RIGHT SIDE UP:

PAYMENT FOR ECOSYSTEM SERVICES ON PRIVATELY OWNED GRASSLANDS IN NEBRASKA

by

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Grasslands are an important ecological and economic resource in the United States. As part of a natural system, these landscapes can provide income for ranching operations and employment in rural communities; habitat for grassland plants, animals, and migratory species; and offer other services not always readily observed such as improved soil health, clean water, and carbon sequestration. Despite the overarching benefits, the conversion of grasslands to other uses remains widespread throughout much of the remaining Great Plains ecosystem.

Shifting from livestock ranching to another land use often reflects a tipping point. This occurs when the alternative land use is perceived to outweigh the risks and losses stemming from grassland conversion. Large areas of grasslands are privately owned in the US, but many of the benefits that are provided are nontraditional public goods. The conversion of naturally functioning landscapes can be ecologically disruptive and come at a detriment to both private and public interests. Alternative marketing opportunities and revitalized conservation efforts may be necessary to create linkages between private land management and the supply of services from healthy grassland ecosystems.

Using Nebraska's statewide wildlife management plan as a guide, we developed a hypothetical grassland ecosystem services market and tested the programmatic

preferences of ranchers who would sell the services produced from their lands. In testing attributes related to management, contract length, and payment level, we found that ranchers indicated strong preferences for the types of management actions that were incentivized and not the accompanying contract length or payment. This research contributes to conservation literature in the areas of conjoint choice experiments and incomplete confounded factorial experimental design. It may also have utility in the form of market research for the future piloting of ecosystem services programs.
Keywords: payment for ecosystem services; human-centered design; ranching; grassland conservation programs

"While conservation actions in the past have had notable successes, they have not been sufficient to stem the overall tide of species decline. There is a need for a comprehensive, systematic, and proactive approach to conserving the full array of Nebraska's biological diversity."

- Nebraska Natural Legacy Project, 2011

ACKNOWLEDGEMENTS

Growing up in northwest Iowa, I relished in the stories of what made grasslands great. To learn that birds, mammals, and hordes of insects were just a part of everyday life was hard to fathom. By then, of course, the spectacular arrays of wetlands, the mosaics of prairie habitats, and the diversity of avifauna had become just that...stories. To think that over one million square miles with some of the richest species diversity could one day disappear is troubling. Because, at least for now, it forces us to accept that immense swaths of the Great Plains have already vanished. For anyone who considers grassland preservation and expansion a cause worth supporting, thank you.

To the innumerable collaborators of this project, I owe you a debt of gratitude for your time and energy. Without you, this work would not have been possible: Nebraska Cattlemen's Association; USDA, North Central Research, Sustainable Agriculture Research and Education; Nebraska Extension; Nebraska Game and Parks Commission; Nebraska Grazing Lands Coalition; Sandhills Task Force; The Nature Conservancy Nebraska; Ficke Cattle Company; Dr. Jerry Volesky; Dr. Craig Allen; and the hundreds of ranchers who participated in the study—during calving season no less.

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CHAPTER 1: INTRODUCTION

Background

Grasslands are considered one of the most widespread, most imperiled, and least protected vegetation types on earth (Hoekstra, et al., 2005; Lipsey et al., 2015). Because of their productivity—often resulting from centuries of natural and pastoral interactions—these areas have long been a prominent target for conversion to agriculture (Samson & Knopf, 1994; Hoekstra et al., 2005). As climatic conditions shift and the demands for food, fuel, and fiber increase with the global population, it should be expected that grasslands continue to be among the world's most altered and least protected ecosystems (Wright & Wimberly, 2013).

According to Rashford et al. (2011), converting native grasslands to other uses (i.e., cultivated cropland) is "historically extensive and continues worldwide today" (p. 277). In the US, the development of the Great Plains grasslands was borne out of economics and farm policy sown in the 1870s (Samson & Knopf, 1994). In the century that followed, Claassen et al. (2012) suggest that an estimated 260 million acres of the region's 550 million acres of native grasslands were upturned. Today, estimates suggest North American grasslands only cover 40% of the historical range (Wilsey et al., 2019).

In the last twenty years, dramatic price swings in crop commodities have further increased grassland losses in the US. A precise accounting remains elusive—due to decentralized approaches in cataloging cropland (Joshi et al., 2019). However, an analysis by Claassen, et al. (2012) suggests the entire Northern Great Plains (NGP)—about 18% of all domestic grassland acres—accounted for 57% of the gross domestic grassland to cropland conversion from 1997-2007. In the last ten years, following historic commodity price increases, other studies in this region suggest that an average of 1-5% of NGP grasslands are converted every year (Claassen et al., 2012; Wright & Wimberly, 2013; Gage et al., 2016).

While the record-high commodity prices have subsided, Lark et al. (2020) suggest the threat to grasslands persists. Their recent analysis, examining conversion trends during and after the 2007-2012 commodity price booms, indicates the total rate of converted acres did fall following the 2011-2012 peak. However, the gross conversion rate stabilized near 1 million acres per year for several years thereafter. Further, the researchers suggest, due to a lack of other suitable lands for conversion, longstanding habitat or land that was categorized as agriculturally marginal was brought into production. Overall, the highest rates of loss of "natural landcover" occurred in the western corn belt and western Great Plains—the leading edge of westward land-use conversion (Olimb & Robinson, 2019).

Western grasslands in the US are arguably the last remaining vestige of the Great Plains, and cattle ranching has been its principal use for decades (Fleischner, 1994). However, this dynamic has changed rapidly since the 2000s. Economic conditions in agriculture, trends in urbanization, and energy development—as well as demographic and normative trends in ranching communities—are pushing these remaining grasslands and associated natural communities to a breaking point (Goldstein et al., 2011). To what extent policy should be used as an intervention tool appears to be a moving target for policymakers, conservation managers, and agricultural producers.

Grasslands embody America's ancestral and modern agricultural identity. These areas are steadfastly revered and create emotional connections to the landscape that often permeate through generations (Gutwein & Goldstein, 2013; Havstad et al., 2007; Gentner & Tanaka, 2002). With the pressures from cropland conversion, urbanization, energy development, and woody encroachment on the rise, these grasslands future as the "Great Plains" is uncertain. If the array of benefits grasslands offer is to be maintained, a shift in conservation strategies and scale is urgently needed to address the growing needs of ranchers, rural economies, and wildlife populations (Krausman et al., 2009).

Complexities in Land-use Conversion

The issues surrounding grassland conversion are complex and interconnected, but not unfamiliar. Profitability, suburban population expansion, energy development, and an aging workforce are commonly cited as drivers of land-use conversion (Goldstein, 2011). Technological innovations in equipment, seed genetics, agrichemicals, and irrigation systems are also principal factors as intensive agriculture expands into marginally productive regions (Claassen et al., 2012). Shifts in climate and weather are also aiding row-crop expansion as areas previously deemed unsuitable are targeted for production (Reitsma et al., 2015). Several analyses (Rashford et al., 2011; Wang et al., 2017; Lark et al., 2019) have detected linkages to federal policy—predominantly crop insurance—as a multiplier effect, thus increasing motivations to convert grasslands.

The historic row crop price increases in the early 2000s offer context. At that time, federal crop subsidies for corn, wheat, and soybeans totaled $11.1 billion while those for livestock grazing were $267 million (Environmental Working Group, 2005). The subsidies provided a new risk aversion tactic that had otherwise been unavailable to many farmers (US GAO, 2007; Miao et al., 2016). Claassen et al. (2012) explain that the combination of subsidies (i.e., marketing loans, disaster assistance, and crop insurance) led to an additional 2.9% increase in total cropland acreage expansion during this period. Bauman et al. (2014) also found that many of the subsidy programs during this timeframe had inverse effects on enrollment in land conservation programs. These conditions helped exacerbate typical grassland conversion rates according to Miao et al. (2016). The researchers suggest that because subsidies effectively covered losses for cropping previously unsuitable areas, some of the overall risks and cost of land conversion were mitigated as part of a broader commodity safety net.

State and federal subsidization of biofuel industries are also driving motivations to convert grasslands (Nash, 2007; Fargione et al., 2009; Wright & Wimberly, 2013). During the initial buildout of the industry in the early 2000s, 4.2 million acres of grasslands within 100-miles of these refineries helped fuel the demand for corn-based ethanol (Wright et al. (2017). As production targets increased, semi-arid grasslands that were highly unsuited for crop production were also converted to cropland and sustained through increases in irrigation (Wright & Wimberly, 2013). The viability for crop-based biofuels as a greener alternative to oil is diminishing as the high costs of land conversion, water use, and reliance on fossil fuels are becoming realized (Ott et al., 2020). However, Lark et al. (2015) suggest that the industry and policies surrounding have already prompted "the greatest transformation to cropland since the 'fencerow-to-fencerow' era of the 1970s" (p. 1).

The promise of higher returns from alternative land use is an important consideration for someone in livestock ranching. But in totality, what are the sunken costs of converting grasslands to other uses? Increases in soil erosion and decreases in grassland-dependent species are widely recognized as side-effects of land-use conversion

(Pimentel et al., 1995; Swengel & Swengel, 2015; Lipsey et al., 2015). There are also concerns about the release of ancient carbon stores (Eve et al., 2002; Gascoigne et al., 2011), impairment of water resources due to depletion and the introduction of agrichemicals (Faber, et al., 2012), as well as the extirpation of soil life (Lipson & Kelly, 2014). If widespread grassland conversion continues across the remaining 770 million acres of grasslands in the US (USDA, 2021c), a disruption in the delivery of some ecosystem services at regional and national scales should be expected (Lark et al., 2020; Gage et al., 2016).

Statement of the Problem

Why private landowners choose to engage in operational diversification or outright land-use conversion is settled among researchers: it is complex. There are economic motivators, but there are also technological advancements, personal norms, and lifestyle amenities that may simultaneously be at play when operational decisions are formulated (Kennedy et al., 2016; Gutwein & Goldstein, 2013; Claassen et al., 2012). Regardless of the rationale, the interminable loss of environmental benefits is normally expected because of the financial costs associated with landscape conversion and future land restoration (Wachenheim & Lesch, 2014). Additionally, services such as carbon sequestration (Eve et al., 2002), the building of organic matter, and recovery of the soil biota can take decades to achieve (Gelfand et al., 2011), often with varying degrees of success (Wang et al., 2017).

There is less consensus surrounding the most effective policy mechanism that can address the steady decline of grasslands. With an annual budget of $5.7 billion (USDA ERS, 2016), the USDA's voluntary conservation programs are considered the premier resource for private lands conservation. However, research shows these programs are more supportive of crop production and less conducive to incentivized conservation or assurances of environmental quality (Smith et al., 2011; Lichtenberg, 2014; Claassen et al, 2016). For example, despite record-high participation in 2007, the core suite of conservation offerings were dramatically reduced in the ensuing Farm Bills. The question of how to achieve increasing needs for long-term conservation alongside the shrinking availability of programs adapted for the short-term is problematic.

The Conservation Reserve Program (CRP), one of the most widely recognized voluntary conservation programs in the US, provides an interesting case study. Since 2007, legislative action has lowered acreage targets in each of the three subsequent Farm Bills. This has resulted in landowner enrollment declines of more than 14 million acres over the same period (USDA, 2021a). One programmatic counterpart, the Conservation Stewardship Program, experienced an over two-thirds reduction in acres under contract dropping from 20 million to 6.42 million since 2009 (USDA, 2021b). It has been suggested that precipitous drops in acreage enrollment can exacerbate environmental degradation, triggering net losses to habitat and associated wildlife (Lark et al., 2020). This occurs as previously undisturbed, environmentally sensitive, or marginally productive areas are brought into crop production because of a lack of suitable land-use alternatives (Hendricks & Er, 2018).

Morefield et al., (2016) note changes in enrollment targets often coincide with the expansion of cropland acres across the US. This reflects the origins of these programs as supply management tools (Reichelderfer & Boggess, 1988), but even recent policy updates mirror a legislative prioritization of production versus conservation (Hellerstein, 2017). As incentives and enrollment opportunities have decreased, so too has landowner interest in programs such as CRP (Osteen et al., 2012). According to Hendricks & Er (2018), the effectiveness of using commodity price control mechanisms for land conservation is questionable given enrollment caps are set years before the market conditions are known. Given these trends, it may not be prudent to rely solely on federal programs to achieve long-term, landscape-scale conservation of grasslands.

The compounding effects of farm policy, commodity prices, and a lack of suitable land-use alternatives raise important questions about the current state and future design of grassland conservation programs. How do we not only enhance the conservation of grasslands but also safeguard the benefits that are provided at regional and national scales? One alternative conservation framework that has emerged in the literature, payment for ecosystem services (PES), notably shifts resources away from a narrow set of management practices and redirects it toward landscape-level management of ecosystem services (Engel et al., 2008).

Voluntary conservation programs are normally rooted in what Sorice and Donlan (2015) suggest is a well-intentioned reaction to focus exclusively on the needs of imperiled species. While this approach has been popular with incentivized programs of the past (Dayer et al., 2018), it notably does not align with the needs, values, or abilities of those tasked with the species' recovery or protection effort (Donlan, 2015). The most obvious implication becomes one of persistence: will the desired management activity continue beyond the life of the incentive? An accounting of expiring CRP contacts from 2010-2013 in 12 Great Plains states would suggest not. Morefield et al. (2016) found a near 30% return rate to intensive agriculture following contract expiration, and grasslands were the largest type of lands converted (360,000 ha). While the authors note reduced enrollment targets and commodity prices helped propel this trend, the lack of returns for taxpayer investment is problematic in the absence of behavioral persistence (Dayer et al., 2018).

Sorice and Donlan (2015) further suggest that because voluntary conservation program participation is “grounded by place, and occurs in different social, political, cultural, and economic contexts” (p. 791), programs of the future should take proactive measures to better account for participants’ rights, livelihoods, and values. While the dynamics of conservation in agricultural landscapes are no doubt complex, successful conservation efforts must produce cost-effective, long-term, and landscape-level impacts. It is from this lens that we explore the foundation of a human-centered approach to grassland ecosystem services conservation in the Great Plains.

Ecosystem services, broadly operationalized by Daily (1997) “are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life” (p. 3). While this is no longer an innovation in communicating the benefits of the naturally occurring systems, there are shortcomings in incentivizing the conservation of the many services healthy grasslands provide. PES programs aid this process by incorporating free-market enterprise with the supply of services resulting from sustainable grassland management (Hansen et al., 2018).

Research Question

The research question posited in this quantitative analysis was: which combination of contract attributes are most likely to lead to the participation of ranchers in a grassland payment for ecosystem services program? A supplemental area of interest for our study pertained to the identification of lower-order interactions among conservation management practices, payment levels, and contract lengths.

Significance of this Study

Federal subsidies and direct payments for conservation-orientated activities to private landowners are not new, coming to the mainstream during the economic and ecological turmoil of the 1930s. While there have been notable successes in the areas of species and habitat protection, conservation efforts have largely been unsuccessful at stopping overall species decline (Schneider et al., 2011). At a period when livestock ranchers attempt to navigate rising input costs, thin profit margins, turbulent international trade policy, and increasingly high property taxes, converting grasslands to other uses may be the only plausible option for operations to remain profitable.

The decision to convert grasslands to row cropping systems is not a turnkey financial strategy, it emphasizes relative prices and expected returns over many years (Rashford et al. 2011; Miao et al., 2013). However, in the past 20 years, grassland conversion has outpaced conservation and rivaled mass conversion events preceding the Dust Bowl and those of the fencerow-to-fencerow era in the 1970s (Lark et al., 2015). This study looks to PES programs as a framework to stabilize rancher revenues, enhance conservation outcomes, maintain ecosystem services, and keep the remaining Great Plains grasslands right side up.

Definition of Terms

When introducing new programmatic or conceptual models, terminology and frameworks are utilized to further the reader's understanding of the scientific research or industry practice. To assist in the clarity of this publication, commonly cited terms and definitions from PES researchers are included here:

Biodiversity - The phenomenon of how organisms and their genetic differences interact among ecological communities, landscapes, and ecosystems West (1993). Biodiversity plays multiple roles in the delivery of ecosystem services (Mace, Norris, & Fitter, 2012).

Ecosystem services - A framework for analyzing relationships between humans and nature. Specifically, according to Daily (1997), "…the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life."

Grasslands - Land cover/use terminology applied interchangeably in reference to native grasslands, tame seeded grass, rangelands, and associated habits (e.g., wetlands).

Heterogeneity - The complexity and/or variability of a system property in space and or/time (Li & Reynolds, 1995).

Human-centered conservation design - An innovative solution to conservation issues that incorporates empathy for participants, co-designing program approaches, and transfer technology through rapid prototyping of program concepts (Sorice & Donlan, 2015).

Motivation crowding - Theory that suggests increases in prosocial behavior through external incentives will fluctuate based on a 'crowding-in' or 'crowding-out' of intrinsic motivations (Cranford & Mourato, 2014).

Nebraska Natural Legacy Project - Nebraska's state wildlife management plan. This planning document is required by the federal government in all states and revised at least every ten years.

Payment for ecosystem services (PES) - A broad term used to describe emerging environmental markets (Gutwein & Goldstein, 2013). PES programs are often viewed as environmental subsidies, wherein a landowner receives a compensatory payment for engaging in conservation activities on private lands (Hansen, et al., 2018).

Persistence - The assumption that landowners who participate in incentive programs will continue the practice once the payments expire (Dayer, Lutter, Sesser, Hickey, & Gardali, 2018).

CHAPTER 2: REVIEW OF THE LITERATURE

Introduction

Grasslands are an important ecological and economic resource in Nebraska. These areas provide income for ranching operations and rural communities, habitat for prairie plants, animals, and migratory species, and offer non-typical tax revenue for local governments from activities like tourism and recreation (Vaisley & Strankman, 1999). As rich fields of species diversity, vast stores of ancient carbon, and strongholds of superior habitat, the existence of this ecosystem is seen as essential in mitigating the ranging impacts of a changing climate (Bakker & Higgins 2009; Lark et al., 2019). Yet, the Great Plains is considered one of the most threatened ecosystems in the world (Hoekstra et al., 2005).

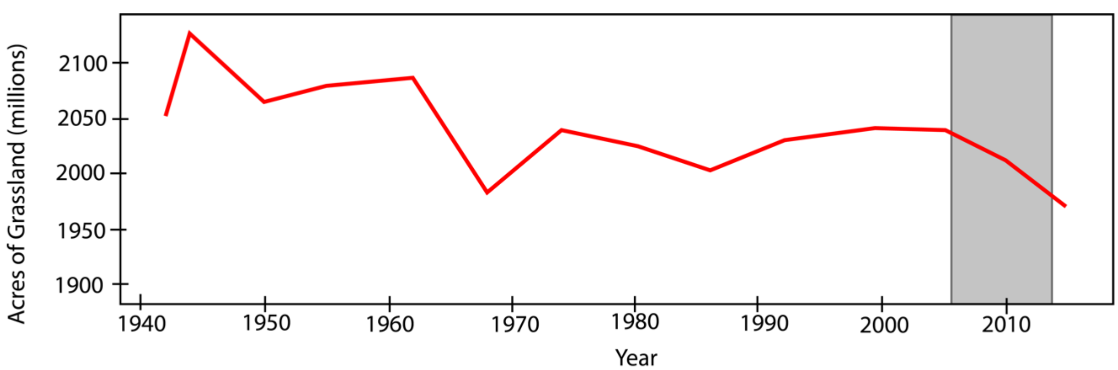

Figure 1. Changes in grassland acres in the Great Plains ecosystem from 1945-2015. Increases after 1940 correspond to Dust Bowl recovery and declines after 1960 reflect a combination of government policy and the advancement of center-pivot irrigation. The shaded area represents a period of record-high commodity prices and declining enrollment targets for Farm Bill conservation programs. Adapted from "Modeled Historical Land Use and Land Cover for the Conterminous United States," by T. Sohl, R. Reker, M. Bouchard, K. Sayler, J. Dornbierer, S. Wika, R. Quenzer, A. Friesz, 2016, *Land Use Science, 11*:4, 476-499.

In North America, analyses of the Great Plains grasslands (Hoekstra et al., 2005; Wilsey et al., 2019) indicate that more than 50% has been converted for human uses (Figure 1). Of the three dominant grassland ecotypes in this region, all have experienced significant reductions since the government-sponsored settlement of the region began. The tall-grass ecotype now encompasses only 11% of its historic range, followed next by mixed grass at 24%, and shortgrass at 54% (Wilsey et al., 2019). The rate of conversion in remaining tracts of temperate grasslands is occurring five times faster than what can be protected (Lipsey et al., 2015). The shift in some areas is so vast, one study concluded that in the late 2000s, it rivaled deforestation rates in the Amazon (Gosnell et al., 2011). Given these substantial declines, the Great Plains is considered at risk of losing ecological function (Hoekstra et al. 2005).

Factors Influencing Grassland Conversion

The Northern Great Plains (Nebraska, North and South Dakota, Montana, and Wyoming) is among areas that have experienced some of the most significant changes in the past 30 years. Estimates in this region suggest that between 2006-2012, the conversion of grasslands occurred at 1-5% per year depending on precise location (Claassen et al. 2012; Wright & Wimberly, 2013). By year-end in 2012, Claassen et al. (2012) estimated the region accounted for 57% of all domestic grassland to crop conversion despite encompassing just 16% of the country's total grassland acres. In their analysis of regional trends, these researchers concluded producers here were "…far more likely to convert" grasslands than in other areas of the country (p.46).

While these recent surges in conversion rates are attributed to price increases of commodity crops such as corn, soybeans, and wheat, the period from 2008-2012 also coincides with the rapid expansion of the ethanol industry and the lowering of enrollment targets for federal conservation programs (Lark et al., 2020). In totality, these conditions precipitated the conversion of 53 million acres of Great Plains grasslands (World Wildlife Fund, 2020) and one of the most significant land-use change events in US history (Wright & Wimberly, 2013). USDA researchers analyzing the aftermath suggested that the farm conservation policies enacted alongside economic drivers helped create a situation that was counterproductive to the goals of grassland conservation (Claassen et al., 2012).

The relationship between policy and commodity prices during 2008-2012 has received considerable attention from researchers (e.g., Lark et al., 2019; Wang et al., 2017; Wright & Wimberly, 2013). These studies suggest the two factors provided strong incentives for conversion because it effectively lowered an individual's financial risk. An analysis of insurance payments from 1994-2013, for example, showed that higher risk areas received higher net insurance payments than minimal risk counties (U.S. GAO, 2015). Additionally, crop insurance policies in unsuitable areas helped reduce the total cost of land conversion per acre as some agricultural losses were now guaranteed (Miao et al., 2016). This arrangement acted as the catalyst in the eventual conversion of 23 million acres of grassland, shrubland, and wetlands during this four-year period from 2008-2011 (Faber et al., 2012).

If commodities served as the boom, then the bust during this period came from impacts to the natural environment. Chief among them, the loss of avifauna (Green et al., 2005), accruement of significant carbon debt (Fargione et al., 2008), and the runoff of millions of pounds of agrichemicals and sediment into waterways (Flynn et al., 2017).

One recent assessment of pollinator and waterfowl habitat in the Great Plains by Lark et al. (2020) concluded the pervasive encroachment of cropland into lands of high conservation value was ongoing, despite the known implications of farming lands that are marginally productive and have high yield deficits. Continued conversion of grasslands in the Missouri River Basin, for example, has been projected to release 1.7 trillion gallons of surface runoff and millions of more pounds of agrichemicals and sediment and serve a key driver in the extinction of birds (Green et al., 2005)

The financial returns made possible by alternate uses of grasslands will undoubtedly impact the condition or alteration of the landscape (Rashford et al., 2011). However, this implies that any action that increases profitability becomes the single motivation for land-use change (Wang et al., 2017). We find this to be succinct, but not wholly representative. The agricultural typology literature suggests a variety of factors (e.g., age of practitioners, declining regional suppliers, competition for water) exist in livestock ranching—often reinforced by markets and policy—that can bring about the decisions to convert grasslands (Havstad et al., 2007; Skaggs, 2008; Goldstein, 2011; Kennedy et al., 2016). Advances in technology have also played an increasingly larger role. Studies report genetically modified, or hybrid seeds have helped drive an increase in the amount domestic cropland acres (Wang et al., 2017; Gage et al., 2016). Alterations in regional climatic patterns are also expected to further intensify land-use conversion trends in the near future (Broch et al., 2013).

There is a market-based assumption that when commodity prices fall, the amount of land converted to produce commodity crops also decreases. This is evidenced by research from Gage et al. (2016), however, the reductions are far more modest in relation to the overall grassland conversion rate. While prices fell following the historic highs of 2008-2012, further analysis of grassland acreage suggests that the annual rate of conversion in the Great Plains stabilized at more than one million acres per year (World Wildlife Fund, 2020; Lark et al., 2020). While some of the exacerbating conditions have dissipated since 2012 (e.g., commodity prices, adjustment to Farm Bill policy), Lark et al. (2019) predict all Great Plains states, regardless of the extent of their remaining grasslands, are likely to have increased conversion rates in the future relative to their previous baselines acres.

Conditions in the Livestock Industry

Profitability is undeniably a driving force for land-use conversion, and the top dollar that was once fetched for corn and soybeans can incentivize landowners to bring new land into crop production (Rashford et al., 2011; Claassen, 2012; Miao et al., 2016). While commodity price increases are rightfully accompanied by concerns about grassland conversion, there is also a unique set of conditions in the livestock industry that are making it more challenging for ranchers to continue their operations.

Despite relatively high prices for livestock, for example, the rising input costs of feed, transportation, and equipment (Figure 2) can force an operation to diversify or outright leave the ranching industry (Gutwein & Goldstein, 2013). If this trend occurs at scale, a decline in the number of ranchers per capita can have additional negative economic impacts for the remaining ranching community. For instance, if cropping systems displace livestock operations, regional suppliers of industry-related services may close or relocate because of the tipping point between supply and demand (Rowe et al., 2001). This would likely increase the expenses of the ranch, but it may spill over into tenure agreements as rental fees rise alongside competition for high-quality grazing lands (Gutwein & Goldstein, 2013).

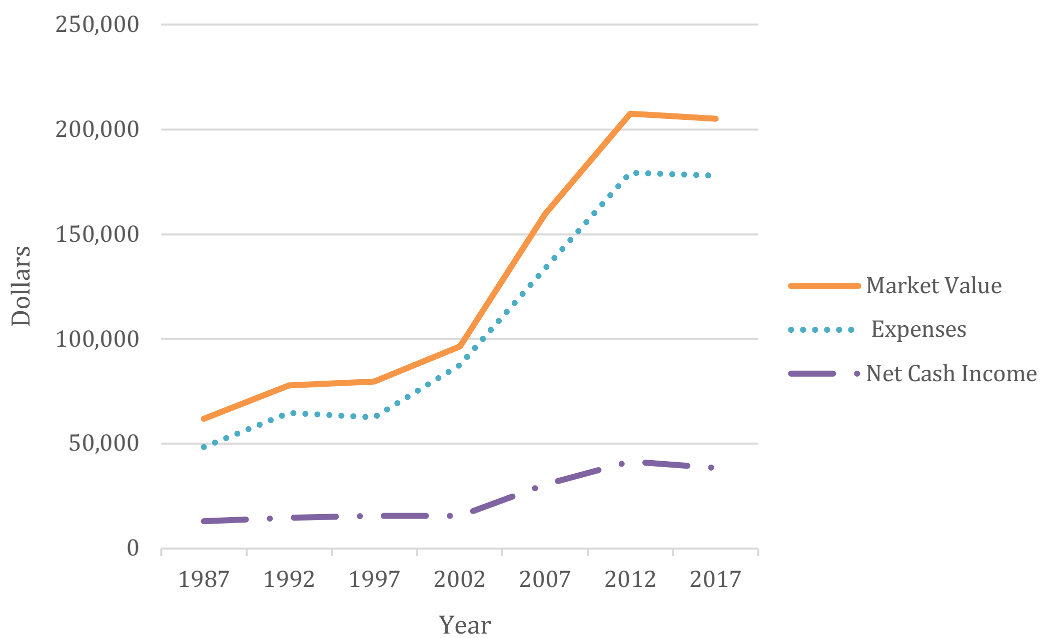

Figure 2. A graphic representation of economic conditions in Nebraska's ranching industry based on USDA Census of Agriculture NAICS economic data from 1987-2007. While the average producer's livestock market value has increased, a corresponding increase in the expenditures to raise these animals has kept pace. Meanwhile, the average rancher's net cash income has not yet surpassed $50,000. Adapted from "Census of Agriculture: Nebraska State Level Data 1987 – 2017," by US Department of Agriculture, 1987-2019.

Other influences on land-use decisions can be more directly attributed to long-standing demographics shifts in rural areas. The availability of qualified individuals to assist in ranching activities may be reduced as younger generations move and experienced ranchers reach retirement age (Gale, 2003; Wachenheim & Lesch, 2014). This may bring some or all lands utilized for grazing into crop production to offset the workload associated with livestock (Reitsma et al., 2015). Additionally, uncertainty about operational succession can increase pressure to dissolve a ranch or transition it to produce other commodities (Toombs et al., 2011). These trends have alarmed even the highest policymakers in agriculture who see it as a major loss to both the industry and the ecosystem services that are provided as public goods (Tauer, 2017).

A particularly unique challenge in agriculture is the fluidity of many internal and external factors. Our examination of the conservation literature suggests that science, technology, society, policy, economics, and climatic conditions can all serve as drivers of land-use change (Gage et al., 2016; Claassen et al., 2012; Goldstein et al., 2011; Wang et al., 2017). Further, according to Wright and Wimberly (2013), many of these are occurring simultaneously:

> A shift from livestock to corn/soy cropping is consistent with a tipping point at which increasing rates of return caused by, e.g., rising commodity prices, subsidized crop insurance, improved corn and soybean cultivars, and adoption of no-till technologies make grassland conversion more profitable than continued livestock production (p. 4136).

The lack of economic linkages between grassland ecosystem services and ranching viability is problematic given the cultural and ecological importance of the Great Plains ecosystem. While a rancher may be motivated to steward his or her lands to ensure operational longevity, their business strategy might not align with an ecosystem-level conservation approach in service of the public interest (Goldstein et al., 2011). Furthermore, even if there were substantial public support for the protection of privately-owned grasslands, the economic rationale for taxpayer investments has not been adequately demonstrated (Bernues et al., 2019).

Ecological Impacts of Grassland Reduction

Grassland-dependent species like birds help serve as a bellwether for understanding the implications of a rapidly changing Great Plains ecosystem. In the past 50 years, declines exceeding 50% have been observed in at least eight grassland-bird populations (Sauer et al., 2014). With et al. (2008) suggest this is underestimated as population dynamics of birds are unlikely to keep pace with the recent and rapid cropland expansion event of 2008-2012. This uncoupling of landscape dynamics from population trends, according to With et al. (2008), suggest that the worst of species declines may not currently be realized. The delayed feedback makes species recovery efforts challenging not only because of the difficulty in restoring grassland habitat (Wang et al., 2017), but because many grassland specialists are known to avoid re-introduced or exotic grasses (Davis et al., 2013).

There are several other negative ecological effects that result from the conversion of grasslands to intensive agriculture. As grasslands are removed, associated animal and plant communities that service soil productivity or pest control will begin to decline (Foley et al. 2005; Green et al., 2005). Simultaneously, stores of ancient, sequestered carbon are released (Fargione et al., 2008), soil erosion rates can begin to rise (Montgomery, 2007), and water quality in absence of buffering and filtration regimes decreases (Moss, 2008). While the development of croplands from grasslands does come with modest increases in food production, studies are demonstrating the trade-offs come at disproportionate and excessive costs to wildlife (Lark et al., 2020), biodiversity, and water quality (Olimb & Robinson, 2019).

Turner and Daily (2008) suggest the maintenance of biodiversity, as part of an ecosystem management strategy, has many characteristics of what society normally recognizes as public goods (e.g., clean water, pollinator services). Therefore, it is important to consider, argues Havstad et al. (2007), that grasslands encompass nested public and private goods. These goods are made available across a host of temporal and spatial ranges (Turner & Daily, 2008). However, the lack of uptake in managing overall ecosystem health has left temperate grasslands with the least intact biodiversity of any habitat type in the world (Newbold et al., 2016). While it is expected that the delivery of ecosystem services declines in absence of biodiversity, the complexity of these interactions is not well understood (Mace et al., 2012).

Assessments of biodiversity and heterogeneity can serve as ecological indicators of ecosystem health. Operationally, according to Li and Reynolds (1995), heterogeneity can be viewed as a building block of “complexity and/or variability of a system property in space and/or time” (p. 280). Biodiversity, for its part and according to West (1993), is an assessment of all these blocks simultaneously in “the variety of organisms, their genetic differences, and the communities and ecosystems, and landscape patterns in which they occur” (p. 3). As grassland areas shift to homogenous structures (commodity crops or introduced forage), both heterogeneity and biodiversity can be expected to decline. Accompanying these decreases are limitations in the quantity, quality, and reliability of some services provided to society by healthy grassland ecosystems (Mace et al., 2012).

Ecosystem Services Delivery from Grasslands

Because concepts such as biodiversity are often abstract and do not readily lend themselves to the daily lives of ranchers or the public, a closer examination of the array of services provided by grassland ecosystems is warranted. The concept of ecosystem services is described by Daily (1997) as "…the actual life-support functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well" (p. 3). These functions fall into four broad categories of services: provisioning, regulating, cultural, and supporting (Goldstein et al., 2011).

The ecosystem services of grasslands (Table 1) vary at vast temporal and spatial scales (Power, 2010). As a supporting service, this includes nutrient cycling and soil formation. As a provisioning service, grasslands allow access to fresh water, food, fiber, and fuel. As a regulatory force, these areas offer pollinator services, maintenance of the hydrologic cycle, climate mediation, and waste absorption and processing. Lastly, grasslands serve as important cultural icons for many facets of society—offering education, aesthetic, spiritual, and recreational opportunities (Skaggs, 2008). In the delivery of any service, grasslands are dynamic both in the capacity to produce and deliver the aforementioned goods (Havstad et al., 2007).

The valuation of an ecosystem service rests at the crossroads of sociocultural motivations for economic and environmental sustainability (Joshi et al., 2019). In the instance of agriculture, both a necessary and dominant form of land management, it will both provide and consume ecosystem services (Power, 2010). For example, management activities may prioritize soil erosion and nutrient retention over the possible extinction of grassland-dependent species (Yahdjian et al., 2015). In both cases, the provisioning or consumption of ecosystem services depends on the management of short-term and long-term objectives (Power, 2010). Determining how to best achieve the co-production of agricultural goods and ecosystem services through management is of growing and urgent interest in the grasslands (Boughton et al., 2019)

Table 1. *Examples of Ecosystem Services Derived from Grasslands*

Ecosystem service	Definition	Examples
Provisioning		
Food		
Crops	Plants cultivated for humans or managed animals	Hay, alfalfa, corn, cattle
Livestock	Animals raised for consumption	Cattle, sheep
Wild foods	Edible plants or animals harvested from the wild	Elk, deer, antelope
Fiber		
Wood-based	Products made from harvested trees	Firewood
Other fibers	Products made from non-wood fibers	Leather, wool
Regulating services		
Air quality	Emitting or extracting chemicals from atmosphere	Fire emits particulates
Carbon sequestration (climate regulation)	Influence of grasslands on global climate	Grasses and soils capture carbon dioxide
Water regulation	Timing and magnitude of water runoff, flooding, recharge, etc.	Playa lakes recharge aquifers
Water purification	Filtering pollution, decomposition of waste, etc.	Wetlands filter waste
Erosion regulation	Role vegetation cover plays in soil retention	Grass prevents soil loss
Disease regulation	Role of grasslands on incidence of pathogens	Control of mosquitoes

Table 1. Examples of ecosystem services derived from grasslands (continued)

Ecosystem service	Definition	Examples
Crop pollination	Transferring pollen from female to male flowers	Bees pollinate nearby crops
Pest regulation	Role of ecosystems in prevalence of pests	Bats consume bugs
Natural hazard regulation	Reducing damage from natural disasters	Vegetation reduces flood damage
Cultural services		
Recreation	Pleasure derived from outdoor activities	Hunting, bird watching
Aesthetic and spiritual values	Inspiration derived from nature	Sense of awe, viewsheds
Maintenance of traditional lifestyles	Role of ecosystems in supporting traditional ranching activities	Ranch livestock and stewardship activities
Research and education	Role ecosystems play in learning	Rangeland research
Supporting services		
Nutrient cycling	Role of ecosystems in nutrient flow and recycling	Decomposition of organic matter contributes to fertility
Primary production	Formation of biological material by plants through photosynthesis	Algae in wetlands
Water cycling	Flow of water through ecosystems	Transfer of water from soil to plants to air, and air to rain

Note. Adapted from "Beef and beyond: Paying for ecosystem services on Western US rangelands," by J. H. Goldstein, C. K. Presnall, L. López-Hoffman, G. P Nabhan, R. L. Knight, G.B. Ruyle, and T.P. Toombs, 2011, *Rangelands,* 33, p. 6. Copyright 2011 by the Society for Range Management.

Goldstein et al. (2011) suggest that while ranchers do have an inherent interest in the long-term stewardship of grasslands, the lack of economic linkages to the public goods that are produced creates inconsistency in the supply and demand of these services. For example, in absence of market continuity, ranchers need only to consider self-interest (i.e., earning a living) and may choose to under-provide in core areas that would otherwise build on services like biodiversity (Turner & Daily, 2008). Establishing market-based mechanisms to better account for the unseen, but critical services grasslands provide is seen as one conceivable way to achieve a balance between delivering ecosystem services and the production of agricultural goods (Gutwein & Goldstein, 2013).

Frameworks to Deliver Grassland Ecosystem Services

Because private landowners steward half of the remaining grasslands in the country, it would seem plausible that declines in grassland acreage are due to a lack of applicable markets or conservation options. Another explanation may reside in the frameworks used in conservation or commodity markets. According to Bennett et al. (2017), one issue is that federal policy and conservation strategies often overlook the societal conditions from which land alterations arise. While there is an assumption that federal conservation programs deliver positive social outcomes (Burton et al., 2008), research in long-term participation and the persistence of incentivized management activities is notably lacking (Dayer et al., 2018).

Another consideration is that many conservation efforts tend to limit the scope of management to only the needs of certain species (Greene, 2005). Despite knowledge of the importance of biodiversity and social/cultural ties to land use, narrow financial incentive programs are usually offered as the sole solution (Sorice & Donlan, 2015). Furthermore, stakeholder involvement in the design and implementation of these programs is usually limited to informal engagement or public commenting processes (Santo et al., 2015). A participant-focused approach to conservation has been put forth for consideration but is still largely absent from much of the conservation literature. This reflects a belief in the social sciences that human dimension research is not thoroughly incorporated into the design phase of program development (Sanquist et al., 2010).

Sorice & Donlan (2015) argue that today's conservation efforts may realize greater benefits by seeking ways to "explicitly incorporate potential participants' needs" (p. 788) into program design. The researchers suggest this approach is better viewed as a nudge rather than a direct financial incentive. Such an approach not only incorporates stakeholder feedback, but it allows the design and administration of the program by its participants to generate more predictable benefits and costs (Santo et al., 2015). This may lead to greater confidence among participants and non-participants since programs were developed in a collaborative manner (Sorice & Donlan, 2015). As trust is reported as a key component in rancher collaborations (Sliwinski et al., 2018), bottom-up approaches that can offer first-hand accounts of the experience are necessary to increase ranchers' participation (Kennedy, 2018).

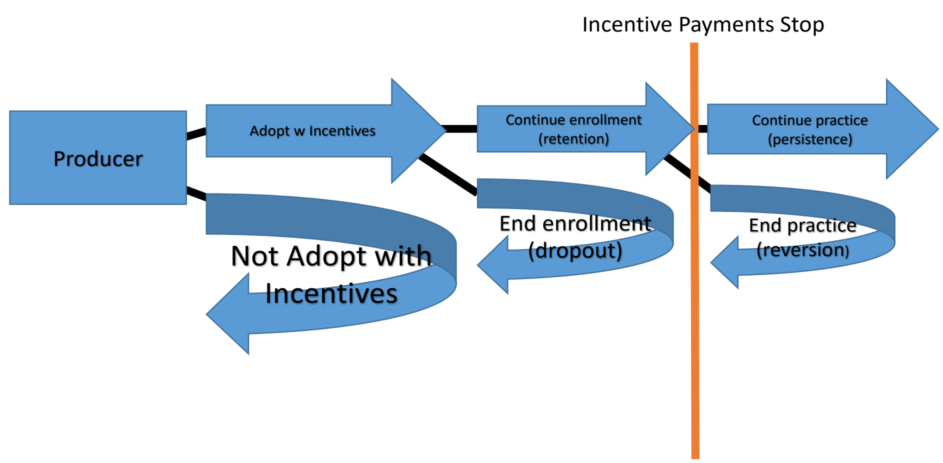

Figure 3. Model for persistence in conservation programs. As payments end, non-pecuniary incentives that elicit intrinsically motivated behavior become more important to ensure the conservation practice is continued. Adapted from "Private Landowner Conservation Behavior Following Participation in Voluntary Incentive Programs: Recommendations to Facilitate Behavioral Persistence," by A. Dayer, S. Lutter, K. Sesser, C. Hickey, and T. Gardali, 2018, *Conservation Letters,* 11, p. 3. Copyright 2018 Wiley Periodicals, Inc.

Another design consideration is how incentives (i.e., payments) affect the long-term adoption of conservation practices. Sorice and Donlan (2015) note the overemphasis on financial incentives stems from a misguided perspective that money is the binding agent for long-term behavior change (Van Vugt, 2009; Ferraro & Kiss, 2002). A sustained behavior in this study is referred to as persistence (Figure 3): the continuation of a practice when financial incentives end (Dayer et al., 2018). Conceptually, persistence has application to conservation program design as it seeks to produce cost-effective, long-term conservation outcomes. Within the current body of research, however, the understanding of how and why landowners engage in conservation practices over time is lacking (Reimer et al., 2014).

When a participant perceives a conservation program as supportive rather than controlling, however, the intrinsic motivations of the participant are less likely to be crowded out (Frey & Jegen, 2001). Behaviors that are internally motivated (i.e., not directly resulting from compensatory payments) are likely to be sustained over time, addressing issues regarding cost-effectiveness and persistence of management practices (Ryan & Deci, 2000; DeCaro & Stokes, 2008). If billions of dollars are to remain invested in Farm Bill conservation programs (USDA ERS, 2016) it would make fiscal sense to pursue design considerations that attempt to address behavioral persistence when the payments end (Dayer et al., 2018).

Emerging Grassland Markets: Payment for Ecosystem Services

In the US, a range of strategies has been used to influence land-use practices. The first federal programs were aimed to combat Dust Bowl era soil erosion. Later, these were used to influence market supply and commodity prices. In recent decades, these morphed to reduce risk and expand ecosystem conservation (Cain & Lovejoy, 2004). The latest innovations have sought to integrate private investments, creating market-based solutions such as carbon trading, wetland banking, and biodiversity credits (Pirard, 2012). However, two of the largest challenges for grassland conservation have been the adoption of practices at scale and persistence of management activities beyond the length of the incentive (Augustine et al., 2019).

The incorporation of market-based instruments to improve conservation outcomes in grasslands is underway in Wyoming (Hansen et al., 2018), California (Buckley Biggs et al., 2021), and Colorado (Gutwein & Goldstein, 2013). Payment for ecosystem services (PES) has been offered as one solution to create more beneficial outcomes for ranchers' livelihoods, grassland ecosystems, and for society (Cheatum et al., 2011). PES programs target a broad array of services that can be managed by private landowners to enhance the delivery of ecosystem services often considered to be nested public goods (Garbach et al., 2012). Gutwein and Goldstein (2013) suggest that the creation of these "environmental markets" may enhance opportunities for land managers to align operational goals, financial strategies, and conservation outcomes.

PES programs can also be categorized as an environmental subsidy, a policy intervention, and a commodities exchange rolled into one (Engel et al., 2008). Incentives offered to landowners, based on conditional delivery of predetermined services and/or the actions required to deliver those services, are a fixture in PES programs (Hansen et al., 2018). A unique and important feature of PES, as indicated by Gosnell et al. (2011), is that the suite of services to be sold follows traditional commodity behavior. Landowners have equity in the market, allowing them to hold or sell their services at periods of their choosing. Normally included are also provisions of “additionality” (services delivered are higher than they would be in absence of the practice) and “avoided loss” (acreage reductions are prevented under business-as-usual scenarios (Gutwein & Goldstein, 2013).

PES contracts stipulate the rule-making rights as well as how new practices can be created or modified. Building in this flexibility not only increases landowner satisfaction but it also increases program participation (Gosnell et al., 2011). Additionally, PES contracts are often not individual agreements between buyer and seller, but by a third-party or cooperative that can better serve the needs of contractual design and reporting (Gosnell et al., 2011). This has obvious benefits in terms of aggregating participant impacts for higher rates of return, but it would reduce the likelihood any one individual can influence a set of management rules or make modifications (Larson et al., 2010; Wunder, 2013).

There is agreement that sound natural resource management accounts for past and present ecologic function, human influences, and a basic understanding of the socio-economic values of the system to be managed (Dietz et al., 2003; Berkes & Turner, 2006; Hayes et al., 2014). However, less attention is given to the role local knowledge and preferences should play in the design of conservation policy or programs (Clements et al., 2010; Petheram & Campbell, 2010) An important distinction of PES programs is that stakeholders can engage at various levels of the process. Using collaborative processes can assist in debunking the notion that conservation is incongruent with agriculture and can lead to increased participation (Sorice et al., 2011). In this respect, PES may be more advantageous than similar programs as it can build social capital by paying for results landowners help devise (Burton et al. 2008). When programs can balance improving participant livelihoods with the rulemaking and compliance of conservation programs, resource managers are more likely to adopt practices to sustain the resource system (Persha et al., 2011; Hellin & Schrader, 2003; Schlager & Ostrom, 1992).

Even when programmatic design and participation are in alignment, adoption may be limited if there is an inability to make program modifications at an individual level (Cheatum et al., 2011; Hayes et al., 2014; Hansen et al., 2018). One solution utilized by Ostrom (1990) for communally managed systems, was to propose a set of design principles utilized in other successful programming, then allow for stakeholders to make and modify these when establishing a program framework. This, according to Hayes et al. (2014) is consistent with findings on why resource managers are more likely to adopt new management practices or sustain existing ones.

If mutually beneficial outcomes in conservation are to be achieved, Hayes et al. (2014) also note the sociocultural drivers of land-use conversion should receive robust consideration. The assumption that a direct economic incentive alone, facilitated through a conditionality clause, will be a sufficient pro-environmental response may not be wholly accurate when we examine the total area of grasslands that are converted each year. Studies in ranching have shown that family, tradition, lifestyle, connection to the land, and amenity values are strong motivations for ranching (Gutwein & Goldstein, 2013; Havstad et al., 2007; Gosnell & Travis, 2005). Additional research has also shown that while profitability is a factor, is not necessarily the primary driver for decisions in ranching (Smith & Martin, 1972; Gentner & Tanaka, 2002).

The true potential of PES, according to Toombs et al. (2011), is that these payments could establish a new asset class that binds wealth to services provided from healthy grasslands through sustainable livestock ranching. Because ranchers engage in rearing livestock for several reasons, conservation policy that relies on the imperfect assumption that a practitioner's motivations are exclusively driven by economic self-interest is likely to overlook opportunities for behavioral persistence and increased participation (Sorice & Donlan, 2015).

CHAPTER 3: METHODOLOGY

This study conducted an ex-ante conjoint choice experiment to measure Nebraska ranchers' preferences for attributes commonly found in payment for ecosystem programs (PES). For the purposes of this research, "ranchers" refer to cattle producers who own or rent native grassland in the state. Our research was informed by the work of Hansen et al. (2018) who focused on PES with ranchers in Wyoming. Ranchers for this study were recruited through a variety of traditional and nontraditional methods due to the COVID-19 pandemic and health safety protocols. Accordingly, the survey was only available to participants through an online survey platform.

Limitations to in-person gatherings increased our reliance on stakeholder-based organizations such as the Nebraska Cattlemen Association to assist with rancher recruitment for the study. Based on their membership information, we sent invitations to participate in the survey through email, text, and postcards to ranchers operating cow/calf pairs in the state (n=1,548) during two outreach attempts. Additionally, we procured a mailing list from a third-party vendor to send postcard invitations directly to ranchers. Parameters of ranchers engaged in cow/calf operations, on improved pasture or grasslands, of at least 50 acres or more (n=5,743) were selected. These individuals received two postcards (one invitation, one reminder) requesting their participation in the study. We also disseminated invitations for participation through social media, electronic newsletters, and media outlets. With the outreach information that was quantifiable, we determined our study sample to represent 7,291 ranchers in Nebraska.

Limits to in-person gatherings led us to forego all attempts at face-to-face data collection. Our survey was made available only through an online survey platform

(Qualtrics) for a duration of 8-weeks. Our objective was to reach ranchers operating in Nebraska, with various levels of expertise, and different operational capacities. However, determining rancher typology from the limited information we could gather was a challenge. Therefore, we found it appropriate to examine known demographic information about ranchers in Nebraska based on the USDA's (2019) Census of Agriculture, using the North American Industry Classification System (NAICS) standard. This system is the federal statistical standard by which agencies such as the USDA classify a variety of industries, including many of those involved in agriculture.

Using techniques outlined in conjoint choice research, we quantified choice set data to assess marketplace behavior regarding rancher acceptance of PES program attributes. Conjoint choice experiments (CCE), related to conjoint analysis according to Yong (2004), can be traced to random utility theory, discrete choice analysis, and choice modeling. CCE differs from conjoint analysis in that it directly elicits respondent preferences in an effort to better understand the complexities of how products are valued (Louviere & Woodworth, 1983). CCE is sometimes referred to as a discrete choice experiment, but there are noteworthy differences described in the literature. A closer review of these techniques can be found in Louviere et al. (2010).

Attributes in this research refer to the variables that encompass the structural makeup of each hypothetical PES choice set. Study participants were tasked with evaluating a series of choice sets and selecting the most preferred alternative. This allowed us to quantify the perceived value of each attribute with the resulting data informing its "utility" (Yong, 2004). Utility refers to an attribute's relative worth, which can be expressed numerically. Low values indicate low utility and high values represent increased utility. These utilities are useful for conducting preference simulations, revealing an overall preference share for a PES attribute among study participants. We find this to be one of the primary advantages of CCE as the utility reflects "trade-offs" participants must make when formulating decisions that will affect their ranching operations (Yong, 2004).

The variables that were tested in the hypothetical PES programs were based on the structure of those found in USDA conservation programs. Offerings such as the Conservation Stewardship Program are contractual, encompassing a management activity, compensatory payment, and a length of time for which the arrangement is valid (US GAO, 2007). The contract length and payment level attributes used were based on the model study and our feasibility analysis with ranchers, natural resource professionals, and farm policy experts. The management attributes we tested were derived from recommendations put forth in the state's wildlife management plan: the Nebraska Natural Legacy Project (Schneider et al., 2011).

Table 2. *Choice Combinations Based on Contract, Payment, and Management Attributes*

Attribute	Variables tested
Contract length (years)	5, 10, 20
Payment levels (dollars/acre)	5, 25, 50, 100, 250, 500
Management actions	16 total (see Table 4)
Total	288

Note. Contract variables for length (3) and year (6) were adapted from offerings currently found in Farm Bill conservation programs. The variables (16) tested for the management attribute were adapted from the Nebraska Natural Legacy Project (Schneider et al., 2011). This resulted in a total of 288 possible choice combinations.

The resulting attributes and variables (Table 2) in aggregate consisted of 288 choice combinations that were possible (16 management; 6 payment levels; 3 contract lengths). Because of this, we utilized an incomplete confounded factorial design to arrive at the choice sets for testing. A common challenge with CCE, one that we address through incomplete confounded factorial methodology, is it asks participants to rate the entirety of attributes present. In this case, reviewing all 288 program profiles would result in survey fatigue and the emergence of bias in a rancher's selection (Yong et al., 2010). An incomplete factorial design allows us to narrow the total number of profiles presented to a participant, while still testing the main effects of management, payment length, contract duration, and lower order interactions among the three. This technique allows us to elicit responses that are free from subject effect (Kanmongne & Eskridge, 2013).

Survey respondents were assigned to review the choice sets in one factorial array (i.e., block) as a side-by-side comparison of two program profiles. This study examined 128 choice combinations that were represented across eight factorial blocks. These eight blocks were constructed to ensure an even distribution of data across the experiment, allowing us the ability to examine how the three attributes affected participant choices. Within each block, subjects were presented with eight choice sets in which to select their preferred program offering. If a subject did not prefer either program or was unsure about their intentions regarding a choice set, they could select neither.

Participants were also asked a brief series of demographic questions (Table 3) to obtain baseline information about respondents and relative locations in the state. For our purposes, ranchers of all experience levels and operational classifications were of interest. However, one screening question was included to allow those not involved in cattle ranching to self-select out of the survey. As previously discussed, incomplete confounded factorial designs are not conducive to a full estimation of treatment interactions and effects. However, as our interest was narrowly focused on the significance of payment levels, contract lengths, and management actions on preferences, we did not examine correlations of these demographic variables on the programmatic variables we selected for testing.

Table 3. *Demographic Questions Posed to Survey Respondents*

Questions				
Which best describes your grazing operation?	Which zip code(s) are most of these lands located?	How many years have you raised and managed grazing animals?	How would you describe the acres your animals graze on?	How many acres are involved in your grazing activities?

Note. To address survey fatigue and anticipated low response rates, this study was narrow in the demographic information collected. These questions were developed through our feasibility analysis within the ranching and natural resources communities.

A noteworthy difference between this research and the model study was in the management attributes that were tested. Hansen et al. (2018) feasibility analysis drew upon direct consultation with various stakeholders in a targeted study area. For this research, which sought to establish a baseline for management across a much larger geographic region (the state of Nebraska), we adopted management strategies that already received considerable stakeholder review from the Nebraska Natural Legacy Project (NNLP). Of additional relevance was NNLP's emphasis on accentuating biodiversity, a key indicator on the delivery of ecosystem services (Mace et al., 2012; Freese et al., 2014; Goldstein et al., 2011).

Table 4. *Nebraska Natural Legacy Project's Conservation Actions to Address Barriers to Conservation and Stresses Affecting Species and Habitats*

Actions Related to Fire
1. For select grasslands, use patch-burn grazing and other grazing systems that combine the interaction of fire and grazing to mimic pre-settlement disturbances.
Actions Related to Grazing/Haying
2. Use diverse grazing/haying systems on private and public lands that enhance biological diversity and sustain natural communities. Initiate research that evaluates the effectiveness and profitability of biological diversity-friendly grazing/haying systems (e.g., reduced stocking rates, rotational systems).
3. Develop and distribute a "best management practices" guide on grazing that can be used to improve management of grasslands and riparian areas for biological diversity. Include information on sources of technical information, funding programs, wildlife-friendly fencing specifications, etc.
4. Support diverse haying strategies (e.g., on wet meadows) that stagger timing and height of cutting, promote increased plant and animal diversity, and avoid peak nesting periods for grassland birds.
5. Promote the use and availability of locally adapted native seed sources for pasture and rangeland seedings.
6. Promote livestock grazing/haying systems that have built-in drought management contingencies (e.g., grass banking).
Actions Related to Hydrology
7. Promote and provide incentives for the use of wildlife-friendly conservation buffers, grassed waterways, sediment traps, etc. on lands adjacent to wetlands, rivers, streams, reservoirs, and lakes to prevent siltation and protect water quality.
8. Promote the development and use of water conservation measures such as more water-efficient irrigation systems, xeriscape landscaping, water-conserving appliances, etc.
9. Use and promote restoration and management techniques that utilize native, locally adapted species whenever possible. Discourage the use of non-native species in restoration/management projects. Encourage private seed companies to provide local-ecotype seed and harvesting and planting services.
10. Renovate aquatic habitats by removing introduced rough fish to improve water quality, enhance aquatic vegetation and increase biological diversity. | Seek measures that prevent the introduction, breeding, and use of potentially invasive non-native species by nurseries, hatcheries, universities, etc.
Actions Needed to Reduce Habitat Fragmentation
11. Discourage the placement of woody plantings and food plots within natural grassland communities, especially when it will result in increased fragmentation.
12. Provide incentives to private landowners to maintain natural habitats and to cooperatively manage large blocks of habitat as complexes that conserve biological diversity.

13.	Seek to remove or create bypass structures around dams and other impediments that restrict the natural movement of aquatic species.
Actions Needed to Reduce the Impacts of Pollution	
14.	Promote the practice of integrated pest management (e.g., non-chemical controls such as biocontrol and tillage, spot spraying) through outreach and incentives to minimize impacts to biological diversity.
15.	Implement and seek funding for conservation practices such as filter strips, grassed waterways, sediment control basins, and grassed buffers to minimize the effects of fertilizers and pesticides on wetlands, streams, rivers, and reservoirs.
16.	Work with agricultural and conservation partners to prioritize installation of conservation buffers, conservation tillage practices, etc. within watersheds where benefits to biological diversity would be highest.
17.	Promote management practices that limit the impacts of nutrients, sedimentation, bacteria, and pesticides to help protect water quality. Examples include nutrient application on cropland, sediment control on construction sites, incentives for organic farming and low-chemical farming, etc.

Note. Only 16 of the 17 management recommendations were tested as two closely related variables were combined to reduce the total number of choice sets. Adapted from "The Nebraska Natural Legacy Project: State Wildlife Action Plan," by R. Schneider, K. Stoner, G. Steinauer, M. Panella, and M. Humpert, 2011.

The statistical analysis that was employed in this study is based on McFadden's (1974) utility model of consumer choice. This was modified to include the random block effects where each respondent is randomly assigned to one and only one block (Kanmongne & Eskridge, 2013). Specifically, the consumer choice utility is described as:

$$U_{ijkl} = v_{ijkl} + \varepsilon_{ijkl}$$

where:

U_{ijkl} = the utility to subject *l* who chooses alternative (profile) *i* in choice-set *j* within block k;

V_{ijkl} = the predictor component of the utility; and

E_{ijkl} = the residual component.

Here the predictor v_{ijkl} is linear in the parameters and to account for correlation among responses within subjects, it is expressed as a mixed-effect model:

$$v_{ijkl} = \underline{x}'_{ijkl}\underline{\beta} + \underline{Z}'_{ijkl}\underline{u}$$

where:

$\underline{x}'_{ijkl}$ = a vector of attribute levels,

$\underline{\beta}$ = a vector of parameter coefficients for the fixed effects,

$\underline{Z}'_{ijkl}$ = a classification vector for the random effects, and

$\underline{u}$ = a vector of random subject effects.

Since the choices are multinomial (choice 1 or 2 or neither), a multinomial logit link function with the base as the "neither" category (C) will be used as the response of which the predictor was a mixed linear model with the factors as the fixed effects and the blocks as the random effects. Specifically,

$$\text{Logit}\,(p_{ijkl}\ /\ p_{cjkl}\,) \;=\; v_{ijkl} = \underline{x}'_{ijkl}\underline{\beta} + \underline{Z}'_{ijkl}\underline{u}$$

where p_{ijkl} = is the probability that an alternative (profile) *i* in choice-set *j* within fraction *k* is chosen by a random subject *l.*

The logit model above is a generalized linear mixed model and was fit with SAS Proc Glimmix to test for main effects and first-order interactions of the attributes. See Kanmogne and Eskridge (2013) for more details on the statistical analyses of confounded factorial conjoint choice experiments.

CHAPTER 4: RESULTS AND FINDINGS

Using NAICS (North American Industry Classification System) estimates referenced in the USDA's (2019) Census of Agriculture, our sample population constituted 63% of the 11,551 ranches engaged in cattle production on grasslands in Nebraska. Over the 8-week survey period, we registered 251 completed surveys from producers—a 3.5% response rate of our study's sample population. Our geographic assessment (Figure 3) shows respondents were primarily operating in north-central Nebraska (Sandhills region), one of the largest contiguous grasslands in the Great Plains.

In comparison to NAICS data about Nebraska's ranchers, we found our sample population to be reflective of many of the core demographic characteristics outlined. For example, across categories such as ownership, total acres grazed, type of grazing, and average experience, we find the responses in our sample to mirror statewide trends. For example, 52% of participants reported owning grazing lands utilized in their operation with 77% having more than 20 years of experience. NAICS survey data indicates that 54% of ranchers reported owning the lands they grazed and 74% had 11+ years of experience. In comparing the type of lands grazed, we find similar trends with survey 78% of respondents reporting they grazed rangeland compared to 84% of those in the NAICS survey.

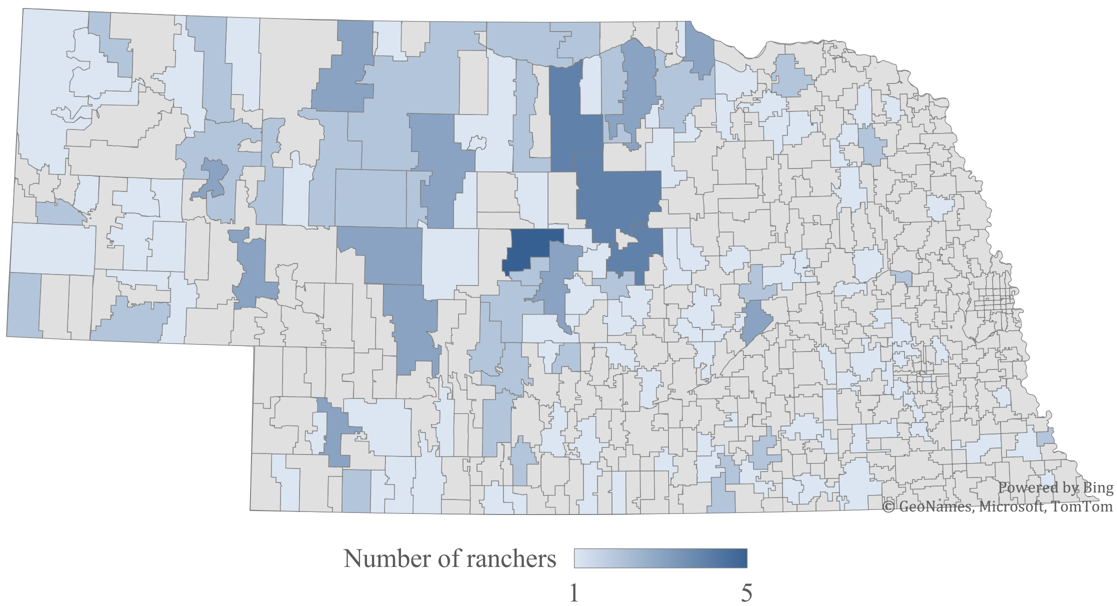

Figure 4. Locations where ranchers had grazing animals, reported by zip code. Up to five zip codes per rancher were allowed.

Ranchers self-identified across many of the demographic classifications that were presented (Table 5). A majority of ranchers in this study reported having 20+ years of experience (77%) while conducting their ranching activities on native grasslands (78%). There was a mix in ownership type with 52% reporting they owned the land they grazed, and 33% reporting they utilized a combination of ownership and rentals to manage their herds. No participants utilized grazing allotments on federal or state land, mirroring the larger trend of private land ownership in Nebraska. Additionally, producers represented many different operational capacities. Approximately 48% of ranchers reported they utilized 1,000 acres or more and 88% of all respondents were involved in activities on >100 acres.

Table 5. *Demographic Comparison of Nebraska Ranchers Using PES Survey Responses and USDA NAICS' Standard*

Characteristic (PES Study)	Ranchers (n = 251)	Characteristic (NAICS Standard)	Ranchers (n = 11,551)
Experience (years)		Experience (years)	
0-5	6.0	0-5	12.6
6-10	7.0	6-10	12.9
11-20	9.2	11+	74.5
20+	77.0		
Land ownership		Land ownership	
Own	52.8	Own	54.3
Tenant	14.0	Part owner	32.2
Combination	33.0	Tenant	13.5
Grazing type		Grazing type	
Grassland	78.6	Pasture or rangeland	84.9
Improved pasture	1.0	Pastured forestland/other	0.97
Pastured forestland/other	3.4		
Ranch by size (acres)		Ranch by size (acres)	
0 to 5	1.8	0 to 9	0.97
6 to 20	1.3	10 to 49	16.0
21 to 50	3.6	50 to 69	3.6
51 to 100	5.5	70 to 99	5.3
101 to 200	9.1	100 to 139	5.0
201 to 500	20.6	140 to 179	5.3
501 to 1,000	14.2	180 to 219	3.2
1,000+	47.7	220 to 259	2.5
		260 to 499	11.9
		500 to 999	11.3
		1,000 to 1,999	9.3
		2000 +	17.0

Note. Data represented as a percentage share of total unless otherwise noted. USDA Census (2019) data utilizes NAICS beef cattle ranching and farming standard. Some classifications differ based on parameter assessments used by the respective studies.

Our experimental model detected an indifference for many of the attributes and variables that were tested. Management attributes, however, were found to have a highly significant effect ($p<0.0001$) on respondents' preferences for a given program (Table 6). This was observed in Type III tests of fixed effects where preference share of management, payment, length, and the combination of the latter two were examined. In an analysis of payment levels and contract lengths, neither had a significant effect on the respondent's preference for the choice sets that were presented. This indicates there was a level of indifference to every individual payment or contract attribute regarding participation in our grassland payment for ecosystem services program.

Table 6. *Fixed Effects Tests of Management, Payment, Contract, and Interactions*

Attribute	Degrees of freedom	F-Value	Pr > F
Management	15	12.34	<.0001
Payment	5	0.70	0.6197
Contract length	2	0.28	0.7540
Payment & length	10	1.65	0.0866

Note. Management actions as an attribute class were found to have significant effects on the rancher preferences for any given choice set. Treatment effects considered significant at $p < .05$.

In the broader context of the 16 management practices tested, 61% of participants preferred management actions that were tied to practices known to improve biological diversity such as reduced stocking rate, rotational grazing, stockpiling (Table 7). Conversely, the least preferred practices were related to the management of water resources on the ranch. Approximately 8% of respondents suggested they were willing to remove structures that restricted water movement or remove species or vegetation that had been introduced. Further, participants did not appear to have strong interests in reducing nutrient or insecticide applications to improve water quality (21.97%).

Table 7. *Ranchers' Preferences for Management Actions as Part of PES Program Offering*

Management action	Estimate	Standard error	T Value	Mean % Share (n=251)	Standard error mean
Use a grazing practice to improve biodiversity	-0.4859	0.1030	-4.72	61.52	.06337
Use grazing/haying systems with built-in drought management	-0.8611	0.1168	-7.37	42.27	.04936
Utilize native, locally adapted species in restoration/management projects	-0.8789	0.1412	-6.23	41.52	.05863
Use a combination of grazing and prescribed fire to benefit wildlife or habitat	-0.8946	0.1200	-7.46	40.88	.04905
Remove or discontinue woody plantings within grasslands or improved pasture	-0.9198	0.1130	-8.14	39.86	.04503
Use adapted native seed sources for pasture and grassland seeding	-1.0427	0.1256	-8.30	35.25	.04428
Incorporate wildlife-friendly fencing in grasslands and riparian areas	-1.2461	0.1371	-9.09	28.76	.03944
Manage grasslands in cooperation with other large blocks of habitat to conserve wildlife	-1.2468	0.1484	-8.40	28.74	.04264
Stagger timing or height of haying to increase plant and animal diversity	-1.4220	0.1400	-10.16	24.12	.03376
Practice integrated pest management to enhance biodiversity	-1.4559	0.1546	-9.42	23.32	.03605
Upgrade or install water conservation measures	-1.5097	0.1457	-10.36	22.10	.03220
Reduce nutrient and insecticide applications to protect water quality	-1.5154	0.1519	-9.98	21.97	.03337
Implement filter strips, grassed waterways, etc. to minimize the effects of fertilizers and pesticides on wetlands and waterways	-1.7263	0.1635	-10.56	17.79	.02910
Incorporate wildlife-friendly conservation buffers for waterways to prevent siltation	-1.7858	0.1633	-10.94	16.77	.02738
Remove structures that restrict the natural movement of aquatic species	-2.4792	0.2379	-10.42	8.381	.01994
Remove introduced "rough fish" or aquatic vegetation to improve water quality	-2.4913	0.2260	-11.02	8.28	.01872

Note. Least squares means converted to percentage share. A mean value near 33.0 would demonstrate indifference for a given attribute variable. Verbiage presented here was condensed for ease of display.

In an examination of lower-order interactions among contract length and payment level, we did not detect significance among these attribute classes or the variables that were tested (Table 8). Additionally, no specific themes about program configurations were apparent (i.e., low payment, short contract length). A leading trend among ranchers in this study was the use of high payments and longer lengths, however, these preferences were not statistically significant among the ranchers we surveyed.

Table 8. *Lower Order Interactions Among Payment, Contract Length, and Combination*

Characteristic	Estimate	Standard error	DF	T Value	Mean (n=251)	Standard Error Mean
Payment (dollars)						
5	-1.5536	0.1343	3613	-11.57	0.2115	0.02840
25	-1.7095	0.1433	3613	-11.93	0.1810	0.02592
50	-1.6468	0.1342	3613	-12.27	0.1927	0.02585
100	-1.5202	0.1354	3613	-11.23	0.2187	0.02961
250	-1.6247	0.1378	3613	-11.79	0.1970	0.02714
500	-1.5671	0.1593	3613	-9.84	0.2087	0.03324
Contract length (years)						
5	-1.6431	0.1233	3613	-13.32	0.1934	0.02385
10	-1.5819	0.1238	3613	-12.78	0.2056	0.02546
20	-1.5858	0.1239	3613	-12.80	0.2056	0.02538
Payment and Length						
$5 per acre for 5 years	-1.5431	0.1709	3613	-9.03	0.2137	0.03652
$5 per acre for 10 years	-1.5354	0.1689	3613	-9.09	0.2154	0.03637
$5 per acre for 20 years	-1.5822	0.1679	3613	-9.42	0.2055	0.03450
$25per acre for 5 years	-1.9399	0.1819	3613	-10.67	0.1437	0.02614
$25 per acre for 10 years	-1.4543	0.1711	3613	-8.50	0.2336	0.03996
$25 per acre for 20 years	-1.7342	0.2213	3613	-7.84	0.1765	0.03906
$50 per acre for 5 years	-1.6341	0.1710	3613	-9.56	0.1951	0.03337
$50 per acre for 10 years	-1.5777	0.1815	3613	-8.69	0.2064	0.03747
$50 per acre for 20 years	-1.7286	0.1701	3613	-10.16	0.1775	0.03021
$100 per acre for 5 years	-1.5186	0.1594	3613	-9.53	0.2190	0.03492
$100 per acre for 10 years	-1.4189	0.1832	3613	-7.75	0.2420	0.04433
$100 per acre for 20 years	-1.6231	0.1953	3613	-8.31	0.1973	0.03854
$250 per acre for 5 years	-1.4886	0.1581	3613	-9.41	0.2257	0.03569
$250 per acre for 10 years	-1.9635	0.1976	3613	-9.94	0.1404	0.02773
$250 per acre for 20 years	-1.4218	0.1751	3613	-8.12	0.2413	0.04224
$500 per acre for 5 years	-1.7343	0.2168	3613	-8.00	0.1765	0.03828
$500 per acre for 10 years	-1.5418	0.1831	3613	-8.42	0.2140	0.03919
$500 per acre for 20 years	-1.4250	0.1978	3613	-7.21	0.2405	0.04756

Note. Pr > |t| = <.0001. Least squares means results based on the experimental model. A mean value near >.33 demonstrates indifference for a given level of an attribute. No variables within payment, contract length, or a combination of the two attributes were significant preferences among ranchers in this study.

CHAPTER 5: DISCUSSION AND RESEARCH NEEDS

Ranchers must account for a growing number of influences if they are to remain successful in the livestock industry. Grassland conservation programs are no different. Government policy, commodity markets, information networks, technology advancements, and other factors may all contribute to a rancher's decision to convert native grasslands to alternative uses. However, our study suggests that the significance of financial incentives used to influence those decisions may be overemphasized.

Few in the livestock or natural resources sectors would argue that compensatory payments are not enticing features to offer ranchers engaged in conservation. However, what we found in the literature and confirmed in our study was its importance may be overstated. In the attributes we tested–management, contract length, and payment level–only management variables were found to have significant effects on a rancher's preference for any given payment for ecosystem services (PES) program. This finding was similarly evidenced in the model study by Hansen et al. (2018), where ranchers self-reported that the nature of the management action and its intended outcomes were of higher importance than the payment level.

Analysis of the relationships among contract lengths and payment levels also yielded no conclusive evidence of the importance to ranchers who participated. Together, these findings suggest the need to offer conservation programs that reflect the challenges of cattle ranching in a natural grassland system. This might also indicate, as the literature confirms, that creating participant flexibility in any program offering is an important design consideration.

This research also provides important clues in how conservation programs can be developed and discussed with ranchers moving forward. For example, using biodiversity both as a metric and a tool for private land conservation. What we discovered is that of all 16 management actions we tested, using grazing to conserve biodiversity was preferred over all other possible program options. This suggests not only that biodiversity is a recognized term within Nebraska's ranching community, but it also indicates ranchers see biodiversity as a management strategy that can coexist with the core business of livestock production.

In a closer examination of the least preferred management actions, we found the lowest to all to be related to the management of water. This is problematic given water's importance in agriculture, conservation, and society. Because our work shows that biodiversity is becoming more familiar conceptually within the ranching community, a conservation program offering like PES might look for more ways to specifically address biodiversity needs in relation to aquatic resource management. For example, rather than consultations on individual impaired species, it may be more effective to highlight the overall net decline of the aquatic ecosystem and what these declines tell us about water quality and landscape health.

It is important to note that there will also be trade-offs to consider in relation to ecosystem service production. For example, raising livestock as a provisioning service may at times conflict with others like pest regulation or pollinator services. To be successful, detection and monitoring must be rigorous to ensure the supply of ecosystem services remains constant and is not prioritized for the delivery of any single service. Not only do these programs need to achieve the measurable conservation and delivery of ecosystem services, but these programs need to enhance profitability and demonstrate congruency with ranching lifestyles.

Our review of the literature also sheds light on the need for PES and other conservation programs to create more intentional feedback loops with ranchers. Local participation and decision-making ability are particularly attractive to ranchers, but notably absent in many of today's conservation offerings (Donlan, 2015). A robust PES program would incorporate stakeholder involvement at several levels (i.e., program design, price negotiations, satisfaction surveys, etc.). This approach mirrors principles laid out in human-centered design and persistence frameworks, ensuring those charged with stewarding natural resources are also protected with technology transfer, financial investment, and localized decision-making ability. With these elements present in the correct proportion, programmatic satisfaction will remain high and bring about the best possibility of behavioral persistence if the option to participate in PES markets remains constant.

The success of a PES program will in part be based on the ability to first meet the needs of livestock producers, then align with other conservation outcomes, and conclude the arrangement with the eventual sale of the ecosystem service (Hansen et al., 2018). In any phase, these programs will see additional benefits by emphasizing ranchers' roles as ecosystem stewards, educating the public and other landowners about the services and marketing opportunities that healthy grasslands provide (Gutwein & Goldstein, 2013). In some cases, PES programs will need to align with pre-existing arrangements or even be started from scratch (Engel et al., 2008). In every situation, programmatic offerings must possess an understanding of local dynamics and support a rancher's freedom of choice in conjunction with their quality of life (Sorice & Donlan, 2015).

Shortcomings of PES Application

There are several concerns about the real-world application of PES programs. There is a philosophical debate: the potential of ecosystems to be engineered for only the most profitable/beneficial services (Redford & Adams, 2009). There are critiques of relevance, ensuring program design and implementation are a net gain for a rancher's bottom line (Didier & Brunson, 2004). There are also questions about fairness and profiteering among the ecosystem service sellers, suggesting that "someone's getting rich off of [ranchers]" (Gosnell et al., 2011, p. 23). Conversely, a publicly-funded approach may create the perception that PES programs are a social safety net for ranchers (Gutwein & Goldstein, 2013). Further yet, there are several examples in the US and abroad where conservation programs were designed in ways that did little to ensure that conservation of species or resources would occur (Wunder, 2006).

Another area of concern surrounds the integration of money and policy. Research has noted that while financial incentives can increase the adoption of a new practice, it does not always lead to the retention of the technique when payments end. Hayes et al. (2014) point to interdisciplinary studies in psychology, agricultural policy, and economics that show directly incentivized conservation can produce short-term gains that may be followed by unintended, long-term consequences (Cardenas et al., 2000; Hellin & Schrader, 2003; Grothmann & Patt, 2005; Vignola et al., 2010). For example, without careful compliance measures, revenue generated from a PES program may create the financial flexibility to invest in agricultural expansion in other areas when the payments end (Goh & Yanosky, 2016). Even more extreme, Engle et al. (2008) point to instances where PES participants engaged in environmentally destructive management to qualify for higher payments later.

Incentive-based conservation is also believed to usher in phenomena such as motivation crowding. This exists when a practitioner's intrinsic motivations to act on behalf of a common good are "crowded-out" because it is believed sufficient compensation is not in place to justify the effort (Frey & Jegen, 2001). Incentives, therefore, model the notion that self-interest is the appropriate action in place of prosocial behavior (Cardenas et al., 2000). Bénabou and Tirole (2003) note incentives are also thought to compromise the role of self-determination, thus making intrinsic motivators no longer necessary. Further, they suggest, a perception may arise that if incentives are needed to perform a task, the activity itself is inherently negative.

There are also structural critiques of PES programs that deserve consideration. Several of these apply because of the large geographical areas grasslands cover. A fallacy of composition becomes an adding-up problem, suggesting what works in one area may not work at other temporal or spatial scales (Skaggs, 2008). Additionally, there are substantial complexities to quantify and verify things like soil carbon sequestration across the spectrum of program participants (Gosnell et al., 2011). "Free-riding" is also believed to occur, wherein some individuals will benefit from the goods produced despite not participating or fully paying the costs that led to its provision (Obeng et al., 2018). In a grassland PES program, the suite of commodities produced and the interactions between them will be difficult to truly ascertain (e.g., biodiversity). This may further increase motivations to free-ride as the number of buyers of any single ecosystem service increase (Gosnell et al., 2011).

With a conservation effort as large as a domestic grassland PES program, there will be a necessity to streamline and maximize efficiencies. However, institutional approaches often are bureaucratic and make participation cumbersome (Gutwein & Goldstein, 2013). For example, in instances of a localized drought, the inability to modify a contractual arrangement could have lasting repercussions to the producer's financial objectives and the integrity of the managed resource. Because ranching is closely tied to the natural environment, programs that fail to address the need for increased flexibility may remain unpopular (Kennedy et al., 2016). Furthermore, ranchers are often opinion leaders in rural communities, and a negative experience could quickly enter local information exchanges and affect program adoption (Gosnell et al., 2011).

Limitations of the Research

A limitation to this research was undoubtedly the medium for which it was distributed. Based on conditions originating from directive health measures and COVID-19, we chose to move the entirety of this survey online. Previous research with ranchers often carries low response rates (Kennedy, 2018; Sliwinski, 2018; Troy et al., 2005). However, our 3.5% response rate likely reflects that the survey was only available in one medium. While we believe certain inferences can be made based on USDA (2019) Census Data, it is problematic to project these findings to all of Nebraska's ranching operations.

There are also limited applications of this research when examining the relationships that may exist among the management, payment, and contract length variables that were tested. As we sought to explore baseline preferences for programmatic structure, we intentionally used a methodology that allowed us to test a wide range of attributes. This provided us an opportunity to explore lower-order interactions, which we believe will be useful for researchers continuing to explore the feasibility of PES programs in Nebraska's grasslands. However, we would urge caution in drawing definitive conclusions about any one specific attribute variable.

Opportunities for Future Research

We believe there are an array of contributions that others can make to further the research of PES programs in Nebraska. First, we find it logical to continue research in this field with practitioners who operate working ranches and are currently engaged in conservation stewardship. Building on studies surrounding ranchers' perceptions of biodiversity and innovation (Sliwinski et al., 2018; Kennedy et al., 2016), an effort to create the sociological framework that moves a PES concept to a human-designed conservation program is a critical need.

Another area of need surrounds the creation of the collaborative trust networks that are inherent to successful PES programs. We believe this can be accomplished through securing research funding, which is part of a leveraged approach to assist ranchers with developing pilot locations statewide. These sites, similar to other sites used for technology transfer, should be equipped to serve as the first information exchanges among potential program participants. These sites need to be accessible, replicable and bring together the cadre of entities that will be needed to make PES successful.

The third and largest need will come from the understanding of how to establish the market-based instruments that will lead to PES adoption. This research will need to cover areas of ecosystem service delivery, monitoring, and compliance, as well as how to market these services in a manner that resembles a commodities market exchange. Furthermore, because healthy grasslands exemplify diversity and complexity, it would only make sense for future research to embody an interdisciplinary approach that bridges natural-world capital with land manager motivations.

Conclusion

As livestock producers attempt to navigate shifting consumer preferences, rising input costs, and turbulent trade relationships, ranchers may be ready for alternative options that can diversify revenue streams and support their quality of life. If that can come from the marketing of non-traditional commodities such as ecosystem services remains to be seen. However, our research shows there is an appetite among ranchers to manage for goals such as biodiversity conservation. Given biodiversity's importance to the health and productivity of grasslands, this has promising implications for future conservation partnerships with ranchers.

Entities interested in grassland conservation may note this research did not find evidence of a statistical relationship between management actions and the compensatory/contract attributes. This suggests that current and future conservation efforts may benefit from allocating more resources to develop programs in consultation with ranchers (i.e., human-centered design), and rely less so on the financial incentives. Furthermore, conservation programs that assist producers with marketing their livestock products as compatible and supportive for wildlife, clean air, and water will find a larger market share among an increasingly urbanized public. If this can be accomplished through sound management and product marketing, creating the additional economic link to supplying an array of ecosystem services could be within reach.

At the surface, PES programs appear to be a dramatic overhaul to current grassland conservation efforts. While PES seeks out innovation and alternative frameworks (e.g., practitioner-orientated, biodiversity conservation), it is important to recognize that there are already mechanisms in place that compensate ranchers for ecosystem services (e.g., protection of water resources). Furthermore, if federal funding and the resulting acres targeted for grassland conservation continue to decline, a new generation of conservation programs must emerge if the full suite of ecosystem services provided by healthy grasslands are to be maintained on the Great Plains. Given the sustained declines to grasslands, it may not be prudent to assume ranchers can or should provide these public benefits without some sort of incentive structure.

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APPENDIX A - INFORMED CONSENT POSTCARD

Dear Participant,

Researchers at the Institute of Agriculture and Natural Resources at the University of Nebraska-Lincoln are collecting information in order to understand Nebraska ranchers' preferences for the design and implementation of grassland conservation programs. The results of this study will help us create a program that will provide economic links between ranching viability and maximum public and ecological benefit.

This web survey is short and should only take about 10-15 minutes to complete. To access the survey online, please go to the link listed below go.unl.edu/grasslands

The information you provide will be kept confidential and only be used for the research purposes of this project. All results will be reported so that no individual can be identified. Your participation is voluntary but greatly appreciated, and you may skip any questions you prefer not to answer. There are no known risks to participating in this survey, and you can refuse to participate at any time without harming your relationship with the University of Nebraska. There are no direct benefits to participation, though your feedback will help develop a grassland conservation program that benefits both the environment and Nebraska ranchers like you.

If you have any questions about the survey, please do not hesitate to contact Kyle Martens who is conducting this survey at 402-472-2660 or kmartens3@unl.edu If you have questions about your rights as a participant, please contact the UNL Institutional Review Board at 402-472-6965 or irb@unl.edu.

Survey link: go.unl.edu/grasslands

Thank you for your time,

Kyle Martens,

Graduate Student and Researcher
School of Natural Resources, University of Nebraska - Lincoln

APPENDIX B - INSTITUTIONAL REVIEW BOARD LETTER

Nebraska University of Lincoln

Official Approval Letter for IRB project #20884 - New Project Form

December 23, 2020

Kyle Martens
School of Natural Resources
FORS 202E UNL NE 685830815

Mark Burbach
School of Natural Resources
HARH 623 south UNL NE 685830996

IRB Number: 20201220884EX
Project ID: 20884
Project Title: Rancher Preferences for Conservation Program in Nebraska Grasslands

Dear Kyle:

This letter is to officially notify you of the certification of exemption of your project for the Protection of Human Subjects. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects at 45 CFR 46 2018 Requirements and has been classified as exempt. Exempt categories are listed within HRPP Policy #4.001: Exempt Research available at: http://research.unl.edu/researchcompliance/policies-procedures/.

o Date of Final Exemption: 12/23/2020
o Certification of Exemption Valid-Until: 12/23/2025
o Review conducted using exempt category 2(ii) at 45 CFR 46.104
o Funding (Grant congruency, OSP Project/Form ID and Funding Sponsor Award Number, if applicable): University, University of Minnesota USDA (Prime Sponsor), OSP project #51663, OSP form #133764; Grant Congruency Review conducted 12/04/2020 BRF

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:
* Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
* Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
* Any protocol violation or protocol deviation
* An incarceration of a research participant in a protocol that was not approved to include prisoners
* Any knowledge of adverse audits or enforcement actions required by Sponsors
* Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
* Any breach in confidentiality or compromise in data privacy related to the subject or others; or
* Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board.

If you have any questions, please contact the IRB office at 402-472-6965.

Sincerely,

Rachel Wenzl, CIP
for the IRB

Association for the Accreditation of Human Research Protection Programs, Inc. Full Accreditation

APPENDIX C - INTERNET SURVEY & IMPLIED CONSENT INTRODUCTION

Nebraska's grasslands are an important ecological and economic resource for Nebraska. These areas provide ranching families with an income, a connection to the land and are often closely tied to family tradition. These lands also provide important habitat for prairie plants, animals, and migratory waterfowl. Despite the many benefits these intact grasslands provide, conversion to other land uses remains common throughout much of the remaining Great Plains grasslands.

Numerous incentives for the conservation of "goods and services" exist for grasslands in the United States. Direct payments for the conservation of these resources are popular among some ranching families. However, in Nebraska, the need for technical and financial incentives to do conservation work is growing and is outpacing the ability to meet demand.

An emerging conservation program that may potentially fill this void is called payment for ecosystem services, or PES. These PES programs assess landowner stewardship practices; identify nontraditional goods produced such as clean water, reduced soil erosion, or wildlife habitat; and then market and sell these goods. Potential buyers often include energy companies aiming to offset their production or development activities, state or local governments seeking to maintain water quality, and nonprofits interested in species conservation.

Contracts for PES are voluntary and function like other programs, such as conservation stewardship program (CSP). One core difference is that PES programs can be leveraged alongside CSP, providing more operating income for ranchers. Additionally, neighbors can form cooperatives pooling their goods together to gain a higher price.

This study seeks to understand what preferences Nebraska grassland managers have for conservation programs. You will be presented with a series two management options with an associated payment level and contract length are presented. Please select which option is the most attractive or select neither.

The information you provide will be kept confidential and only be used for the research purposes of this project. All results will be reported so that no individual can be identified. Your participation is voluntary but greatly appreciated, and you may skip any questions you prefer not to answer. There are no known risks to participating in this survey, and you can refuse to participate at any time without harming your relationship with the University of Nebraska. There are no direct benefits to participation, though your feedback will help develop a grassland conservation program that benefits both the environment and Nebraska ranchers like you.

APPENDIX D: SURVEY SAMPLE QUESTIONS

Please select which of the two management options are most attractive or select neither.

Program A	
Management Practice:	Incorporate wildlife-friendly conservation buffers on lands adjacent to wetlands or waterways to prevent siltation (e.g., grassed waterways, sediment traps).
Contract Length:	10 years
Payment Level:	$50 per acre

Program B	
Management Practice:	Practice integrated pest management (e.g., non-chemical controls such as bio-control and tillage, spot spraying) to enhance biodiversity.
Contract Length:	20 years
Payment Level:	$250 per acre

○ Neither

APPENDIX E: FACTORIAL ARRAY EXPERIMENTAL DESIGN

-- block=1 ---

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
1	1	1	0	15	1	5	0	1
2	1	2	1	14	2	4	0	1
3	1	3	2	13	0	3	1	2
4	1	4	3	12	2	4	1	2
5	1	5	4	11	0	3	2	0
6	1	6	5	10	2	4	2	0
7	1	7	6	9	0	1	0	1
8	1	8	7	8	2	5	0	1

-- block=2 ---

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
9	2	1	1	15	3	4	0	1
10	2	2	2	14	0	1	1	2
11	2	3	3	13	2	5	1	2
12	2	4	4	12	3	4	1	2
13	2	5	5	11	0	1	2	0
14	2	6	6	10	2	5	2	0
15	2	7	7	9	3	4	2	0
16	2	8	0	8	0	2	0	1

-- block=3 ---

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
17	3	1	2	15	3	5	0	1
18	3	2	3	14	0	2	1	2
19	3	3	4	13	3	5	1	2
20	3	4	5	12	0	2	2	0
21	3	5	6	11	3	5	2	0
22	3	6	7	10	1	5	0	1
23	3	7	0	9	1	2	0	1
24	3	8	1	8	4	5	0	1

-- block=4 ---

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
25	4	1	3	15	1	5	1	2
26	4	2	4	14	1	2	1	2
27	4	3	5	13	4	5	1	2
28	4	4	6	12	0	3	2	0
29	4	5	7	11	1	2	2	0
30	4	6	8	10	4	5	2	0
31	4	7	1	9	0	4	0	1
32	4	8	2	8	1	3	0	1

-- block=5 --

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
33	5	1	4	15	0	4	1	2
34	5	2	5	14	1	3	1	2
35	5	3	6	13	0	4	2	0
36	5	4	7	12	1	3	2	0
37	5	5	0	11	0	5	2	1
38	5	6	1	10	1	4	0	1
39	5	7	2	9	2	3	0	1
40	5	8	3	8	0	5	1	2

-- block=6 --

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
41	6	1	5	15	1	4	1	2
42	6	2	6	14	2	3	1	2
43	6	3	7	13	0	5	2	0
44	6	4	0	12	1	4	2	0
45	6	5	1	11	2	3	2	0
46	6	6	2	10	1	5	0	1
47	6	7	3	9	2	4	0	1
48	6	8	4	8	0	3	1	2

-- block=7 --

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
49	7	1	6	15	2	4	1	2
50	7	2	7	14	0	3	2	0
51	7	3	0	13	2	4	2	0
52	7	4	1	12	0	1	0	1
53	7	5	2	11	2	5	0	1
54	7	6	3	10	3	4	0	1
55	7	7	4	9	0	1	1	2
56	7	8	5	8	2	5	1	2

-- block=8 --

Obs	block	pair	mgt1	mgt2	pay1	pay2	length1	length2
57	8	1	7	15	3	4	1	2
58	8	2	0	14	0	1	2	0
59	8	3	1	13	2	5	2	0
60	8	4	2	12	3	4	2	0
61	8	5	3	11	0	2	0	1
62	8	6	4	10	3	5	0	1
63	8	7	5	9	0	2	1	2
64	8	8	6	8	3	5	1	2