40% Cost Share				
50% Cost Share				
60% Cost Share				
70% Cost Share				
80% Cost Share				
90% Cost Share				
100% Cost Share				

7. How many additional hours of labor per week would you be willing to work to adopt rotational grazing practices and participate in the subsidy program described in question #6? Additional labor would include installing fencing and moving cattle between grazing paddocks once a week.

   ____

8. What is the maximum length of an agreement, in years, in which you would adopt management practices on your land to increase ecosystem services?

   ____

ii. Ecosystem Services Questions

1. How would you rank the following ecosystem services that are produced on native grassland and pasture ecosystems in order of how beneficial they are to society, 1 being the most beneficial and 3 the least beneficial?

    a) Carbon sequestration: __________
    b) Wildlife and habitat conservation: _____________
    c) Water quality: ___________

Please answer questions 2 through 6 from your own personal perspective.

2. In my opinion, my current management practices are effective at providing the following ecosystem services:

    a) Carbon sequestration:

        i) Strongly disagree
        ii) Disagree
        iii) Agree
        iv) Strongly agree

    b) Wildlife and habitat preservation:

        i) Strongly disagree
        ii) Disagree
        iii) Agree
        iv) Strongly agree

    c) Water quality:

        i) Strongly disagree
        ii) Disagree
        iii) Agree
        iv) Strongly agree

3. Would you consider changing management practices if it increased ecosystem services?

    a) Yes
    b) No

3.b) Why did you answer yes/no?

4. Pasture and grassland landowners and lessees have a responsibility to use management practices that conserve or enhance ecosystem services on their land.

   a) Strongly disagree
   b) Disagree
   c) Agree
   d) Strongly agree

5. I would be willing to reduce my cattle grazing stocking rate, meaning decrease the number of animal units per acre on my land, if it would increase ecosystem services on my land.

   a) Strongly disagree
   b) Disagree
   c) Agree
   d) Strongly agree

6. The government should provide monetary compensation to grassland/pasture landowners and lessees for producing and conserving ecosystem services on their land.

   a) Strongly disagree
   b) Disagree
   c) Agree
   d) Strongly agree

iii. Willingness-to-Accept Questions

Assume the government created a monetary subsidy that supported ranchers to implement management practices that increase ecosystem services on grasslands and pastures. By implementing the management practices, the rancher may incur additional costs or forego income from a loss in production.

1. Would you be willing to decrease your grazing intensity by 10% to increase ecosystem services on your land for a subsidy payment of:

Payment Amount	Definitely Not	Probably Not	Probably	Definitely
$1/acre				
$5/acre				
$10/acre				
$20/acre				
$30/acre				
$40/acre				
$50/acre				
$60/acre				
$70/acre				
$80/acre				
$90/acre				
$100/acre				

2. What management practice or practices would you be willing to adopt on your land that you believe would increase carbon sequestration and storage?

3. What management practice or practices would you be willing to adopt on your land that you believe would increase the quantity of wildlife and wildlife habitat?

4. What management practice or practices would you be willing to adopt on your land that you believe would increase water quality?

iv. Demographics

1. How many head of cattle do you own?

    ____

2. How many acres of land do you use for raising cattle (grazing, growing feed, other uses) that is:

    a) Owned? __________

    b) Rented/leased? __________

3. For how many years have you been raising cattle?

    ____

4. Did you use pastures that were formerly owned and managed by either the federal or provincial government?

    a) Yes
    b) No

5. Do you plan on leasing formerly government owned grasslands/pastures?

    a) Yes
    b) No

6. Have you or do you use or participate in any government offered BMP programs?

    a) Yes (Please specify: ____)
    b) No

7. What percentage of your total income is derived from cattle production?

a) 0-19%
b) 20-39%
c) 40-59%
d) 60-79%
e) 80-100%

8. What percentage of your total income is off-farm income?

a) 0-19%
b) 20-39%
c) 40-59%
d) 60-79%
e) 80-100%

9. Approximately how many more years do you plan on ranching? Do you have a succession plan in place for your cattle operation if and when you are done ranching? If yes, what is it (sell, pass onto family member, etc.)?

Years:_______________ Yes or No IF Yes: _______________________________

10. Do you have any surface water, such as a lake, stream, or slough, present within your pasture system?

a) Yes
b) No

11. What is your age?

a) 29 or less
b) 30-39
c) 40-49
d) 50-59
e) 60 or over

12. What is the highest level of education you have completed?

a) Less than grade 12
b) Grade 12
c) Some post secondary education
d) Post secondary degree/certificate/diploma attained
e) Graduate degree

13. Gender?

____

14. What rural municipality number is your home ranch located in?

____

Appendix B: Survey Comments

Question: Is there a type of policy or program not mentioned in question #1 that you would prefer to have available to you that would encourage management practices which would lead to increased ecosystem services on grasslands?

Responses:

1. Being paid for programs under Growing Forward 1 that aren't under Growing Forward 2 such as windbreaks, cross-fencing, and seeding sensitive lands.
2. If the public wants ecosystem services and to keep native grasslands, should "put their money where their mouth is", pay for them and make ranching a profitable option.
3. Keep water infrastructure program in place, encourage assistance/cost share on cross-fencing, assistance for fencing new areas not currently used for agriculture, and re-establish unproductive lands (incentives should be in place).
4. A program that offered a percentage tax break/relief if you met a certain environmental criteria on your grassland, a measurable conservation goal relative to starting conditions. Would get relief based on how many goals you meet. Needs to be universal, voluntary, flexible, and reasonable.
5. Don't necessarily want to be paid for carbon sequestration or other services, but don't want it to cost anything either to operate, some sort of recognition could work.
6. Habitat banking -- selling habitat credits to others based on how many at-risk species you protect on your land (market based approach of buying/selling credits, better managed grass has more credits).
7. Landowners should have more say in wildlife management, more control.
8. No oil/gas production in foothills/mountain areas, keep cattle away from water sources.
9. Prefer that the conservation and carbon sequestration policy be added into existing frameworks, such as the Environmental Farm Plan or Saskatchewan Verified Beef, as they already have some of the basic info on the programs and would avoid redundancy and extra unwanted paperwork or office time.
10. Would be beneficial to have a program, not through the gov't but through another organization, to put some money towards the purchase of land that is going to be used for pasture or hay production to allow producers to be competitive with grain producers.
11. If they bill ranchers for cows through carbon tax, should have a cost sharing thing that is a net benefit to ranchers.

12. Exemption from proposed carbon taxes.
13. NO.
14. Incentives.
15. Not in favour of government programs for the most part.
16. Interested in "results-based" programs. Different from cost share in that it doesn’t provide a reimbursement, rather it pays producers for maintaining a specific set of habitat parameters, for example "healthy" range health or specific habitat targets for wildlife. Only triggers rewards when the targets are met, it doesn’t allow for penalties if targets are not met.
17. A carbon credit payment – similar to how cultivated land credits are traded.
18. Combination of extension and cost-share.
19. I would like to be paid on an acre basis for wildlife habitat conservation in functioning wetlands, streams, and treed areas. This payment would be yearly and encourage farmers, like myself, to maintain these areas while the area around us has been heavily drained and into annual crop production. Funding for seeding cover crops, polyculture crop mixes, and perennial forage as well as implementing rotational grazing systems and watering systems is a must!
20. Create a program similar to carbon credits for farming.

Question: Why would you consider changing management practices if it increased ecosystem services?

Responses:

1. For good of future generations, wildlife, and the good for everyone in general.
2. Right thing to do, ranchers are the initial stewards of wildlife and land.
3. For sustainability.
4. If I increase ecosystem services, it will increase net profits/benefits in the end as a producer over time.
5. Healthy ecosystem beneficial for everybody, better I treat the land the better I am as well.
6. Do the right thing, as long as it doesn't hurt financial situation.
7. "Consider" -- I'd be open to what might be needed.
8. Always looking to improve habitat quality and environment for conservation purposes.
9. Just a good thing to do, beneficial in the end.
10. Answered no - happy with way things are.
11. Ranch health is all encompassing, systems and management practices that affect the ecosystem undoubtedly will have a positive impact on range health, cattle, soil, and water quality. As such, our ranch see ecosystem and ranch management as complimentary practices.
12. Already do some environmentally friendly practices like fencing off dugouts, would like to do more rotational grazing, other practices as we see fit.
13. What's good for the environment is good for everyone/everything.
14. Increased herd health from better water and grass quality. Healthier and more sustainable land/soils.
15. Everyone needs to get involved in improving environment.
16. For the betterment of land and its production in not only my operation now but also into the future, and also to protect the value of the resource.
17. If changing management practices increased ecosystem services without negatively affecting utilization of the resource we would likely consider it.

18. Believe it is important.
19. Because we believe healthier ecosystems means cleaner water for your livestock, healthy grasslands and improved habitat for wildlife; Habitat important to us.
20. Increases grass.
21. Our management practices already contemplate maximizing the provision of ecosystem services. That said, as stewards of the environment, we would consider changing management practices that increase ecosystem services, particularly if there was economic benefit.
22. As a landowner you have responsibility to operate the land in the best interest of all species that depend on that land for survival, operate in the best interest of all and consider how your actions impact everything.
23. Answered no - most of what we do now is to increase water quality.
24. A strong ecosystem is a resilient ecosystem and better able to withstand climatic variation. That hopefully would lead to financial stability as well on our operation, with the ultimate goal of sustaining our ranch for future generations.
25. We are working towards selling more Ecosystem goods and services and believe that there is a market for these directly or as an attribute of our product (eg: direct beef sales). As well, environmental improvements also relate to greater production and profitability in our business since we are focused heavily on grazing.
26. Any improvement in ecosystem services is worth attempting.
27. We already have and are already operating our farm to increase soil health and long-term sustainability of our operation. Help from the government on this would be great to encourage our farm to adopt these practices quicker and encourage other farmers/ranchers to adopt sustainable agricultural practices.
28. Although I feel I am doing the best possible as a land manager, I feel that there is always room for improvement no matter how good of job you are doing. With research there might be more information that I might be able to incorporate into our operation.
29. As a mother and grandmother who's family is involved in farming and ranching I want our grasslands and croplands to provide them with a safe and good lifestyle.

Question: What management practice or practices would you be willing to adopt on your land that you believe would increase carbon sequestration and storage?

Responses:

1. Greater rotation.
2. Timing of grazing, leaving thatch to avoid erosion.
3. Better grass management through rotational, bale grazing; increase organic matter.
4. Leaving more cover, fencing out water holes, more grass the better.
5. Would be willing to do things if they work for the operation, rotational graze somewhat already.
6. Different ways of producing feed, no till, permanent cover.
7. Reseeding low productive areas.
8. Already doing best we can.
9. Responsible grazing.
10. Don’t overgraze.
11. Relay cropping for extended grazing season, continued and improved reduced till systems for winter feed options, high intensity/low duration grazing management practices, new forage varieties.
12. Rotational grazing.
13. Rotation grazing; planting permanent grass/hay on marginal soils; rejuvenate pastures to reduce invasive weeds.
14. Need more info on options.
15. Already take action.
16. More rotational grazing, longer rest times between grazing.
17. Late grazing of native grass.
18. Using cover crops, annual crops.
19. Proper grazing techniques.
20. Makes best economic sense to maximize carbon sequestration and storage, would implement further fencing and direct seeding/reduced soil disturbance should reseeding be required.
21. More grass seeding on marginal land and reduced tillage.
22. Don’t believe there's anything more we could do.

23. Need to see some carbon storage data and do some benchmarking on my pastures to determine which pastures I think would increase soil carbon, not sure if any changes to current regime would make a real difference.
24. Many have been adopted, but we would increase our intensive rotation into more difficult to access areas. We would be unlikely to reduce the intensity of grazing (more likely to increase) on a square footage basis, but would extend the duration between grazing.
25. Adaptive grazing, cover crops, bale grazing.
26. Cover crops, polyculture mixes, seeding to good perennial forage mix, different crops in rotation, reducing straw use or buying straw, reducing fertilizer use through using more diverse mixes and intercropping, rotational grazing, growing legumes, no-till… we already do all this. I would just like to be paid to NOT drain and NOT plough down sloughs and trees on our land, which covers around 20% of our land base.
27. I currently practice rest rotation grazing. I would be willing to consider other grazing strategies to increase carbon sequestration and storage.

Question: What management practice or practices would you be willing to adopt on your land that you believe would increase the quantity of wildlife and wildlife habitat?

Responses:

1. Cutting hay later in season.
2. Don't know how to increase, wildlife already in good state.
3. Winter grazing systems.
4. Already good, don't know what we could do to make better, perhaps better seasonal hunting.
5. Already good, what we're doing now is working.
6. Don't allow hunting, but not many management changes you could do to increase.
7. Reseeding and fertilizer application.
8. Limit hunting and try not to ruin water sources/quality.
9. Don't do anything now to decrease it, don't clear bush.
10. Don't overgraze.
11. Riparian management, riparian restorations, grazing management, wildlife friendly fencing.
12. Produce more grass.
13. Rotation grazing and fencing off waterways.
14. Fence off riparian areas, limit hunting access, putting out waterfowl nests.
15. Already take actions.
16. Leave more natural standing trees in place rather than transfer into farmable, seedable land.
17. Not sure.
18. Appropriate stocking rates for diverse ecosystems and need.
19. Proper grazing techniques, like rotational grazing, so wildlife have access to healthier grasslands.
20. Rotational grazing, late hay cutting.
21. Already fence out pastureland, don't use ammonia, proper wildlife strategies should be directed and implemented by government, one-off strategies rarely effective and overly burdensome.
22. Grass seeding, delayed hay cutting or grazing, and leaving some brush.

23. Do everything already, wild animals more or less have free reign.
24. Some practices outlined in Environment and Climate Change Canada's Species at Risk Plans may be useful.
25. Season of use, intensity (stock density), augmentation of habitat (eg: planting pollinators/trees).
26. Adaptive grazing, cover crops, bale grazing.
27. Not having to drain or push down treed areas.
28. I would like to have temporary fencing that can be taken down for moose/elk. Currently I struggle with moose/elk taking fences out in the fall. If there was a way for fences to be taken down in the fall & put up in the spring, it’s labour intensive but so is fixing fence constantly.

Question: What management practice or practices would you be willing to adopt on your land that you believe would increase water quality?

Responses:

1. Need windbreaks.
2. Don't know how to increase.
3. Keep cattle out of water any way you can.
4. Keep cattle away from water runs, don't feed in those areas.
5. Better dugout management, pumping water out.
6. Maintain water quality by having protected water source then pumping water to where it's needed.
7. Prevent erosion, buffer zones between grass and water, limit access to water from domestic animals, don't allow free access to waterway.
8. Fencing off dugouts and pumping them.
9. Fence out water system/supply.
10. Remote water systems.
11. Fencing dugouts and water systems.
12. Exclusion fencing of water, remote watering systems, and developing water sources.
13. Fencing off groundwater access areas, increase use of solar pumping stations, improve drainage.
14. Fence dugouts.
15. Leave more natural tree populations, rest periods between grazing, solar pump water out of lowlands and dugouts.
16. Not sure.
17. Already drilled wells, fenced waterways, installed solar water systems.
18. Ensure livestock have limited access to water sources to minimize water quality degradation.
19. Rotational grazing, fencing, grass seeding.
20. Have already fenced water bodies and use solar trough, would be willing to upgrade watering systems if a better option became available.
21. Remote watering and fencing off riparian areas.
22. Look after water already.

23. Pumping water out of dams and offsite to cattle into troughs would be helpful. Measure water quality regularly.
24. Off site watering, fencing more riparian areas, changing season of use.
25. Adaptive grazing, cover crops, bale grazing.
26. Not having to drain or push down treed areas.
27. I would like to have off-site water stations and sloughs fenced off. As well as a fence along our 1/4 mile of lake shore.

General Comments

1. Have to know where to look to find programs, and better ways to meet goals than reducing stocking rates/grazing intensity.
2. Don't believe reducing stocking rate is true method, "a misnomer", prefer flexibility for contract length, too many current barriers (paperwork) in current cost share programs.
3. Conservation easement distant third for program rankings, and too busy to do additional paperwork.
4. Important to have succession plan, wouldn't go over 60% cost share because rancher should have "skin in the game", info on programs is there but you have to seek it, need to recognize asset of native grasslands/prairie to society as a whole, grasslands neglected for a long time in the past, need policies that use sound economics to protect grasslands, find something acceptable to ranchers and public, although many people don't want government involvement.
5. Not sure if I want to be paid for providing ecosystem services, just don't want it to cost money, but not sure if monetary compensation is right way to do it. Changing management practices depends the private effects, limited contract length because there's always new information.
6. Cattle people are good conservationists, but when it comes down to it you have to look after yourself, need some financial incentive or reason to do certain practices.
7. Need compensation in order to lower stocking rate, margins are too tight on cattle.
8. Long lasting relationship between large animals and grasslands, long ago buffalo and now cows, that contributes to range health, there have always been large animals on grasslands. Most operations are not doing things that harm the environment anyways, they manage the land responsibly. Easements take decision making away from rancher. Ultimately ranchers need to make ends meet. Government not good at letting people know of opportunities and programs out there. Already do high intensity/ low frequency grazing. Don't know enough about carbon sequestration personally; would make management changes as long as it doesn't take away from bottom line. Prefer high intensity grazing for short duration as grazing method, and then move between areas often. If charging for hurting environment, should also give back if improving environment.
9. Difficult to find out about programs, need more outreach. If asking for more work from rancher and higher costs, need to pay for it.

10. Noted they are a 5th generation rancher for ranch experience.
11. Don’t believe we overgraze now.
12. Noted that ranchers already forego income by choosing to maintain grasslands instead of farming for crops on it. Require more details on potentially decreasing stocking rate, healthy ranges will have a mosaic of high, medium, and low patches of grazing level, don't see how a general blanket reduction in stocking rate could increase ecosystem services. Who is the responsibility to manage grasslands responsibly to? To society, their self, bankers or lenders? Number of additional work hours dependent on ability to provide or move water to livestock, depending on cross fencing could take 20-30 additional hours to move water to some parts, 5-10 to others. Will cross fencing actually meet the goals? What is the goal, and what would I do for water? Could effect producers in different regions differently, and may not address root problem, just installing fencing for the sake of doing it. Cross fence policy doesn’t seem that effective to me, would caution against policies that encourage practices like this.
13. Farm has been raising cattle over 100 years. Have already extensively deployed intensively managed grazing systems; Didn't answer labour, inapplicable as already did those practices.
14. Overgrazing is not a function of stocking rate but of time, very few pastures are overstocked, and a decrease in rate only leads to selective overgrazing/partial over rest. Same answer for management practices because they are all tied together and can't be managed separately.
15. Didn't answer additional labour since already implemented rotational grazing.
16. Didn't answer several questions since our land is rented out to other livestock producers, don’t ranch much ourselves anymore. Felt some questions were inapplicable because of this, would have to come to a management and monetary agreement beforehand with the renter. More information about carbon sequestration needs to be provided to producers. Feels good programs and practices are in place for wildlife. Effectiveness of management practices and grassland health relies heavily on amount of rainfall and snowfall throughout the year.

Appendix C: Raw Data

ID	PREF_EXTENSION	PREF_COSTSHARE	PREF_EASE	VOL_ADOPT	SEARCH_COST
1	2	3	1	4	3
2	2	3	1	4	2.5
3	2	3	1	4	3
4	1	3	2	3	3
5	3	2	1	3	3
6	2	3	1	3	3
7	2	3	1	3	3
8	1	2	3	3	2
9	1	3	2	3	3
10	1.5	3	1.5	3	2
11	3	2	1	1	2
12	1.5	3	1.5	3	3
13	1.5	3	1.5	4	2.5
14	2	3	1	3	3
15	2	3	1	3	2
16	2	3	1	3	2
17	1	3	2	3	3
18	2	3	1	3	3
19	3	2	1	4	2
20	2	3	1	3	3
21	2	3	1	3	3
22	2	3	1	3	2
23	2	3	1	3	4
24	2	3	1	3	2
25	3	2	1	2	3
26	2	3	1	1	2
27	2	3	1	3	3
28	3	2	1	4	2
29	1	3	2	3	2
30				3	3

ID	TRAN_COST	MIN_COSTSHARE_PROB	MIN_COSTSHARE_DEF	LABOR
1	4	50	60	8
2	3	20	50	7
3	1	40	70	3
4	3	30	50	5
5	3	50	80	2
6	2	50	60	10
7	2	40	70	1
8	3	50	70	10
9	3	50	80	2
10	2	30	50	10
11	3	50	70	6
12	2	60	60	5
13	2.5	10	10	7
14	2	50	70	2
15	2	40	50	2
16	3	50	80	2
17	3	50	60	10
18	2	10	50	2
19	3	40	50	5
20	3	10		4
21	3	50	80	3
22	2	40	50	4
23	2	50	80	4
24	1	70	100	2
25	4	30	30	10
26	2	10	70	
27	4	40	80	10
28	3	10	50	5
29	3	30	50	
30				

ID	CON_LENGTH	C_SEQ	WILDLIFE	WATER_QUALITY	PROVIDE_CSEQ
1	10	3	1	2	4
2	15	2	3	1	4
3	5	1	2	3	3
4	20	2	1	3	3
5	5	2	3	1	3
6	10	1	3	2	3
7	5	1	3	2	3
8	3	2	1	3	3
9	10	1.5	1.5	3	3
10	5	1	2	3	3
11	5	1	2	3	4
12	3	2	3	1	3
13	3	1	2	3	4
14	10	2	1	3	3
15	5	1	2	3	2
16	2	3	1	2	4
17	15	2	1	3	3
18	3	1	2	3	3
19	1	1	3	2	3
20	10	1	2	3	3
21	10	1	3	2	3
22	5	1	3	2	3
23	10	1	2	3	3
24	10	1	2	3	2
25	10	1	3	2	4
26	10	3	1	2	4
27	10	2	3	1	4
28	3	1	2	3	1
29	10	1	2	3	4
30		1	2	3	

ID	PROVIDE_WILDLIFE	PROVIDE_WATERQ	VOL_CHANGE	RESPONSIBILITY
1	4	3	1	4
2	4	4	1	4
3	4	4	1	4
4	3	4	1	4
5	4	3	1	4
6	4	3	1	4
7	3	3	1	4
8	3	3	1	3
9	3	3	1	3
10	3	3	0	3
11	3	3	1	4
12	3	4	1	3
13	4	4	1	3
14	3	2	1	3
15	3	2	1	3
16	3	3	1	3
17	3	3	1	4
18	3	3	1	3
19	3	3	1	3
20	3	3	1	3
21	4	3	1	3
22	3	3	1	3
23	4	4	1	4
24	3	4	0	3
25	4	3	1	3
26	4	4	1	4
27	3	4	1	4
28	1	1	1	3
29	4	4	1	4
30	3	3	1	3

ID	VOL_REDUCE	GOV_SUPPORT	WTA (PROBABLY)	WTA (DEFINITELY)
1	2	4	40	100
2	2	4	20	30
3	2	3	20	50
4	3	3	5	10
5	2	2.5	40	50
6	3	4	20	60
7	1	2	50	80
8	3	3	50	70
9	2	3	20	50
10	2	3	30	50
11	2	3	50	
12	2	3	10	10
13	2	2.5	10	20
14	2	4	40	70
15	3	3	40	50
16	2	3	50	80
17	3	4	20	40
18	2	4	50	70
19	3	3	40	70
20	3	3	50	
21	3	3	30	50
22	3	3	50	70
23	4	4	50	70
24	2	3	70	100
25	1	3	30	
26	2	4	40	70
27	1	3		
28	3	4	1	10
29	3	4	5	10
30	3	3		

ID	WTA1	WTA2	WTA3	CATTLE	ACRES	EXPERIENCE

1	30	90	100	240	1524	48
2	10	20	30	1000	9500	45
3	10	40	50	1150	12800	20
4	1	5	10	300	5760	57
5	30	40	50	300	1300	40
6	10	50	60	500	4800	35
7	40	70	80		1020	35
8	40	60	70	1878	17280	27
9	10	40	50	200	800	20
10	20	40	50	135	500	30
11	40			350	2000	15
12	5	10	10	110	1100	25
13	5	10	20	275	1100	27
14	30	60	70	80	1600	8
15	30	40	50	100	640	30
16	40	70	80	200	4640	45
17	10	30	40	300	1680	50
18	40	60	70	500	3900	50
19	30	60	70	150	6000	25
20	40			250	3000	30
21	20	40	50	275	5100	55
22	40	60	70	200	2140	37
23	40	60	70	140	910	24
24	60	90	100	500	5000	50
25	20			512	5280	18
26	30	60	70	350	4000	20
27				400	5500	20
28	1	5	10	350	7920	5
29	1	5	10	210	760	15
30				60	1120	48

ID FORMER GOV PLAN TO PROGRAM_PARTICIPAT CATTLE_INCO

	PASTURE USER	LEASE	ION	ME
1	0	0	1	5
2	1	0	1	5
3	1	1	1	5
4	0	0	1	5
5	1	0	1	2
6	1	1	1	5
7	0	0	0	2
8	1	1	0	3
9	1	1	0	4
10	1	1	0	1
11	0	0	1	3
12	0	0	0	2
13	0	0	1	5
14	0	0	1	2
15	0	0	0	2
16	1	1	0	1
17	0	0	1	5
18	1	0	0	5
19	1	0	1	1
20	0	0	1	5
21	0	0	1	4
22	0	1	0	3
23	0	0	1	1
24	1	1	0	4
25	1	1	1	5
26	0	0	1	4
27	0	0	1	5
28	0	0	1	2
29	1	1	0	3
30	0	0	0	2

ID	NONFARM_INCOME	PLAN_TO_FARM	SUCCESSION_PLAN	SURFACE_WATER	AGE
1	1		1	1	5
2	1		1	1	4
3	1	15	0	1	3
4	1	0	1	1	5
5	1	25	0	1	3
6	1	10	1	1	4
7	4	10	1	1	4
8	1		1	1	1
9	1	10	1	1	5
10	2	10	1	1	4
11	2	30	1	1	2
12	3		0	1	1
13	1		0	1	3
14	1	30	0	1	2
15	4	10	0	1	4
16	1		1	1	5
17	1	5	1	1	4
18	1		0	1	4
19	1	7	1	1	4
20	3	20	1	1	3
21	1	15	1	1	4
22	1	15	0	1	4
23	1	15	1	1	4
24	1	20	1	1	4
25	1	40	0	1	2
26	2	40	1	1	3
27	1	30	0	1	3
28	1	40	0	1	2
29	1	30	1	1	2
30	1	5	1	1	5

ID	EDUC	EDUC_BINARY	MALE	RM_NUMBER	BROWN_SOIL
1	3	0	1	493	0
2	2	0	1	250	1
3	4	1	1	5	1
4	1	0	1	39	1
5	4	1	1	429	0
6	2	0	1	228	1
7	4	1	1	520	0
8	2	0	1	26	1
9	2	0	1	428	0
10	2	0	1	428	0
11	5	1	0	131	1
12	4	1	1	61	0
13	3	0	1	398	0
14	4	1	0	430	0
15	4	1	1	158	1
16	2	0	1	347	1
17	2	0	1	93	0
18	2	0	0	165	1
19	4	1	0	228	1
20	4	1	0	131	1
21	4	1	1	132	1
22	1	0	1	398	0
23	4	1	1	339	0
24	2	0	1	378	1
25	4	1	0	76	1
26	4	1	1	Vermillion River (AB)	0
27	2	0	1	8	1
28	5	1	0	154	1
29	4	1	0	Wetaskiwin County (AB)	0
30	2	0	0	190	1