SOCIAL CONSIDERATIONS FOR THE MAINTENANCE OF ECOSYSTEM SERVICES IN AGRICULTURAL LANDSCAPES

A Dissertation

by

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ABSTRACT

Global reports citing declining biodiversity have resulted in calls for an increased focus on private lands' role in biodiversity conservation. Conservation in private lands can be thought of as an integrative, socio-ecological challenge. Given the impacts that private land management practices can have in agricultural lands, understanding the factors that contribute to landowners' management decisions can be especially important. Ecosystem services, and in particular cultural services, have been employed as a way to account for the contributions of ecosystems to human well-being and embed people within their environment. Using ecosystem services as a framework and a mailed questionnaire, my dissertation examined the relationship between: landownership motivations and land management activities with consideration of demographic factors; social factors that are associated with coordination of land management activities that have the potential to scale up conservation activities; and incorporation of ecosystem services into conservation planning to understand their distribution and account for tradeoffs associated with different approaches to conservation programs in the Teas Gulf Coast Prairie. I identified that landowners who had higher place-based motivations were more likely to be actively engaged in wildlife-centered land management practices than those with landownership motivations more focused in other areas. I also observed that landowners who consulted with professionals, had larger, more diverse consultation networks and more civic engagement were more likely to increase their land management coordination or coordinate with their neighbors. I identified the presence

and distribution of Cultural Biodiversity in the GCP. Cultural Biodiversity reflects the values that people attribute to wildlife, both via management and recreational hunting. When considering Cultural Biodiversity in conjunction with conservation value, it becomes apparent that in the GCP, conservation strategies that engage intrinsic and extrinsic motivations are needed to most effectively and efficiently engage landowners. Taken together, my dissertation research highlights the importance of considering cultural ecosystem services and contributes to the emerging dialogue about the contribution of landowner-centered approaches to understanding social-ecological systems and for informing policies. My dissertation also highlights how relational values can provide an avenue for future research that considers the embeddedness of humans and their environment.

DEDICATION

For Kristin, Enzo and Ari.

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1. INTRODUCTION

We are now in the Anthropocene, an epoch when anthropogenic forces have exceeded natural ones in driving global cycles (Steffen et al., 2007). This new era is having a profound influence on the earth's biota; globally, species extinctions are occurring at an unprecedented rate (Díaz et al., 2006; Steffen et al., 2007; Rockström et al., 2009). It is estimated that global biodiversity has been in a substantial decline for the past 40 years, and some argue that we have entered the sixth mass extinction (Butchart et al., 2010; Barnosky et al., 2011). During this time, the rate of decline has not decreased and despite conservation efforts, on average, the threat of extinction has increased (Butchart et al., 2010). Importantly, these declines are taking place in the context of policies that translate into increased extinction threat for the world's biodiversity but with a slowed human response (Butchart et al., 2010). Given this trajectory, current policies focused solely on increasing the extent of conservation lands are not adequate to arrest biodiversity loss now or in the future.

Agriculture is a major environmental disturbance worldwide that underlies the Anthropocene. Agricultural lands, the world's largest land use, account for approximately 38% of non-ice global land cover (Ramankutty et al., 2008; Foley et al., 2011). Some ecosystems have been disproportionately affected by agricultural conversion, including over half of savannah and grassland ecosystems (Ramankutty and Foley 1999). Furthermore, the global extent of agricultural lands is increasing and is expected to continue to expand in the upcoming years (Tilman et al., 2002). At broad spatial and temporal scales, population growth is a key factor in agricultural land expansion (Ehrlich et al., 1971; Waggoner and Ausubel, 2002; Lambin and Meyfroidt, 2011), while at smaller scales consumption patterns can play a role (Foley et al. 2011). Estimates of human population growth indicate that food production is one of the foremost challenges of this millennium, as food demand is expected to double by 2050 (Ericksen et al., 2009; Godfray et al., 2010). Technological advances in agriculture have translated into increased yields that have helped land conversion to increase at a slower rate than the growth in food demand, but these advances have been associated with an increase in intensification (Matson et al., 1997; Ramankutty et al. 2018). Intensified agriculture results in highly altered ecosystems that adversely affects ecosystem processes (Matson et al., 1997). As forecasted increases in food demand continue to manifest, additional stress will be placed on already declining biodiversity. Strategies that set aside land for nature comes at the expense of other potential uses which can result in significant reductions in regional and global food production (Lambin and Meyfroidt, 2011; Mehrabi et al. 2018). Such tradeoffs have resulted in debates as to whether conservation can best be achieved by setting aside protected areas or working to provide habitat within agricultural lands (Phalan et al., 2011; Fischer et al. 2014).

Global reports citing declining biodiversity have resulted in calls for an increased focus on all lands that can play a role in biodiversity conservation (Miller and Hobbs, 2002; Leemans and de Groot, 2003a; Díaz et al., 2006; Rockström et al., 2009; Butchart et al., 2010; Durán et al., 2014). A substantial proportion of biodiversity is found within agricultural lands, and given agriculture’s global extent it is clear that these lands will continue to play a substantial role in biodiversity conservation outcomes in the future. How agricultural lands affect biodiversity is complex. It is argued that factors such as location, spatial orientation, type of agriculture and agricultural extent are important considerations in this evaluation and that these impacts are scale dependent (Fahrig et al., 2011). The complexity of the factors, scale and their interactions means that there is room for argument regarding which approach to agriculture can best achieve the goal of food provisioning and biodiversity conservation now and into the future (Phalan et al., 2011, Tscharntke et al., 2012).

Underlying the discussion of how to achieve conservation benefits in agricultural lands are both theoretical considerations of social and ecological processes, ultimately, conservation in these lands can be thought of as an integrative, socio-ecological challenge (e.g., Tscharntke et al., 2012; Fischer et al. 2014; Landis 2017). From an ecological standpoint, it is necessary to understand the effects of agriculture on biodiversity across taxa, under different cultivation regimes and landscape configurations to identify underlying processes that are occurring and which groups of species are likely to be affected (Fahrig et al., 2011). In and of itself, this is a complex question that seems to be context specific, but with some emerging patterns (Landis 2017). One such pattern is that functional types of organisms are differentially affected; generalist species are able to persist in agricultural lands, which may translate into communities that are less diverse with an overall loss of specialist species (Hurst et al., 2013). Some of these effects can be mediated by incorporation of natural or semi-natural vegetation into the cultivated areas (Andrén, 1994, Fahrig et al. 2011). Furthermore, some species are more susceptible to the impacts of habitat fragmentation than others (Andrén et al., 1997; Mac Nally et al., 2000; Fahrig, 2003).

Given the impacts that land management practices can have in agricultural lands, understanding the factors that contribute to landowners' management decisions can be especially important. Furthermore, many agricultural landscapes are home to species that are already imperiled without adequate public lands to ensure species viability (e.g., Attwater's prairie chicken; *Tympanuchus cupido attwateri*; USFWS, 2010), or the amount of public land within a landscape is insufficient for ecosystem processes to occur, which further increases their importance. In general, agricultural landscapes are not primarily publicly held, and thus any conservation program or initiative must rely on policies that seek to voluntarily engage landowners in land management behaviors that provide conservation benefits (e.g., Tscharntke et al. 2005). However, landowner decisions are not made in isolation, but rather in relation to their social environment.

Landowner decision-making is highly heterogeneous and complex. Researchers have shown that economic factors are not the only elements that contribute to landowner decisions (Koontz, 2001), and that a full range of social psychological considerations are likely employed during the decision-making process (Lindenberg and Steg, 2007; Lubell et al., 2013). Understanding some of the key factors that contribute to a landowner's decision to engage in behaviors can inform the design of policies, programs and the processes by which they are undertaken ultimately leading to conservation benefits (e.g., Ma et al. 2012; Sorice et al. 2012). Agricultural landscapes directly illustrate the coupling between their social and ecological systems; the linkage between the ecological effects of land use, social interactions, policies and landowner behavior and the resultant outcomes. Understanding landowners, their motivations, social environment, values and land management behaviors can contribute to an understanding of social-ecological systems in an agricultural context and, ultimately applications that can increase or maintain the ecosystem services that these landscapes provide.

1.1. Conceptual Frameworks

1.1.1. Ecosystem services

Ecosystem services are "the conditions and processes through which natural ecosystems, and the species that make them up sustain and fulfill human life" (Daily, 1997, pg. 3). Thus, ecosystem services have been employed as a way to demonstrate the linkage and reliance that humans have with their environment. There are 4 categories of ecosystem services that pertain to different forms of connection: provisioning (e.g., food, raw materials, medicinal resources), regulating (e.g., climate, air quality, wastewater treatment storm moderation), supporting (e.g., habitat and genetic diversity), and cultural (e.g., recreation, aesthetics, spiritual experience; de Groot et al., 2002). Many services extend beyond the specific location into which they originate and provide benefits to society-at-large. In this regard, ecosystem services are a pragmatic way to connect society to ecosystem processes, reflecting the myriad ways that humans relate to and rely on their environment. Since the inception of this concept, ecosystem services have had a utilitarian purpose, and have been used to translate natural processes for cross-disciplinary incorporation into decision making (Costanza et al., 1997; Daily, 1997).

In the first attempt to account for the contributions of ecosystems to human well-being, Costanza et al. (1997) translated ecosystem services into a monetary value so policy makers had a metric to account for their contribution in relation to economic services and manufactured capital, to help reduce their treatment as externalities. This analysis synthesized valuation studies based upon replacement costs and willingness to pay to arrive at a valuation for each ecosystem, which resulted in a cumulative ratio of ecosystem services to world Gross National Product as 1.8 to 1 and a total value of $33 trillion. Since its publication, there has been much more focus on ecosystem services with substantial effort devoted to valuations (de Groot et al., 2010; de Groot et al., 2012, Yi et al., 2017).

Following Costanza et al. (1997) the next most comprehensive assessment of ecosystem services was conducted as part of the Millennium Ecosystem Assessment (MA; MA, 2005). Again, a key goal was to explicitly connect ecosystem services to human wellbeing in an accessible way for policy makers, which provided an evaluation of the strengths of the linkages between ecosystem services and the potential for mediation of these linkages by socio-economic factors. Thus, in the MA the focus was more qualitative, focusing on the change in ecosystem services rather than an explicit valuation and relating them to the Millennium Development Goals. By modeling different management scenarios, the MA demonstrated how policy approaches could help conserve and restore ecosystem services. The MA highlighted the unsustainability of the global trajectory by showing the increase in demands placed on ecosystem services and also their degradation.

General arguments against the valuation of ecosystem services center upon their inherently utilitarian approach to understanding and valuing ecosystem processes. In a review of critiques of the ecosystem services concept, Schröter et al. (2014) found 7 commonly supplied arguments and rebuttals. These critiques were related to environmental ethics, conservation strategies and the science-policy interface. In my discussion of ecosystem services, the most salient critiques are centered on valuation, commodification and payment for ecosystem services (PES), and environmental ethics. The critiques of valuation are centered on economic framing, which argue that treating ecosystem services as functions can lead to commodification of nature. However, some argue this critique draws too stark of a conclusion, there are different degrees to valuation. As Gomez-Baggethun and Ruiz-Perez (2011) state: "The key difference between economic framing of the environment and valuation resides in the distinction between goods/services and commodities, and between use value and exchange value" (pg. 623). They also stress that economic valuation has utility to serve as a tool as a part of evaluations, potential to contribute to innovation in conservation approaches, and utility to reinforce the conceptualization that "ecosystems are not only a matter of ethics and aesthetics, but also a basic condition for human life and subsistence (Gomez-Baggethun and DeGroot, 2010)" (Gomez-Baggethun and Ruiz-Perez, 2011, pg. 624). Furthermore, as the MA demonstrates, more qualitative approaches to valuation can yield policy insights.

Value is an inherently relative term. Valuations are frequently appropriate for specific livelihood circumstances and these differences need to be controlled for when comparing values from different locations (de Groot et al., 2010). Furthermore, values may be underestimated for people that are highly dependent on the service; ecosystem services often form a safety net which people rely on to survive during times of scarcity (Leemans and de Groot, 2003). The values of services can fluctuate. For some services, values can be very high regardless of circumstances, and theoretically values may approach infinity especially as quantities of essential services approached zero (McCauley, 2006). This is especially the case for supporting and provisioning services. For example, the provision of oxygen would be such a case. An ecosystem service for one may be a disservice for another. whether an ecologic process results in a service (or disservice) largely depends on the standpoint from which it is experienced (Zhang et al., 2007; Dunn, 2010; van Dohren and Haase, 2015). There has been an increase in the number of studies that have documented ecosystem disservices and they have been found in ecological, economic, human health, psychological and general realms (van Dohren and Haase, 2015). Thus, too much emphasis should not be placed on specific valuations and considering services from a systems perspective can help understand the interaction between services.

As Costanza et al. (1997) point out in these instances, it may be beneficial to evaluate how changes in the quantity or quality of ecosystem services affects human welfare rather than valuation, relative comparisons can be useful and applied to policy-related questions. Since the MA there has been a concerted effort to tie biodiversity to human well-being and the need for conservation action and further research to evaluate these relationships with application in mind. For example, Diaz et al. (2006) explicitly links the importance of biodiversity to the livelihoods of many of the most vulnerable populations. Additionally, Cardinale et al. (2012) and Isbell et al. (2011) found a consensus in the literature that biodiversity loss adversely affects ecosystem services. It has also been found that “the types, the range and especially the relative abundance of functional traits in biotic communities” (Bello et al., 2010, pg. 2884) are associated with ecosystem services (Cardinale et al. 2012). Furthermore, bundles of these traits are associated with specific ecosystem services providing a basis for management.

A commonly invoked critique associated with valuation of ecosystem services is centered on their commodification and the resultant outcomes, such as PES. In this critique, the idea of valuation is extended to the point of commodification, which raise concerns that nature will only be conserved when it has monetary value for humans negating, or crowding out, intrinsic motivations for conservation (McCauley 2006). This commodified approach can result in ecosystems and their processes being captured by market forces. Furthermore, there is the potential that the estimated price may not be the true price and so actual value is misrepresented (Wittmer and Gundimeda 2012). However, as Costanza et al. (1997) argues, choices involve valuation either implicitly or explicitly. In these instances, economic valuation may be the best option to help evaluate potential tradeoffs and policy alternatives, helping to make the externalities visible (de Groot et al., 2010). However, rebuttals to this critique mirror those associated with valuation, but perhaps because PES are more closely tied to implementation they should be viewed specifically as a tool that can be used to yield conservation benefits when specific conditions are met (Wunder 2013). The development and reliance on markets and market-based mechanisms should not be blindly embraced, but rather these approaches should be informed by science-based approaches. An overly strong reliance on market-based mechanisms can result in short-term benefits at the cost of long-term outcomes. One such area that has garnered a significant amount of research is PES schemes.

The environmental ethics critique is associated with the philosophical justification for environmental conservation and whether actions should be undertaken for anthropocentric or biocentric values. This is a more philosophical critique, but still grounded in valuation and commodification. Some have highlighted the potential shift that ecosystem valuation represents from conservation as a moral decision to one that is utilitarian or economic and the implications of such monetization that could eventually lead to services or biodiversity being on the wrong end of the equation or being privatized (de Groot et al 2012; Wittmer and Gundimeda 2012). One of the outcomes of the ecosystem service-based approach is the formation of markets or market-based approaches for conservation action, which may not be appropriate for some cultural contexts (Wunder 2013). However, it is argued that approaches that draw attention to cultural services have potential to include intrinsic values (Callicott 2006 as in Schroter et al. 2014).

Cultural ecosystem services have increasingly been advocated as a way to include values that are not as directly tied to utilitarian relationship with human well-being (e.g., Chan, Guerry et al., 2012; Daniel et al., 2012; Fish et al. 2016). Cultural ecosystem services are services that result in cultural values and benefits that may include, spiritual, recreational, therapeutic, aesthetic and knowledge derived from a landscape or ecosystem (Costanza et al., 1997; Daniel et al., 2012; De Groot et al. 2010). These services are generally less prone to economic valuation and substitution because they are associated with non-material, intangible benefits that are context dependent (Chan et al. 2012, Daniel et al., 2012). Cultural ecosystem services can be more complicated to consider within the ecosystem service framework, because they are derived in relation to the social sub-system to a greater extent than other ecosystem services (Daniel et al. 2012). Cultural services can be thought of as deriving from the symbolic meanings that are attributed to a landscape (Kirchhoff, 2012). In this way, the service is not derived as a direct relation to the service or ecosystem in question, rather the service results from an interpretation of a symbolic landscape that is not directly resulting from the ecosystem itself but rather from "aesthetic-symbolic objects." From this perspective, not all cultural ecosystem services should be placed within the ecosystem services framework. However, it is clear that many cultural services are derived from the landscape in which they are found, where the cultural symbolism evolved or where place attachment developed (Daniel et al., 2012). Regardless, of how they are ultimately dealt with, it is clear that cultural services are important to consider, and derivation of their value is more abstract than for other service types. In this regard, their perception becomes even more notably relative and tied to the perspective and context of a specific group or entity.

When considered together, the critiques and rebuttals associated with ecosystem services highlight that they are not a panacea, but have utility as a way to conceive of the relationship between human well-being and the environment. Thus, ecosystem services should be pragmatically employed in conjunction with other values to achieve specific conservation and policy outcomes. One such application is to rely on ecosystem services to conceptualize the linkage between people and their environment within some Social-Ecological Systems (SES) models and also more generally as a practical translation of ecosystem processes into an anthropocentric form. Understanding the linkages between sub-systems in a SES is one of the keys to understanding their dynamics and to adequately link sub-components, the linkage must share characteristics with both systems, serving to translate one system's outputs into another's inputs and vice versa. The linkage thus must embody a translational quality. In this regard, the integration of many social ecological systems has been outlined using the concept of ecosystem services.

1.1.2. Social-ecological systems

Understanding the relationship between social and ecological systems is a challenge that has received significant research interest in the last 20 years (Berkes et al., 2000; Turner et al., 2003; Chapin et al., 2010). Fields developed in the 1980's and 1990's that were concerned with human-environment relationships, including political ecology, conservation biology, ecological economics and aspects of human geography, among others (Soulé, 1985; Daly and Farley, 2011; Robbins, 2011), developed their own approach to conceptualizing interrelationships. This has resulted in limitations within each field due to the emphasis of individual aspects of their focal systems and on disciplinary scope (e.g., conservation biology focus on biodiversity). This has inhibited integration across disciplines due to a lack of common concepts and terminology (Ostrom, 2009). In an ongoing process that began in the 1990's, there has been substantial effort to understand the relation between ecological and social systems and to incorporate them into cohesive frameworks; at least 16 such frameworks having been developed (Binder et al., 2013).

One of the most commonly cited reasons for this research interest is the goal of increasing the knowledge that can be gleaned from disparate research fields in an effort to more effectively and sustainably manage resources (Ostrom, 2009). In this regard, the development of an overarching framework through which to examine social-ecological systems is a challenge that has been identified as needing resolution to increase the understanding and sustainability of social-ecological systems (Collins et al., 2011). One of the biggest hindrances to the understanding of social-ecological systems is the lack of a common terminology through which to describe processes that are occurring (Brondizio et al., 2009). As a framework, the use of a common language can help move towards a common understanding of the system dynamics in relation to the key components of the systems (McGinnis and Ostrom, 2014). There are several difficulties that are inherent in relating different components of a system, namely a mismatch in the scale at which system dynamics/analysis is appropriate, and the perspective from which the system is approached. As such, SES can best be thought of as a framework that can serve to unite different theories in a way that allows for communication across traditional disciplinary boundaries (McGinnis and Ostrom, 2014).

Across the different fields, what has become common is embedding the considerations of the social and ecological systems together as subject to equivalent processes that leads to general patterns within the different systems. The study of social-ecological systems is transdisciplinary, integrative and has developed in different primary fields of study and has been based in Panarchy theory (Gunderson and Holling, 2002) and complexity theory (Norberg and Cumming, 2008). As such, there has been a diversification in the emphasis that has been placed on different aspects of the system. In general, SES research has focused on understanding system dynamics and ways in which to understand their vulnerability, increase their resilience, and sustainability (Berkes et al., 2000; Anderies et al., 2004; Walker et al., 2006). Within these areas SESs have sought to apply a systems-based approach across the different domains to develop a conceptualization that yields common understanding or "diagnosis of sustainability" (McGinnis and Ostrom, 2014).

Researchers have proposed some general principles for SESs (Gunderson and Holling, 2002; Walker et al., 2004; Walker et al., 2006, Liu et al., 2007). SESs seek to model and describe collective social action and ecological dynamics in a complex system with multiple stable states that are the result of non-linear dynamics and thresholds (Liu et al., 2007). Additional concepts associated with SESs include: multiscalar dynamics, panarchy and the nestedness of the adaptive cycle, resilience, and transformability (Gunderson and Holling, 2002; Liu et al., 2007; Walker et al., 2004, Walker et al., 2006). From these general characteristics, more concrete propositions can be drawn, which include, among others: fast and slow variables interact across temporal and spatial scales; SES dynamics are mostly attributable to a relatively small number (3-5) variables in a given scale); and diversity (functional and response) plays a role in ecosystem dynamics (Walker et al., 2006). Resilience is the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004)." Related to resilience is adaptability. Walker et al. (2004) highlight that SESs are dominated by human action and thus have the ability to adapt the systems to their desired outcomes, or more generally actors within a system can transform it to an alternate state.

Inquiry into SESs is marked by a systems-based approach. The overall dynamics of the system are based upon an understanding of SES as a series of interconnected subsystems much in the way that biological organisms are understood (Ostrom, 2009). Although the subsystems can be understood in isolation, much useful information is learned from understanding the interrelationships among the different subsystems. When considered as a whole, complex systems may exhibit emergent properties. Furthermore, much as human health is composed of many interrelated criteria, so is the integrity or "health" of an SES composed of many criteria from different sub systems (e.g., Turner et al., 2003).

Inherent in the conceptualizations of SESs are the feedbacks among the different framework components and sub-components. Disciplines have organized the relationships among the sub-components differently. For example, in ecological economics, systems are arranged in a nested fashion based upon their scale, reflecting the hierarchical nature of SESs. Conversely, the Institutional Analysis and Development (IAD) framework focuses on the different subcomponents that include resources, resource system, users and governance structures, which are embedded in larger social and ecological, reflecting the interest in governance (Ostrom, 2009). Conversely, Collins et al. (2011) outline social systems and ecological systems composed of different functions, structures and processes (Figure 1.1). The different systems are linked by disturbances and ecosystem services and placed within a larger context of external drivers. Feedbacks are essential to create the linkages that allow the different properties of SESs to emerge. However, in order to ensure that the connections are translatable, conceptualizations that bridge the sub-domains are necessary. As such, this translation needs to account for and link the impacts in one area with those in another. Within these different conceptualizations, the key area of differentiation is the way in which they connect the model's sub-components/sub-systems. In this regard, ecosystem services provide an apt conceptualization that ties human well-being to ecosystem processes. Several, SES models incorporate ecosystem services (Leemans and de Groot, 2003; Redman et al., 2004; Daily et al., 2009; Collins et al., 2011).

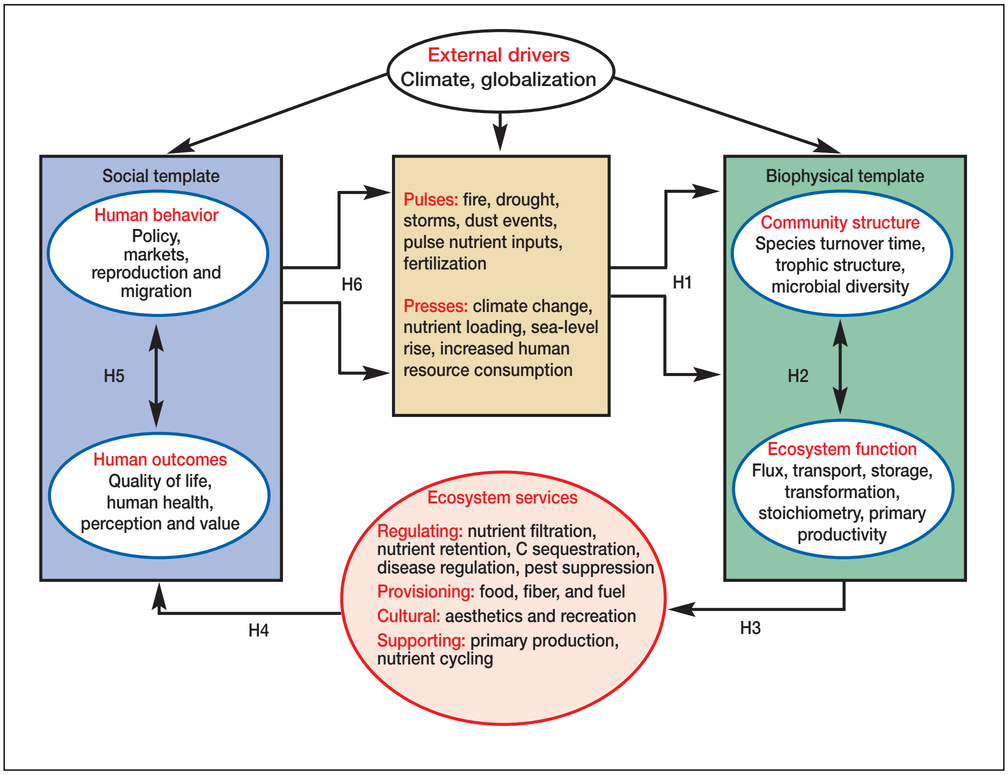

Figure 1.1 Schematic representation of the Pulse-Press Dynamics model (reprinted from Collins et al., 2011).

Although, ecosystem services in and of themselves are considered a SES framework they do not outline social dynamics (Binder et al., 2013). In the early iterations, frameworks were concerned with valuation and making clear the relationship and reliance between ecosystems and human well-being (e.g., Costanza et al., 1997, De Groot et al., 2002; MA 2005). These frameworks have utility for guiding policy and providing an inclusive approach to valuation. These approaches have limitations, however, in that they do not describe the dynamics between the social and ecological systems. Others have expanded on the ecosystem services approach to help account for some of the dynamics and processes of the system. The Sustainable Rangeland Roundtable's Integrated Social, Economic, and Ecological Conceptual (ISEEC) framework is a framework that relies on ecosystem services to gauge the effect of human disturbance in rangelands in a way that can be systematically compared between regions (Fox et al., 2009). In the ISEEC framework, ecosystem services serve as the key link between the biophysical and socio-economic impacts of different activities that ultimately lead to changes in the capital (natural, social, economic) of the rangelands. This framework has been applied to the study of energy production, where specific ecosystem services and their indicators were identified as they related to key linkages within the ISEEC framework which demonstrates the utility of integrating system dynamics beyond just valuation (Kreuter et al., 2012).

As conceptualizations such as the ISEEC demonstrate, the location of the ecosystem services as a connection between the social and biophysical and their ability to be measured via proxies makes them good foci for investigations that seek to explicitly link or embed humans with their environment. The Pulse Press Dynamics (PPD) model developed by Collins et al. (2010) uses both ecosystem services and push-pull ecosystem dynamics to link social and ecological systems in a framework (Figure 1.1). In the PPD model, there are four major components: social systems, press and pulse events, biophysical systems and ecosystem services that are affected by external drivers. In turn, the social system is composed of human behavior and human outcomes. The social system is related to the biophysical system via pulses and presses. Pulses are short-term events and presses are longer duration shifts. The biophysical system is composed of community structure and ecosystem functions, which are related to the social environment via ecosystem services. Ecosystem services can take four different forms: regulating, supporting, provisioning and cultural. Social and ecological drivers can act upon the system at broader scales. The PPD model focus on processes and their social and ecological outcomes. The relationships between the different components is what is important. Unlike other models, the PPD incorporates external factors into the model and allows for variable temporal interactions via the pulse and press drivers. The PPD model has been parameterized effectively for the examination of different SESs (e.g., Collins et al., 2011; Gardner et al., 2013; Wilcox et al. 2018).

The PPD is especially suited to describing the implications and relationships among variables in relation to temporal shifts. The PPD is particularly apt at describing how the social template (or sub-system) affects presses that affect the biophysical template and vice versa, making clear that human behavior can affect ecosystem processes. However, the PPD framework is less effective for illustrating the relationship of cultural ecosystem services within each of the sub-systems. Cultural ecosystem services have been underrepresented in the consideration of ecosystem service valuation (de Groot et al. 2010; Chan et al., 2012). Recent efforts have been made to conceptualize cultural services in SES frames or in "environmental settings" (e.g., Church et al. 2011; Fish et al., 2016). These models complement the PPD model by providing a clearer explication of the complex relationships among the ecological and social sub-systems, highlighting the unique nature of cultural services when compared to the other types of ecosystem services which the PPD simplifies (Figure 1.2). In particular, cultural services are related to both environmental spaces and cultural practices, or more generally the physical and abstract, constructed landscapes that are constrained by the biophysical domain in which they are found (e.g., Kirchoff 2012).

With the conceptualization of Social-ecological systems as a network of sub-systems, understanding the relationships among them can contribute to the understanding of the larger system (Ostrom, 2009). My dissertation examined the linkages among the social and ecological systems in the Texas Gulf Coast Prairie (GCP) with the PPD framework as a guide. Although not a comprehensive delineation of the framework, when taken together my analyses will contribute to an understanding of the dynamics between social and ecological systems and the resultant landscape implications for the GCP. In particular, I examined the relationship between: 1) landownership motivations and land management activities with consideration of demographic factors; 2) social factors that are associated with coordination of land management activities that have the potential to scale up conservation activities; and 3) incorporation of ecosystem services into conservation planning to understand their distribution and account for tradeoffs associated with different approaches to conservation programs. Each of these aspects of my dissertation are presented in the subsequent three chapters, respectively.

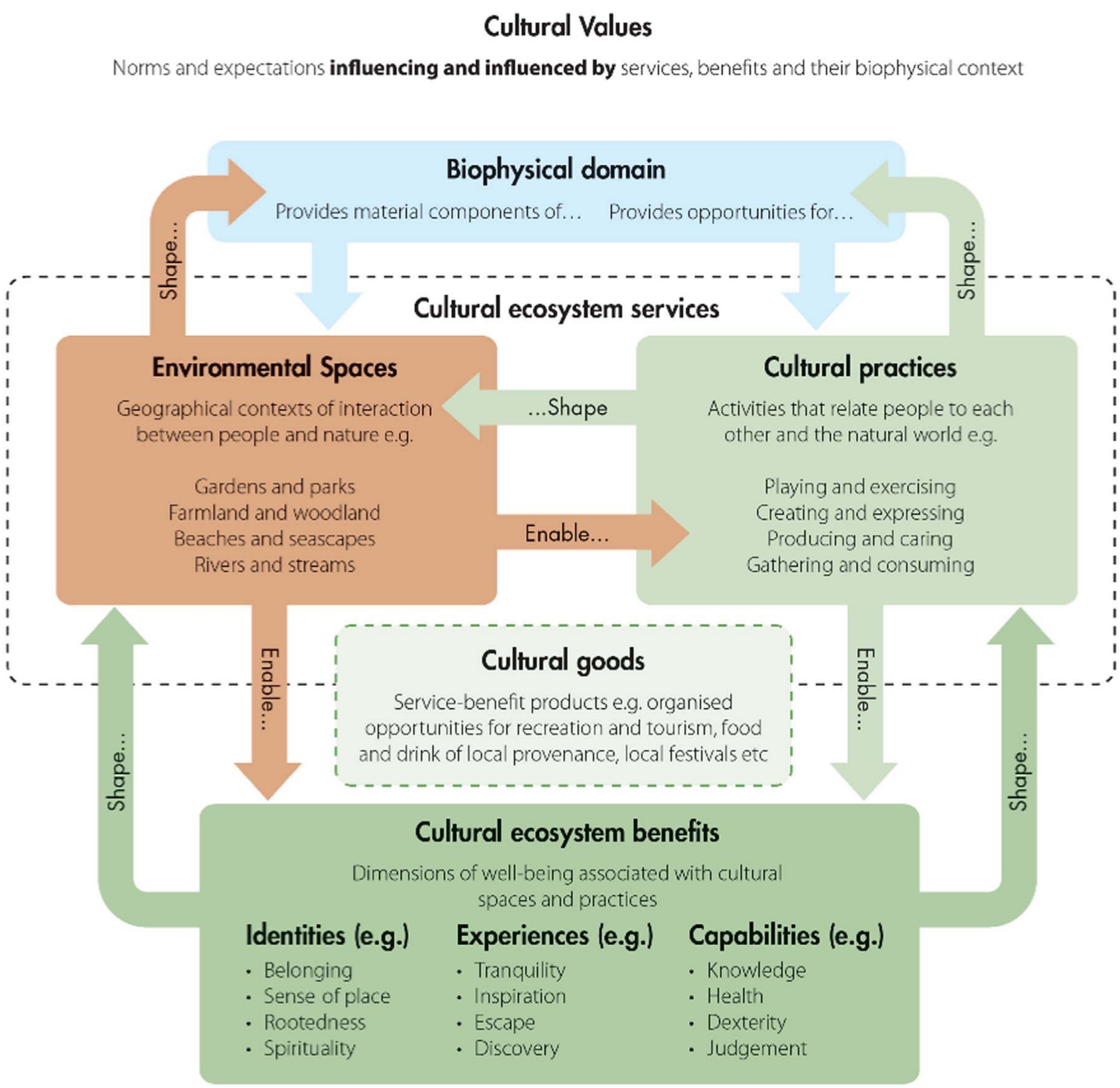

Figure 1.2 Conceptual framework of cultural ecosystem services (reprinted from Fish et al. 2016).

Although based in the ecosystem services approach and PPD framework to understand the linkages among the social-ecological systems, my dissertation also focuses on some of the emergent qualities associated with the connections and linkages outlined in SES frameworks. There has recently been a call to consider relational values that are embedded in SESs (Chan et al. 2018). Relational values are associated with human well-being that is derived from the relationship of humans with nature and are the "constitutive" result of humans, nature, and their relationship (Chan et al. 2018; Knippenberg et al. 2018). My study of landowners' relationship with their land and the broader SES can inform the study of relational values (e.g., Allen et al. 2018). In particular, my examination of landownership motivations (Chapter 2), social networks and community involvement (Chapter 3), and ecosystem service values (Chapter 4) highlight how themes associated with "place", and people's relationship with it, can relate to conservation behavior and inform conservation strategies. In Chapter 5, I integrate my findings into a more comprehensive discussion of relational values along with a discussion of directions for future research.

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2. ROLE TYPES OF LARGE TEXAS LANDOWNERS OF THE GULF COAST PRAIRIE: CHARACTERISTICS AND PRACTICES

2.1. Introduction

In North America, many landscapes are mostly privately owned with less than 6% of the overall land area in nature reserves (Scott et al., 2001). In many landscapes where agricultural production is the primary land use, public lands provide insufficient habitat to support native biodiversity and protected areas are often located in marginal areas, such as higher elevation locations with less productive soils (Scott et al., 2001; Smith et al., 2001). Therefore, the capacity of many production landscapes to support native biodiversity can be profoundly affected by landowners' management behaviors; such landscapes have frequently experienced significant declines in biodiversity and an increase in extinction risk for numerous species (With et al. 2008).

In addition to habitat conversion and loss, the configuration of landscape elements may affect ecological processes and biodiversity. Many landscapes, especially grasslands and savannahs, are susceptible to disruptions of disturbance regimes that influence their ecological processes. Historically, these ecosystems with a dominant herbaceous layer depended on periodic fire and herbivory to contain woody plant establishment and proliferation; the absence of such disturbances can result in shifts to woodland states that are difficult or impractical to reverse (Fuhlendorf et al., 2009). To offset the disruption of such naturally occurring disturbance events, land management can play an important role in providing proxies for disturbances via certain practices, such as prescribed burning and concentrated grazing. However, for such practices to benefit landscape-scale biodiversity, they must be applied by a large number of contiguous landowners over large areas in conjunction with other policy-level approaches to address landscape fragmentation (Fuhlendorf et al. 2017).

Landowners base their management decisions on multiple criteria which include consideration of the place where they own their land and their production orientations (Primdahl and Kristensen, 2011). Landowners may adopt different roles according to their land ownership motivations, values, and goals that translate into propensities for different land management practices (Sorice et al. 2012). Broad scale shifts in such land management propensities can substantially influence ecological processes and the delivery of associated ecosystem services. For example, shifts from production-oriented to lifestyle-oriented motivations for land ownership may result in an increase in woody plants (Sorice et al., 2014; Groth et al. 2017). In other cases, landowners who inherited land were found to manage their land with longer planning horizons and expressed an intention to transfer it to their heirs (Majumdar et al., 2009). Thus, landowner motivations represent an important consideration for understanding landowners' management behavior and thus the biodiversity conservation and ecosystem services landscapes provide, especially in production landscapes.

Given the important role of private landowners in maintaining biodiversity in production landscapes, initiatives have been implemented to incentivize landowners to voluntarily engage in environmentally beneficial land management behaviors. Some examples of such incentivization efforts include: public acknowledgement of beneficial behaviors, Safe Harbor Agreements, Conservation Reserve Program, conservation easements/tax credits, cost-share agreements and rental payments (e.g., Keystone Center 2006). These initiatives rely on outreach and marketing to engage landowners, however, rarely do those conducting outreach and education have sufficient resources to reach all prospective landowners in a meaningful way. Targeting landowners with large properties and who may be more likely to engage in environmentally beneficial behavior may be an important strategy to maximize the ecosystem benefits and financial efficiency of outreach efforts. Effective outreach involves more than just reaching prospective landowners, but also providing a message that will induce landowners to engage in land management practices that complement other ongoing conservation efforts. In this regard, understanding landownership motivations can help develop conservation program attributes and tailor recruitment messages that convey information relevant to landowner decision-making (e.g., Pelletier and Sharp, 2008). Therefore, descriptions of landownership motivations can be used to understand both current management behavior, predict shifts in land management over time, modify conservation initiatives and tailor outreach efforts to be more relevant for a diverse mix of landowners and land management goals.

Using a mail-survey, I asked landowners to describe their landowner role identity using landownership motivations. I then examined landowner role identity with consideration of place-based motivations and interpreted constructs associated with these motivations which I used to segment landowners into types. I evaluated whether these role types sufficiently differentiated landowners by their characteristics and whether types were associated with variation in environmentally significant behaviors, specifically wildlife management practices, role commitment and conservation attitudes. Finally, I discuss how my landowner typology relates to other studies and I discuss a theoretical basis for landowner segmentation that can benefit future studies aimed at understanding landowner motivations and their link with behavior.

2.1.1. Landowner typologies

Landowner typologies have been used to categorize the composition of individuals within a population of interest (Majumdar et al., 2008; Sorice et al., 2012; Dayer et al., 2014; Groth et al., 2017). Adequately identifying landowner types involves selecting variables that enable parsimonious segmentation with significant explanatory power, clear differentiation among types, and easy observability (Dayer et al., 2014). Inherent in this approach is an assumption that landowner segmentation reduces data complexity using a framework that describes meaningful, real world patterns of landownership.

Two approaches to landowner segmentation have commonly been used to inform research questions. The first categorizes landowners based on certain behaviors, including information seeking (Surendra et al., 2009), enrollment in conservation programs, or land management decisions (Jansujwicz et al., 2013). The second uses motivational descriptors to categorize landowners based on their reason for owning land (I. Majumdar et al., 2008; Sorice et al., 2012; Orsini, 2013). Other approaches involve partitioning landowners using multiple criteria, such as occupational identity (Groth et al., 2017), or reasoned action cognitions (Dayer et al., 2014).

Landowner motivations have been useful for forming typologies. Nielsen-Pincus et al. (2015) found that landowner motivations embodied three desirable characteristics for segmentation: interpretability, distinct classifications, and a relationship to land management preferences. Although applied to landowner motivations, these criteria mirror those of Rich (1992) who identified seven criteria for classifying organizations; this approach is useful for ensuring reproducibility, especially for evaluative criteria. Dayer et al. (2014) subsequently examined the concordance between Rich's organizational criteria and motivation typologies. They found motivation typologies were inconsistent with Rich's criteria because despite having a theoretical grounding they did not specify what types should be present. Thus, landowner motivations have utility for describing landowner types but the theoretical underpinnings need additional consideration.

Landowner motivations have been used without much explanation of their theoretical basis; however, the underlying assumption appears to be that landowners act rationally. The identified motivations typically are associated with attainment of two types of ecosystem services, provisioning and cultural. As an example, Dayer et al. (2014) identified landowner motivation types as consumptive, living off the land and non-consumptive, with the first two categories relating to provisioning services and the third is related to cultural services. Sorice et al. (2012) identified three types of landowners based upon their motivations; they included agricultural production, financial investment, and lifestyle. Here again, motivations are tied to ecosystem services: agricultural production as a provisioning service, lifestyle as a cultural service and financial investment via land appreciation as a result of the combination of these two services. In these cases, it is assumed that management decisions are driven by utility maximization as determined by landownership motivations. This rational actor assumption has been common in landowner studies. However, land management decisions are complex and involve the evaluation of a multitude of options under considerable uncertainty, which requires substantial effort to strategically evaluate different potential outcomes. In these instances, it is likely that individuals will seek to reduce their cognitive burden via a reliance on previous experience, norms, or cultural expectations. One way this is accomplished is via the development and adoption of context specific identities.

2.1.2. Identity Theory

Identity theories describe the way in which entities or individuals' identities are formed and how they are employed to direct behavior. The two most researched theories are Social Identity Theory (Tajfel et al. 1979; Hogg 2006) and Identity Theory (Burke 1991); both are centered on understanding the role of the self in behavior and decision making but emphasize different aspects of identity. Social Identity Theory is primarily centered on understanding how identity relates to membership or placement in categories or groups, while Identity Theory is focused on different roles (Stets and Burke 2000). In these theories, identity is formed via a process of self-categorization or self-assignment. Through interactions with other entities or individuals, norms and meaning are conveyed, which in turn are internalized during the formation of different identities that are combined to make the self (Turner et al. 1987; McCall and Simmons 1978). Not all identities are activated in a given situation, but rather are arranged hierarchically. Social Identity Theory arranges identities in a hierarchy of inclusiveness (e.g., Texan vs. American), whereas Identity Theory creates hierarchies in terms of different role identities (e.g., landowner vs. spouse). The processes of differentiation in both theories indicates consideration of different criteria as individuals seek to act in congruence with their identities' meanings and expectations (Stets and Burke 2000). The activation of different identities depends upon their salience in different situations and contexts.

Landowner role identities have been used to segment agricultural producer identities (Groth et al. 2017). In this approach, the landowner role was described in terms of an occupational identity, and landowners were segmented according to their production orientations based on the extent to which they identify as an agricultural producer. The dimensions used to outline the agricultural producer identity included: self-categorization, evaluation, importance, attachment, social embeddedness, behavioral involvement (Groth et al., 2017). Although well-founded theoretically, landowner occupational identity is limited to production landowners and does not relate to the increasingly large proportion of non-production-oriented landowners in many rural areas.

Just as agricultural producer identity has been determined to be meaningful for explaining land management decision-making, place-based identity also is likely to play a role in landowners' decision-making processes because landownership represents a manifestation a place attachment. For certain landowners, place-based identity is likely more salient and leads to greater commitment to the land than the agricultural producer role because their attachments to community and the natural environment may be more important to them than the resources they can derive from their land. Place identity is the meanings that compose a self-identity cultivated through interactions with a specific geographic location (Lai and Kreuter, 2012). Landowners may engage in behaviors that are not directly tied to their identity as a landowner, but may reflect their other roles that can be tied to the land. In short, it is possible to view landownership not as an occupation, but rather as something that is place-based. Many people may not perceive landownership as a role, but rather a reflection of their attachment to the place where their land is located. Therefore, it is possible to think of the landownership as the reification of place attachment (Egoz, 2012). The role of place-based identity has not been examined in relation to the description of landowner types.

2.2. Methods

2.2.1. Study Area

The study was conducted in the Gulf Coast Prairie of Texas, which historically ranged along the Gulf of Mexico from Louisiana to the southern tip of Texas, and is part of the Gulf Coast Prairies and Marshes (GCP) Ecoregion. The segment of the GCP located northwards of Corpus Christi is a flat, low-lying plain that is approximately 80-145 km (50-90 miles) wide, with a maximum elevation of 109 m (360 ft), and across which precipitation increases along a south-north gradient from 66-114 cm (26 and 48 inches) (Griffith et al. 2007). Historically, a large proportion of the vegetation consisted of prairie grasslands while trees occurred in clusters, called mottes, and along riparian zones and increased in prevalence with distance from the coast (Griffith et al., 2007).

The combination of overgrazing and disruption of natural fire regimes has resulted in an increase in woody species (Smeins et al., 1992; Archer et al., 1995; Griffith et al., 2007). Additionally, within the GCP the non-native Chinese tallow (*Sapium sebiferum*) and Chinese privet (*Ligustrum sinense*) have become established and pose a threat to the continued existence of native prairie (Grace, 1998; Griffith et al., 2007; TPWD, 2012).

Before European settlement, Native Americans burned the prairie regularly and, beginning in the 1800's, Spanish settlers grazed cattle and horses in it (Lehman 1965 in Griffith et al., 2007). Prairie once covered 9 million acres but, mainly due to agricultural development, today less than 65,000 acres in Texas and less than 100 acres in Louisiana remain making it one of the US's most endangered ecosystems (Smeins et al., 1991; USFWS 1999). As a result, many native species have been extirpated and others, such as the Attwater's Prairie Chicken (APC, *Tympanuchus cupido attwateri*), are critically endangered (USFWS 2010). Consequently, Gulf Coast Prairie habitats, including grasslands, have received conservation priority (Grace et al., 2000; TPWD, 2012).

The GCP is experiencing patterns of decline that are typical of North American grasslands. These declines are attributable to a combination of causes, including: afforestation, land use and ownership fragmentation, habitat loss, and ecosystem degradation (Brennan et al., 2005). Within the US, grassland species, especially birds, are experiencing drastic declines (Sampson and Knopf, 1994). While critically endangered, APCs represent a good conservation surrogate for other vulnerable grassland bird species because they require large patches of habitat (>10,120 ha) to support viable populations and habitat restoration, improvement and connectivity are essential for their recovery (USFWS, 2010).

In Texas, 95% of the land is privately owned and some regions have an even higher percentage of private ownership (IRNR, 2014). Along the Texas Gulf Coast, most remaining coastal prairie is located within privately owned lands, making engagement with landholders critical for the recovery of grassland species (Williams and Harrell, 2009; USFWS 2010). The major land-uses within these private lands are cattle ranching, crop production, energy production and urban development (USFWS, 2010). Recovery of endangered species requires trade-offs between accommodation of their habitat requirements and economic use of the land.

This study was conducted in the central portion of the GCP ecoregion, focusing on two different areas within the historic range of the prairie (Figure 2.1). Due to the constraints associated with survey sample selection, I focused on two contiguous northern counties (Austin and Colorado) that included the Attwater's Prairie Chicken National Wildlife Refuge (APC-NWR) and four contiguous southern counties (Refugio, Goliad, Calhoun, Victoria) that included the Refugio-Goliad Prairie Conservation Area (RGP). These two study sites encompassed a high degree of the social and climatic variation of the region. Predominant land uses in the study shifted from ranching in the south to row crops in the north, while precipitation decreased on a north-south gradient.

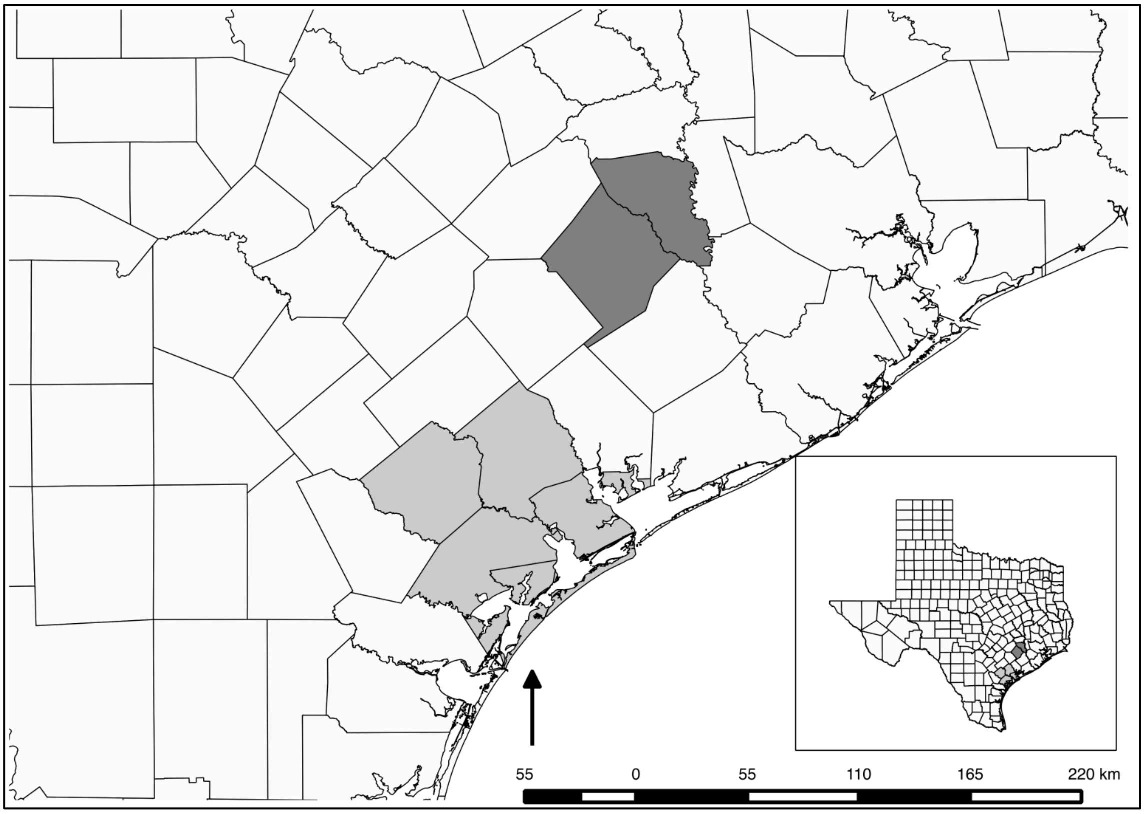

Figure 2.1 Study site location map showing counties that comprised the North (dark gray) and South (light gray) study sites in the Gulf Coast Prairie of Texas.

2.2.2. Survey sample and mail survey

I developed a survey questionnaire based on feedback regarding land management in the GCP from landowners, land managers and academic researchers. Using tax records, landowners who owned parcels large enough to conduct wildlife-centered land management activities were randomly sampled. Based upon the habitat requirements of white-tailed deer (*Odocoileus virginianus*) and northern bobwhite quail

(*Colinus virginianus*), both of which are economically valuable game species, a minimum property size of 40 ha (~ 100 acres) was selected for the study because it could theoretically support wildlife recreation. I used a statistical power analysis at a confidence level (α) of 0.05, to determine my sample size of ~900 landowners (400 from each site, and 103 WMA members from throughout the study area). I conducted the mail survey using a modified multiple contact method (Dillman et al., 2014), which included a series of five mailings spaced over a 49-day period from October through December 2015. The 16-page questionnaire incorporated a combination of 5-point Likert-type response options and short answer and multiple-choice questions to solicit landowners' perspectives regarding different statements. Prior to contacting survey participants, my study and associated materials were approved by the Texas A&M University Institutional Review Board (# IRB2013-0449D).

2.2.3. Landowner role identity

In order to segment the landowners, I used a series of statements adapted from other landowner segmentation studies (Majumdar et al., 2008; Sorice et al., 2012; Ferranto et al., 2013). These statements included monetary and non-monetary considerations with reference to lifestyle, social, conservation, and economic place-based motivations (Table 2.1). To elucidate landowner role identities (Simon, 1992; Stets and Burke, 2000), I asked survey participants to use a 5-point scale (1 = strongly disagree … 3 = neutral … 5 = strongly agree) to indicate their level of agreement with a series of statements describing them as a landowner ("I am someone who owns my land in order to…"), with these statements' wording tailored to reflect the conditions of the

Gulf Coast Prairie. By asking landowners about descriptions of them as a landowner, I engaged landowners' identities rather than the reasons they own their land *per se*. In this regard, I interpreted responses as landowners' values for different aspects of landownership via an idealized view of their role identity (e.g., Hogg and Reid 2006).

I used the motivational structures identified among California forest owners in Ferranto et al. (2013) as the basis for a confirmatory factor analysis (CFA) using the R Lavaan package. These motivational structures were chosen because of their inclusion of a broad base of landownership motivations as identified by a review of previous landowner segmentation studies. I specified a factor structure that was equivalent with a reduced number of statements in Ferranto et al. (2013) with an additional statement ("add to existing landholdings") to create a factor with 3 statements. Thus, my financial motivation construct was slightly modified (Table 2.1). The CFA was conducted after ordered variables were specified and missing values were imputed using median values. Diagonal weighted least squares were used to estimate model parameters (www.lavaan.ugent.be; accessed 01-Mar-2017). Root Mean Square of Approximation (RMSEA) was used to determine model fit because it favors parsimony (Byrne 1998 as in Hooper et al., 2008). An RMSEA parameter value of less than 0.07 with an upper confidence interval limit of less than 0.08 was considered acceptable (Hooper et al., 2008).

Table 2.1 Landownership motivation scores based on an exploratory factor analysis using a varimax rotation and the regression method. (Cronbach's alpha values for each factor are provided and the factor with which each ownership motivation statement was most strongly associated is indicated in bold, while blank cells indicate the statement did not load on that motivation factor after rotation)

Statement	Factor				Ferranto et al. Factor
	Environmental Conservation (0.92)	Lifestyle (0.86)	Community (0.80)	Use (0.73)	
Reasons for owning land					
help protect environment	**0.81**	0.24			3
preserve open space/natural resources	**0.84**	0.18			3
protect non-game wildlife	**0.82**	-0.17	0.21		
protect biodiversity	**0.83**	-0.22		0.22	
escape city crime and pollution	0.27	**0.6**			1
live in a small community		**0.76**			1
live a simpler lifestyle		**1.03**	-0.11	-0.13	1
live closer to friends and family	-0.11		**0.65**	0.22	2
connect to a higher power			**0.95**	-0.18	
help the local economy	0.16	-0.1	**0.79**		2
add to existing landholdings		-0.15		**0.91**	
provides a source of income		0.32		**0.45**	2
hunt wildlife	0.11	-0.15	-0.11	**0.77**	
live near natural beauty	0.55	0.43		-0.11	1
benefit land appreciation	0.33	0.34	0.18		4
good financial investment					4
grow/raise own food	-0.17	0.39		0.46	
live independently	0.13	0.27	0.32	0.14	
good place to raise my children	0.13	0.34	0.2	0.15	2
continue family tradition or business		0.43	0.2	0.24	2

The variable factor scores were used to conduct hierarchical clustering of landowners using R package Hclust. The dendrogram was used to decide on the most appropriate number of clusters that enabled interpretation of the landowner types (McCune and Grace, 2002). The clustering solution was verified using R package NBClust, which uses various clustering indices to indicate the most highly supported number (Charrad et al., 2014). A six-cluster solution was selected after evaluating two and eight clusters.

Additionally, I created a scale to determine landowner commitment to their role identity, which is "…the sum of forces, pressures or drives that influence people to maintain congruity between their identity setting and the input of reflected appraisals from the social setting" (Burke and Reitzes, 1991, pg. 243). As a social process, the importance people place on different groups' perceptions of them as a landowner can indicate how likely they are to engage in behaviors congruent with their role identity. To create the scale, I averaged the responses to three permutations of a statement that evaluated importance of landowner role identity: "It is important to me that [entity] view me as a rancher/farmer/landowner." The entities that were substituted in the statements were: 1) themselves, 2) people in the area, and 3) friends and family. For these statements, a five-point Likert-type response scale was used (1 = strongly disagree … 3 = neutral … 5 = strongly agree) to indicate agreement.

2.2.4. Landowner characteristics and relation to the land

To describe how recognizable and interpretable the landowner types were, I evaluated several observable characteristics that relate landownership motivations. These characteristics included a combination of five demographic and four land ownership variables. The demographic variables included age, gender, education, primary occupation, and rural land heritage; and landownership variables included length of land tenure within their family, percent of income derived from their land, average hours spent on their land, acres owned, and method of land acquisition.

2.2.5. Attitudes towards conservation of the Gulf Coast Prairie

I asked landowners their agreement or disagreement with three questions to better understand their views and attitudes regarding conservation of GCP. All of the questions were 5-point Likert-type scales (1 = strongly disagree … 3 = neutral … 5 = strongly agree). The first two questions asked respondents to indicate whether they valued the GCP (1: "The Gulf Coast Prairie is a valuable resource that is unique and irreplaceable."; 2: "The biodiversity of the Gulf Coast Prairie is worth saving."). The third question asked landowners about landowners' role in conservation of the GCP ("Gulf Coast Prairie Landowners are not doing enough to conserve biodiversity.").

2.2.6. Wildlife management practices

To understand the relationship between landowner roles and land management, I identified several practices that have the potential to yield beneficial outcomes for biodiversity. In landscapes, such as the GCP, large (>40 ha) landholdings are more likely to provide sufficient wildlife habitat for prairie species, such as the APC than smaller parcels. In order to evaluate current wildlife management behavior, I evaluated landowners' current wildlife management practices. Using a list of specific terrestrial management practices required to qualify for a wildlife tax exemption, survey participants were asked to indicated which practices they employed on their land (TPWD, 2010). Twenty management practices were included in the questionnaire (9 habitat-improvement, 4 predator-control, 2 supplemental-food/water, 3 supplemental-shelter, and 2 animal census/population monitoring practices; Table 2.2). Overall, differences among the wildlife management practices and also differences among the categories of practices were evaluated.

2.2.7. Data analysis

In order to evaluate the differences between landowner characteristics and wildlife management practices, I used a combination of non-parametric tests. I used the Kruskal-Wallis test of difference in medians to analyze differences in the distribution of wildlife management practices among different landowner types. Given unequal landowner-type sample sizes, I used the Dunn test for stochastic dominance to analyze pairwise differences in medians (Dunn, 1964; Zar, 2010). The data were continuous and it was assumed that distributions of each variable were the same. Given these conditions, Dunn's test can be interpreted as a test for differences of medians (Zar, 2010). Additionally, the Holm's Bonferroni adjustment was applied to significance values to account for the number of multiple pairwise comparisons. The Pearson's chi-squared test of independence was used to compare categorical variables (Ott and Longnecker, 2012). If the test was significant, pairwise differences were evaluated further using R to conduct a post-hoc pairwise chi-squared test.

2.3. Results

Of the 902 mailed surveys, a total of 295 (32.7%) were returned. Of these returned surveys, 261 (28.9%) were usable for this analysis once incomplete surveys and respondents who did not meet the minimum landowner size were removed.

2.3.1. Landownership motivation factor identification

The confirmatory factor analysis (CFA) did not support a similar structure of latent constructs as those identified by Ferranto et al. (2012). The CFA indicated a poor model fit for the latent constructs, with a root mean square error of approximation (RMSEA) of 0.07 and 90 percent confidence interval of 0.055 and 0.085. Therefore, the model was at the upper bounds of, or exceeded currently accepted values for acceptability.

As a result of this finding, a principal component analysis (PCA) was conducted with the full matrix of motivational items included in the study. Based upon scree plots of the components and the principal coordinates with eigenvalues > 0.95, a four-factor solution was supported (Table 2.1). A PCA with the polychoric correlation matrix was conducted using a varimax rotation, the regression method, and the minimum residual factor method. Missing values for each variable were imputed using the median scores.

Of the 20 motivation-related statements, seven were eliminated from further analysis because they did no clearly load on an individual factor. The remaining items loaded onto four factors, which were treated as motivation scales (Table 2.1). The statements were treated as follows: **Environmental Conservation** – associated statements centered on the protection and conservation of land and biodiversity; **Rural**

Lifestyle – associated statements primarily focused on life in a rural area; **Community** – associated statements reflect a connection to the place based upon the social environment (connection to a higher power was also indicated in this factor, suggesting the spiritual community of the respondents); and **Use** – associated statements related to a utilitarian view with respect to the provision of income, land assets, and hunting opportunities.

2.3.2. Landowner role types

I clustered landowners into six different types of landowner roles based upon their scores for the 4 landownership motivation scales via the hierarchical clustering of principal components. However, one type was represented by only four landowners and was, therefore, removed from subsequent analysis. I interpreted the remaining landowner types based upon their relative scores for the four motivation scales. Overall, the mean scores for 'Rural Lifestyle' (4.1), 'Environmental Conservation' (4.3), 'Use' (3.7), and 'Community' (3.7) motivations were all in the "agreement" portion (> 3.0) of the 5-point scale ($p < 0.001$; t = 18.8, 25.5, 10.6, 12.4, respectively; Table 2.2).

Working Place: The 31.3% of respondents I categorized as 'Working Place' role landowners exhibited landownership motivations that were above the average scores for 'Use' (3.9; 95% C.I. 3.7 – 4.0) and 'Community' (3.8; 95% C.I. 3.6 – 3.9); and below the average scores for the 'Rural Lifestyle' (3.6; 95% C.I. 3.4 – 3.7) and 'Environmental Conservation' (4.2; 95% C.I. 4.1 – 4.4) scales. Working Place landowners deviated most significantly from the average score for the 'Rural Lifestyle' factor. Working Place' landowners were distinct from 'Amenity' and 'Lifestyle' landowners based on ‘Environmental Conservation’ and ‘Use’ ownership motivations and from ‘Conservation’ and ‘Entire Place’ landowners based on all four ownership motivation factors (Table 2.3).

Entire Place: The 24.5% of respondents I categorized as ‘Entire Place’ landowners exhibited landownership motivations that were significantly higher than the average scores for ‘Rural Lifestyle’ (4.9; 95% C.I. 4.8 – 5.0), ‘Environmental Conservation’ (4.7; 95% C.I. 4.5 – 4.8), ‘Use’ (4.6; 95% C.I. 4.5 – 4.7) and ‘Community’ (4.5; 95% C.I. 4.4 – 4.7; Table 2.2). Thus, these landowners expressed a strong landowner role identity that spanned all four ownership motivation categories. ‘Entire Place’ landowners were distinct from ‘Working Place’ and ‘Lifestyle’ landowners based on all four ownership motivation factors and from Amenity and Conservation roles identity based on Lifestyle, Community and Use ownership motivation factors (Table 2.3).

Amenity: The 18.5% of the respondents I categorized as ‘Amenity’ landowners exhibited landownership motivations that were significantly higher than the average scores for ‘Rural Lifestyle’ (4.8; 95% C.I. 4.6 – 4.9) and ‘Environmental Conservation’ (4.7; 95% C.I. 4.5 – 4.8), below the average scores for Use (3.2; 95% C.I. 2.9 – 3.3) and near the average score for Community motivations (3.7; 95% C.I. 3.5 – 4.0) ownership motivation scales. ‘Amenity’ landowners were distinct from ‘Lifestyle’ landowners with respect to Environmental Conservation, from Working Place landowners in term of the Environmental Conservation and Use, from Conservation landowners in terms of

Table 2.2 Mean and median scores for landowner role identity type scores in terms of Environmental Conservation, Rural Lifestyle, Community and Use ownership motivation factors.

Landowner Role Type	**n (% sample)**	**Motivation**											
		Rural Lifestyle			Environmental Conservation			Use			Community		
		Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median
Working Place	83 (31%)	3.6	0.7	4	4.2	0.6	4.1	3.9	0.7	4	3.8	0.6	3.7
Amenity	49 (19%)	4.8	0.4	5	4.7	0.3	4.8	3.2	0.8	3.3	3.7	0.8	3.7
Lifestyle	39 (15%)	4.1	0.8	4	3.4	0.6	3.5	3	0.7	3	3.3	0.9	3
Conservation	21 (8%)	3.1	0.5	3.3	4.7	0.4	4.8	2.9	0.8	2.7	2.8	0.5	3
Entire Place	65 (25%)	4.9	0.3	5	4.7	0.5	5	4.6	0.4	4.7	4.5	0.6	4.7
Overall	257	**4.1**[a]	1	4.3	**4.3**[b]	0.7	4.5	**3.7**[c]	0.9	3.7	**3.7**[d]	0.9	3.7

Comparisons against a test value of 3; t values = a) 18.8, b) 25.5, c) 10.6, d) 12.4. All p-values < 0.001.

Table 2.3 Significant differences ($p \leq 0.05$) among median values of landowner role identity types for each of the four ownership motivation factors: Lifestyle (L), Environmental Conservation (E), Community (C), and Use (U).

Landowner Role Type	**Landowner Role Type**				
	Working Place	Amenity	Rural Lifestyle	Conservation	Entire Place
Working Place	-	E, U	E, U	L, E, C, U	L, E, C, U
Amenity	E, U	-	E	L, C	L, C, U
Lifestyle	E, U	E	-	E	L, E, C, U
Conservation	L, E, C, U	L, C	E	-	L, C, U
Entire place	L, E, C, U	L, C, U	L, E, C, U	L, C, U	-
Number of significantly different factors (mean)	3	2	2	2.5	3.5

Lifestyle and Community, and from Entire Place landowners by Lifestyle, Community and Use factors (Table 3).

Lifestyle: The 14.7% of the respondents I categorized as 'Lifestyle' landowners exhibited landownership motivations that were significantly lower than the average scores for 3 scales: Use (3.0; 95% C.I. 2.7 – 3.2), Community (3.3; 95% C.I. 3.0 – 3.6) and Environmental Conservation (3.4; 95% C.I. 3.2 – 3.6) and average scores for Rural Lifestyle (4.1; 95% C.I. 3.8 – 4.3). They diverged the most significantly from the average landowner in relation to the Environmental Conservation motivation scale. 'Lifestyle' landowners were distinct from 'Amenity' and 'Conservation' landowners in terms of Environmental Conservation motivations, from 'Working Place' landowners in terms of Environmental Conservation and Use, and from ‘Entire Place’ landowners in terms of all four ownership motivation factors (Table 2.3).

Conservation: The 7.9% of respondents I categorized as ‘Conservation’ landowners expressed landownership motivation that were below the average score for Lifestyle (3.1; 95% C.I. 2.9 – 3.4), Use (2.9; 95% C.I. 2.6 – 3.1), and Community (2.8; 95% C.I. 2.5 – 3.2) ownership factors, and higher than average scores for the Environmental Conservation (4.7; 95% C.I. 4.6 – 4.9) factor, thereby expressing a singular ownership motivation. ‘Conservation’ landowners were distinct from ‘Amenity’ landowners in terms of Environmental Conservation and Rural Lifestyle, from ‘Working Place’ landowners in terms of all for ownership motivation factors, from ‘Lifestyle’ landowners with respect to Environmental Conservation, and from ‘Entire Place’ landowners in terms of Lifestyle, Community and Use ownership motivation factors (Table 2.3).

Although I used a clustering algorithm to differentiate landowner role types by their land ownership motivations, not all types were equally distinct in relation to their average number of motivation scales that had significantly different mean values (Table 2.3). Based upon this criterion, the most distinct landowner role type was: ‘Entire Place’ (3.5) followed by ‘Working Place’ (3), ‘Conservation’ (2.5) and then ‘Amenity’ and ‘Lifestyle’ (2) landowners.

2.3.3. Commitment to role identity

Overall, my study indicated that landowners were committed to their landowner role identity; the average commitment score value was 4.0 (sd = 0.9; Table 2.4). However, there was a significant difference in the commitment score between landowner role types (F = 11.8, $p < 0.001$); specifically, pairwise comparisons indicated that 'Entire Place' landowners had a higher score than all other landowner role types with the exception of 'Amenity' (mean differences: 'Working Place' = 0.5, 'Lifestyle' = 0.6, 'Conservation' = 1.5), while 'Conservation' landowners were significantly less committed to their role than all other landowner role types (mean differences: 'Working Place' = -0.9, 'Amenity' = -1.1, 'Lifestyle' = -0.8; Table 2.4).

Table 2.4 Mean score and for landowner role commitment scale for the different landowner roles identified. The pairwise significant differences are also indicated (Welch F = 11.8, $p < 0.001$).

Landowner Role Type	Mean Commitment Score	Std. Dev.	95% Confidence Interval	
			Lower	Upper
Working Place	3.9	0.9	3.7	4.1
Amenity	4.1	0.1	3.8	4.4
Lifestyle	3.8	0.1	3.5	4.1
Conservation[A]	3	0.2	2.5	3.4
Entire Place[B]	4.4	0.9	4.2	4.6
Overall	4	0.9	3.8	4.1

A: Significant difference from Conservation: Working Place (p = 0.004); Amenity (p <0.001); Lifestyle (p = 0.020); Entire Place (p <0.001).
B: Significant Difference from Entire Place: Working Place (p = 0.005), Lifestyle (p = 0.010)

2.3.4. Characteristics

Several landowner demographic characteristics differed significantly among the landowner role types (Table 2.5). The average age differed significantly between the five landowner role groups (F = 4.5, $p = 0.002$); ‘Amenity’ (+6.4 years, $p = 0.020$) and ‘Lifestyle’ (+7.9 years; $p = 0.008$) landowners were significantly older than ‘Entire Place’ landowners. The percentage of landowners who were retired also varied among landowner types ($Chi^2 = 11.7$, df = 4; $p = 0.020$), a higher percentage of ‘Entire Place”, “Amenity” and ‘Lifestyle’ landowners were retired than was expected. The percentage of landowners who were employed as full-time ranchers or farmers varied among landowner types ($Chi^2 = 17.2$, df = 4; $p = 0.002$); ‘Conservation’ landowners had a lower percentage than was expected while ‘Entire Place’ had a higher percentage than was expected. Landowner role types did not differ in their average years of formal education (Welch F = 2.03, $p = 0.097$). There was not a significant difference in the percentage of females among the landowner types ($Chi^2 = 4.8$, df = 4; $p = 0.312$).

Landowners role types differed in some characteristics associated with their connection to their land. The median number of hours per week landowners spent on their land differed significantly different between landowner types (H = 22.6, $p < 0.001$). ‘Entire Place’ landowners spent significantly more hours at their place per week than ‘Working Place’ (+40, H = -4.3, $p < 0.001$) and ‘Conservation’ landowners (+52, H = -3.4, $p = 0.007$). The percentage of household income earned from their land also differed significantly between the five types (H = 23.8, $p < 0.001$); ‘Entire Place’ landowners earned a higher percentage of their household income from their land than ‘Working Place’ (+5%, H = -3.1, $p = 0.021$) landowners. Conversely, the median time that ‘Conservation’ landowners spent on their land per week was lower than ‘Lifestyle’ (-9%, H = 3.2, $p = 0.014$), ‘Amenity’ (-9%, H = 3.5, $p = 0.005$) and ‘Entire Place’ (-9%, H =

4.4, $p < 0.001$) landowners. The percent of respondents who grew up in a farming or ranching household also differed significantly among the five groups ($Chi^2 = 21.7$, df = 4; $p < 0.001$); a higher percentage of "Entire Place" and fewer 'Conservation' landowners grew up on a farm or ranch than was expected.

Landowner groups did not vary in some characteristics associated with their land and landownership. They did not vary with respect to mean years of family ownership of their property (Welch F = 0.232, $p = 0.920$) Among all of the respondents, most indicated they inherited their land (42%), followed by those who bought their land (31%) and those who both bought and inherited their land (27%; Table 2.6). The differences in the proportions of these three categories of land acquisition did not differ significantly between the five landowner groups ($Chi^2 = 6.46$, df = 8, $p = 0.596$). The median amount of land owned was 300 acres (121.4 ha) and, due to the wide ranges of property size of respondents in each group, there were no inter-group differences in median property size (H = 8.2; $p = 0.085$).

2.3.5. Attitudes towards conservation of the Gulf Coast Prairie

Overall, landowners expressed positive attitudes for the Gulf Coast Prairie, they indicated that they valued the GCP. In particular, they indicated that the GCP was unique and irreplaceable (mean = 4.2) and also that the biodiversity of the GCP was worth saving (mean = 4.2). They also somewhat agreed that landowners were not doing enough to conserve this biodiversity (mean = 3.4). There were differences in the distribution of responses to these attitude statements among landowner types (H = 25.3, 30.1, 23.0, respectively, $p < 0.001$). When conducting pairwise comparisons of the

Table 2.5 Mean values for the different landowner characteristics and land relationship characteristics. Significant differences (alpha = 0.05) are denoted with a superscript, tests were a combination of Welch's F test, Kruskal-Wallis and chi-squared tests. For significant results, pairwise tests were run using Holm corrected.

	Landowner Role Type				
Variable	Working Place	Amenity	Lifestyle	Conservation	Entire Place
Age (years)^{A}	66.4 (12.2)	70.2 (11.1)	71.7 (11.5)	63.5 (11.9)	63.8 (10.9)
Gender (female)	21%	34%	21%	24%	32%
Hours on Land^{B}	33.0 (42.3)	57.9 (62.6)	46.4 (55.4)	36.6 (53)	79.4 (65.7)
Household Income from Land^{C} (%)	15.5 (23.7)	27.4 (35.6)	18.2 (21.8)	3.5 (5.2)	33.9 (36.6)
Grew up on Farm^{D}	54%	64%	64%	24%	77%
Retired^{E}	38%	54%	58%	33%	30%
Hectares Owned	280.7 (898.6)	281.7 (403.6)	247.3 (415.7)	167.1 (213.4)	286.1 (297.8)
Period of Family Ownership (years)	72.3 (44.7)	74.4 (47)	72.9 (48.4)	69.2 (62)	78.6 (48.2)
Years of Education	15.7 (4.5)	14.9 (4.6)	14.8 (3.0)	17.2 (4.6)	14.3 (4.5)

Pairwise Differences (alpha = 0.05, Holm Corrected):

A: Lifestyle > Entire Place (p = 0.030); Amenity > Entire Place (p = 0.008);

B: Entire Place > Working Place (p <0.001); Entire Place >Conservation (p = 0.026); Entire Place>Lifestyle (p = 0.040);

C: Entire Place > Conservation (p <0.001); Entire Place > Working Place (p = 0.002); Lifestyle > Conservation (p = 0.020)

D: Entire Place > Conservation (p=<0.001); Entire Place > Working Place (p = 0.027); Amenity > Conservation (p = 0.012); Lifestyle > Conservation (p = 0.018)

E: none, uncorrected were (Amenity / Entire Place; Lifestyle / Entire Place)

Table 2.6 Method of land acquisition for different landowner types in the Texas Gulf Coast Prairie. The 3 categories are inherited (land was only acquired via inheritance), bought (land was only acquired via purchase), and combination (land was acquired via inheritance and purchase).

Land Acquisition Method	**Landowner Role Type**					**Total**
	Working Place	Amenity	Lifestyle	Conservation	Entire Place	
Inherit	34	22	17	9	27	109
Combination	23	11	9	3	23	69
Bought	25	17	14	9	15	80
Total	82	50	40	21	65	258

types, 'Lifestyle' landowners had a distribution of responses that was different from all other landowner types for each of the statements (adjust $p \leq 0.032$), while none of the other groups were different from each other for any of the questions ($p \geq 0.430$).

2.3.6. Wildlife management practices

The average number of practices that respondents indicated they employed varied across some of the different management practice categories (Table 2.7). The average number of practices that landowners indicated they used were 7.1 (representing 36% of all 20 listed practices; Table 8). Among the different categories of practices, the highest average number of management practices employed related to 'Supplemental Food/Water' (45% being 0.9 of 2 practices), followed by 'Habitat Improvement' (42% being 3.8 of 9 practices), 'Predator Control' (35% being 1.3 of 4 practices), 'Supplemental Shelter' (20% being 0.6 of 3 practices) and 'Census Methods' (20% being 0.4 of 2 practices).

Among the landowner role types, there was a difference in the number of practices that were used by landowners on average (H = 13.1, df = 4, $p = 0.011$); 'Entire Place' and 'Working Place' landowners, on average, used the most wildlife management practices, whereas 'Lifestyle' landowners applied significantly fewer practices than these landowner types (H = -3.4, p = 0.007; H = 2.8, $p = 0.46$, respectively; Table 2.8). There were also significant differences in the use of practices among landowner role types in relation to the number of 'Habitat Improvement' and 'Census Methods' practices used (H = 16.8, p = 0.002; H = 10.6, $p = 0.030$; H = 12.5, $p = 0.010$, respectively). 'Entire Place' landowners used more 'Habitat Improvement' practices than 'Lifestyle' and 'Conservation' landowners. 'Entire Place' and 'Working Place' landowners used more 'Census Methods' than 'Lifestyle' landowners; although there was a difference indicated in the number of 'Supplemental Shelter' practices performed, none of the pairwise tests were significant. There were no significant differences among landowner role types in relation to 'Predator Control', 'Supplemental Food and Water', and 'Supplemental Shelter' wildlife practice categories (H = 8.9, p = 0.06; H = 6.5, $p = 0.16$; H = 10.6, $p = 0.031$; respectively). Although 'Supplemental Shelter' was globally significant, none of the pairwise contrasts were significant.

Table 2.7 The percentage of wildlife management practices performed by survey respondents in the Gulf Coast Prairie. (Categories and Practices are from Texas Parks and Wildlife (2010))

Category	Practice	Percentage using
Habitat Improvement	Use rotational grazing	47
	Improve rangeland condition	57
	Apply prescribed fire	8
	Chemically manage brush	53
	Mechanically manage brush	58
	Manage for native plant species	40
	Restore/reintroduce wildlife populations	22
	Protect habitat for species of concern	42
	Control invasive plant species	57
	Mean	**42**
Predator Control	Control predators (coyote, etc.)	40
	Control feral hogs	55
	Control problem birds (cowbird, starling, etc.)	9
	Control fire ants	31
	Mean	**34**
Supplemental Water/Food	Provide supplemental water (develop springs, artificial water, etc.)	45
	Manage pastures, old field, hay meadow, croplands to benefit wildlife	43
	Mean	**44**
Supplemental Shelter	Install/develop nesting habitat (bat boxes, nest boxes, natural cavities, snags)	10
	Establish desirable woody plants and shrubs for wildlife habitat	15
	Create brush piles, retain slash, half cut trees/shrubs for habitat	35
	Mean	**20**
Census Methods	Conduct wildlife counts (spotlight, daylight or aerial)	35
	Census or monitor non-game, endangered or protected wildlife species	8
	Mean	**22**
Other	Install High Fences on Property	4

Table 2.8 Mean number of practices reported as performed for each Texas Parks and Wildlife Department wildlife management category by each landowner role identity type. (Statistically significant differences are bolded and resulting significant pairwise differences are shown)

Landowner Role Type	Wildlife Management Practices Employed (mean)					
	Habitat Improvement (of 9)	Predator Control (of 4)	Supplemental Food/Water (of 2)	Supplemental Shelter (of 3)	Census Methods (of 2)	**Total (of 20)**
Working Place (WP)	4.1	1.5	0.9	0.5	0.5	7.5
Amenity (A)	3	1.2	1	0.9	0.4	7.2
Lifestyle (L)	2.7	1	0.6	0.4	0.2	4.8
Conservation (C)	2.8	1.1	0.8	0.9	0.6	6.1
Entire Place (EP)	4.6	1.6	1	0.5	0.5	8.2
Mean	3.8 (42%)	1.4 (35%)	0.9 (45%)	0.6 (20%)	0.4 (20%)	7.1 (36%)
Kruskal-Wallis	**16.8**	8.9	6.5	**10.6**	**12.5**	**13.1**
significance *(p)*	**0.002**	0.063	0.164	**0.031**	**0.014**	**0.011**
Significant Diff. (adj. p <0.05)	EP > L, EP > C	-	-	-	WP > L, EP > L	WP > L, EP > L

2.4. Discussion

Via landownership motivations, I have provided a realistic description of the diversity of large (>40 ha) landowners found in the GCP, which, in turn, can be used to highlight the association of landowners with their land management practices. With the size of the parcels they manage, large landowners' land management practices have a strong influence on the provisioning of ecosystem services, and ultimately the conservation potential of the GCP (e.g., Olenick et al., 2005). Landownership motivations are fundamentally about the relationship between landowners and their property, their description of these motivations is a way to understand how they view their role as a landowner in the broader social-ecological system. Landowners with different self-perceptions of their role as rural property owners are likely to respond differently to various outreach programs conducted by agencies and organizations. Targeting program attributes, informational tools and outreach activities to more accurately address landowner self-perceptions will likely improve conservation outcomes (e.g., www.engaginglandowners.org) as landowners adopt conservation practices, which is especially important in endangered landscapes such as the GCP.

The four landownership motivation categories that my research identified ('Lifestyle', 'Community', 'Environmental Conservation', and 'Use') differed from those of other segmentation studies which I used as the basis for characterizing landowners in the GCP (Ferranto et al., 2012; Sorice et al., 2012). I identified three landowner motivation categories that were similar but not identical to those described by Ferranto et al. (2012) and Sorice et al. (2012); which generally related to lifestyle, the natural environment and agricultural production. The ‘Lifestyle’ motivation was most similar across all studies and it related to statements centered on the simple, crime and pollution free qualities of a rural life, while my ‘Use’ motivation differed from these studies.

Landowners in my sample grouped hunting wildlife, agricultural production and investment motivations together, which I interpreted as a utilitarian, or ‘Use’ motivation. In the Texas Hill Country, an investment motivation contributed to the segmentation of “Agriculture Production” landowners, while in California “Investment” landowners were a distinct group. These other study areas likely have real estate markets that are more investment oriented than the GCP. In 2017, the cost of land in the GCP was more than double the state average while the growth rate of land prices didn’t outpace the state average (https://www.recenter.tamu.edu/data/rural-land; accessed April 2018), making other Texas regions’ lower land costs and higher rate of appreciation more attractive for investment (Wilkins et al., 2000). Additionally, since 1965, the median parcel size sold in the GCP has decreased and Texas lands return a higher price per acre for smaller (< 40 acres) parcels which indicates lands are undergoing fragmentation or subdivision (Miller, 2006). The real estate market and relatively few opportunities to acquire larger (>40 acre) properties may limit land acquisition solely for investment, which results in landowners’ investment motivation being included with a broader suite of utilitarian (e.g., agriculture, hunting) motivations.

My study found support for, and variation regarding, place-based landownership motivations among landowner types. Statements that characterized the ‘Community’ motivation were associated with aspects of landownership unique to the place where their land was held: family, religious connection and assistance to community, while the 'Environmental Conservation' motivation was characterized by statements related to protection of the natural environment or biodiversity. Such protection motivations have been associated with strong place attachment (Lokocz et al., 2011). More generally, pro-social behavior is grounded, in part, in some form of shared identity or attachment, whether to place, group or another individual (Brewer & Kramer, 1986; Tidwell, 2005; Gosling and Williams, 2010; Axson and Kirani, 2014). 'Community' and 'Environmental Conservation' motivations clearly differentiated landowner role identities, and likely have significant impacts on behavior.

Place-based motivations serve to embed a person within a community and ecosystem, and so can be thought of as key components of the land ethic that was promoted by Leopold (1949) and discussed by others (Callicott, 1987). The dimensions I identified mirror those associated with place attachment: place identity, place dependence, nature bonding, and social bonding (Raymond et al., 2010), and also several themes associated with forest landowner decision-making: emotional land attachment with a stewardship ethic; functionality and pragmatism (utility); family, lifestyle, and land connections (Gruver et al., 2017). I did not directly measure place-attachment or identity or the affective dimensions associated with these constructs, which can affect property-protective behaviors (Lai and Kreuter, 2012) and is an area for future research. Ultimately, a more comprehensive place-based approach to landowner segmentation represents a fruitful direction for additional theoretical development and application, as a way to understand land management from the landowner perspective.

Not all landowner role identities were equally distinct in relation to their landownership motivations. 'Entire Place' and 'Working Place' landowners were most similar and composed the majority (58%) of landowners. Unlike the three other landowner types, they identified strongly with the 'Use' motivation, which may be attributable to their agricultural heritage and early life experiences. On average, landownership spanned multiple generations; landowners inherited their lands and thus have familial attachments to it. Length of landownership is associated with willingness to engage in conservation programs (Langpap, 2004). There was a difference in whether or not landowners grew up on a farm or ranch. Fewer 'Conservation' landowners grew up in farming or ranching household than any other landowner type. Childhood experiences can have a strong influence on the formation of a place-based role identity and the heritage associated with the land can further increase this identity (Morgan, 2010). Additionally, landowners who had relatively low 'Use' motivations were generally older than average; these 'Lifestyle' and 'Amenity' landowners may be reflecting different stages of retirement and a resultant shift in their role identities away from agricultural production. Thus, although a 'Use' motivation was relatively high among the majority of landowners, place-based motivations served to differentiate landowner types, which in turn reflected their land management decisions.

In general, as the number of motivations with high scores increased, so too did the commitment landowners expressed toward their role identity. As the strength and diversity of landownership motivations and place-based attachments increases, it is likely that commitment to their landowner role will as well; this role will become more salient and integrated into a landowner's sense of self (Stets and Burke, 2000). Furthermore, landowners with stronger commitment indicated that they employed more practices that were beneficial for wildlife, which may indicate that these behaviors are more resilient, or at least that these landowners are more likely to continue to act in accordance with their landowner identity (e.g., Lind-Riehl et al., 2015). Furthermore, committed landowners may be less likely to divest or subdivide their landholdings (Bliss and Martin, 1988; Gruver et al., 2017). Understanding the self-conceptualizations of the role identity and its link to management practices can help identify which practices are likely to be maintained in the prairie. Increasing the connection of landowners to the community and environment of the GCP can help increase their commitment to the landowner identity, capacity to actively manage their property, and their adoption of practices that are beneficial for wildlife. Linking behaviors beneficial to wildlife with the landowner role, of which the 'Use' motivation represents a key component, can help increase their adoption and continued use (e.g., McGuire et al., 2013). In this study, the most committed landowners also used the most management practices that were beneficial for wildlife. It is important to view and recognize landowners as stewards of the lands they inhabit who should be engaged in conservation initiatives when possible to help foster their continued use of wildlife management practices.

A fundamental consideration of landowner typologies or segmentation is the ability to relate the underlying partitioning criteria to observable variables (Dayer et al., 2010). In my study, landowner motivations segmented large acreage landowners, which were correlated with several different observable characteristics: age, agricultural background, income derived from land, hours on land and retirement status. The proportion of household income gained from the land and the number of hours spent on the land were most indicative of different landownership motivations and types. When these two variables are combined they can provide an indication of what type of landowner the individual is likely to be. A landowner with high values for both of these variables would likely be a landowner, who is more predisposed to engage in, or be receptive to land management that benefits biodiversity, while a low score in time on land would indicate a landowner who may need technical assistance to help them engage in wildlife-beneficial land management. Conservation landowners did not reside on their land but spent some time there each week which could be interpreted as a form of absenteeism. As in my study, absenteeism has been associated with less active management of the land or engagement in conservation programs (Kendra and Hull, 2005; Rickenbach and Jahnke, 2006; Petrzelka et al., 2012; Sorice et al. 2018). Therefore, when trying to identify landowner types in the field, these variables may be among the most useful indicators that can be inferred with a basic familiarity with the landowner. Conversely, the lack of significant differences among landowner types with respect to gender, education, tenure or number of acres owned indicates that these criteria should not be relied upon to identify types of large acreage (>40 ha) landowners in the GCP.

Perhaps most importantly, there was no difference in the amount of acreage owned among large landowner types. Previous studies have found smaller landholdings, which were removed from my sample, associated with amenity and lifestyle landowners

(Daley et al., 2004; Kendra and Hull, 2005; Ferranto et al. 2013). Although large acreage landowners have been associated with production, or investment-orientations (Sorice et al. 2012; Ferranto et al., 2013), I identified 'Lifestyle' and 'Amenity' landowners in my sample. The typical amenity landownership scenario is that landholdings are progressively subdivided and acquired by people who are not primarily interested in agricultural production and, consequently, are willing to acquire properties that are too small to provide a sole source of income, thus contributing to landscape fragmentation (Kendra and Hull, 2005; Petrezalka et al., 2013). The presence of 'Amenity' landowners in my sample indicates that they are not solely associated with smaller (<40 ha) landholdings and may not only be "new to the land" landowners or amenity migrants (Rudzitis, 1999; Gosnell and Travis, 2005). I found evidence for 'Amenity' landowners who likely returned to their familial lands, which presents an interesting scenario wherein returning landowners may shift the composition of values, motivations and land management of an area but in different ways than has been previously described for amenity migrants (Gosnell et al., 2007; Gill et al., 2010).

2.4.1. Management implications

Wildlife management practices were associated with the 'Use' motivation. The inclusion of a hunting statement in this motivation scale likely contributed to this relationship, particularly for habitat management. Additionally, many habitat management practices promoted by the TPWD are congruent with preferable range management practices. The presence of environmental conservation motivations did not necessarily translate into use of wildlife management practices, 'Conservation' landowners performed relatively few habitat management practices. Having owned their land for less time, it is likely that 'Conservation' landowners lack the knowledge or capacity to employ many wildlife management practices. In this regard, 'Conservation' landowners may represent a group for conservation practitioners to preferentially target for program recruitment. With less experienced landowners such as these, practitioners can help them develop their abilities to fulfill their conservation motivations. 'Conservation' landowners may yield significant conservation benefits for relatively little investment of resources. Furthermore, conservation practitioners should work with all landowners to help promote underutilized practices (e.g., prescribed burning) that have the potential to yield benefits for biodiversity (TPWD, 2010). These efforts have been underway in the GCP, but as this study indicates, there is potential for additional adoption of these practices.

Conversely, 'Lifestyle' landowners represent a group who are best to deemphasize in efforts to recruit landowners for conservation efforts. Landowners in this group performed few conservation behaviors but also expressed lower value for the biodiversity of the GCP and indicated they felt that landowners were doing enough to conserve biodiversity. In this regard, 'Lifestyle' landowners can represent a resource "sink", where the outreach resources expended are not likely to result in the adoption of behaviors. This type of landownership may have implications for biodiversity conservation, 'Lifestyle' landowners were the most distinct type and were least likely to engage in wildlife management activities, as others have also found (Sorice et al., 2014). Understanding land management behavior of 'Lifestyle' landowners merits additional research, particularly given the demographic trends towards aging rural landowners who are more likely to fall into this landowner category. The differentiation of landowners who are and are not predisposed to engage in conservation behaviors can help make outreach efforts more efficient. In this study, farm heritage and income were useful criteria for differentiation and more effort could be given to identify other observable factors at a scale that is meaningful for program objectives (e.g. by soil and water conservation districts).

2.4.2. Conclusion

As my study has demonstrated, landowner typologies have considerable utility to help guide conservation efforts in the GCP. Many times, it is assumed that landowners are behaving purely in relation to their self-interest, however, this study indicates this may not always be the case. Some landowners are motivated to own their land for reasons that are associated with their attachment to the place where they are found. Landowners with these place-based motivations are demonstrating the embeddedness and attachments that compose the foundation of the Land Ethic. Thus, these attachments can be used to help foster behaviors that are beneficial for conservation by providing a strong connection between the behaviors and the preservation of the biodiversity and community of an area (e.g., Primdahl et al., 2013). Behaviors that are associated with place-based motivations may be more resilient, as they may be associated with other role identities that a landowner may have. However, for some landowners these connections may also make changing behaviors difficult. It is assumed that many behaviors that are associated land management are the result of economic based decision-making, and accordingly there has been an emphasis placed on aligning financial incentives so that behaviors are adopted. With identification of the important role that place-based motivations play in landownership motivations, it becomes important to demonstrate how behaviors tie to community and conservation outcomes.

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3. SOCIAL CAPITAL AND LAND MANAGEMENT COORDINATION: THE ROLE OF LANDOWNER ASSOCIATIONS IN FOSTERING ECOSYSTEM SERVICES

3.1. Introduction

Worldwide, grassland biodiversity is in decline due to land conversion, biological invasions and woody plant encroachment. Grasslands generally have fertile, productive soils that may not be present within the wider landscape and so can be particularly attractive for agriculture, but even less productive grasslands are subject to conversion because their conversion is relatively easy (Rashford et al., 2011; Wright and Wimberly, 2013). Given these characteristics, grassland conversion can be driven by fluctuating commodity pricing, slope and productivity (Stephens et al., 2008; Wright and Wimberly, 2013). In lieu of outright conversion, grasslands can also be lost as a consequence of land management practices. With overgrazing, climate shifts, disruption of disturbance regimes and/or an absence of active management, grasslands can be prone to woody plant encroachment or the establishment of invasive species (Archer et al., 1995; Van Auken, 2000; Wilcox et al., 2018). These threats have combined to disproportionately imperil grasslands; their rate of conversion has exceeded the rate of protection by up to 8 times resulting in widespread habitat loss and fragmentation (Hoekstra et al., 2005; Pool et al., 2014). Of threatened North American ecosystems, grasslands compose over half (55%) of ecosystems that are critically endangered (have experienced declines of greater than 98%; Noss et al. 1995).

Historically, efforts to conserve biodiversity in grasslands have focused on addressing threats via the creation and protection of conservation lands (Hoekstra et al., 2005). However, in recent years there has been acknowledgement of the limitations associated with the opportunistic allocation of conservation lands (e.g., Neke and Plesis, 2004). Such ad hoc creation of conservation lands can be inefficient and, at worst, counterproductive to conservation goals by not allocating scant resources in an effective manner (Margules and Sarkar, 2007). Furthermore, acquisition of lands for conservation can have the impact of increasing the development pressures on land within a given landscape, which points to a need for a comprehensive approach to conservation (Armsworth et al., 2006). Consequently, a systematic conservation planning approach that identifies and prioritizes areas in relation to their conservation potential has been promoted (Margules and Sarkar, 2007). As adoption of strategic planning has increased, limitations of a preservation-centric approach have been identified. In many threatened ecosystems, extensive private ownership and existing land uses are significant barriers to the allocation of conservation lands at the scale necessary to attain meaningful progress toward conservation outcomes (Ciuzio, Hohman et al., 2018). As a result, emphasis has been placed on increasing the conservation value of landscapes with extensive agricultural production via a shift in conservation strategies away from land allocation and toward management on private lands that benefits biodiversity (Kamal et al., 2015). Although these private lands may not provide as many conservation benefits as those of less modified lands, they can serve as important habitats for a wide range of species (e.g., Winter et al., 2006).

Biodiversity beneficial management can be fostered via the use of incentives, including conservation easements, management cost shares and rental payments (e.g., Langpap, 2006; Zabel and Roe, 2009) that are targeted in focal areas. For example, species ranges or watersheds have been given a focus in conservation efforts (e.g., Prior-McGee et al., 2007; Linke et al., 2008). Even with a regional focus, not all lands have the same conservation potential due to their location, size or relative orientation or potential for habitat, among others (Margules and Sarkar, 2007; Humphries et al., 2008). Furthermore, many lands are not of sufficient size to support focal conservation species (e.g., golden-cheeked warblers [*Setophaga chrysoparia*]; Butcher et al., 2010). This pattern is especially true in prairie landscapes where species may be particularly susceptible to impacts of habitat loss and fragmentation, and therefore, more dependent on relatively large, intact habitat patches (e.g., USFWS, 2010).

Given the emphasis on the inclusion of private lands in conservation initiatives, strategies to increase their contribution to conservation outcomes are important. One such strategy is to focus recruitment efforts on obtaining conservation agreements on private lands that will increase the contiguous acreage allotted for conservation (Rickenbach et al., 2011). From a practitioners' perspective, there is an incentive to direct their efforts toward larger landholdings, due to the relative efficiency this approach can yield in terms of acres per effort. However, a focus solely on large landholdings may not provision adequate habitat, may direct conservation efforts to sub-optimal locations, or result in the targeting of poor-quality habitat (Margules and Sarkar, 2007). Alternatively, groups of owners of smaller parcels can join together to cooperatively manage their lands for conservation benefits via cross-boundary cooperation (Rickenbach et al., 2011). Such cooperative initiatives have been shown to increase the cost effectiveness of land management by increasing the scale at which conservation actions are applied (Schulte et al., 2008). However, cross-boundary conservation is currently not supported by dedicated landowner incentive programs and, have not been widely adopted (Kittredge, 2005; Rickenbach and Jahnke, 2006). Rickenbach et al. (2011) identified several factors that can contribute to successful cross-boundary conservation, including: willing landowners, or "boundary spanners", institutional support, and policies that reorient existing programs to incorporate spatially-integrated incentives. Given fulfillment of these criteria, conservation efforts in areas with smaller parcel sizes may become more efficient, thus increasing the conservation of landscapes that have undergone or are susceptible to fragmentation or parcelization. In cross-boundary conservation scenarios, individual land management decisions must consider broader conservation plans with neighboring landowners, translating into a need for coordination of land management practices among landowners, agencies or organizations.

One land management coordination strategy has focused on engaging landowners in voluntary associations that work together toward a focal management goal. Examples of these associations include, wildlife management associations (WMAs) and prescribed burn associations (PBAs). WMAs are landowner associations that seek to increase the scale of wildlife and habitat management to that of game species by coordinating management (TPWD, 2004; Wagner et al., 2007). WMAs seek to bring landowners together to coordinate activities among its members so that, within their boundary, wildlife population management is accomplished for members' benefit, WMA members can collectively manage the harvest and/or wildlife managers can treat the WMA as one unit. Additionally, members can manage their land with consideration of the wildlife resource within the WMA area. As landowner driven organizations, associations are highly diverse. In Texas, the first WMA was established in 1955 and they have increased in popularity and now there are almost 150 found throughout the state (TPWD, 2004; 2017). These associations have been shown to increase social capital (Wagner et al., 2007), however, it is unclear if this social capital translates to an increase in coordination of land management activities in other domains. Social capital has been demonstrated to be transferrable, and can span organizations and institutions to provide benefits that accrue within a community (Coleman, 1988; Putnam, 2000).

Given their role as an entity for communication and coordination, there is potential for additional impacts associated with WMAs that extend beyond their specific wildlife management goals. WMAs may provide broader or "spillover" effects for habitat management, wherein, WMA activities can increase social capital (networks and trust), group identity and cross-boundary cooperation among landowners. If these effects are present, they may translate cooperation and coordination of land management activities of sufficient scale to impact biodiversity conservation of the landscape.

In order to evaluate the potential impacts of associations on biodiversity conservation, I investigated whether there was a difference between WMA members and non-members in relation to different aspects of social capital and land management coordination and I then evaluated the importance of different variables for land management coordination.

3.1.1. Conceptual model

In this manuscript, I refer to cooperation as any behavior that is undertaken that attempts to assist another in achieving their desired outcome. When cooperation is proposed to occur among adjoining parcels of land I will use the term cross-boundary cooperation (Rickenbach et al., 2011). Both cooperation and cross-boundary cooperation are important for obtaining the objectives outlined by strategic conservation planning. Cooperation can help agencies' conservation efforts in private lands and cross-boundary cooperation can help increase the contiguous area of lands managed for biodiversity and thus their effective area.

Engaging in coordinated land management involves negotiating agreements. These agreements may be formal or informal and will most likely result in some form of negotiated tradeoffs or compromise for one or both parties. Entering into an agreement can reduce the flexibility of a landowner to pursue their own goals because their decisions must consider others' interests. The negotiation of such agreements can incur transaction costs that are affected by relational and technical considerations (Parkhe, 1993). In particular, coordination involves the formation of working relationships in which roles, viewpoints, goals and expertise must be understood and negotiated. Conversely, from a technical standpoint the "how" and "what" of the activities that will be coordinated must be agreed upon. Given these considerations, transaction costs may act as an impediment to engaging in cooperative conservation agreements as individuals must develop the interpersonal or institutional relationships and trust necessary to enter into an agreement (Parkhe 1993; Zaheer et al., 1998). In these instances, social capital may catalyze agreements if it decreases the transaction costs and increases the likelihood that agreements will be honored (Inkpen and Tsang, 2005).

Originally used by Hanifan (1916), social capital was conceptualized as a collective resource with the potential to assist the individuals of a community. Social capital was viewed as a resource that could improve the well-being of the individual and satisfy social needs but also scale up to provide benefits to strengthen the entire community. In the past several decades, social capital has received significant research interest and reinvigoration. As described by Coleman (1992), social capital could be attributed to different forms of social relations in 3 primary areas: 1) information channels, 2) norms and effective sanctions, and 3) obligations, expectations and trustworthiness. These components were not seen to reside in individuals, but rather in the institutions within which people are embedded. In this regard, social capital is conceptualized as a public good, and not able to be exclusively captured by individuals. For this reason, social capital often forms and dissipates as a result of non-target activities that engage people in networks of interaction.

Whether social capital is a public or private good has been the source of discussion and is of import for understanding its dynamics. Lin (1999) identified 2 levels of inquiry for social capital; individual and group level. At the individual level, social capital has the potential to provide a return on investment that the individual is able to capture, although these returns are incomplete, benefits do accrue at the group level.

Conversely, there are other instances in which the group, or relational, level is the focus of social capital. Thus, different dynamics are important at the individual and relational levels. Lin (1999) defined social capital as: “resources embedded within a social structure which are accessed and/or mobilized in purposive actions (pg. 35).” In this definition, social capital takes an active, individual form and is comprised of networks (or network position) and resources that are embedded in the network structure. However, a focus on the individual aspects of social capital doesn’t account for its emergent aspects and limits it to resources that can be mobilized. Thus, it may be that institutional or group-level capital may be mobilized by an individual (e.g., money for goods) and although the individual may contribute to the formation of this institution by participating in the system it creates, they are clearly exploiting a common good.

Social capital can originate from several different sources. Portes (1998) summarized the sources of social capital as instrumental and consummatory types of social capital. Instrumental sources as composed of 2 sources. Enforceable trust: networks of exchange, norms, and sanctions to ensure reciprocity. This is the relational concept of Coleman (1988) and institutions as conceived by Ostrom and others (e.g., Brondizio and Ostrom, 2005). Second, norms of reciprocity and resulting accumulation of obligations from others, which it is understood, will be repaid but the form and timeline are not specified. This is similar to Lin’s (1999) network theory of social capital. Consummatory types of social capital are also composed of 2 sources. “Bounded solidarity” is an identity-based source of social capital in that individuals are motivated by their identity to their group to contribute share resources among members. The last is "value introjection," whereby the outcome of exchanges is the result of their embeddedness in a social structure, returns may be related to the social group within which the exchange takes place. Partitioning these different sources is not discrete, consummatory and instrumental sources overlap. However, it is clear that networks, trust and norms of reciprocity are important to consider. Furthermore, social groups that can contribute to the formation of a group identity can also play an important role in facilitating the development and expression of social capital.

At the group level, social capital can be thought of as a common good. Once social capital accumulates within an individual it can be used to accrue broader benefits that can transfer within the community. Given the role of social capital in increasing the trust, reciprocity and networks within a community, it is likely that it can serve as a catalyst to decrease the apparent transaction costs associated with land management coordination and thus increase the likelihood of coordination.

3.1.2. Gulf Coast Prairie

In pre-colonial times, the Gulf Coast Prairie and Marshes (GCP) extended along the Gulf of Mexico from Louisiana to Mexico and has been influenced by humans for hundreds of years. Native Americans were present in the GCP from at least 500 BC (Chipman, 1992). The GCP was also the site of early movements of European colonizers into what is now the United States. Spanish colonies were established in the GCP as early as 1682 and there was a concerted effort to increase the presence of Europeans in the region to claim the land (Weber, 1992). These and subsequent efforts resulted in the formation of large ranches. As the site of some of the first oil and gas discoveries in Texas in the early 1900's, land use intensity began to increase in the GCP. This trend continued with the conversion of lands to crop production and pasture (USFWS, 1999). Consequently, the GCP has been the site of land conversion and habitat fragmentation for a significant amount of time, which has resulted in disruption of the ecological disturbances, such as grazing and fire, that maintained the prairie ecosystem.

The GCP was once home to wildlife and processes that impacted the prairie. American bison (*Bison bison*), which were likely present in the GCP, could contribute to the maintenance of open areas of grassland via their intense grazing and sharp hooves when they preferentially grazed regrowth in recently burned areas (Knapp et al., 1999). Direct fire effects, which were most important, included woody plant suppression and acceleration of nutrient cycling in the ecosystem (Anderson, 2006). However, bison were extirpated from the GCP by 1825 and beginning in 1850 wildfires were suppressed as settlers sought to avoid property damage (TPWD, 2012). Currently, prescribed burning in the GCP is not implemented to the extent necessary to achieve ecosystem-wide goals for the maintenance of prairie habitats (Grace, 1998; TNC, 2002; TPWD, 2012).

As the GCP has been anthropogenically influenced and its historic ecological processes disrupted, the ecosystem has become imperiled. As a result, the GCP has become one of the most endangered ecosystems in the world. In Texas, its area has decreased from 2.6 million hectares (6.5 million acres) to less than 26,300 hectares (65,000 acres) and in Louisiana the loss has been even greater with a decline from 1 million hectares (2.5 million acres) to less than 40 hectares (100 acres) (USFWS, 1999). Consequently, much of the ecoregion's biodiversity is imperiled or has already been extirpated. In particular, bison (*Bison bison*), red wolf (*Canis rufus*), pronghorn antelope (*Antilocapra Americana*) and prairie vole (*Microtus ochrogaster*) have been extirpated, while others such as the Attwater's Prairie Chicken (APC, *Tympanuchus cupido attwateri*) are endangered. The plant community has also been affected by the combination of invasive plants, land conversion and disruption of ecological processes. At least 12 species are listed as threatened or endangered (TPWD, 2012).

Although there are no explicit guidelines of how much land area is sufficient to adequately provision wildlife habitat, a global target of 17% of each countries' lands to be set aside for biodiversity conservation (Leadley et al., 2014). Less than 5% of Texas land is publicly owned, with a conservation mandate (IRNR, 2014; Vincent et al., 2017). Furthermore, some ecosystems are better conserved than others (IRNR 2014; Leadley et al., 2014), with landscapes that are suitable for agriculture, ranching or other commodity production being more likely to be privately owned. Thus, in ecosystems such as the GCP, private lands have an important role to play in biodiversity conservation. However, gaining meaningful conservation benefits from these lands requires that land management is accomplished at adequate scales.

3.1.3. Cross-boundary coordinated land management

The conservation challenges encountered in the GCP are analogous to those associated with the patterns of decline in grasslands globally. In relation to private lands, these are related to the inadequacy of individual landholdings for sustaining wildlife populations. For example, in Texas a viable bobwhite population requires 1415-2830 ha (3500-7000 acres) of habitat an area that exceeds the average Texas ranch size (Brennan et al., 2008). As a response to this challenge, groups of landholders can join together to cooperatively manage their lands, increasing the effective area of lands devoted to wildlife management. Such cross-boundary conservation has been shown to increase the cost effectiveness and scale of land management and conservation actions (Schulte et al., 2008), and it places emphasis on the spatial aspects of conservation, wherein the conservation value of land is relational and dependent on the geographic arrangement of associated land parcels (Margules and Pressey, 2008). Some conservation auction systems, such as the CRP, have placed spatial orientation into their bid evaluation criteria; bids that create a contiguous area of habitat are valued more highly than those that do not (Kittredge, 2005). Programs have also incorporated agglomeration bonuses paid to landholders for aggregating their lands into cohesive units devoted to conservation (Kittredge, 2005). While these approaches have potential for increasing existing patch sizes, they have not been widely implemented. Agglomeration requires a significant amount of coordination among landholders, which depends on trust, shared liability, and increased initial transaction costs, which may pose a barrier to enrollment or formulation of bids.

Relatively little research attention has been focused on understanding the social context of agglomeration or cross-fence conservation, and most have been undertaken in forestland. Ferranto et al. (2013) examined the receptivity to cross-boundary cooperation among California landowners with different land management motivations, and found that coordination was most likely to occur in order to reduce wildfire risk and improve wildlife habitat. This coordination likelihood was closely tied to management motivations and their position along a profit-amenity continuum. In accordance with utility maximization theory (Butler, 2005), landowners who had high scores on amenity and profit motivations were more likely to manage cooperatively than those who expressed less interest in a broad range of motivations; moreover, landowners who owned their land for income purposes were more likely to engage in coordination. Schulte et al. (2008) outlined ecological and economic benefits that could accrue from cross-boundary coordination in forestlands. They found a high potential for cooperation and estimated 3-6% economic gains resulting from cooperation but that there would likely not be a meaningful reduction in the amount of fragmentation because of the small parcel sizes in the area. In forestlands, such as these cross-boundary coordination benefits include economies of scale for harvesting and management activities, fire protection, insect and disease control. While, these benefits accrue at the landscape scale, benefits for individual land parcels may create sufficient incentive for landowners to act purely out of self-interest. For example, coordination to decrease the spread of fire and disease could serve to help ensure the timber stands reach a harvestable age. Conversely, in grasslands the benefits of collaboration are less direct than for forestlands, landowners may gain economy of scale benefits from the prescribed fire and other treatments.

In the rational utility maximization model, it is assumed that landowners will act to gain the most benefit or utility from their land via a conscious evaluation of the costs and benefits associated with their land management decisions (Butler, 2005). This model does not make assumptions about the specific utility or benefits that the landowners are seeking to maximize, which could be tied to either monetary or non-monetary goals. At the risk of the potential for tautologies, where the definition of a goal can be tied to what has been maximized, it is clear that a landownership motivation should be closely tied to landowners' management decisions. The Theory of Planned Behavior, which is widely applied theory in landowner studies, could be interpreted to fall within this general model, as landowners evaluate criteria when engaging in decision-making (Ajzen, 1991). Understanding the motivations for engaging in conservation programs can have important applications for conservation planning and the design of conservation programs to fulfill their motivations (Raymond and Knight, 2013).

When considered together it is probable that landowners' likelihood to engage in cross-boundary cooperation is associated with landowners' motivations and social capital. Social capital can be associated with the groups of which landowners are members. I tested several hypotheses associated with these patterns. I hypothesized that landowners who were members of associations would be more likely to engage in coordination. I also hypothesized that landowners who were more investment and production oriented would be more likely to engage in cooperation. Furthermore, I examined which social factors were associated with the likelihood to coordinate land management.

3.2. Methods

3.2.1. Study area

To encompass the diversity of lands within the GCP ecoregion, I conducted the study in two different focal areas within the historic range of the GCP. Specifically, I focused on land that included the Refugio-Goliad Prairie Conservation Project (RGP; Refugio, Goliad, Calhoun, Victoria counties) and land surrounding the Attwater's Prairie Chicken National Wildlife Refuge (APC-NWR; Austin and Colorado counties) for a paired comparison of landowner views. The lands around the APC-NWR were the "North" site and those including the RGP were the "South" site. The North site is slightly cooler and wetter than the South site and experiences seasonal drought less frequently (Griffith et al., 2007). These geographic and climatic variations translate into slightly different ecological and social systems between sites. The North is more suited to crop production including rice, sorghum, cotton and soybeans, whereas lands in the drier South are mostly used for cattle grazing and ranching (Griffith et al., 2007) and properties are substantially larger than in the North (USDA, 2012; IRNR, 2014) (Table 3.1). Additionally, the North is closer to the Houston metropolitan area, which tends to increase land values and decrease property sizes as amenity landowners relocate to the rural areas (IRNR, 2014). Hunting leases occur within both study sites.

3.2.2. Survey and sampling design

I used county tax records to identify all landowners who owned more than 100 acres (40 hectares) of land. This parcel size was large enough to support wildlife populations and were based upon the estimated size needed for northern bobwhite quail

(*Colinus virginianus*). I used a statistical power analysis to determine the survey sample size of 903 (400 in each site and 103 WMA members) (Ott and Longnecker, 2015). The names of WMA members were added to ensure that they were adequately represented in the survey sample. I conducted the mail survey using the protocols of Dillman's Multiple Contact Method (Dillman, 2007). I used a series of five mailings spaced over a 49-day period, that included a presurvey letter, 2 reminder postcards, a questionnaire and a replacement. The survey was initiated on August 24, 2015 and the last mailing was sent on Oct 19, 2015. Questionnaires that were received by the end of November were included in this study. The study and associated materials were approved by the Texas A&M University Institutional Review Board (# IRB2013-0449D).

Table 3.1 Average age, farm/ranch size, income, and percent of income derived from livestock and crops in the North and South study sites. Source = USDA 2012, Census of Agriculture.

Site	County	Average Age (years)	Average Size (hectares)	Average Income ($1000)	Livestock %	Crops %
North	Austin	60.4	71.2	20.8	60	40
	Colorado	61.5	124.6	43.2	35	65
South	Calhoun	60.5	282.1	37.4	33	67
	Goliad	61.7	170.4	16.5	80	20
	Refugio	60.2	741.8	166.2	76	24
	Victoria	59.6	115.7	31	42	58
Average	North	61	97.9	32	47.5	52.5
	South	60.5	327.5	62.8	57.8	42.3
	Total	**60.7**	**251**	**52.5**	**54.3**	**43.2**

I developed the survey questionnaire based upon feedback gathered from land managers as well as researchers who were familiar with Texas landowners. The questionnaire was 16 pages and covered a range of topics including: land management practices, farm and ranch characteristics, attitudes, and concerns. I also asked survey participants about their levels of community involvement, sources of land management information, considerations that factor into their land management decisions and general demographic characteristics (e.g. age, employment, etc.). Most questions used 5-point response scales to solicit respondents' level of agreement with a statement, the importance of a particular practice, or how well a statement described them (1 = strongest negative response [e.g. "strongly disagree", "very unimportant"]; 3 = neutral [i.e., "neither positive nor negative"]; 5 = strongest positive response [e.g., "strongly agree", "very important"). The questionnaire requested that the person responsible for land management decisions complete the survey.

I used a combination of a follow up survey, comments on incomplete questionnaires and opportunistic telephone conversations with non-responding participants to understand if there were differences between responding and non-responding landowners. The one-page follow up survey was mailed once to 200 non-responding landowners, 90 in the North and South and 20 WMA members and included an introductory front-page letter and questions on the back. The questionnaire consisted of selected questions from the original questionnaire and also a question that asked why they did not complete the initial questionnaire.

The dependent and independent variables were collected using the questionnaire and used for the data analysis described below.

3.2.3. Dependent variables

Landowner Coordination Intention: In order to outline coordination intention, I first asked landowners a series of questions about their current coordination behavior. These questions asked how often they coordinated their land management with different entities (neighboring landowners, other people in the area, agencies or organizations). Landowners indicated the frequency of coordination using a 5-point scale (1 = Never or almost never; 3 = A few times a year; 5 = More than once a month). I averaged these scores for all questions and then transformed them to a dichotomous variable. Scores that were greater than 1 (Never or almost never) were assigned a value of 1 (coordinate), while those that were less than 1 were assigned a value of 0 (no current coordination). I next asked landowners about how likely they were to increase the ways and frequency of their coordination with different entities within the GCP (neighboring landowners, other people in the area, agencies or organizations) during the next 5 years. I used an exploratory factor analysis (EFA) to group similar statements and evaluated reliability using Cronbach's Alpha > 0.7. I averaged the scores. This scale (Coordination Intent) was used to compare means between groups. I recoded this average score into a dichotomous variable, scores that were less than 3 (unlikely to increase) were assigned a 0 and those 3 (neutral) or greater were assigned a value 1 (maintain or increase).

I then combined the scores to create a categorical variable that considered current behavior. For this combined variable (Intention for Coordination Change) I created 4 categories: 1) none (no current or future coordination); 2) decrease in coordination (currently coordinate but will do less in the future); 3) neutral or likely to begin coordination (don't currently coordinate but will likely increase coordination in the future); 4) maintain/increase coordination (currently coordinate and plan to maintain or increase in the future).

Outcomes to increase neighbor cooperation: I also asked landowners how likely or unlikely they were to cooperate with neighbors given a series of 10 different outcomes. This series of questions covered a range of hypothetical, beneficial outcomes associated with coordination that included conservation (e.g., prairie conservation), resources (e.g., technical guidance) and landowner centered benefits (e.g., political power). Respondents indicated their likelihood on a 5-point response scale (1 = very unlikely, 3 = neutral, 5 = very likely). I used an exploratory factor analysis to group similar outcomes. I evaluated the reliability of scales using Cronbach's Alpha > 0.7. I transformed the score into a dichotomous variable. I changed all dependent variable values that were equal to or below 3 (neutral on the response scale) 0 or "not likely" and values greater than 3 were recoded as 1 or "likely."

3.2.4. Independent variables

Trust and Reciprocity: I asked participants a series of questions to evaluate their trust and reciprocity for various groups: neighbors, other members of the community, people of the GCP, and Texans in general. In order to evaluate their trust, we asked landowners: "I have amount of trust in [group]." In order to evaluate their level of reciprocity, we asked landowners "When they are in need I very much want to help [group].” Landowners indicated their agreement with each statement on a 5-point response scale (1 = strongly agree, 3 = neutral, 5 = strongly disagree), the Trust and Reciprocity variables were the averaged value for all responses for these statements.

Consultation Network and Information Source Diversity: In order to compare differences in the diversity of sources that landowners used to learn about land management options I used the Shannon Diversity Index. Based in Information Theory, Shannon’s Diversity (H) describes the entropy of a community based upon the evenness and abundance of species within a community. Although used primarily for analysis of ecological communities, H can be adapted for other uses as it is a way to quantify the information contained within a focal area of interest. In the ecological interpretation, H is a quantification of the information or uncertainty that is found with each species of a community (Shannon, 1948). This approach can be applied to other situations where there are objects that vary in abundance. For consultation networks, I used the count of each type of person who was consulted within their networks for the matrix used to derive H. For the information diversity, I used the different information sources and their relative frequency of use as indicated in the questionnaire for the H matrix. Thus, both measures reflect relative differences in landowner acquisition of information regarding land management options.

Relative Importance of Consultant Type: Respondents were asked to rank and categorize the consultant based their importance for helping guide their land management decisions. I derived an index of importance to calculate the importance of different types of people within landowners’ consultation networks. I obtained these index values by first grouping the types of consultants into 2 categories: professionals and peers. Peers included neighbors, friends, family, and other landowners, while professionals included land managers, agency and organization staff. Although the categories were not mutually exclusive, each individual within the network was placed into an individual category by each respondent, indicating the role in which the particular person was perceived by the responding landowner. Based upon their ranking within the networks, the different individuals were given value that was inverse to their ranking (i.e., most important was given a 5 while the 5th most important was given a 1). The scores for these different categories were summed and divided by the total points that were available (15) and ranged from 0 to 1. In this way, the relative importance was calculated for the different categories. For example, if professionals were the most and 3rd most consulted people the relative importance would be (5 + 3) / 15 = 0.53.

Number Consulted: I calculated the number of people that were consulted by each landowner in relation to their land management decisions. The number of people that it was possible to indicate were consulted was limited to five. Therefore, the variation in number of people who were indicated as consulted reflected only those who consulted less than 5 people.

Association membership: I asked landowners whether they were members of a landowner association. Their membership was indicated as a binary yes = 1 or no = 0.

Civic Engagement: I created a composite measure of civic engagement. I asked landowners about the number of activities they attended across a diverse range of organizations, including: community government, ranch and farm organizations, prescribed burn association, outdoor association and conservation group. I asked them to indicate the frequency with which they attended meetings or functions on a 5-point scale (1 = Never or almost never, 2 = About once a year, 3 = A few times a year, 4 = About once a month, 5 = More than once a month). I averaged the score for these categories to provide a measure of civic engagement to create a variable that ranged from 1-5.

Landowner role type: Using a list of landownership motivations, I derived five landowner role types: Working Place, Lifestyle, Amenity, Conservation and Entire Place (Hurst and Kreuter, In review). Working Place and Entire Place landowners were centered upon a combination of utilitarian and place-based motivations for land ownership, whereas Lifestyle and Amenity landowners were more focused on lifestyle considerations and less on the social community in the area where their land was located. Conservation landowners were motivated primarily by prairie and biodiversity conservation in the GCP.

Location: Because of the intra-regional differences in the agricultural operations, I identified whether respondents' properties were located in the North or South study areas. Given these differences, efforts had been made to engage landowners in environmentally beneficial practices, including the Refugio-Goliad Prairie Conservation Project (TNC, 2002) that has sought to engage landowners in practices that benefit prairie biodiversity, specifically the APC. These efforts could affect individual landowner's decision making and may also affect the cultural character of the region as it relates to prairie biodiversity, consultation and coordination. These potential impacts could have resulted in variation of the landowners' willingness to engage in coordination of their land management activities.

3.2.5. Data analysis

I evaluated the differences between the focal variables and the WMA members and non-members and also study sites using parametric and non-parametric tests. In particular, I evaluated whether data fulfilled the assumptions needed for an ANOVA (Ott and Longnecker, 2015). If the assumptions were fulfilled, then ANOVA was used; if not, then I used a non-parametric test. For categorical data, I used Chi^2 tests and the Mann-Whitney U test, respectively (Ott and Longnecker, 2015) and I applied $p < 0.05$ to identify statistical significance. For multiple comparisons I used a Bonferroni Correction to adjust for the family wide error rate.

In order to identify the variables that contributed significantly to the intention to coordinate and also the Likelihood of outcomes to influence coordination with neighbors I conducted a hierarchical stepwise logistic or multinomial regression. I evaluated the model variables and model fit for each multinomial Logit model using Cox-Snell and Nagelkerke's R^2. These measures are pseudo measures of the proportion of variance explained by the model, they serve as indices to the model fit and cannot be interpreted in the same way as an R^2 in ordinary least squares regression (Field et al., 2012). I used the likelihood ratio test to evaluate whether the model explained more variation than the null model. I used a backward stepwise regression to select which of the focal variables should be included in the final model by evaluating whether their inclusion resulted in a statistically significant ($p < 0.05$) coefficient estimate at each step and to minimize the suppressor effects possible with forward regression (Field et al., 2012). The initial model consisted of 12 continuous and categorical variables (Table 3.2).

Stepwise regression does not ensure that the "best" or most parsimonious model is selected, but rather that the variables that are included are statistically significant. For this reason, the use of an information theoretic approach has been advocated to help identify the most parsimonious model when considered holistically (Burnham and Anderson, 2003). However, a preliminary exploration of my data indicated no model was strongly supported, which suggested that model averaging is appropriate (Burnham and Anderson, 2003). Model averaging, however, may provide misleading results, particularly when there is multicollinearity (e.g., Cade, 2015). In light of these considerations, I decided to proceed with a stepwise regression variable selection approach. Stepwise regression eliminates multicollinearity via the selection criteria, but it can result in a misunderstanding of variable importance. In particular, the importance of included variables may be overstated because their selection can covary with unselected variables, which may also have a relationship with the dependent variable.

I used a backward stepwise regression to select the variables to remove from the model, with selection based upon the effect on likelihood ratio. I interpreted the variables that were statistically significant based upon their standardized beta 95% confidence interval. For the beta values, I present the conditional values. Furthermore, I standardized the continuous variables with a mean of 0 and a standard deviation of 1 before the regression to allow for the binary and dummy variables to be compared.

Table 3.2 Independent variables and their type, included in the initial logistic regression model.

Variables in Model	Type
Trust	continuous
Reciprocity	continuous
Size of network	ordinal
Network Diversity	continuous
Peer Importance	continuous
Professional Importance	continuous
Landowner Type	categorical
WMA membership	dichotomous
North	dichotomous
Neighbor Advice	ordinal
Current Coordination	continuous
Information Diversity	continuous
Civic Engagement	continuous

3.3. Results

A total of 902 survey questionnaires were mailed to landowners within the GCP. Of these, 13 were undeliverable and 29 respondents indicated they did not meet the acreage requirements for inclusion in the study, no longer owned land, or the addressee was deceased. Thus, the effective survey sample contained 860 landowners. I received 356 (41%) returned questionnaires, 162 (46%) were from the North and 194 (55%) from the South study areas. However, 86 of the returned questionnaires were not completed because the respondents chose to opt out of our study. Thus, the useable number of responses was 264 (31%), of which 134 (51%) were from the North study area and 130 (49%) from the South study area.

Of 200 mailed non-response survey questionnaires, 28 (14%) were returned. Of these, six were returned partially completed or with an indication they had already mailed a full-questionnaire, for an adjusted response rate of 11% (n = 22). This small sample size limited comparative analyses, but no statistically significant differences were identified in characteristics between survey respondents and non-respondents in relation to age, weekly hours spent on their land, percent of income derived from their land and acres owned. Of the non-respondents who returned the one-page questionnaire, 9 (32%) indicated either they had not participated in the study because of "privacy concerns/too intrusive" or because of "time commitment/questionnaire too long" while 6 (21%) selected both of these reasons. Additionally, at least 3 others (10%) selected "don't see a benefit", "not interested in study goals", and "health" reasons for not participating. Other reasons that were provided included physically unable to complete a questionnaire due to age or eyesight and lack of knowledge.

Overall, the average age of survey respondents was 68.1 (sd = 12) years, and there was no significant difference between the North and South study areas (t = -1.2, df = 259, p = 0.231). The respondents were 74% male (n = 200) with the same male to female respondent proportions in the North and South (Chi^2 = 0.124, df = 1, p = 0.725). The average number of years of education was 15.2 (sd = 4.3), which is 3.2 years post high school, with no meaningful difference between the North and South (t = -0.082, df = 257, p = 0.934).

Landholding size varied significantly between the North and South study regions being 263.0 ha (649.8 acres, sd = 1432.4) on average, with the average size for the South being significantly bigger than the North (South = 309.0 ha, 763.6 acres, sd = 959.9, North = 209.3 ha, 517.3 acres, sd = 1831.1 acres, respectively; t = 7.36, df = 263, $p < 0.001$). The average percentage of income landowners derived from their agricultural properties was 22.7% (sd = 29.7%) but also significantly more in the South than the North (South = 28.0%, sd = 32.3%; North = 16.6%, sd = 25.2%, respectively; t = -11.8, df = 251, $p < 0.001$). The distribution of landowner motivations among respondents in the North and South study sites did not differ statistically ($Chi^2 = 5.519$, df = 4, $p = 0.238$) or in the focal variables (Table 3.3).

Significant differences were observed between WMA members and non-members in a number of variables (Table 3.4). Association members had significantly higher trust than non-members, reciprocity, number of people consulted, the importance of land management professionals in their consultation networks, and diversity of their consultation networks. There were no statistically significant differences between the members and non-members with respect to diversity of information sources used, the importance of peers in their consultation networks, or distribution of landowner motivation types.

Table 3.3 The median, mean and standard deviation for focal variables for respondents who resided in the North and South study sites, along with the t-test statistics for each contrast. No significant differences were observed.

Variable	**Location**						**Test results**		
	North			South			**t**	**df**	***p***
	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.			
Trust	3.4	3.4	0.9	3.4	3.3	0.9	0.486	255	0.63
Reciprocity	4	3.8	0.8	3.9	3.8	1	0.287	251	0.77
Information Diversity	0.9	0.9	0.03	0.9	0.9	0.03	-0.23	262	0.82
Consultation Diversity	0.8	0.7	0.2	0.8	0.7	0.2	-0.19	262	0.85
Number Consulted	5	4.1	1.7	5	4.1	1.7	na	na	na
Peer Importance	0.7	0.6	0.3	0.6	0.6	0.3	0.909	261	0.36
Professional Importance	0.2	0.2	0.2	0.2	0.2	0.2	-0.97	261	0.33
Coordination Intent	3.2	3.1	1.1	2.8	2.6	1.1	-0.26	258	0.8

Table 3.4 The median, mean, standard deviation of focal variables for members and non-members of WMAs, along with the t-test statistics for each contrast. Significant differences are indicated with an asterisk and are based upon the Bonferroni adjusted p-value (p = 0.0177).

Variable	**WMA Membership**						**Test results**		
	Members			Non-members			**t**	**df**	***p***
	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.			
Trust	3.8	**3.7***	0.6	3.2	**3.2***	1	4.659	256	<0.001
Reciprocity	4	**4.2***	0.5	3.8	**3.6***	1	4.541	252	<0.001
Information Diversity	0.9	0.9	0.03	0.9	0.9	0.02	-1.508	263	0.133
Consultation Diversity	0.8	0.7	0.2	0.8	0.7	0.2	0.666	263	0.506
Number Consulted	5	**4.7***	0.8	5	**3.9***	1.9	na	na	na
Peer Importance	0.7	0.6	0.3	0.6	0.6	0.3	1.751	262	0.081
Professional Importance	0.3	**0.3***	0.2	0.1	**0.2***	0.2	3.79	262	<0.001
Coordination Intent	3	**2.8***	1	2.7	**2.3***	1.1	3.535	259	<0.001

3.3.1. Coordination Intent and Intention for Coordination Change

Overall, the mean value for intention to coordinate with other landowners or entities among landowners (Coordination Intent) was low; the median (3) and mean (2.5, sd = 1.1) values on the 5-point response scale corresponded to neutral and somewhat disinclined to coordinate, respectively. However, there was a statistically significant difference in intention to increase coordination between WMA members and non-members. When treated as a categorical variable, nearly three times as many landowners indicated they would not (n = 197, 74%) rather than would (n = 68, 26%) increase their coordination. There was no difference in the number of different landowner motivation types who were more or less likely to coordinate in relation to their overall intent, or between respondents in the North and South sites (Tables 3.3, 3.4). When, combining landowners' current coordination and intended future coordination together (Intention for Coordination Change), there was a significant difference in the proportion of landowners who indicated no current or future coordination (n = 119, 44%); neutral or likely to begin coordination (n = 91, 35%); maintain/increase coordination (n = 39, 15%); decrease in coordination (n = 9, 3%). There was also a difference among WMA members and non-members in the number of respondents in these categories; WMA members varied from the expected number in the none ($Chi^2 = 40.72$, $p < 0.001$) (Table 3.5).

Table 3.5 The difference in Intention for Coordination Change among landowners who were WMA members or non-members.

Intention for Coordination Change		WMA Membership		Total
		Non-Member	Member	
None	Count	98	21	119
	Expected	80.3	38.7	
Decrease	Count	3	6	9
	Expected	6.1	2.9	
Increase / Begin	Count	61	30	91
	Expected	61.4	29.6	
Continue / Increase	Count	12	27	39
	Expected	26.3	12.7	
Total	Count	174	84	258

All three Intention for Coordination Change categories included in the multinomial regression models were statistically significant, Landowner Motivation Type was not significant at the Bonferroni Adjusted level (0.013; Table 3.6). The study site location variable was not selected in the final model. The Likelihood Ratio Test indicated that the final model improved the fit over the intercept-only model (Table 3.6). The pseudo R^2 values indicated there was moderate model fit (Cox-Snell = 0.46, Nagelkerke = 0.52, McFadden = 0.30).

For the statistically significant explanatory factors, there was variation among the different groups between the “None” versus the “Maintain/Increase” contrast (Table 3.7). For the “None” versus the “Maintain/Increase” contrast, the effect of WMA membership was 2.6 which was significant (Table 3.7). When controlling for Landowner Type, Civic Engagement, and Neighbor Advice, WMA non-membership resulted in a 2.6 increase in the log odds of “None” vs “Maintain/Increase” coordination. As a person changed from a member to non-member, the odds of not coordinating are multiplied by 13.68, thus the odds of not coordinating increase by 12.68 times. When controlling for Landowner Type, WMA non-membership, and Neighbor Advice, the effect of Civic Engagement was -1.456 which was significant (Table 3.7). Each category increase in Civic Engagement resulted in the risk of “None” relative to “Maintain/Increase” being multiplied by 0.23. Thus, the odds of “None” relative to “Maintain/Increase” decrease by 77% for each category increase. When controlling for Landowner Type, WMA non-membership, and Civic Engagement, the effect of Neighbor Advice was -1.377 which was significant (Table 3.7). For each category increase in Neighbor Advice resulted in the risk of “None” relative to “Maintain/Increase” being multiplied by 0.252. Thus, the odds of “None” relative to “Maintain/Increase” decrease by 75% for each category increase.

Table 3.6 The -2 log likelihood of the model and likelihood ratio test (Chi^2, df, significance) for multinomial logistic regression of the Intention for Coordination Change.

Variable	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood of Reduced Model	Chi^2	df	Significance (*p*).
Intercept	306.333a	0	0	.
Landowner Type	325.506	19.173	8	0.014
WMA member	328.837	22.505	2	< 0.001
Civic Engagement	335.378	29.045	2	< 0.001
Neighbor Advice	341.578	35.246	2	< 0.001

Table 3.7 The parameter estimates for a multinomial regression of landowners' Intention for Coordination Change.

Variable	B	Std. Error	Chi^2 (Wald)	df	Significance (p)	Exp(B)	95% Confidence Interval for Exp(B)	
							Lower Bound	Upper Bound
None[a]								
Intercept	1.944	0.823	5.583	1	0.018			
Landowner Type								
Working Place[b]	0.613	0.692	0.785	1	0.376	1.847	0.475	7.173
Amenity[b]	0.099	0.7	0.02	1	0.887	1.104	0.28	4.35
Lifestyle[b]	Unreliable estimate							
Conservation[b]	1.958	1.285	2.322	1	0.128	7.083	0.571	87.885
WMA non-member[c]	2.616	0.589	19.705	1	**<0.001**	13.68	4.31	43.421
Civic Engagement	-1.456	0.305	22.756	1	**<0.001**	0.233	0.128	0.424
Neighbor Advice	-1.377	0.276	24.894	1	**<0.001**	0.252	0.147	0.433
Begin/Increase[a]								
Intercept	1.294	0.734	3.109	1	0.078			
Landowner Type								
Working Place[b]	0.92	0.582	2.492	1	0.114	2.508	0.801	7.855
Amenity[b]	-0.644	0.61	1.115	1	0.291	0.525	0.159	1.736
Lifestyle[b]	Unreliable estimate							
Conservation[b]	1.27	1.195	1.131	1	0.288	3.562	0.343	37.023
WMA non-member[c]	1.549	0.496	9.744	1	**0.002**	4.705	1.779	12.44
Civic Engagement	-0.689	0.231	8.879	1	**0.003**	0.502	0.319	0.79
Neighbor Advice	-0.475	0.224	4.509	1	**0.034**	0.622	0.401	0.964

a: The reference category is: Maintain/Increase.

b: "Entire place" landowner type is the reference category

c: WMA member is the reference category

For the statistically significant explanatory factors there was variation among the different groups between the "Begin/Increase" versus the "Maintain/Increase" contrast (Table 3.7). For the "Begin/Increase" versus the "Maintain/Increase" contrast, the effect of WMA membership was 1.549 which was significant (Table 3.7). When controlling for Landowner Type, Civic Engagement, and Neighbor Advice, WMA non-membership resulted in a 1.549 increase in the log odds of "Beginning/Increase" vs "Maintain/Increase" coordination. As a person changed from a member to non-member, the odds of not coordinating are multiplied by 4.705, thus the odds of not coordinating increase by 371%. When controlling for Landowner Type, WMA non-membership, and Neighbor Advice, the effect of Civic Engagement was -0.689 which was significant (Table 3.7). Each category increase in Civic Engagement resulted in the risk of "Beginning/increase" vs. "Maintain/Increase" coordination being multiplied by 0.502. Thus, the odds of "Beginning/increase" vs "Maintain/Increase" coordination decrease by 50% for each category. When controlling for Landowner Type, WMA non-membership, and Civic Engagement, the effect of Neighbor Advice was -0.475 which was significant (Table 3.7). Each category increase in Neighbor Advice resulted in the risk of "Beginning/Increase" vs. "Maintain/Increase" coordination being multiplied by 0.252. Thus, the odds of "Beginning/Increase" vs "Maintain/Increase" coordinating decrease by 75% for each category increase in Neighbor Advice.

3.3.2. Likelihood of cooperating with a neighbor given an outcome

Based upon the EFA, I treated the outcomes as one scale because most of the variation among statements (87%) was captured by one dimension, which I interpreted as “Likelihood of cooperating with a neighbor given an outcome”, or the likelihood of cooperating with a neighbor if it would result in a beneficial outcome. The overall average score for “Likelihood of cooperating with a neighbor given an outcome” was 2.8, (sd = 1.2, median = 3). WMA members had a higher mean likelihood to cooperate with neighbor given outcomes than non-members (2.6 vs. 3.1, F = 8.9, $p = 0.003$) as did those who had versus didn’t have an intention to increase coordination (3.4 vs. 2.5; U = 5.5, $p < 0.001$), however there was not a difference between locations (North = 2.7, South = 2.8, F = 1.4, $p = 0.25$).

When evaluating the “Likelihood of cooperating with a neighbor given an outcome” as a binary variable, there was a difference between groups. Cross tabulations between Likelihood given outcomes and WMA members and non-members and those who were likely and unlikely to engage in coordination (Intention) were both significant ($Chi^2 = 9.8$ and 24.4, respectively; p < 0.001, Table 3.8 & 3.9).

The 5 step backward logistic regression for “Likely to cooperate with neighbor given an outcome” resulted in a statistically significant model composed of 7 variables and a moderate model fit ($Chi^2 = 76.135$, $p < 0.001$; pseudo R^2 values: Cox-Snell = 0.31, Nagelkerke = 0.42, Table 11). The study site location variable was not selected in the final model. Of the 7 variables in the model, 4 were significant. The effect of Peer Importance was -0.881 which was significant (Table 3.10). When controlling for the other model variables, Peer Importance resulted in a 0.415 increase in the log odds of “Likelihood given outcomes.” For a one unit increase in Peer Importance, the odds of “Likely to cooperate with neighbor given an outcome” decreased by 58%. The effect of

Current Coordination Activity was 0.591 which was significant (Table 3.10). When controlling for the other model variables, Current Coordination resulted in a 1.806 increase in the log odds of "Likelihood given outcomes." For a one unit increase in Current Coordination, the odds of "Likely to cooperate with neighbor given an outcome" increased by 81%.

Table 3.8 Cross tabulation of binary variable for "Likelihood given outcomes" and those who were likely and unlikely to engage in coordination (Intention). There was a significant difference between groups ($Chi^2 = 24.4$; $p = 0.000$).

Coordination Intent		Likelihood of Neighbor Coordination Given Outcomes		Total
		Unlikely	Likely	
Unlikely	Count	106	61	167
	Expected Count	89.3	77.7	167
Likely	Count	17	46	63
	Expected Count	33.7	29.3	63
Total	Count	123	107	230

The effect of Consultation Diversity was 0.633 which was significant (Table 3.10). When controlling for the other model variables, a one unit increase in Consultation Diversity resulted in a 1.883 increase in the log odds of "Likely to cooperate with neighbor given an outcome." For a one unit increase in Consultation Diversity, the odds of Coordinating given outcomes increased by 88%. The effect of the

Lifestyle landowner type was -2.399 which was significant (Table 3.10). When controlling for the other model variables, a change from an Entire Place to Lifestyle landowner resulted in a 0.091 increase in the log odds of "Likelihood given outcomes." For a change from an Entire Place to Lifestyle landowner, the odds of Likely to cooperate with neighbor given an outcome decreased by 91%.

Table 3.9 Cross tabulation of binary variable for "Likelihood of Neighbor Coordination Given Outcomes" and "WMA members and non-members" with actual and expected counts. There was a significant difference between groups ($Chi^2 = 9.8$; $p = 0.000$).

WMA membership		**Likelihood of Neighbor Coordination Given Outcomes**		**Total**
		Unlikely	Likely	
Non-Member	Count	93	60	153
	Expected Count	81.8	71.2	153
Member	Count	30	47	77
	Expected Count	41.2	35.8	77
Total	Count	123	107	230

Table 3.10 The parameter estimates for a logistic regression of landowners' likelihood to coordinate with neighbors when given a beneficial outcome.

Variable	B	S.E.	Chi^2 (Wald)	df	Significance	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
WMA member (1)	-0.15	0.44	0.122	1	0.727	0.859	0.37	2.01
Neighbor Advice[a]			7.368	4	0.118			
Never	-2.75	1.23	5.003	1	0.025	0.064	0.01	0.71
Once a year	-2.02	1.24	2.638	1	0.104	0.133	0.01	1.52
Few times a year	-1.89	1.23	2.385	1	0.123	0.151	0.01	1.66
About once a month	-2.3	1.49	2.373	1	0.123	0.1	0.01	1.87
Landowner Type[b]			11.535	4	0.021			
Working Place	-0.76	0.45	2.926	1	0.087	0.466	0.19	1.12
Amenity	-0.25	0.51	0.231	1	0.631	0.782	0.29	2.14
Lifestyle	-2.4	0.74	10.448	1	0.001	0.091	0.02	0.39
Conservation	-0.29	0.65	0.197	1	0.657	0.748	0.21	2.69
Consultation diversity	0.633	0.26	5.819	1	0.016	1.883	1.13	3.15
Peer importance	-0.88	0.26	11.7	1	0.001	0.415	0.25	0.69
Trust	0.37	0.22	2.948	1	0.086	1.448	0.95	2.21
Current Coordination Activity	0.591	0.28	4.361	1	0.037	1.806	1.04	3.15
Civic Engagement	0.405	0.21	3.703	1	0.054	1.5	0.99	2.27
Constant	2.322	1.24	3.504	1	0.061	10.2		

Cox-Snell R= 0.31, Nagelkerke R= 0.42, -2Log Likelihood = 204.5

a: reference category = more than once a month; b: reference category = entire place

3.4. Discussion

In this study I sought to describe differences in the characteristics of landowners who were and were not WMA members and to evaluate whether this membership was related to their likelihood of coordination. My hypothesis that WMA members would have higher social capital (trust, reciprocity) and larger consultation networks (number of people consulted) was confirmed. WMA members also had significantly higher scores for the importance of land management professionals in their consultation networks. The difference in consultation network size may even be larger than what I observed. Reporting of network size was limited to the 5 most important people, which may have reduced the ability to observe differences in network size. These differences along with the importance of information source diversity related to coordination behaviors, make it clear that the way landowners gather and incorporate information into their decision-making processes can impact their likelihood of engaging in coordination.

WMA membership had the largest impact on the odds of landowners' intention to engage in additional coordination. WMAs may play a role in the intention to coordinate, although significant differences related to social capital, consultation networks and intention to coordinate were found, it remains unclear whether the difference between association members was due to their membership, contributors to their membership, or a combination of these two scenarios.

The design of my study did not allow for an evaluation of the causality associated with WMA membership. It is likely that WMAs serve as an indicator of landowners who are likely to engage in coordination behavior but also serve to augment the different factors that are associated with coordination (e.g., Wagner et al., 2007). Thus, it is likely that group membership/network structure and behavioral intention are mutually reinforcing (e.g., Quintelier et al., 2011). Namely, landowners who expressed that they were likely to coordinate were more likely to join a landowner association, which for most is a form of coordination. In turn, association membership likely contributes to further development of their social capital, networks and ultimately affects their behaviors. Disentangling the role of landowner associations will require a more in-depth approach using longitudinal or manipulative experimental study designs (Quintelier et al., 2011; Groce et al., 2018).

Among factors associated with the intention to engage in coordination behaviors those identified as most important related largely to the social interactions of landowners: Civic Engagement, Consultation Network Diversity, Peer Importance and Neighbor Advice. Although these factors did not have the same relationship, it is clear that landowners' social environment is important to consider when evaluating their likelihood to coordinate their land management either generally or with neighbors. While consultation Network Diversity, Civic Engagement, and Neighbor Advice were all associated with higher coordination intention or likelihood, Peer Importance decreased the likelihood of coordination among landowners. Higher Peer Importance reflects a relative lack of engagement with land management professionals, agency staff or others who may provide more diverse advice regarding land management. In this regard, it may be that bridging ties in consultation networks become important to integrating new information and different social norms (e.g., Granovetter, 1983;

Coleman, 1998). It has been observed that diverse social networks contribute to political action (Quintelier et al., 2011). However, it should be noted that in some instances less diverse social network with members who hold strong norms of environmental conservation may help to reinforce environmentally beneficial behaviors (Abrahamse and Steg, 2013). Given my analysis, a focus on landowners' network structure and distributing and improving access to different information sources could help to foster cooperation.

A key challenge for conservation practitioners appears to be to facilitate the initial instance of coordination. Of the relatively few landowners who were currently involved in coordination, few indicated they were likely to decrease their coordination in the future. Providing rationale for, and fostering outcomes of coordination, that address factors associated with Self Determination Theory (SDT) may be helpful for initiating and maintaining these coordination behaviors. According to SDT, individuals will tend to seek and maintain behaviors that support autonomy, competence and relatedness factors associated with human needs (Deci and Ryan, 2000). When people engage in behaviors that result in attainment of these psychological needs their well-being is maintained or increases (Deci and Ryan, 2000). Accounting for these needs can increase the likelihood of coordination, however, fostering these outcomes involves understanding coordination from the landowner's perspective (Sorice and Donlan, 2015). For conservation practitioners, fostering these attributes may not change the nature of coordination *per se*, but may involve refining communication strategies to highlight: the importance of behaviors, conservation outcomes derived from the behaviors, and the role of landowners as stewards, while also providing technical assistance or resources. Once coordination is achieved, efforts should be made to make these behaviors salient for landowners so they identify themselves with these behaviors.

Despite the utility of landownership motivation types for describing landowner characteristics and management practices (Sorice et al., 2011; Hurst and Kreuter, In review), there was not a strong association between motivation type, coordination likelihood or association membership. The "Likelihood given outcome" variable, reflected the low degree of variation among responses for the different outcomes of neighbor coordination and can thus be interpreted as landowners' general attitude toward neighbor coordination (e.g., "Are you likely to coordinate with your neighbor if it results in a benefit?"). This is an indication that specific outcomes or the ability of coordination to contribute to land management goals do not factor strongly in landowners' intention to coordinate with their neighbors, while other factors (e.g., interpersonal relationships) may become more important.

The regression results indicated that there was a difference in likelihood of coordination and coordination intent between "Entire place" and "Lifestyle" landowners. Entire Place landowners had high motivations associated with rural lifestyle, environmental conservation, utilitarian uses of their land and the community when compared to other landowners were the most likely to coordinate with their neighbors for a given outcome. By contrast, Lifestyle landowners were most interested in the rural lifestyle and were older and less involved in land management in general were less likely to coordinate (Hurst and Kreuter, In review). It may be the case that, although place-based motivations (community and conservation) can contribute to coordination intention, the presence of an economic motivation is a key factor in landowners' coordination intentions. Providing tangible economic benefits and justification as were identified by Schulte et al. (2008) can thus be important for fostering cooperation. Efforts should be made to quantify and describe these benefits in ecosystems where coordination is desired. The relationship between coordination likelihood and specific outcome scenarios merits additional examination because understanding this relationship could be used to inform efforts to increase coordination.

Practitioners' efforts aimed at increasing coordination in general, should preferentially target landowners in WMAs. Landowner associations serve as a filter to collect landowners who are more likely to engage in coordination of their land management activities, and so provide an opportunistic and convenient way for agency or organization staff to conduct targeted outreach via interactions with landowners in conjunction with the associations' meetings or communications where accessible and easily distributed messaging and materials may be effective. Landowner associations can provide an opportunity for land managers to develop relationships and trust with landowners. Furthermore, associations have the potential to bring neighboring landowners together during meetings or other association activities. In this regard, practitioner efforts can be directed to facilitate the development of relationships among landowners. Together these efforts can help foster the development of diverse consultation networks, relationships with neighbors and conservation norms that are likely to increase coordination.

A limitation of landowner associations is the relatively few times in which meetings are held, commonly 1-2 times a year. In this regard, practitioners could work to facilitate meetings, field days, or other association activities. Other types of associations, particularly prescribed burning associations, that gather landowners more frequently and in diverse settings (e.g., in the field) have been demonstrated to increase social capital (Toledo et al., 2014). In the GCP there are several prescribed burn associations. Prescribed burn associations (PBAs) have been used to increase the use of prescribed burning throughout the Great Plains (Twidwell et al., 2013). Given their prevalence, WMAs can work in conjunction with PBAs to complement their habitat management efforts and increase their social capital. However, getting GCP landowners to coordinate their management will be a difficult undertaking. Despite the established and targeted efforts of the Refugio-Goliad Prairie Conservation Project, there was not a difference between study sites in relation to coordination intention or likelihood to coordinate which indicates that this effort had not resulted in observable differences during the time of my survey.

Landowners who had a higher degree of civic engagement, not just membership in land management associations, were more likely to engage in coordination. Recruitment of landowners for coordination initiatives should focus on landowners with high civic engagement. The importance of civic involvement was not tied to the domain or type of group, but rather in landowners' embeddedness within their community. In this regard, social capital can be a common-good. The capital is found within the community and the civic organizations of the GCP, which are contributing to the conservation potential of the landscape via the likelihood that landowners will coordinate their land management with other entities. Most of the benefits of the conservation of prairie biodiversity also accrue at broad scales and so there is an alignment of these benefits.

Despite my description of variables associated with land management coordination, the study has some limitations. The pseudo R^2s of the regression models indicated there was substantial variation that was not described by the variables included in the models, which may have been partially attributable to the reduction of variability by my data reduction techniques (Altman and Royston, 2006). Although some psychological variables (landownership motivations) were included, my analysis focused mostly on social variables. Other factors such as previous experience and interpersonal relationships could affect landowner decisions to coordinate.

Based upon my survey of non-responding landowners, the generalizability of my study is best limited to large landowners in the GCP. Non-respondents indicated that they likely had lower trust of research programs and agencies, in general, than respondents. Privacy is one of the most common concerns related to surveys and may result in a small systematic bias with non-respondents (Singer et al., 2003). Given the focus of my study on trust and interactions with other members of the GCP community and the lower trust of non-respondents, it is likely my study resulted in a sample that is more likely to engage in coordination than the GCP large landowner population more broadly. Additionally, it is likely that the population of landowners in the GCP is less disposed to engage in coordination with landowners, agencies, or organizations than those in other regions of the United States. Texans may be less likely to manage lands for public goods (e.g., ecosystem services) than those in other states due to strong property rights orientations and individualism (Kreuter et al., 2006).

3.4.1. Conclusion

As conservation practitioners explore ways to increase the conservation potential of lands in the GCP, land management coordination represents an important strategy for implementation of conservation plans. In this regard, it is important that land management coordination is more strongly affected by characteristics of landowners' consultation networks than by their trust and reciprocity. Also, those who engaged in a coordination activity were more likely to express they were likely to coordinate with their neighbors or in the future.   In this regard, wildlife management associations in the Texas GCP can play a role in fostering ecosystem services via their utility in engaging landowners in activities that foster the development of their consultation networks and coordination of land management. The conservation of the GCP is a vexing challenge, but it appears that outreach strategies centered around WMAs have more potential than ad hoc engagement with landowners to increase the agglomeration of lands into patch sizes that are meaningful to achieving conservation outcomes for prairie biodiversity.

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4. TARGETING AND INFORMING CONSERVATION EFFORTS IN PRODUCTION LANDSCAPES USING ECOSYSTEM SERVICES

4.1. Introduction

Systematic conservation planning seeks to identify priority conservation areas by applying the knowledge and principles of landscape ecology to ensure that future biodiversity goals are met and that reserves are comprehensive, adequate, and representative (Margules and Sarkar, 2007). Researchers have found that ad hoc and expert driven conservation area acquisition can yield sub-optimum conservation of critical ecosystem patterns and processes (Pressey, 1994; Margules and Pressey, 2000; Cowling et al., 2003). With these shortcomings in mind, systematic conservation planning gained prominence as a way to better attain conservation outcomes. The basic steps included in this planning framework are data compilation, target identification, review of existing conservation areas, additional area selection, plan implementation, and maintenance of the value of conservation areas (Margules and Pressey, 2000; Groves et al., 2002). The last step can be used to reassess the effectiveness and what changes need to be made to reach the targets that were initially set. Additionally, Groves et al. (2002) highlight 7 steps for conservation planning: identify conservation targets; collect information and identify knowledge gaps; establish conservation goals; assess existing areas; evaluate ability of conservation targets to persist; assemble a portfolio of conservation areas, and identify priority conservation areas. These conservation planning approaches rely on quantifying the importance of geographic areas in relation to their current and future conservation value in order to determine land-use configurations and networks that make the most efficient use of the landscape for conservation outcomes (Margules and Sarkar; 2007). Planning acknowledges the interrelationship of land-uses across the landscape, and management for biodiversity can be optimized by ensuring the inclusion of habitat patches and corridors for a wide range of species and ecological processes (Margules and Sarkar; 2007).

Strategic conservation planning is not prescriptive, but rather is a decision support tool, which provides a way to consider multiple potential configurations that could meet conservation targets. These configurations are interdependent; a shift in one component requires accommodation by another, ideally with stakeholder values and goals guiding the process. Thus, conceptualizing the planning process as solely a computational problem in search of an efficiency optimization algorithm may not be beneficial. Furthermore, constraints and trade-offs associated with plan implementation adds complexity to planning; implementation of reserve conservation plans can yield outcomes that are not as effective as ad hoc use of relatively simple decision criteria (Meir et al., 2004). The lack of an objective optimum outcome can be due to several factors. First, many criteria that are incorporated into the planning process are not associated with objective or quantifiable values, which introduces challenges in making the comparisons or trade-offs that are inherent to the conservation planning process (Chan et al., 2012). There is also uncertainty associated with all criteria, including environmental stochasticity, measurement error, and the expected outcomes of different actions.

Conservation planning has generally been concerned with the delineation of conservation area networks, but in many landscapes, there are not adequate undeveloped areas available for conservation. Furthermore, the acquisition of new lands for conservation purposes is often unaffordable at scales necessary for meaningful landscape-scale conservation outcomes (Knight et al., 2010). In landscapes that are primarily privately owned, a focus on conservation potential inclusive of private lands is warranted. Despite this need, substantially less attention has been paid to understanding conservation actions centered within private lands (Knight et al., 2010).

Conservation planning within private lands necessitates an alteration of the typical planning approach to include evaluation of the social environment. A "research-implementation gap" has been identified that may be partly due to a lack of incorporation of social aspects of conservation planning (Knight et al., 2008). Consideration of the social environment is key to increasing the effectiveness of actions and social assessments should be incorporated in conjunction with conservation assessments early in the planning process (Cowling et al., 2008). By incorporating stakeholder input early in the process, the potential for the social and ecological effectiveness increases and the planning-action gap can be reduced (Knight et al., 2006).

Ecosystem services represent a way of incorporating social values within a planning framework (e.g., Bryan et al., 2011; Klain and Chan, 2012). Ecosystem services are "the conditions and processes through which natural ecosystems, and the species that make them up sustain and fulfill human life" (Daily, 1997 pg. 7). The four categories of ecosystem services include: provisioning (e.g. food, raw materials);

regulating (e.g. climate and storm moderation); cultural (e.g. recreation, aesthetics, spiritual experience); and supporting (e.g. habitat and genetic diversity) (De Groot, 2002). Ecosystem services can be thought of as a resource from which society-at-large gains benefits that extend beyond the specific location where they occur and they connect societal needs to ecosystem processes, reflecting the myriad ways that humans use and relate to their environment.

Ecosystem services have been used to translate ecosystem processes and characteristics into different contexts (e.g. economic) for incorporation into decision making (Daily, 1997; Costanza et al., 1998). Researcher and practitioner interest in ecosystem services has increased exponentially and there have been calls for their more meaningful inclusion into conservation planning (Daily et al., 2009), and there has been greater incorporation of these valuations into spatial analyses and conservation planning (Chan et al., 2006, DeGroot et al., 2012).

Ecosystem services have also been used to understand landscape change in the conjunction with anthropogenic disturbances. For example, the Integrated Social, Economic, and Ecological Conceptual (ISEEC) framework relies on ecosystem services as a way to systematically gauge the comparative effect of human disturbances in rangelands across regions (Kreuter et al., 2012). As frameworks, such as the ISEEC, demonstrate, the use of ecosystem services as a connection between the social and biophysical aspects of social-ecological systems and their ability to be measured via proxies makes them a useful tool for investigations that seek to link or embed humans with their environment. Ecosystem services have also been used to identify where synergies and conflicts between ecosystem service provisioning and biodiversity-centered conservation planning occur (Chan et al., 2006). Strategic focus on certain services (e.g., biodiversity, carbon storage, flood control, recreation, water provision) increased the effectiveness of planning by incorporating social considerations, evaluation of trade-offs and "side benefits", which ultimately improved the quality and resilience of planning outcomes (Chan et al., 2006). However, such approaches rely on proxies for cultural ecosystem service values, with an assumption that these values are closely related (Chan et al., 2012). In practice, cultural services are connected to diverse ecosystem services but are often not given sufficient attention in decision making due to their intangible nature, interconnection with other benefits and basis in different socio-cultural contexts (Chan et al., 2012; Satz et al., 2013; Fish et al., 2016).

Approaches that have directly gathered and incorporated social values have yielded insights to inform conservation. An analysis of an Australian landscape found a high degree of spatial variation between areas in terms of their assigned social values and derived conservation values (Bryan et al., 2010). However, approaches such as this and others that incorporate direct, participatory value mapping (e.g., public participation GIS) rely on values being assigned to different areas (e.g., Plieneger et al., 2012). In production landscapes, identifying ecosystem service values is important to help inform conservation programs; however, stakeholders may not have adequate knowledge to assess parts of the landscape they cannot access (e.g., Klain and Chan, 2012).

Using the results from my mail survey questionnaire, I translated ecosystem service valuations that landowners gave their lands into a decision support tool to inform landscape conservation. This tool can be used to both incorporate their views into broader, regional conservation planning and to include different stakeholders into the conservation planning process. In particular, accounting for cultural ecosystem service values can help target and refine conservation plans and strategies (e.g., Guerry et al., 2012; Ban et al., 2013).

4.1.1. Conservation planning and the Gulf Coast Prairie

With the presence of oil and gas development and agriculture, the Texas Gulf Coast Prairie and Marshes ecoregion (GCP) provides a model to demonstrate the potential of a decision support tool that incorporates the consideration of ecosystem processes. The GCP is privately owned to a significantly higher percentage than other regions. In Texas, the majority of lands (83%) are categorized as privately-owned working lands (Lund et al., 2019). Therefore, effective engagement with private landholders is critical for the overall conservation potential within the state.

As a result of the conservation challenges within the GCP, there have been several notable conservation efforts within the region. The Attwater's Prairie Chicken (APC; *Tympanuchus cupido attwateri*) has been the focus of conservation efforts since its listing in 1967 (USFWS, 2010). Since the initiation of these efforts, the importance of large expanses of intact prairie for biodiversity conservation has been recognized and treated as priority for habitat within the GCP and resulted in the creation of the Attwater Prairie Chicken National Wildlife Refuge.

To address the key prairie conservation challenges and maximize regional conservation effectiveness, considerable effort has been devoted to coordinating and engaging regional resources and diverse stakeholders, which include government agencies, non-governmental organizations, and landowner groups. This has resulted in ecoregional assessments that outline the state of land protection and incorporate future scenarios. One of these efforts, the Ecoregional Conservation Plan, marked the first attempt to develop a regional conservation plan. It was undertaken to identify key conservation areas and settled on 86 “portfolio areas” that were of conservation importance (TNC, 2002). An outgrowth of these efforts is the Coastal Prairie Conservation Initiative (CPCI) that engages conservation agencies, organizations and landowners to cooperatively conserve areas in 19 counties in the Texas GCP (Williams and Harrell, 2009; Ortego, 2010). The initiative is a coordinated effort to pool and direct resources available to the different agencies and organizations to yield their most effective use. These resources include cost-sharing and technical guidance for landowners' management activities centered upon the conservation of the GCP. Furthermore, these activities were directed to attain regional conservation goals with an emphasis on increasing prairie habitat patch sizes and connectivity. Incorporation of public values can help to inform these conservation efforts.

4.2. Methods

4.2.1. Study area

To account for some of the variability of environment and conservation efforts within the GCP, I sampled two geographically distinct areas for my survey, which incorporated Austin Colorado counties in the north, and Victoria, Refugio, Goliad and Calhoun counties in the south (Figure 4.1). For modeling, I included all counties that were found within the geographic extent of my study counties (e.g. a polygon formed by the north/south latitude and longitude of the surveyed counties). This created a modeled area that contained portions of 27 counties incorporated within the GCP, Blackland Prairie and Post Oak Savannah ecoregions and covered an area of 62,278 km2 (24,046 mi^2; Figure 4.1). Although this modeled area was relatively large, it does not approach the size of the GCP. There were substantial computational burdens associated with my analysis at this spatial extent, and so I constrained the variables included in the analysis. I used a pixel size of 30 m (~100 feet, 0.00028947 decimal degrees, 0.09 hectare) in the analysis, which is the National Landcover Database (NLCD) resolution and likely the finest resolution at which an analysis of this type would be useful.

4.2.2. Spatial modeling

I combined species and social data to portray the relative ecosystem service values present in the study area. I focused on deriving a relative valuation of ecosystem services in order to avoid valuation biases that can affect direct value assignment techniques (e.g., Turner et al., 2010). Additionally, unlike in cases where ecosystem service values are assigned in public lands where people have common, direct experience (e.g. Sherrouse et al., 2013), private lands are inaccessible. Thus, ecosystem service values that individuals identify within a privately-owned landscape are most likely not based upon direct experience apart from those lands closest to theirs, and so, approaches that ask individuals to place ecosystem service values across a landscape are likely inaccurate. In these instances, modeling approaches are preferable for inferring the distribution of ecosystem services in a landscape.

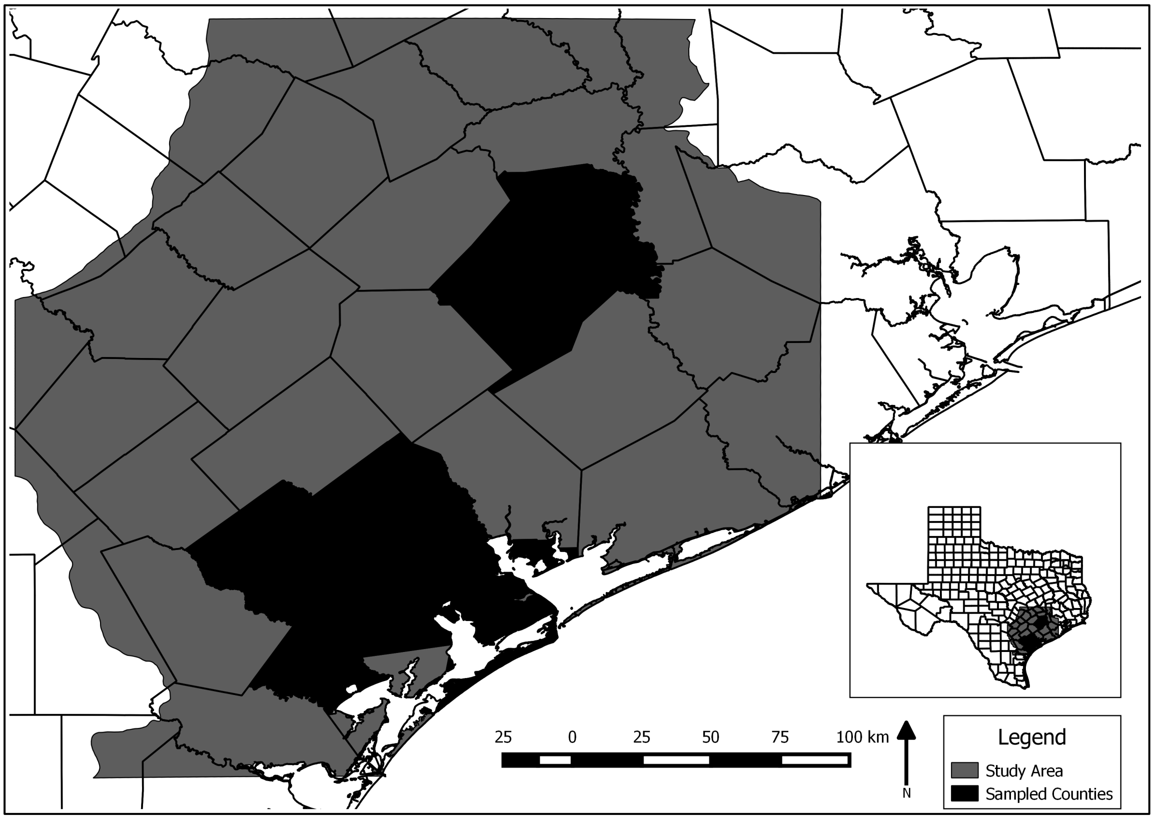

Figure 4.1 Entire study region that shows the counties sampled (black) and the larger geographic areas (gray) that were modeled. Inset: map of Texas showing location of the study area.

In practice, relative valuation is one-step removed from more explicit monetary valuations. Relative valuations limit comparisons to other regions but provide valid comparisons within the region. My valuation approach was appropriate because values were derived for an explicitly bounded area. I identified where ecosystem services were present across the entire study area and then summed these to provide aggregate ecosystem service values.

I calculated ecosystem service values by first identifying points where species or socially-derived ecosystem services were present. I then used these points to model the distribution of individual species and socially-derived ecosystem services within the broader landscape using Maxent. These modeled distributions were used to indicate where each biodiversity-based (threatened and endangered and game species), and socially-derived (cultural biodiversity) cultural ecosystem service was found (Figure 4.2). I aggregated species distributions and socially-derived ecosystem services to derive an overall conservation value and also to inform conservation strategies.

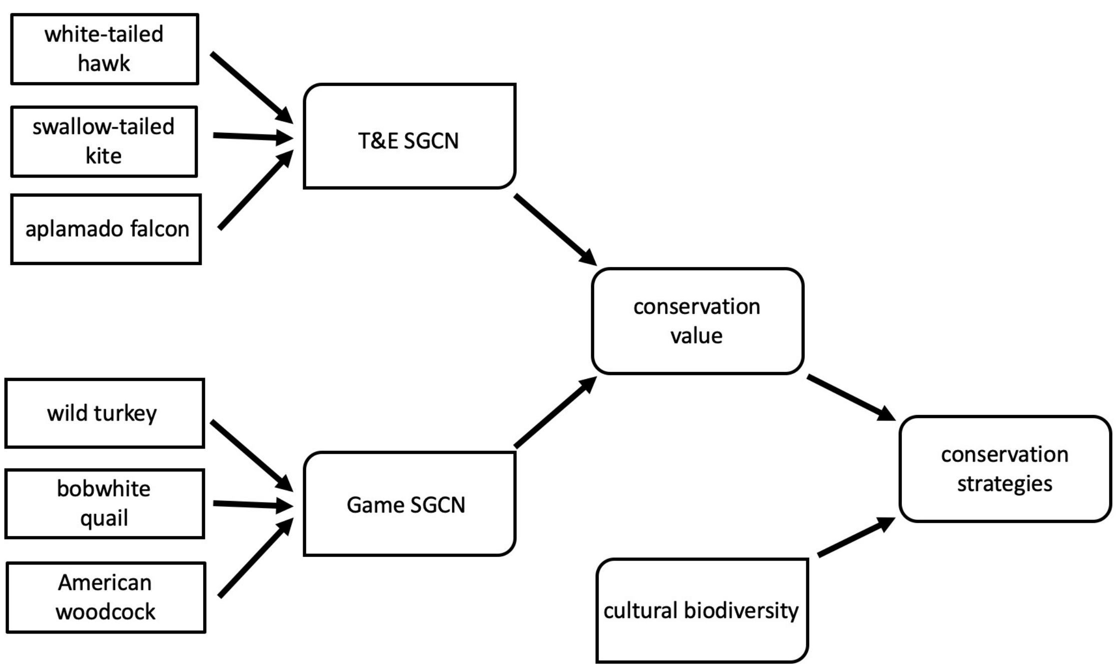

Figure 4.2 A diagram of the components used to conduct the analysis. Arrows indicate that variables were summed to indicate either presence or total value.

4.2.3. Biodiversity-based ecosystem services and conservation value

I used 2 different types of biodiversity to derive conservation values, Threatened & Endangered (T&E) species and game (Game) species. The GCP is home to a significant number of state listed T&E non-aquatic vertebrate species (7 mammals, 17 birds, 16 reptiles and amphibians), and the Blackland Prairie had no additional T&E species (TPWD, 2012). I evaluated the occurrence of upland species that were state-listed as T&E within my study area. For Game species, I selected three species that had potential recreational value as huntable organisms and that were Species of Greatest Conservation Need in Texas (SGCN; wild turkey [*Meleagris gallopavo*] northern bobwhite [*Colinus virginianus*] and American woodcock [*Scolopax minor*]; (TPWD, 2012) (Table 4.1).

I downloaded the species location data from the Global Biodiversity Information Facility (GBIF; www.gbif.org; accessed 15-Dec-2018) database, which consists of collection records, reported observations and survey detections that are compiled from various sources. To ensure there was alignment with the NLCD landcover data I constrained my samples to those that were collected since 2011. I plotted, verified, and removed occurrence locations if they were determined to be incorrect, implausible (e.g., terrestrial species in water) or duplicates. For occurrences with accuracy data, only those with an accuracy better than 15 meters were used. Some endangered species in the GBIF have the accuracy of their locations purposely altered for their protection; this, together with few documented occurrences eliminated some species from further analysis (e.g., Texas tortoise [*Gopherus berlandieri*] and APC). Furthermore, there were no mammal species with sufficient records to be included in the analysis, and I did not include any amphibians due to their association with aquatic habitats. The final T&E species list used for modeling included 3 bird and 3 reptile species (Table 4.1).

Table 4.1 Taxa, species, conservation status and range in the Gulf Coast Prairie and Marshes (GCP) Ecoregion of Species of Greatest Conservation Need that were included in the models for Threatened and Endangered and Game ecosystem services.

Taxa	Scientific Name	Common names	Texas Status	Range in GCP Ecoregion[1]
Threatened and Endangered				
Birds	*Elanoides forficatus*	swallow-tailed kite	Threatened	Upper
	Buteo albicaudatus	white-tailed hawk	Threatened	Throughout
	Falco femoralis	aplomado Falcon	Endangered	Lower to Mid
Reptiles and Amphibians	*Crotalus horridus*	timber (canebrake) rattlesnake	Threatened	Upper to Mid
	Drymarchon melanurus erebennus	Texas indigo snake	Threatened	Lower to Mid
	Phrynosoma cornutum	Texas horned lizard	Threatened	Throughout
Game				
Birds	*Colinus virginianus*	northern bobwhite	NA	Throughout
	Meleagris gallopavo	wild turkey	NA	Throughout
	Scolopax minor	American woodcock	NA	Throughout

1: Approximate regions: Upper = Louisiana border to Houston, Texas; Mid = Houston to Corpus Christi, Texas; Lower = Corpus Christi to Mexico border

4.2.4. Socially-derived ecosystem service values

To identify the cultural ecosystem services, 902 landowners who owned at least 40 hectares (100 acres) of land in my study area were surveyed, with an approximately equal proportion in the northern and southern study areas. Using a 5-point response scale (1 = strongly disagree, 3 = neither agree nor disagree, 5 = strongly agree), I asked respondents a series of questions asking whether they agreed or disagreed that various aspects of their land were important. I conducted the mail survey using the protocols of Dillman's Multiple Contact Method (Dillman, 2007), with five mailings (presurvey letter, 2 reminder postcards, a questionnaire and a replacement) spaced over a 49-day period. The survey questionnaire was approved by the Texas A&M University Institutional Review Board (# IRB2013-0449D).

I first tested the adequacy of the sample data using Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO), with a value of 0.6 being interpreted as adequate and 0.8 as very good (Cerny and Kaiser, 1977). I used a principle components analysis (PCA) with an oblique Oblimin rotation and Kaiser normalization to identify which of the 11 values associated with the landowners' parcels could be grouped together (Field et al., 2014). I used a combination of scree plots and eigenvalues (> 1) and interpretability to indicate how many components were present in the data. Once these components were identified, I interpreted them in relation to the ecosystem services that were most closely aligned with various aspects of their land. I used a rescaled loading score of 0.5 as the cut-off for placing the statements in different ecosystem service scales. I derived scales based upon the components by averaging the scores for the statements that comprised each component, and verified their reliability using Cronbach's Alpha with a value > 0.7 (Schmitt, 1996). I limited my analysis to services that were associated with biodiversity conservation, Cultural Biodiversity.

A card was included with each questionnaire that asked respondents to provide the address to each of their land parcels, which was anonymously joined with their ecosystem service valuations. The physical locations of landholdings were geocoded using the MMQGIS and Google Maps API (Google LLC; Mountain View, California, USA). I plotted, verified, and removed geocoded points that were determined to be incorrect, implausible (e.g., in water) or found in an urban area. An ecosystem service was determined to occur at a location if its derived scale score was 4 or greater, absence of a value at a location was not assumed because other members of the household may have evaluated the location differently. In order to increase the independence of samples, only one address from each respondent was used. For individuals that had multiple land parcels, the most complete address and/or the most salient address (first address they provided) was used.

4.2.5. Ecological variables

I identified four classes of variables that have the potential to affect the distribution of ecosystem services in a landscape and that I used to fit the species distribution models; they included soils, landcover, climate, and topography. To minimize the overshadowing of highly correlated variables in the model, I eliminated variables with a correlation > 0.7 within each class, while also evaluating which variable could be most meaningfully interpreted. I incorporated several soil characteristics into the model, including soil composition (percent sand, clay), prime farmland classification (combines consideration of soil quality, growing season, water availability, and erodibility; NRCS, 1993), soil organic carbon and soil pH (Table 4.2). Apart from the prime farmland classification, data coverage of directly measured soil characteristics were incomplete within my study area, and so I relied on modeled soil property data (Ramcharan et al., 2019).

In order to account for the role of landcover in the distribution of ecosystem services, I primarily relied on the most current National Landcover Dataset (MRLCC, 2011). The NLCD relies on supervised classification of satellite imagery to partition landcover into 20 different land covers types. In order to reduce the classes, I recoded these classifications into general categories (e.g., forest vs. deciduous, evergreen and mixed forest) (Table 4.2). Most occurrence locations were tied to roadways, occurrence records and landowner addresses could lead to a misleading association with the developed landcover if the landcover data were treated as categorical in the model. For this reason, I used distance from landcover class as a model variable to allow for an evaluation of the relative importance of landcover types. Furthermore, after modeling was completed, I treated developed landcover as non-habitat in all subsequent analyses. Petroleum was discovered in the GCP over 150 years ago and since then oil and gas infrastructure has become widespread throughout the region. Due to this longstanding potential impact, I incorporated distance to active oil and gas wells into my model (GLO, 2015).

Table 4.2 List of variables and their category included in the model.

Category	Variable
Soil	Farm Soil
	Percent Sand at 5 cm
	Percent Clay at 5 cm
	Soil Organic Carbon at 5 cm
	PH at 5 cm
Climate	Mean Annual Temperature (Bio1)
	Mean Diurnal Range (Bio2)
	Temperature Seasonality (Bio4)
	Maximum Temperature of Warmest Month (Bio 5)
	Minimum Temperature of Coldest Month (Bio 6)
	Annual Precipitation (Bio 12)
	Precipitation Seasonality (Bio 15)
	Precipitation of Warmest Quarter (Bio 18)
	Precipitation Coldest Quarter (Bio 19)
Topography	Elevation
	Slope
	Aspect
Landcover	Distance to Cultural Locations
	Distance to Oil and Gas Well
	Distance to Shrub
	Distance to Forest
	Distance to Water (large bodies of freshwater)
	Distance to Wetland
	Distance to Cultivated Areas
	Distance to Grass/Herb

Although less variable than landcover, climate and topography did vary across the study region. I relied on modeled climate data because directly measured climate variables are not available at the scale of my study region. Specifically, I used the Bioclim dataset that consists of 19 ecologically meaningful climatic variables (Hijmans et al., 2005). Of the 19 climatic variables, 9 were sufficiently independent to allow for their inclusion in the model (Table 4.2). I used a Digital Elevation Model (DEM) with 1-meter vertical resolution to describe the topography of the study area. In addition to the elevation, I also used the DEM to derive slope and aspect (Table 4.2).

4.2.6. Maxent modeling

In order to model ecosystem service values, I conducted maximum entropy species distribution modeling using the Java applet Maxent (Princeton University, Princeton, New Jersey, USA). The Maxent algorithm relies on training data consisting of species occurrences to constrain and develop probability distributions that are then used to derive probabilities of occurrence for a given the suite of variables (Elith et al., 2011). Maxent modeling has become widely used in ecological research because it has been shown to perform well using a limited number of observations without overfitting the occurrences to environmental data, thereby providing realistic models of species distributions (Elith et al., 2011).

I conducted Maxent modeling using Brown's (2014) recommended practices, including species-specific regional background sampling, rarefied occurrence data, spatially calibrated model parameters, independently evaluated feature class parameters and reduced the correlation of variables used in the model. Species distribution models assume that points are spatially independent, otherwise biased predictions can result due to clustered locations. In order to help increase points' independence, I spatially rarefied occurrence points using PCA of the climate data to estimate the environmental heterogeneity, and then conducted graduated spatial rarefying to eliminate points that were clumped in an area of highly similar environmental data. The rarefying distance was graduated into 3 intervals using the "natural breaks" selection criteria and rarefied points at distances between 2 and 20 km.

I used a 2 km buffered Minimum Convex Polygon (MCP) to provide a bias file for sampling the background data to account for uneven sampling of occurrence points. The use of MCP was a conservative way to account for the landowner sampling strategy and expand the area of inference without expanding the environmental envelope. I used the MCP for the socially-derived points and for species occurrences if the particular species had a markedly restricted distribution within the study area.

4.2.7. Variable importance and model fit

No single value can be used to evaluate the performance of Maxent models; rather fit must be evaluated using a combination of Area Under the Receiver Operator Characteristics Curve (AUC) and their omission and commission errors versus the expected (Merow et al., 2013). Although AUC can overestimate model performance when there is autocorrelation between training and test points and is not an ideal measure of model fit, it is the widely used model evaluation criterion (Lobo et al., 2008). There are few existing alternatives to AUC but the use of cross-validation can assist to describe variation of AUC estimates (Lobo et al., 2008; Merow et al., 2013). The AUC is scaled between 0.5 and 1 and gives an indication of the predictive power of the model; value > 0.5 indicates an improvement over random (Elith et al., 2011; Merow et al., 2013). An AUC value can only be compared between models when the species and landscape are the same (Elith et al., 2011). I relied on jackknifed, or systematically resampled, AUC to determine whether the model fit was adequate enough to allow for additional analysis.

Maxent uses a regularization multiplier to adjust the degree of overfitting present in the model and is conceptually similar to Aikaike Information Criteria (AIC) wherein tradeoffs between model fit and complexity are accounted for (Merow et al., 2013). Regularization affects the model by altering the penalty that different features are given, a multiplier value over 1 thus assesses more of a penalty. It is recommended that different regularization multipliers are used to calibrate a model (Merow et al., 2013). I evaluated multipliers between 0.5 and 3 to refine model fit. I was interested in evaluating the relative importance of different variables and used jackknifing and cross-validation based upon 3 replicates to derive variable importance. I used permutation importance to rank variable importance, which was calculated based upon the decrease in training AUC resulting from sequentially permuting, or randomly shuffling values, for each variable (Phillips, 2006). Variables that produced a larger decrease in AUC were more important and importance was scaled to percent.

Maxent provides a probability of occurrence across the modeled area. I relied on thresholding to select the probability of occurrence at which to designate the ecosystem service as present or absent. The selection of a threshold will introduce some bias and there is no consensus on which criterion to use. Some argue that the selection of threshold criteria should use an objective and validated approach with consideration of study objectives (Peterson et al., 2011), while others argue that thresholding should be avoided because to be ecologically meaningful it should consider prevalence or population density which is not known (Merow et al., 2013). To threshold my data I used the Maximum Sum of Sensitivity and Specificity statistic (maxSSS). MaxSSS provides an estimate that maximizes the True Skill Statistic (TSS) (Liu et al., 2013), which is widely used as a measure of model accuracy for presence-absence data which balances sensitivity and specificity (Allouche et al., 2006; Liu et al., 2013). The TSS ranges from -1 to 1 with a score of 0 suggesting that the model is no better than random at predicting points, and higher positive numbers indicating better model performance. I interpreted areas where species were predicted from this threshold as "habitat" or locations where environmental conditions were present that enabled the attainment of the ecosystem service.

4.3. Results

4.3.1. Variable selection

Of the 902 survey questionnaires mailed to landowners, 13 were undeliverable and 29 respondents indicated they did not meet the acreage requirements for inclusion into the study, no longer owned land, or the addressee was deceased. Of this effective sample of 860 landowners, 356 (41.4%) questionnaires were returned and 190 of these (41% of returned; 22% overall) completed both the questionnaire and address cards. I conducted the PCA on responses from all 356 returned questionnaires. The KMO measure indicated that the sample was adequate (0.76) and Bartlett's test ($Chi^2 = 1081.9$, $df = 66$, $p < 0.001$) indicated there was sufficient correlation among the items for PCA. The PCA indicated that a 3-factor solution was warranted, and the amount of variance explained by the 3 factors was 64% (35%, 16%, 13%, respectively) and Cronbach's Alpha scores were 0.68, 0.79 and 0.81, respectively. The factor loadings are interpreted as ecosystem service categories: Cultural Biodiversity (wildlife recreation and management), Provisioning Biodiversity (hunting operations), Forage Production (agribusiness) (Table 4.3). Using the scale scores, I identified the location of 145 Forage Production, 88 Cultural Biodiversity and 13 Provisioning Biodiversity ecosystem services locations within the study area. Since I was not focusing on Forage Production, these 145 points were eliminated from further analysis (Table 4.4). Moreover, spatial rarefication resulted in reduction of the number of points used to derive the Maxent model to 32 Cultural Biodiversity and 11 Provisioning Biodiversity points (Table 4.4).

4.3.2. Model fit

I calculated model fit values for T&E Species, Game Species, and Cultural Biodiversity (Figure 2). The models for each of these ecosystem services resulted in different parameters for model fit. Based on the different iterations, I used regularization multipliers that ranged from 1.25 to 2.25 with 1.25 and 1.75 most commonly used (Table 4.4).

All of the models exhibited different measures of model fit, their AUC values varied considerably (Table 4.4). The models for Provisioning Biodiversity, Timber Rattler, Texas Horned Lizard, and Texas Indigo Snake did not demonstrate adequate goodness of fit and variability to assure the models provided predictive utility (Table 4.4), and they were removed from further analysis. The Cultural Biodiversity ecosystem service model provided adequate fit, as did three threatened and endangered species all of which were raptor species (swallow tailed kite, white-tailed hawk, and aplomado falcon) (Table 4.4). The three Game SGCN, which were northern bobwhite quail, wild turkey, and American woodcock. The logistic threshold that I used (mSSS) varied for the different models, but ranged between 0.29 and 0.45, which I used as the threshold to delineate the distribution of ecosystem services in the landscape (Table 4.4).

4.3.3. Environmental variable importance

The importance of environmental variables associated with the distribution of the Cultural Biodiversity ecosystem services varied within the study area. The most important variable for the distribution of Cultural Biodiversity was distance to cultivated areas (37.8% permutation importance), followed by distance to shrub (13.6% permutational importance), mean annual temperature (12% permutation importance) and distance to forest (8.4% permutation importance) (Table 4.5). The ranks for each category were highly variable; however, when averaged the Landcover variables were most important (average rank = 4.8), with the others being less important (average rank = 11.2—15.6) (Table 4.6).

Table 4.3 Rotated component loadings, membership (in bold) and their interpretation for principle components analysis of landowners' agreement that each aspect of their land was important. Loadings were calculated using the Oblimin rotation with Kaiser normalization.

Statement	Component[1]		
	Cultural Biodiversity	Provisioning Biodiversity	Forage Production
Being able to hunt and/or fish (recreationally)	**0.6**	0.22	0.09
Being able to enjoy other non-hunting/fishing recreation	**0.67**	0	0.04
Managing large wildlife (primarily deer)	**0.82**	0.11	-0.06
Managing game birds (primarily quail, dove, turkey)	**0.83**	0.04	0.03
Managing for non-game wildlife (songbirds, etc.)	**0.77**	-0.18	-0.02
Operating a hunting enterprise	0.18	**0.85**	-0.05
Selling game leases	0.05	**0.9**	-0.01
Producing browsing livestock (primarily goats)	-0.11	**0.69**	0.07
Producing grazing livestock (primarily cattle and/or sheep)	0.17	-0.05	**0.7**
Producing crops/hay/forage	-0.06	-0.03	**0.81**
Earning a profit	-0.08	0.11	**0.81**

1: Cronbach's alpha: Cultural Biodiversity = 0.68; Provisioning Biodiversity = 0.79; Forage Production = 0.81

Table 4.4 The number of occurrences and Maxent parameters used model, derive and evaluate the distribution of ecosystem services in the Gulf Coast Prairie of Texas.

Ecosystem Service	Species of Greatest Conservation Need	Regularization Multiplier	Total Occurrences	Rarefied Occurrences	Average AUC	Std. Dev.	Logistic Threshold (test mSSS)
T&E Biodiversity	swallow tailed kite	1.75	151	60	0.74	0.04	0.45
	white-tailed hawk	1.75	188	162	0.74	0.05	0.34
	aplomado falcon	1.25	34	NA	0.77	0.08	0.29
	timber rattlesnake	1.25	14	9	0.57	0.16	NA
	Texas indigo snake	1.25	5	5	0.77	0.3	NA
	Texas horned lizard	1.25	22	7	0.54	0.25	NA
Game Biodiversity	northern bobwhite	1.75	26	20	0.74	0.09	0.32
	wild turkey	1.75	1771	123	0.73	0.02	0.35
	American woodcock	2.25	103	45	0.68	0.03	0.39
Cultural Biodiversity	NA	1.25	88	32	0.71	0.11	0.41
Provisioning Biodiversity	NA	1.25	13	11	0.55	0.23	NA

Table 4.5 Percent Contribution and Permutational importance of variables for Cultural Biodiversity ecosystem service distribution model.

Variables		Percent Contribution	Permutational Importance	Rank
Category	**Name**			
Soil	farmclass	1.6	0.9	t-15
	sandpct5cm	0.4	0.3	t-17
	claypct5cm	0.3	0.9	t-15
	soc5cm	6.4	2.2	11
	ph_h205cm	0	0	NA
Climate	Bio_1	6.8	12	3
	Bio_2	7.8	3.3	7
	Bio_4	1.1	2.3	10
	Bio_12	8.2	1	14
	Bio_15	0.3	0.3	t-17
Topography	Elevation	1.6	2.7	9
	Slope	3.3	3.1	8
	Aspect	1.8	0	NA
Landcover	welldist	1.6	1.9	12
	shrubdist	10.4	13.6	2
	forestdist	7.9	8.4	4
	waterdist	4.7	1.7	13
	wtlnddist	5.5	3.8	t-5
	cltvatedist	27	37.8	1
	grassherbdist	3.3	3.8	t-5

Table 4.6 Average rank of importance (out of 20) for different categories of environmental variables for species distribution models of Threatened and Endangered (T&E) Species, Game Species and Cultural Biodiversity, as well as, combined Species of Greatest Conservation Need (T&E and Game) and all combined.

Category	Average Rank				
	T&E	Game	SGCN (T&E and Game)	Cultural Biodiversity	Overall
Soil	13	11.3	12.6	15.6	14.1
Climate	14.5	10.7	14.6	13.2	13.9
Topography	6	12.7	11.3	11.2	11.3
Landcover	9.5	4.7	4.8	10.2	7.5

There was also variation among the importance of variables for the distribution of T&E and Game SGCN (Tables 4.7, 4.8). The variables that were most important for the distribution of T&E species were elevation (4.3 average rank), distance to cultivated and shrub landcover (tied, 5.3 average rank), distance to wetland and percent of sand in soils (8.0 average rank) (Table 4.9). For Game species, the key variables were all associated with landcover, the most important being was distance to cultivated areas (3.0 average rank), followed by distances to shrub (3.7 average rank), forest (5.0 average rank), and wetland (6.3 average rank) landcovers. For SGCN overall, landcover distances were most important: cultivated (4.2 average rank), forest (5.2 average rank), wetland (6.0 average rank), shrub (6.7 average rank) were the most important, followed by sand percent in soil (6.8 average rank) (Table 4.6, 4.9).

4.3.4. Distribution of Species of Greatest Conservation Need

When the individual species layers were combined there were differences in the distributions of the species of greatest conservation need across the landscape. T&E

Species had a distribution that was mostly found near the coastal areas of my study area (Figure 4.3). Overall, 28% of the landscape was identified as habitat for T&E species (Figure 4.4), of which 80% was identified as suitable for one species, 19% for 2 and 1% for all 3 species (Figure 4.5). In contrast, the Game Species were more widespread than T&E Species and were found throughout the study area (Figure 4.6). Game species were indicated as having a potential distribution in 62% of the landscape (Figure 4.4), 70% of which was identified as suitable for one species, 27% for 2 and 2% for all 3 species (Figure 4.5). When considering the four classes of overlapping habitat for T&E and Game species, the limited extent of T&E species was apparent. T&E species overlapped with Game species in 22% of the study area, while there was T&E only in 7% of the study area versus 41% for Game species, there was no habitat in 30% of the study area.

4.3.5. Cultural Biodiversity

Cultural Biodiversity was predicted to occur throughout the study area. Based upon the mSSS threshold, 43% of the study area had potential to provide the Cultural Biodiversity ecosystem service. When considering the overlap with Species of Greatest Conservation Need, most of the areas identified as habitat (63%) overlapped with Game species, while the next most common (22%) was no overlap with Game or T&E species, overlap with T&E and Game species (14%) and T&E species (1%) (Figure 4.7)

Table 4.7 Percent Contribution and Permutational Importance of variables for each threatened and endangered (T&E) species used to calculate the T&E ecosystem service distribution models.

Category	Variable	T&E Species					
		swallow-tailed kite		white-tailed hawk		aplomado falcon	
		Percent Contribution	Permutation Importance	Percent Contribution	Permutation Importance	Percent Contribution	Permutation Importance
Soil	farmclass	2	0.3	3.9	0.5	22.1	0
	sandpct5cm	0.8	6.4	7.2	12.8	2.6	0.6
	claypct5cm	1.3	6.8	4.8	9.4	0.5	0
	soc5cm	1.2	2.9	0.8	0.7	2	0.8
	ph_h205cm	0.1	0	0.8	1.3	12.8	8.9
Climate	Bio_1	2.5	2.2	4.9	4.7	0	0
	Bio_2	15	2.5	1.1	2.5	0.6	0.3
	Bio_4	0.5	0.1	3.8	17.5	0.5	1.3
	Bio_12	0.3	0.5	2.2	7.4	0	0
	Bio_15	13.8	0.4	11.1	2.6	0.3	0
Topography	Elevation	16.3	19.4	6.5	5.1	7.4	26.5
	Slope	2.3	2.6	2.6	0.5	0.2	0.1
	Aspect	2.9	4.9	4.4	3	0	0
Landcover	welldist	0.1	0.8	2.6	1.1	1.3	1.1
	shrubdist	0.3	2.2	9.2	8.8	0.5	0.3
	forestdist	6.2	12.1	13.4	5.2	1.1	3.1
	waterdist	5.9	5.9	1	0.7	9.3	21.7
	wtlnddist	1.2	3	8.1	5.3	29.3	33.5
	cltvatedist	23.8	23.3	8.9	9.2	9	0.3
	grassherbdist	3.6	3.8	2.6	1.7	0.4	1.3

Table 4.8 Percent Contribution and Permutational Importance of variables for each game species used to calculate the Game ecosystem service distribution models.

Category	**Game**					
	northern bobwhite		**wild turkey**		**American woodcock**	
	Percent Contribution	Permutation Importance	Percent Contribution	Permutation Importance	Percent Contribution	Permutation Importance
Soil	8.7	0.3	0.4	0.5	0.6	0.4
	11.4	16.4	3.3	1.2	1.4	3.1
	3.3	2.8	4.1	3.4	2.6	8
	0	0	0.6	0.6	0.3	0.5
	0	0	0.8	0.9	0	0
Climate	0	0	1.2	0.6	0	0
	0.3	0	1	0.6	0	0
	1.8	7.3	1.5	3.6	0.4	1.4
	0	0	1.5	2	0	0
	16.4	2.2	22.6	20.7	7.4	0.6
Topography	0.8	0.8	2.2	1.7	1.1	0.7
	6.5	13.2	15	2.6	0.5	1
	1.8	1.9	0.7	0.7	2.1	1.9
Landcover	2.5	1.8	2.5	3.7	7	5.1
	3	6.8	8.6	10	30.9	35.3
	24.3	13.6	9.9	8.5	6.4	3.2
	0	0	3.9	9.7	8	10.5
	3.4	3.7	5.7	8.5	6.2	3.3
	3.2	9.4	12.9	17.8	24.9	24.7
	12.6	19.9	1.5	2.6	0.2	0.3

Table 4.9 Average rank of permutation importance (out of 20) for species distribution models of environmental variables for Threatened and Endangered (T&E) Species, Game Species and combined species of greatest conservation need (T&E and Game).

Category	Variable	Average Rank		
		T&E	Game	T&E and Game
Soil	farmclass	19	16.3	17.7
	sandpct5cm	5.7	8	6.8
	claypct5cm	9	7.3	8.2
	soc5cm	12.3	17	14.7
	ph_h205cm	13	18.3	15.7
Climate	Bio_1	14.3	19	16.7
	Bio_2	12.7	19	15.8
	Bio_4	8.7	8	8.3
	Bio_12	14	17.3	15.7
	Bio_15	16.3	8	12.2
Topography	Elevation	4.3	12.7	8.5
	Slope	14.7	8.3	11.5
	Aspect	12.7	12	12.3
Landcover	welldist	13	8	10.5
	shrubdist	10.3	3.7	7
	forestdist	5.3	5	5.2
	waterdist	8.7	9	8.8
	wtlnddist	5.7	6.3	6
	cltvatedist	5.3	3	4.2
	grassherbdist	9.7	9	9.3

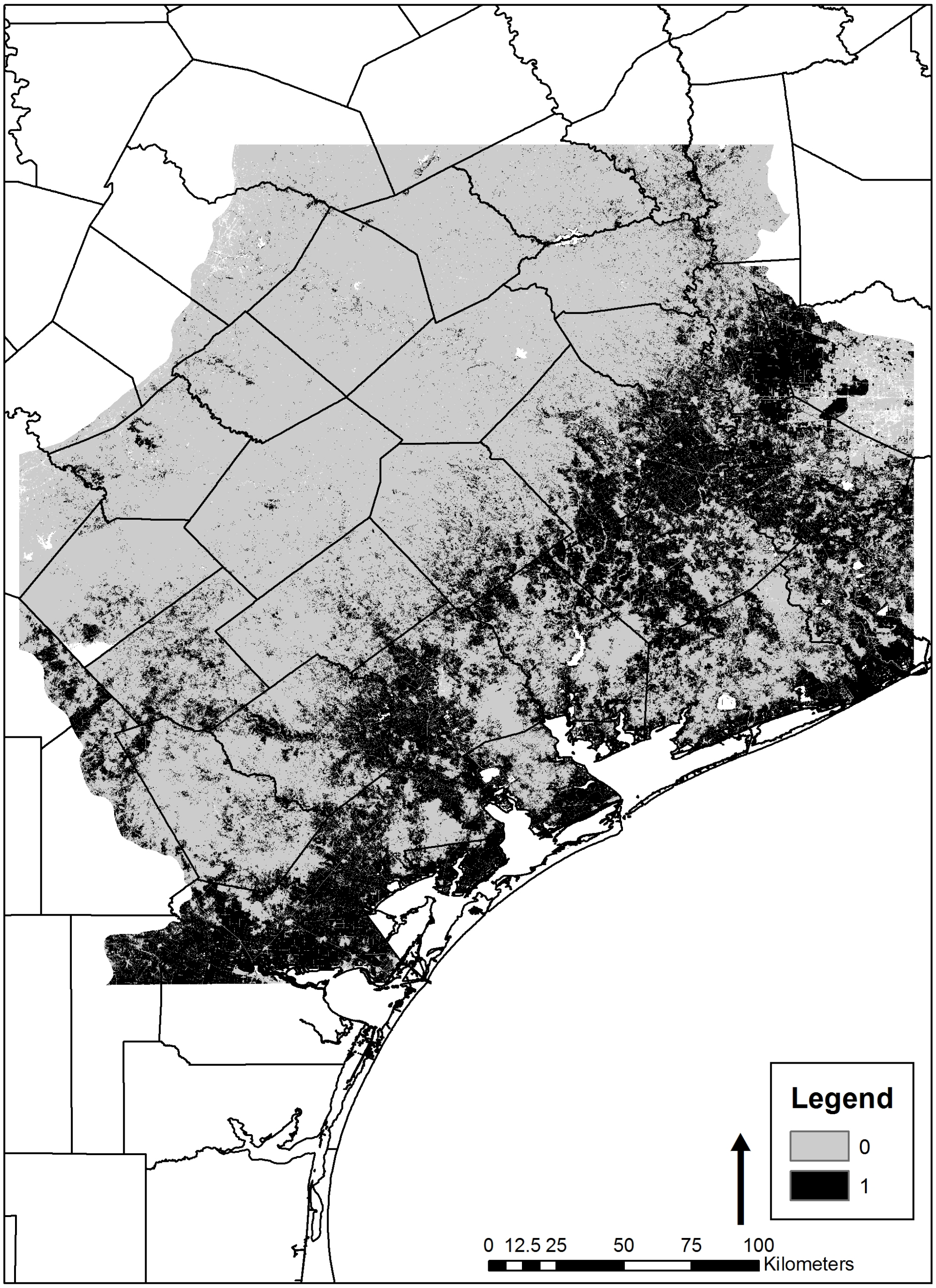

Figure 4.3 The overlapping modeled distributions (black = present) of three (white-tailed hawk, swallow-tailed kite, aplamando falcon) Threatened and Endangered Species in the coastal prairie of Texas.

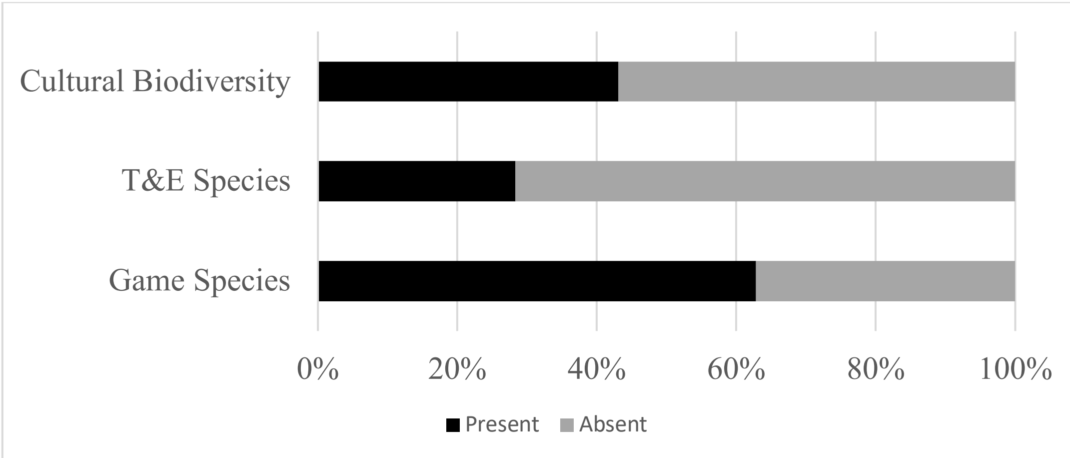

Figure 4.4 Percentage of the modeled landscape that was identified as composing the distribution of Cultural Biodiversity, T&E Species, and Game Species.

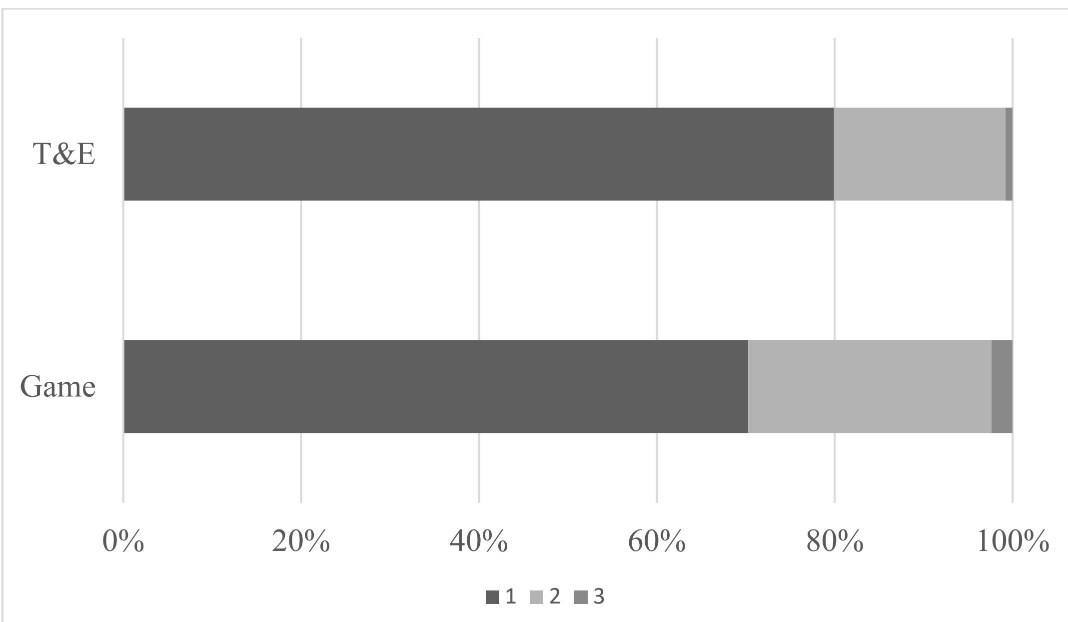

Figure 4.5 Percentage of overlap by the number of distributions of Threatened and Endangered (T&E) and Game Species in areas where they were modeled to be present.

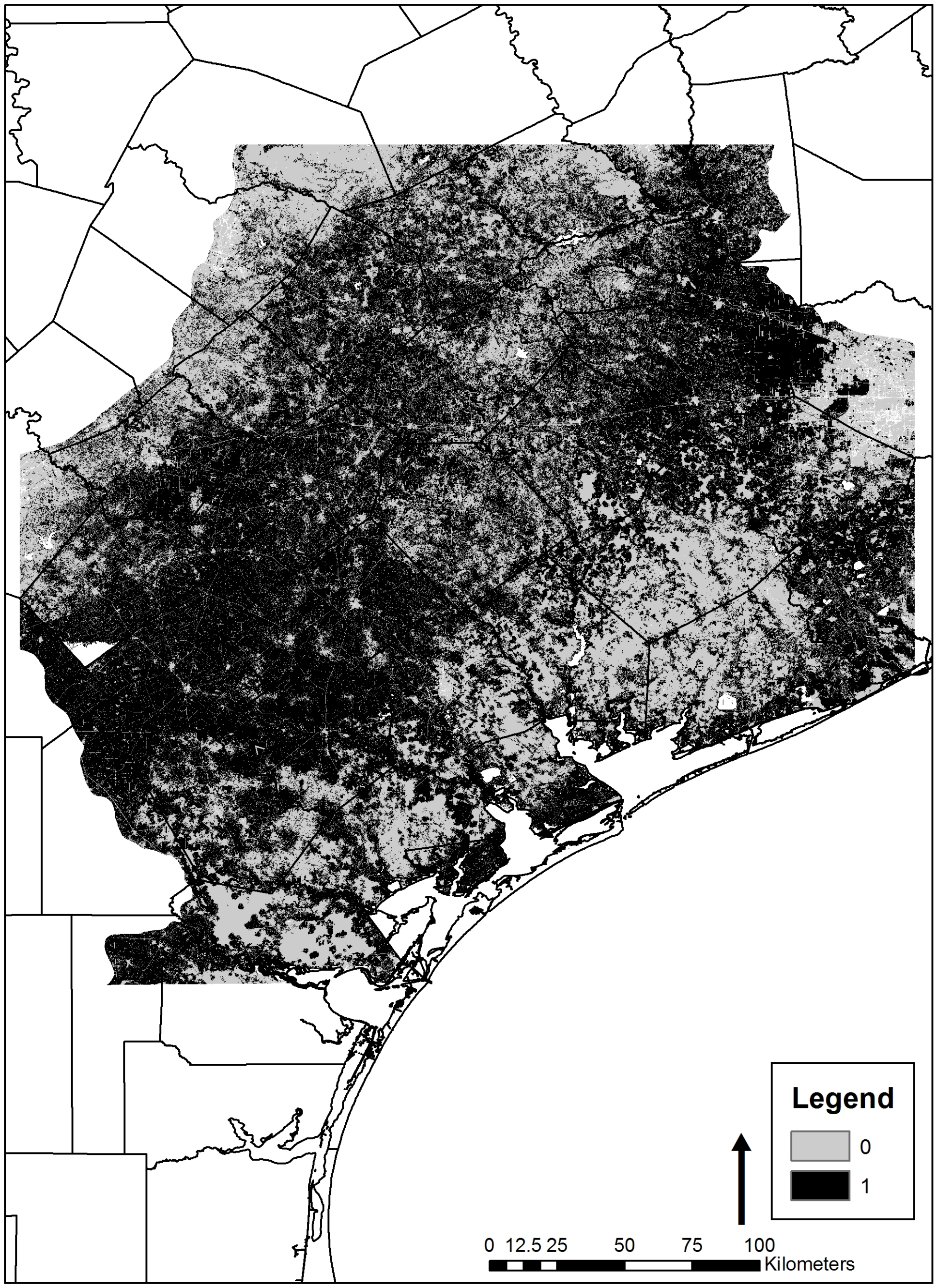

Figure 4.6 The overlapping modeled distributions (black = present) of three (wild turkey, bobwhite quail, American woodcock) Game Species in the coastal prairie of Texas.

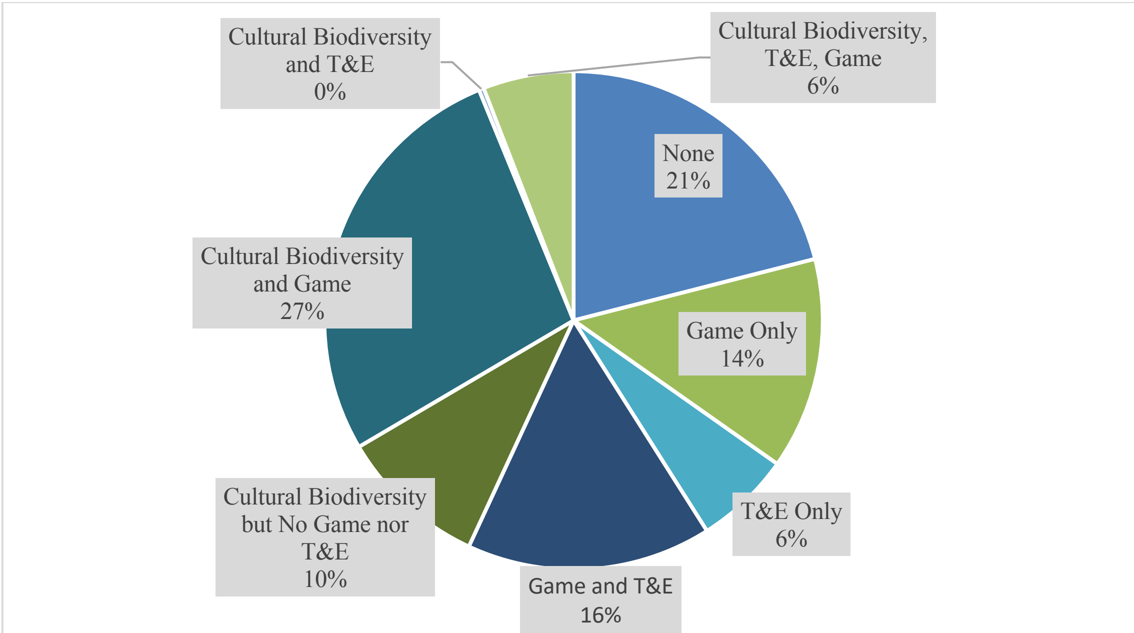

Figure 4.7 Percentage of overlap in the distribution of Threatened and Endangered (T&E), Game Species and Cultural Biodiversity Value in the coastal prairie of Texas.

4.3.6. Management implications and recommendations

Ecosystem service maps can inform the targeting of conservation efforts, and overlap between the T&E and Game maps can be used as a proxy for conservation value. Although I only considered SGCN, these two types of species can be assigned different values according to their degree of endangerment. Assigning T&E species' habitat a higher priority than game species can differentiate areas to target for conservation action. Areas with habitat for both T&E and Game species had the highest conservation value and should be preferentially targeted for conservation action, while those without any habitat should not. Conversely, those areas that have only one type of habitat should also be prioritized, with T&E habitat having more value (Table 4.10, Figure 4.8). While there was 22% overlap between the T&E and Game species in the study area, T&E species were only found in 29% of the study area. In effect, this places a higher value on the areas that have overlapping habitat or T&E species only. The relative lack `of overlap was related to the T&E raptor species that I was able to model, which were largely confined to areas immediately adjacent to the coast. Despite this bias, it is clear that coastal areas do have a significant conservation value as unique habitat, even without consideration of species that depend on aquatic habitats. My analysis indicates there is no disproportionate overlap among species; the use of Game species as focal species for achieving broader conservation goals would likely not result in adequate habitat management in areas where T&E species were also potentially distributed.

Given this conservation value, the interpretation of the implications of the Cultural Biodiversity variable can serve to inform approaches that are used for conservation targeting (Table 4.11, Figure 4.9). In my study, Cultural Biodiversity consisted of values associated with recreational hunting and also management of wildlife. Thus, value was associated with the act of managing land for biodiversity.

Table 4.10 Conceptualization of relative conservation value (with percentage of landscape) as denoted by the overlapping distributions of Threatened and Endangered (T&E) and Game Species of Greatest Conservation Need in the coastal prairie of Texas.

T&E Species	Game Species	
	Absent	Present
Absent	Minimal (30%)	Low (41%)
Present	Medium (7%)	High (22%)

Proper alignment between motivations and strategies of engagement can affect their effectiveness, efficiency and, ultimately, the resilience of conservation behaviors. In this regard, the patterns that I observed in the landscape can yield some insights. Approximately 1/3 of the landscape had conservation value with an absence of Cultural Biodiversity. It may be difficult to engage conservation behaviors on such areas without appealing to landowners' extrinsic motivations by supplying incentives or levying sanctions. An additional 1/3 of the landscape had low conservation value, but may have cultural biodiversity value. These areas may be of low priority for targeting conservation action, but they should not be entirely disregarded by practitioners; rather they should adopt a more passive strategy that is responsive to landowners' requests for assistance. Finally, 1/3 of the landscape had varying conservation value and Cultural Biodiversity values. These areas are locations where efforts should work to foster intrinsic motivations, which involves different strategies for engagement. Due to the novel nature of this analytical approach, it is unclear whether these proportions are similar to those that might be expected in other landscapes; however, it is likely that these proportions would be highly context specific. As an endangered ecosystem, the GCP likely has a higher proportion of SGCN than many landscapes, however, as a production landscape there may be lower proportion of Cultural Biodiversity values than are found in more amenity-oriented landscapes. Regardless, as the conservation value of lands increases, so should the engagement strategies, which should become more comprehensive as the value increases, agencies should devote more resources to engage landowners in multiple different ways that will foster intrinsic motivations. Additionally, it may be appropriate to shift the appeals, messages frames, and strategies to reflect which types of wildlife are present.

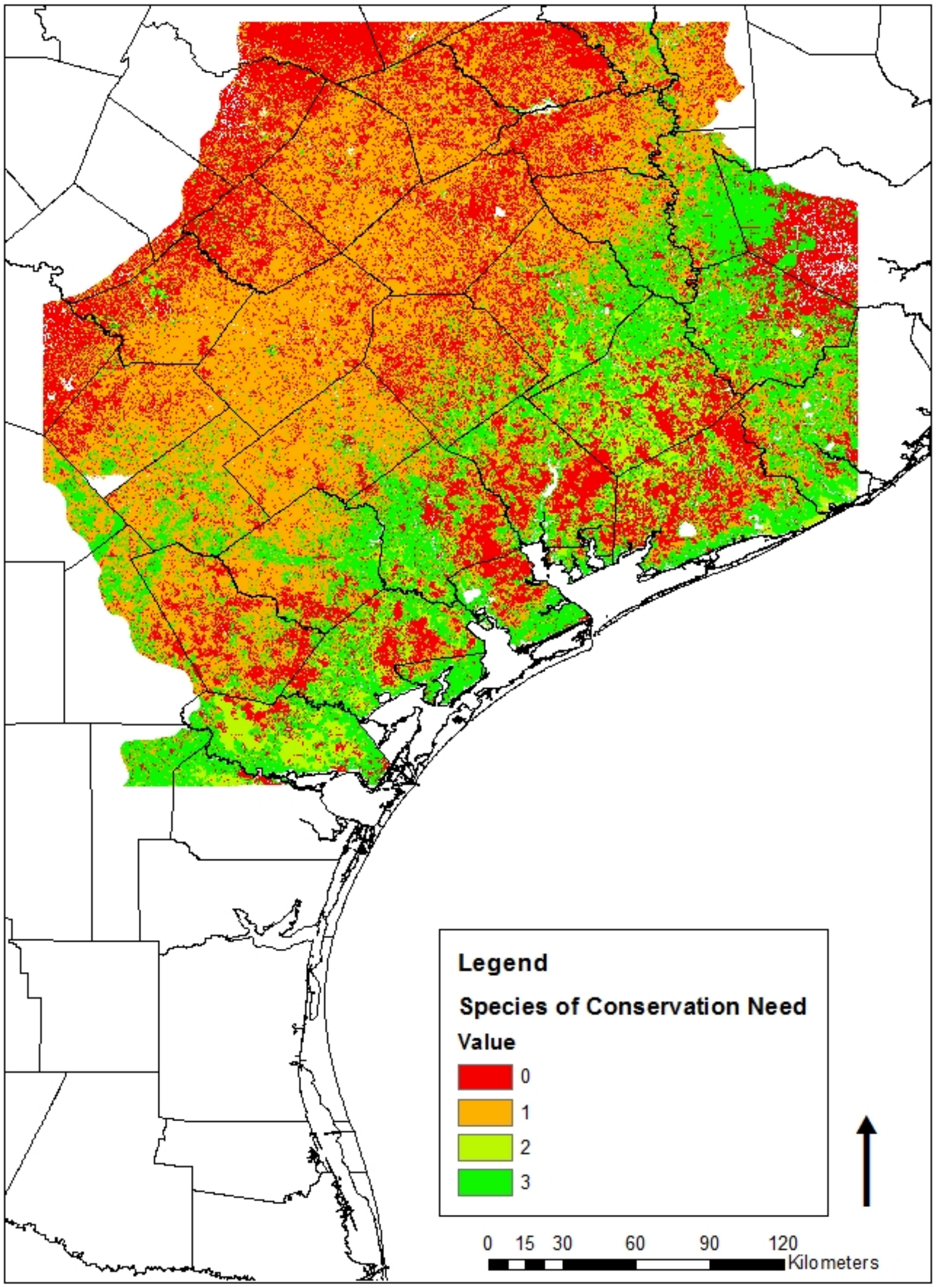

Figure 4.8 Relative conservation value (0 = low) of lands in the coastal prairie of Texas as calculated by the overlapping distributions of Threatened and Endangered (T&E) and Game Species of Greatest Conservation Need.

Table 4.11 Conceptualization of targeted approaches for conservation programs as related to Conservation Value and Cultural Biodiversity. The percentage of the study landscape is provided in parentheses.

Cultural Biodiversity		Conservation Value: Minimal	Low	Medium	High	Motivations to engage
	Absent	Focus efforts away from these areas **(21%)**	Work with local groups for education and outreach to increase valuation of areas **(14%)**	Work with local groups for education and outreach to increase valuation of areas and outreach regarding incentives **(6%)**	Work to increase the feelings of autonomy, competence and relatedness; actively engage landowners in dialogues to help foster these feelings **(16%)**	Extrinsic
	Present	Passively support conservation in these areas, provide resources as requested, work to understand why values are held **(10%)**	Passively support and/or opportunistically approach landowners, foster game management capacity and/or stewardship, recreational values **(27%)**	Actively engage landowners, foster preservation, stewardship values **(0%)**	Target these areas, multiple approaches are available that engage stewardship and/or preservation variables **(6%)**	Intrinsic

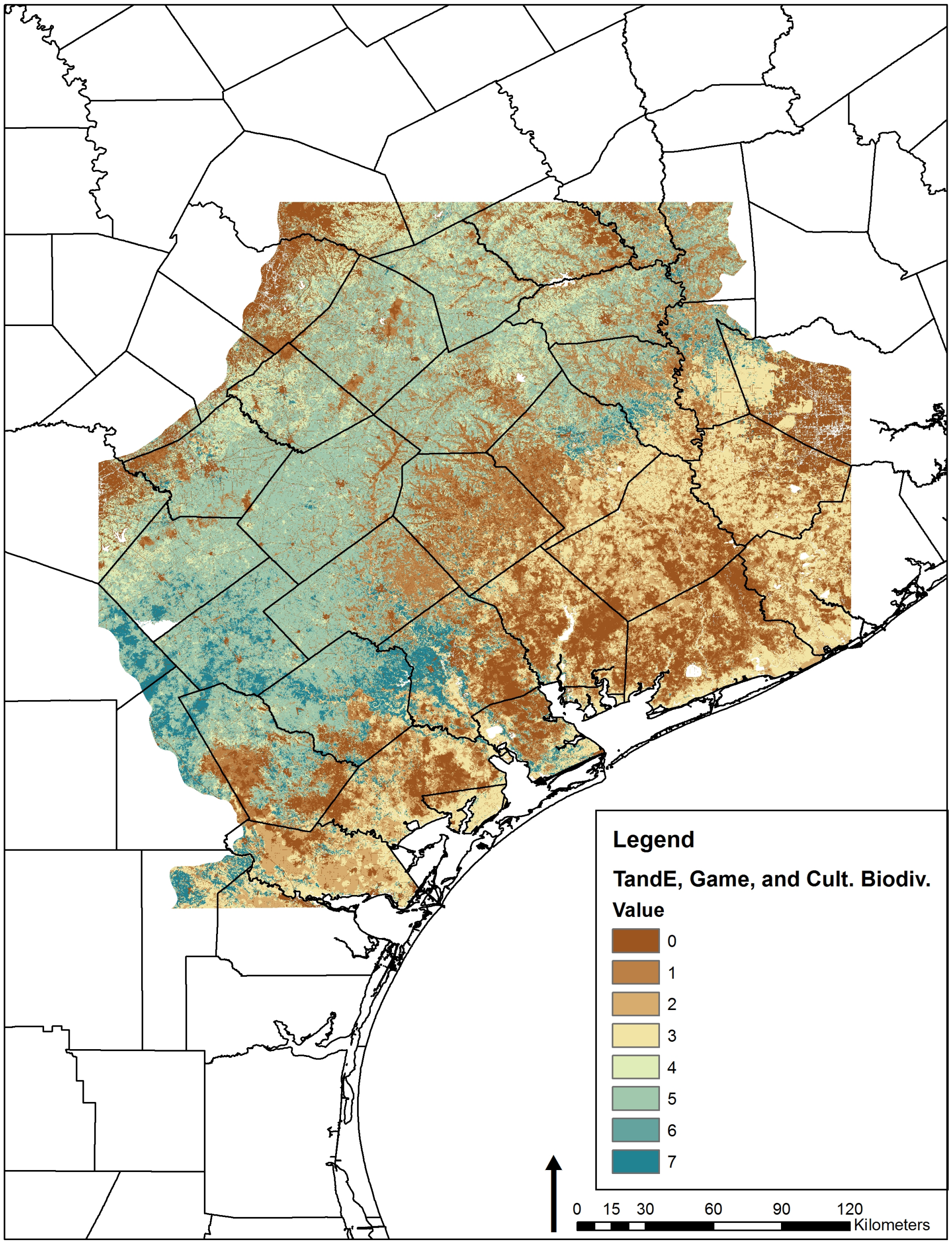

Figure 4.9 Overlapping distribution of Conservation Value and Cultural Biodiversity. Values of 0—4 reflect Conservation Value in the absence of Cultural Biodiversity, while 5—6 reflect the Conservation Value with the presence of Cultural Biodiversity.

4.4. Discussion

My study demonstrates the utility of incorporating consideration of the distribution of different types of ecosystem services into landscape conservation planning in predominantly privately held landscapes. The derivation of species-based ecosystem service distribution models facilitates understanding of variation in the conservation value of the landscape, which can inform the targeting of areas on which to focus conservation efforts. Areas that serve as habitat for T&E and Game species have higher value in such efforts because they are likely to yield greater returns on investments of agency or organizational resources that are devoted towards engaging landowners in conservation programs or agreements.

Accounting for the distribution of Cultural Biodiversity along with conservation value can help highlight strategies or approaches that most effectively engage landowners in conservation programs. Where Cultural Biodiversity is absent, strategies that provide extrinsic motivations for conservation action are most effective, whereas in areas where Cultural Biodiversity is present, strategies that engage landowners' intrinsic motivations are most appropriate. Appealing to intrinsic motivations requires a different approach to conservation than those for extrinsic motivations. Such knowledge can be used to identify focal areas for different types of conservation programs or strategies that are used by conservation practitioners. At broad scales, knowing the proportion of areas in a landscape that are most suitable for different conservation strategies can help guide agency and organizational strategic planning. For example, resources may need to be shifted from recruitment and financial compensation to capacity building, cost-sharing, biological monitoring, and building relationships with landowners, among others. Thus, the integration of different services can help guide agency and organizational conservation efforts by enabling an evaluation of agency and program capacity, and institutional approaches as they relate to on-the ground conservation needs.

It is important to stress that this analytical approach is not prescriptive, but rather a decision support tool that can help guide planning and management efforts. Understanding landowners' values and connecting this to behavior is prone to a high degree of variation because the perception of these values relies on the characteristics of the landowners and their environment. This variation is compounded when combined with uncertainty found in the T&E and Game distribution models. Thus, placing too much emphasis on pixel-level values may be misguided; rather agglomerations of values or "hotspots" (Plieninger et al., 2013) and proportions of values is more appropriate.

Understanding the distribution of ecosystem services can also inform conservation practice via interpretation of the importance of different variables. Perhaps more than the other models, the T&E model reflects the constraints introduced by environmental variables on the distributions of these species. Variables that were most important were associated with topography and more specifically elevation and landcover, which reflects the association of aplomado falcons and white-tailed hawks with low-lying coastal areas near water, habitat associations which are not as pronounced in other regions (Hector 1981; Farquhar 1992, Keddy-Hector 2000, Actkinson et al, 2007).

An advantage of species distribution modeling is the ability to project the potential distributions and prioritize conservation efforts accordingly (Lanham et al., 2015, Shuetz et al., 2015). Both the aplomado falcon and white-tailed hawk are near the limits of their distribution in the GCP and both are susceptible to the impacts of climate change (e.g., Lanham et al. 2015). My study area may incorporate the potential northward shift in the distribution of both species as the climate becomes more similar to areas in the central portions of their range. Other species, which I was unable to model, particularly the Attwater' prairie chicken, are also highly susceptible to climate change (Lanham et al., 2015). This approach can help inform future conservation priorities and should be undertaken to help inform the decisions and prioritizations that are derived from the values supplied by the model. However, whether a further northerly range expansion should be considered or fostered in conservation planning is an important question for stakeholders to consider. In these instances, broader consideration of range-wide distribution may be warranted to determine the study location's importance for conservation in the future.

Although the habitat associations of swallow-tailed kite are not as restricted as the other species, it is also considered a migrant in the GCP. However, the occurrence locations that I used were from multiple times of the year and it is unclear whether they were associated with breeding activity. Regardless, the swallow-tailed kite historically had a much larger range in North America. The distribution that was indicated with my model represents some potential areas for range expansion within the study area. The swallow-tailed kite is dependent on a mix of habitat types, frequently forestland next to more open areas (Hunter et al. 2001). The model indicated many potential habitat areas, particularly areas associated with riparian forestlands. Fostering management associated with forestlands and riparian areas could help to restore this species to areas where it was historically found, providing an area of emphasis for conservation practitioners.

Game species exhibited different distribution patterns than T&E species, with landcover being the most important predictor. It is clear that grasslands and shrublands are important habitat types. However, this importance varies by species; different game species will be favored by different combinations of landcover within a landscape. Management for bobwhite quail at broad scales should place importance on grassland cover, while this will vary at fine scales (e.g., Duren et al., 2011). A close examination of the relationship between the importance and relationship of different variables for game species' distributions could help identify focal habitat variables, which, when combined, could provide an indication of a landscape management regime that would maximize game diversity (e.g., degree of interspersion of grassland and shrubland). The American woodcock is considered to only inhabit the GCP during the winter, which is indicated by my occurrences only falling between November—March. Thus, the model indicated non-breeding habitat. Winter habitat use can have impacts on bird survival and breeding success (e.g., Sherry and Holmes, 1995; Faaborg et al., 2010) and thus represents a key component for landscape management (Sherry and Holmes, 1995).

The interpretation of the Cultural Biodiversity ecosystem service model is not the same as for the species distribution models because the model was derived using response data from landowners. The conceptualization of Cultural Biodiversity that I identified is very similar to the idea of "functional leisure", which is the "…uncoerced activities that people engage in that result in an end product or accomplishment. Land management and conservation activities might fit this definition" (Farmer et al. 2016, "Discussion," para. 6). Farmer et al. (2016) hypothesized that functional leisure is consistent with an association between land management and support for conservation easements (Brenner et al., 2013). In a related vein, Moon and Cocklin (2011) observed that landowners with strong pro-environmental attitudes were more willing to participate in voluntary conservation programs. Thus, when Cultural Biodiversity values are present, there is likely a higher probability of engaging in conservation activities. Furthermore, Brenner et al. (2013) found landowners who recreated on their land or used it for subsistence were more likely to consider conservation easements. Thus, Cultural Biodiversity equates to a higher likelihood of uncoerced or intrinsically motivated biodiversity management and the presence of game species on these lands likely translates to a higher likelihood of engaging in permanent conservation agreements.

Considered more broadly, the parallels between functional leisure and Cultural Biodiversity indicates that where Cultural Biodiversity was present, environmental conditions are present to enable intrinsically motivated conservation behavior. Self Determination Theory explains behaviors that range from nonself-determined to self-determined and which are the result of either extrinsic or intrinsic motivations for the actor (Deci and Ryan, 2000; Ryan and Deci, 2000). Internal motivations derive from values and interests that people hold and, when they form the basis of behaviors, those behaviors are more resilient. People can derive self-esteem, more engagement and higher satisfaction from intrinsically motivated behaviors and these feelings can be enhanced via experiences that foster competence, autonomy and relatedness. Conversely, behaviors that are extrinsically motivated can foster feelings of resentment, disempowerment and coercion. Furthermore, according to motivational crowding theory, the use of incentives and punishments, in some instances can "crowd out" intrinsic motivations (Frey and Jegen, 2002). Thus, whenever possible efforts should be made to engage and/or develop intrinsic motivations for conservation behavior, however this is not always practical.

Intrinsic and extrinsic motivations can be most efficiently engaged via different mechanisms, and it is possible for motivations to be internalized or externalized. To foster intrinsic motivations practitioners should facilitate or enable people to act, while extrinsic motivations are more effectively fostered through incentivization, regulation and coercion of behavior. Strategies to provide extrinsic motivation can take the form of monetary incentives such as rentals and tax credits for lands devoted to conservation (e.g., Bernstein and Mitchell, 2005), regulation and enforcement, or recognition or social sanctions (e.g., Pasquini et al., 2010). These different strategies can also be subject to different time periods and restrictions on permissible activities (Kamal et al., 2015). Intrinsically based motivations can be engaged with strategies that enable and strengthen these motivations, most notably by providing assistance or resources to engage in activities, strengthening social networks associated with the activities, and providing feedback related to their performance in achieving these goals.

The application of Self Determination Theory is more broadly associated with a landowner-centered approach to conservation, wherein program attributes and strategies are considered in terms of how they enable landowners to achieve their goals and gain the benefits they desire from their land (Moon and Cocklin, 2011). Landowner-centered approaches can represent a significant reorientation of conservation strategies away from education and outreach and towards meaningful engagement that fosters connections with and among landowners; programs that solicit and incorporate landowner feedback, enables good management and provides feedback (e.g., Sorice et. al 2015).

As expected from my sampling design, cultivated distance was the most important variable associated with Cultural Biodiversity. While, cultivated lands do not preclude the presence of Cultural Biodiversity, distance to other landcover types, especially shrub and forest, were also important. This indicates that highly heterogenous lands may be particularly associated with the presence of Cultural Biodiversity. Furthermore, the presence of the ecosystem services was almost entirely tied to landcover variables, indicating that there were not climatic, topographic or edaphic factors that were limiting the distribution of Cultural Biodiversity.

While my modeling approach to understand the distribution of ecosystem services in the landscape yielded meaningful insights, it has some limitations. I sampled landowners with > 40 ha properties that were not evenly distributed throughout the study area, and so there may have been some landowner sampling error. Furthermore, probabilities of presence are limited by the suite of variables used in the prediction models. Different model structures could result in significantly different probability distributions and importance of predictor variables across a landscape. Additionally, although I took precautions to reduce model overfitting, the nature of the data and goals of the analysis could have resulted in some overfitting because of the relatively small geographic region with relatively small amounts of topographic and climatic variability. However, given the relative comparisons and no extrapolation beyond the region, an overfitted model was not necessarily a significant issue for my analysis. Projecting results outside of the study area or climatic conditions would require caution because an overfitted model could introduce biases that might affect the projection, and more effort would need to be made to reduce the number of variables in the model. Ideally, future research would result in a study design that accommodates expanded geographic samples. However, this modeling approach is amenable to opportunistic data collection, modeling can be done without systematically sampling an area.

As with any model, understanding the way in which it was derived is integral to its interpretation and articulation of its limitations. I did not attempt to develop the most parsimonious models apart from the methods that were embedded within the Maxent program (regularization multiplier, hinging) or account for overfitting of the model to the environmental data apart from employing best analysis practices (Brown 2014). Transference of Maxent models to other locations or time periods is subject to potential biases and should be done with caution. Maxent performs best in instances of interpolation rather than prediction for which other modeling algorithms may perform better than Maxent (e.g., GARP; Peterson et al., 2007). Despite the limitations and given my study goals, Maxent performed well to identify areas that could be targeted for conservation action.

As this study demonstrated the decisions involved with spatial targeting of conservation actions are met with tradeoffs. There are some areas in the GCP that are highly suitable to target conservation actions, they represent an overlapping of social and ecological ecosystem service values. However, these areas represent a relatively small proportion of the landscape. The remaining areas would likely result in different conservation outcomes if they were targeted. In these areas and situations, models can provide data-based support for discussions used to inform decisions and target the deployment of conservation programs and resources.

Although Maxent is able to perform well with small samples, I was unable to adequately model the distribution of most species (88%) because I was relying upon publicly available species occurrence data. For sensitive, rare, cryptic, or uncharismatic taxa, conservation practitioners may have access to these data but policies related to such data need to be discussed. Presentation of modeled data can be a way to anonymize and unspecify locations of social and species occurrence data while still allowing spatially explicit presentation. Effort may also be needed to direct sampling for these underrepresented taxa. Furthermore, most occurrence locations in production landscapes are biased to disproportionately represent publicly accessible areas (e.g., roads, parks) which can bias the relative importance of soil and landcover data in models such as mine.

4.4.1. Conclusions

Although modeling approaches must be undertaken with caution, my study demonstrates the way in which the distributions of species and ecosystem services are related and can help guide conservation efforts. Ecosystem service values as derived from the distribution T&E, Game species and their overlap vary within a landscape and can inform where to target conservation efforts. However, as discussed by Bryan et al. (2011), different combinations of social and ecological values can inform which strategies for conservation are most appropriate. By expanding upon this approach via the incorporation of Cultural Biodiversity, it is possible to understand the implications and importance of targeting and tailoring different approaches for conservation at the landscape scale. Developing policies and strategies that engage intrinsic and extrinsic motivations of landowners both have merit within a landscape and they should be used in concert to most successfully achieve desired conservation outcomes. This integration of socially derived values has potential to positively contribute to the refinement of conservation programs so that they engage landowners within predominately privately-owned landscapes more effectively. As this study demonstrates, this landowner-centered approach can have significant benefits for effective landscape conservation.

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5. CONCLUSIONS

5.1. Integrative summary

My dissertation has highlighted the way in which ecosystem services can play a role in understanding conservation behavior and their implications for large-scale conservation endeavors. Through the three chapters, I have taken an approach that has documented various landowner characteristics as they relate to ecosystem services.

In Chapter 2, I categorized landowner role types in my study area based upon their land landownership motivations and related this to their land management. From this analysis, I found greater differences in ownership patterns among landowners with at least 100 acres (~ 40 hectares) than might be expected. In particular, a proportion of my respondents were categorized as amenity landowners, despite the larger than average parcel sizes and what would typically be categorized as average to low amenity values (e.g., McGranahan and Beale, 2002). Furthermore, I identified placed-based motivations as a key ownership driver and which differentiate landowners. These motivations are grounded in the social and ecological environment of the Gulf Coast Prairie and Marshes ecoregion (GCP) and they play an important role in differentiating landowners in a way that is reflected in their land management behaviors. Those who had more place-based motivations were more likely to be actively engaged in various land management practices than those whose landownership was predominantly driven by other types of motivators.

In Chapter 3, I evaluated the differences between landowners who were members of wildlife management associations (WMAs) and those who were not members and I identified factors that were associated with a greater likelihood of coordinated land management activities among landowners. In this regard, I found differences between landowners who were and were not WMA members, but was not able to determine causality associated with these variables. I also found that landowners who consulted with professionals, had larger, more diverse consultation networks and more civic engagement were more likely to increase their land management coordination or coordinate with their neighbors. These results are consistent with other studies that found that landowners who had larger and diverse social networks are more likely to engage in conservation action (Lubell et al., 2013). This component of my research highlighted that landowners who were more embedded in their community in terms of their social and consultation networks were more likely to coordinate their land management; the degree to which landowners relate to or are connected with the socio-ecological landscape had a relationship with the likelihood of land management coordination.

In Chapter 4, I applied a modeling approach to explore variation in ecosystem service values across the GCP in order to better target conservation efforts and programs. I found a relatively small amount of overlap between the distribution of T&E species and Game species, which affected conservation values of different lands. T&E species exhibited more restricted ranges near the coast that had, accordingly, higher conservation values that other areas. By contrast, Game species were widespread throughout the study area, but there was also a significant portion of the study area that did not play a significant role in the distribution of either category of species (T&E and Game) that have high conservation values. Such high values can be used to identify target areas that will likely maximize the conservation benefits of various management actions that enhance habitat for such species. In this chapter, I also identified the presence of Cultural Biodiversity values in the GCP. Cultural Biodiversity reflects the values that people attribute to wildlife, both via management and recreational hunting. When considered in conjunction with conservation value, it becomes apparent that in mostly privately-owned landscapes such as those found in the GCP, diverse conservation strategies are needed to most effectively and efficiently engage landowners.

Based in Self-Determination Theory, the conservation approaches that I proposed vary in their targeting of intrinsic vs. extrinsic motivations (Ryan and Deci, 2000). These motivations require conservation approaches that are fundamentally different from one another. Appeals to extrinsic motivations are focused on supplying incentives for conservation action, such as financial or monetary instruments and use of social recognition or sanctions. By contrast, intrinsic motivations can be thought of as facilitation rather than coercion or solicitation and the effectives of strategies for fostering conservation behaviors will more likely be determined to a great degree by the provision of feedback, connection and technical information to landowners. At a minimum, these different approaches necessitate different skill sets but they may also require a reorientation of agencies and programs to better engage with landowners who have different ownership motivations. This need is further highlighted in the GCP where these different ownership motivations may be present in roughly the same proportion within the landscape.

When considered together, my dissertation research indicates the importance of considering a broad array of different social and ecosystem service values for application to biodiversity conservation in the GCP. Among these ecosystem service values, the importance of cultural ecosystem services becomes apparent. In each of my chapters, I identified the role of different values that can be ascribed to cultural ecosystem service values. In the first and second chapters, these values could broadly be ascribed to an affinity for, or connection with, the "place" of which the rural character and ecosystem are an integral part. This connection to the GCP was prominent in whether landowners undertook or were likely to engage in land management activities and their coordination that could scale up to affect the provisioning of ecosystem services within the GCP. Although I did not explicitly outline the characteristics associated with how people defined the GCP "place," it is clear that understanding the component of this place more fully is a useful area of inquiry and is likely composed of social and ecological components.

My identification of the role of place-based motivations and Cultural Biodiversity is a finding that has implications for conservation via their role as relational values. The cultural biodiversity service value was not only associated with the presence of hunting, but also with managing lands for wildlife. This value is, thus, not purely derived by the presence of wildlife recreation but rather the ability of the ecosystem to enable "functional leisure" (Farmer et al., 2016). Functional leisure indicates a value that is not tied to the presence of biodiversity *per se*, but rather in the relation to the utilization and stewardship that landowners are directing toward biodiversity on their land. In this way, functional leisure fits within the broader consideration of relational values, and more specifically those that are related to eudaimonia, or human well-being (e.g., Jax et al., 2018; Knippenberg et al., 2018; West et al., 2018).

Relational values have received research interest recently in response to some shortcomings of the ecosystem services approach (Chan et al., 2016). They have emerged as an integrative approach to valuing ecosystems that extends beyond the utilitarian and intrinsic approaches to valuation of ecosystems; rather, they inhabit a conceptual space that lies between these two approaches to valuation (Chan et al., 2016; Chan et al. 2018). Relational values have been defined as “preferences, principles and virtues associated with relationships, both interpersonal and as articulated by policies and social norms”; they are not “present in things, but derivative of relationships and responsibilities to them” (Chan et al. 2016, pg. 1462). Thus, relational values are also not tied to the intrinsic/instrumental value dichotomy but rather lie in the triad of humans, nature and the character of their relationship (Knippenberg et al., 2018). Given these definitions, place-based considerations and stewardship/cultural biodiversity values can potentially be moved conceptually from the instrumental, “provider-receiver” basis of cultural ecosystem services to relational values that are emergent of the place in the interconnection (e.g., Chan et al., 2018).

Although this study was not implemented to elucidate these relational values, my study results support the future development of this approach. In particular, approaches that are grounded in such frameworks as the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) can be useful to understand and account for the many different values that are present in a landscape (Diaz et al., 2015; Pascual et al. 2017). As my research implies, relational values have implications for landscape-scale conservation, which is presently not adequately accounted for within the existing ecosystem services frameworks. My identification of values that were at least, in part, relational indicates that these are important to consider when trying to understand landowner behavior and its implication for ecosystems.

When taken together, my identification of the importance of place-based motivations and landowner role identity (Chapter 2), social embeddedness (Chapter 3), and cultural biodiversity (Chapter 4) all indicate the importance of considering relational values when characterizing social-ecological systems. As my research indicates these values and motivations can be tied to differences in land management behavior and have implications for landscape scale conservation endeavors. Understanding the implications in more detail will likely lead to further insights that can be used to inform conservation practice in the GCP and beyond. This is a fruitful area of further research, particularly as it relates to private landowners and areas. As my work and others have demonstrated, landowners are stewards of their land and exhibit a connection with it that can be associated with heritage considerations (Chan et al., 2016; Allen et al., 2018). Understanding the presence of these relational values and designing policies that actively engage them can help to increase policies effectiveness and lead to innovations in conservation approaches (Allen et al., 2018). Grounded in a relational values approach, conservation programs can approach biodiversity conservation in private lands using psychological insights drawn from the study of human well-being (e.g., Diener, 1984; Ryff and Keyes, 1995; Ryff, 2014).

The idea of relational values are not new, but rather draw upon literature to translate the connections and care that people express toward nature into a way that can be considered along with other values (Pascual et al., 2017; Allen et al., 2018). The conceptualization of relational values lies at the heart of much conservation effort, making explicit the embeddedness of people in nature. Therefore, relational values can account for many of the underrepresented values present within a landscape. For landowners, this conceptualization can help reinforce and draw attention to their role as stewards of their lands and the degree to which this role relates to the landscape itself. Furthermore, relational values can be incorporated with other values to assist with a more complete accounting of the various values that are derived from the ecosystem. As an outgrowth of discussions centered on ecosystem services, relational values represent a way to conceive of social-ecological systems in a way that is more salient to landowners because, despite their origin from broader ecological processes, relational values are most commonly experienced at the individual level. This salience to individual landowners makes relationally-based conservation approaches more resilient. It is my hope that this dissertation will contribute to the discussion regarding, and inform the use of, socially-derived ecosystem service and relational values for conservation.

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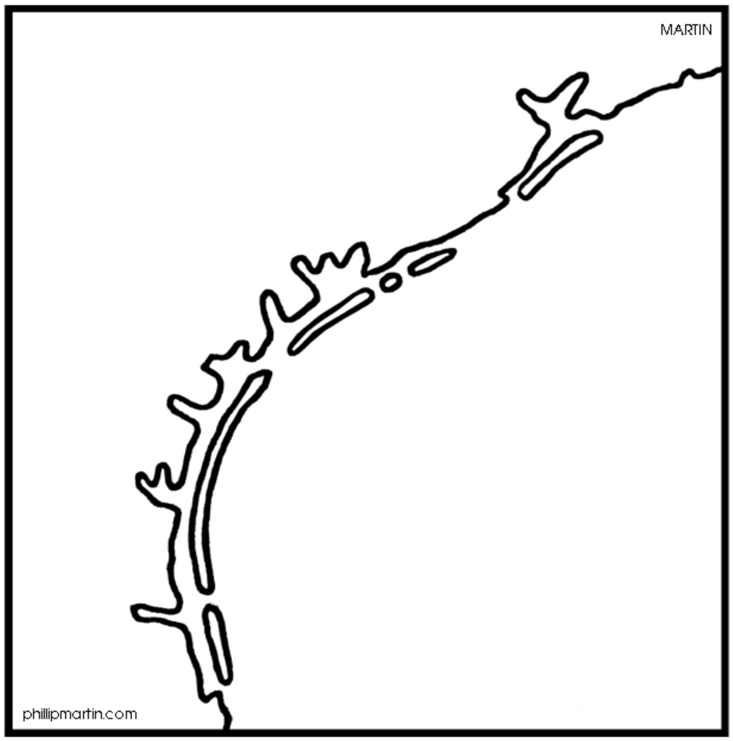
APPENDIX A

MAIL QUESTIONNAIRE

An Investigation of Landowners' Views and Management Practices in the Gulf Coast Prairie



Department of Ecosystem Science and Management,
Texas A&M University

TEXAS A&M AGRILIFE RESEARCH | EXTENSION

TEXAS A&M UNIVERSITY
AGRICULTURE & LIFE SCIENCES
DEPARTMENT OF ECOSYSTEM SCIENCE AND MANGEMENT

1

The Department of Ecosystem Science & Management at Texas A&M University is conducting a survey of landowners in the Gulf Coast Prairie eco-region of Texas. The goal of this study is to better understand landowner perspectives about Coastal Prairie conservation programs. Such programs are only effective if landowners consider such programs to be beneficial and want to participate in them. Therefore, a key objective of this study is to understand how to make Coastal Prairie conservation programs more useful for you, the landowner. By providing information for this study you will contribute to creation or improvement of conservation programs that are appealing for ranchers and farmers and that also benefit the Gulf Coast Prairie eco-region.

The survey questionnaire should be completed by the **LANDOWNER** and/or the **PERSON WHO MAKES THE MANAGEMENT DECISIONS** on the property.

ALL information you provide will remain **STRICTLY CONFIDENTIAL** and you will not be identified with your answers.

INITIAL QUESTION: Do you own or manage 100 acres or more in the Gulf Coast Prairie eco-region?

☐ Yes → Please complete the survey questionnaire beginning on the next page.

☐ No → If you do not own or operate at least 100 acres of property in the Gulf Coast Prairie eco-region, please return the blank questionnaire in the postage-paid envelope provided.

It is important we hear back from everyone who receives a questionnaire, even if they do not own property. By sending the questionnaire back to us, you will be removed from our mailing list.

COMPLETING THE QUESTIONNAIRE: Please answer all questions. Incomplete questionnaires create problems for conducting proper statistical analyses. Please be assured that your identity will remain anonymous.

Many questions in this survey use a rating scale with 5 options. Please circle the number that best describes your opinion. For example, if you were asked to use such a scale to indicate the extent to which you agree or disagree with the statement that "Texas is the best state in the USA" and you strongly agree, you would circle *number 5*, as follows:

1 = Strongly Disagree	2 = Disagree	3 = Neutral	4 = Agree	5= Strongly Agree
Texas is the best state in the USA			1 2 3 4 (5)	

If you encounter a question that does not apply to your property, please indicate this by writing "**NA**" in the margin next to the question.

If you encounter a question for which you do not know the answer, please indicate this by writing "**DK**" in the margin next to the question.

SECTION A. GENERAL LAND CHARACTERISTICS AND PRACTICES

In Section A, we seek information about characteristics of landowners and land management in the Gulf Coast Prairie. We will use this information to determine how these characteristics might influence the responses to the subsequent questions. The information you provide will be aggregated and not used in any way that you can be identified.

1. Do you have a written wildlife management plan for your property? [ ] Yes [ ] No

   IF YES, how many years has the wildlife management plan been in place? _______________ years

2. Do you have a safe harbor agreement for your property? [ ] Yes [ ] No [ ] In Progress

3. Do you have a succession plan to maintain your land in ranching/agriculture when the ownership of your property is transferred? [ ] Yes [ ] No [ ] In Progress

4. In the following table, please circle the number that best indicates the extent to which you agree or disagree with each statement regarding _how it describes you as a landowner_.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
I want to live near natural beauty	1	2	3	4	5
I want to escape from city crime and pollution	1	2	3	4	5
I want to benefit from land appreciation over time	1	2	3	4	5
I want to live in a small community	1	2	3	4	5
I want to live a simpler lifestyle	1	2	3	4	5
I want to help protect the environment	1	2	3	4	5
I want to preserve open space or natural resources	1	2	3	4	5
I want to have a good place to raise my children	1	2	3	4	5
I want to continue a family tradition or business	1	2	3	4	5
I want to be able to grow/raise my own food	1	2	3	4	5
I want to add to my existing land holdings	1	2	3	4	5
I want to use my land to provide a source of income	1	2	3	4	5
I want to live closer to friends or family	1	2	3	4	5
I want to connect with a higher power	1	2	3	4	5
I want to help the local economy	1	2	3	4	5
I want to protect non-game wildlife	1	2	3	4	5
I want to hunt wildlife	1	2	3	4	5
I want to protect biological diversity	1	2	3	4	5
I want to live independently	1	2	3	4	5

5. In the following table, please circle the number that best indicates the extent to which you agree or disagree with each statement about the *Texas Parks and Wildlife Department (TPWD)*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
I feel TPWD staff members understand my issues about land management	1	2	3	4	5
I feel TPWD staff members provide me with choices and options regarding my land management	1	2	3	4	5
TPWD staff members convey confidence in my ability to manage my property well	1	2	3	4	5
Because of TPWD staff member, I have a sense of accomplishment regarding my land management	1	2	3	4	5

6. In the following table, please circle the number that best indicates the extent to which you agree or disagree with each statement about *factors that may influence the way you chose to manage your property for wildlife*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
Because people insist that I manage in the way that I do	1	2	3	4	5
It is a way that I have chosen to contribute to the environment	1	2	3	4	5
I find pleasure in improving the quality of the environment	1	2	3	4	5
Managing the land the way I do, is the sensible thing to do	1	2	3	4	5
The way I manage my land has become a fundamental part of who I am	1	2	3	4	5
Other people will be upset if I don't do anything to benefit wildlife	1	2	3	4	5
I would feel guilty if I didn't manage for wildlife	1	2	3	4	5
It is part of the way I have chosen to live my life	1	2	3	4	5
I don't know, I have the impression that I am wasting time	1	2	3	4	5
I don't know, I can't see how my efforts are helping the environment	1	2	3	4	5
I would feel bad if I didn't do anything for the environment	1	2	3	4	5
I find pleasure in mastering new ways to help the environment	1	2	3	4	5

7. In the following table, please circle the number that best indicates the extent to which you agree or disagree with each statement regarding your *sentiments as a landowner*.

1 =Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
It is important to me that I am a rancher/farmer/landowner	1	2	3	4	5
It is important to me that people in the area view me as a rancher/farmer/landowner	1	2	3	4	5
It is important to me that my friends and family view me as a rancher/farmer/landowner	1	2	3	4	5

8. In the following table, please circle the number that best indicates the extent to which you agree or disagree with each statement regarding *your land management*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
My land management decisions truly reflect who I am	1	2	3	4	5
I feel that I am free to chose the decisions I make about the way I manage my land	1	2	3	4	5
I feel confident that I can manage my land well	1	2	3	4	5
I am able to achieve my land management goals	1	2	3	4	5
I feel the natural environment of the Gulf Coast does not limit or constrain my land management decisions	1	2	3	4	5
The natural environment of the Gulf Coast supports my efforts to manage my property well	1	2	3	4	5
The natural environment of the Gulf Coast allows me to manage my land how I would like to	1	2	3	4	5
The natural environment of the Gulf Coast supports my ability to manage my land effectively	1	2	3	4	5

9. In the following table, please circle the number that best indicates the extent to which you agree or disagree *that each of the aspects of your land is important*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
Being able to hunt and/or fish (recreationally)	1	2	3	4	5
Being able to enjoy other non-hunting/fishing recreation	1	2	3	4	5
Operating a hunting enterprise	1	2	3	4	5
Selling game leases	1	2	3	4	5
Managing large wildlife (primarily deer)	1	2	3	4	5
Managing game birds (primarily quail, dove, turkey)	1	2	3	4	5
Managing for non-game wildlife (songbirds, etc.)	1	2	3	4	5
Producing grazing livestock (primarily cattle and/or sheep)	1	2	3	4	5
Producing browsing livestock (primarily goats)	1	2	3	4	5
Producing crops/hay/forage	1	2	3	4	5
Obtaining income from minerals (mainly oil and/or gas)	1	2	3	4	5
Earning a profit	1	2	3	4	5

SECTION B. WILDLIFE AND MANAGEMENT ACTIVITIES

In Section B, we seek information to help us understand the wildlife and management activities of landowners in the Gulf Coast Prairie. The information you provide will be aggregated and not used in any way that you can be identified.

10. Please check each management activity to indicate whether you have not done, done within the past 5 years, currently do and that you will do in the next 5 years on your property***. In each row, mark all that apply.***

Management Practice	**Not Done**	**Done in past 5 years**	**Done Currently**	**Will do in next 5 years**
Use rotational grazing	☐	☐	☐	☐
Improve rangeland condition	☐	☐	☐	☐
Apply prescribed fire	☐	☐	☐	☐
Chemically manage brush	☐	☐	☐	☐
Mechanically manage brush	☐	☐	☐	☐
Manage for native plant species	☐	☐	☐	☐
Restore/reintroduce wildlife populations	☐	☐	☐	☐
Protect habitat for species of concern	☐	☐	☐	☐
Control invasive plant species	☐	☐	☐	☐
Control predators (coyote, etc.)	☐	☐	☐	☐
Control feral hogs	☐	☐	☐	☐
Control problem birds (cowbird, starling, etc.)	☐	☐	☐	☐
Control fire ants	☐	☐	☐	☐
Provide supplemental water (develop springs, artificial water, etc.)	☐	☐	☐	☐
Manage tame pasture, old field, hay meadow and croplands to benefit wildlife	☐	☐	☐	☐
Install or develop nesting habitat (bat boxes, nest boxes, natural cavities, snags)	☐	☐	☐	☐
Establish desirable woody plants and shrubs for wildlife habitat	☐	☐	☐	☐
Create brush piles, retain slash, or half cut trees/shrubs for wildlife habitat	☐	☐	☐	☐
Conduct wildlife counts (spotlight, daylight or aerial)	☐	☐	☐	☐
Census or monitor non-game, endangered or protected wildlife species	☐	☐	☐	☐
Install high fences on your property	☐	☐	☐	☐

C. LAND MANAGEMENT COORDINATION AND CONSULTATION ACTIVITIES

In section C, we seek information about land management coordination and consultation activities. Some land management activities can be most ecologically beneficial when they are coordinated across property boundaries. We will use this information to help understand factors that influence landowners in the Gulf Coast Prairie to cooperate with each other.

11. Which of the following best describes the way management decisions are made on your land? ***Please check the option that most accurately applies***:
    [ ] You are primarily responsible for management decisions
    [ ] You employ a professional to manage operations
    [ ] Management decisions are made collectively with family members or business associates
    [ ] There is another management arrangement (please specify) _________________________

12. In the following table, please circle the number that best indicates how often you *currently engage in consultations or coordination activities*.

1 = Never or almost never	2 = About once a year	3 = A few times a year	4 = About once a month	5 = More than once a month
Consult with/seek advice of neighbors about your ranch/farm operation	1	2	3	4	5
Coordinate prescribed burns with neighbors	1	2	3	4	5
Coordinate wildlife habitat management with neighbors	1	2	3	4	5
Coordinate wildlife harvest and management activities with neighbors	1	2	3	4	5
Coordinate wildlife habitat management with other people in the area	1	2	3	4	5
Coordinate wildlife habitat management with agencies or organizations	1	2	3	4	5

13. In the following table, please circle the number that best indicates the extent to which you agree or disagree with the statements regarding *future engagement in consultations or coordination activities*.

1 =Strongly Disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Strongly Agree
In the next 5 years, the frequency of activities I coordinate with my neighbors will increase	1	2	3	4	5
In the next 5 years, the frequency of activities I coordinate with other people in the area will increase	1	2	3	4	5
In the next 5 years, the frequency of activities I coordinate with agencies or organizations will increase	1	2	3	4	5
In the next 5 years, the number of ways I coordinate activities with my neighbors will increase	1	2	3	4	5
In the next 5 years, the number of ways I coordinate activities with other people in the area will increase	1	2	3	4	5
In the next 5 years, the number of ways I coordinate activities with agencies or organizations will increase	1	2	3	4	5

14. In the table below, please circle the number that best indicates how likely or unlikely you are to *cooperate with neighboring landowners in the future given each outcome*.

1 = Very Unlikely 2 = Unlikely 3 = Neutral 4 = Likely 5 = Very Likely					
Increase amount of training & education for land management	1	2	3	4	5
Reduce liability associated with management activities (e.g., fire)	1	2	3	4	5
Increase amount of public funds available for land management	1	2	3	4	5
Increase contiguous acreage of land managed for prairie biodiversity	1	2	3	4	5
Reduce the cost associated with land management	1	2	3	4	5
Increase amount of technical assistance for land management	1	2	3	4	5
Increase effectiveness of public money spent on prairie conservation	1	2	3	4	5
Increase input landowners have with management agencies	1	2	3	4	5
Increase power of landowners in negotiations with oil & gas industry	1	2	3	4	5
Increase ecological integrity of the Gulf Coast Prairie	1	2	3	4	5

D. INFORMATION SOURCES AND SOCIAL INTERACTIONS

In section D, we seek information about landowners' social interactions and information sources. We will use this information to help understand how landowners are learning about land management and to help improve communication among groups in the Gulf Coast Prairie.

15. About how many organizations or groups are you an active member of (e.g., service, recreation, community governance, ranch/farm, landowner/wildlife, etc.)? ________________#

16. During the past 5 years, have you held a leadership position (president, treasurer, etc.) in any of these groups or organizations? [ ] Yes [ ] No

IF YES: please write which type of organization(s): ____

____

17. In the table below, please circle the number of the category that best indicates how often you *attend meetings or functions of each of the following organizations or groups*.

1 = Never or almost never 2 = About once a year 3 = A few times a year 4 = About once a month 5 = More than once a month					
Community government (boards, commissions, etc.)	1	2	3	4	5
Ranch/farm organizations (Cattleman's Assn., Farm Bureau, 4-H, etc.)	1	2	3	4	5
Prescribed Burn Association	1	2	3	4	5
Outdoor Association (Ducks Unlimited, Texas Wildlife Assn., etc.)	1	2	3	4	5
Conservation Group (Audubon, Coastal Prairie Partnership, etc.)	1	2	3	4	5

18. In the table below, please circle the number that best indicates how important each *information source is for you in guiding your land management decisions*.

1 = Very Unimportant 2 = Unimportant 3 = Neutral 4 = Important 5 = Very Important					
Education programs	1	2	3	4	5
Field days	1	2	3	4	5
One-on-one, onsite technical assistance	1	2	3	4	5
Organization meetings	1	2	3	4	5
Multi-day course	1	2	3	4	5
University course	1	2	3	4	5
Print media (newspapers, periodicals)	1	2	3	4	5
Electronic media (television, radio)	1	2	3	4	5
Social media (Facebook, Blogs)	1	2	3	4	5
Internet sources (websites)	1	2	3	4	5
Conversations with other landowners	1	2	3	4	5
Observation of what others are doing	1	2	3	4	5

19. In the table below, please circle the number of the category that best indicates how much you agree or disagree that each of the statements *describes you*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
I often place more importance on my relationships with others than my own accomplishments	1	2	3	4	5
When faced with a difficult problem, it is better to decide what to do yourself rather than follow the advice of others	1	2	3	4	5
The social groups I belong to are important to my sense of what kind of a person I am	1	2	3	4	5
In general, if the people around me are happy, I am happy	1	2	3	4	5
I enjoy being unique and different from others in many ways	1	2	3	4	5
It is important to respect decisions made by groups to which I belong	1	2	3	4	5
Belonging to social groups is important to how I see myself	1	2	3	4	5
What happens to me is my own doing	1	2	3	4	5
I feel good when I cooperate with others	1	2	3	4	5
I usually sacrifice my self-interest for the benefit of the group I am in	1	2	3	4	5
I am a unique individual	1	2	3	4	5

20. In each table, please circle the number that best indicates the extent to which you agree or disagree with each of the following statements about *relationships with other people*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
I very much feel a part of, or have concern for:					
My Neighbors	1	2	3	4	5
Other members of my community	1	2	3	4	5
Members of the local Wildlife Management Association	1	2	3	4	5
People in the Gulf Coast Prairie	1	2	3	4	5
Texans in general	1	2	3	4	5
When they are in need, I very much want to help:					
My Neighbors	1	2	3	4	5
Other members of my community	1	2	3	4	5
Members of the local Wildlife Management Association	1	2	3	4	5
People in the Gulf Coast Prairie	1	2	3	4	5
Texans in general	1	2	3	4	5
I very much want to be a responsible citizen among:					
My Neighbors	1	2	3	4	5
Other members of my community	1	2	3	4	5
Members of the local Wildlife Management Association	1	2	3	4	5
People in the Gulf Coast Prairie	1	2	3	4	5
Texans in general	1	2	3	4	5
I have a high amount of trust in:					
My Neighbors	1	2	3	4	5
Other members of my community	1	2	3	4	5
Members of the local Wildlife Management Association	1	2	3	4	5
People in the Gulf Coast Prairie	1	2	3	4	5
Texans in general	1	2	3	4	5

21. During the past six months, approximately how many people did you interact with more than once in regards to land management? _______________#

22. Now, please think of those people who you interact with frequently regarding land management. In each row, please check the *type of person who is the most important, second most important, etc*. **For each row check only one box**.

	Landowner	**Land Manager**	**Relative**	**Friend**	**Neighbor**	**Association Member**	**Agency staff**	**Organization Staff**	**Industry member**	**Other**
Most important Individual	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2nd Most important Individual	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3rd Most important Individual	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4th Most important Individual	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5th Most important Individual	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

SECTION E. WILDLIFE MANAGEMENT ASSOCIATION (WMA)

In section E, we seek information about landowner involvement in wildlife management associations. WMAs have the potential to affect the management of the Gulf Coast Prairie. We will use this information to help understand the characteristics and behavior of WMA members.

23. Are you a member of a landowner association? [ ] Yes [ ] No
    IF YES, continue to the next question; **IF NO,** please skip to the next page

24. What is the name of your wildlife management association (WMA)? ________________________

25. In what year did you join your WMA? ________________________

26. About how many meetings of your WMA do you attend annually? ________________________

27. Within the last 5 years, have you held a leadership position in the WMA? [ ] Yes [ ] No

28. How has your involvement with other (non-WMA) groups changed since joining the WMA?
    [ ] Increased [ ] Decreased [ ] Stayed about the same

29. If you were given a sign indicating your membership in the WMA would you post it?
    [ ] Yes [ ] No [ ] Already have one posted

30. How many members have you recruited to join the WMA? ____________ members

31. Approximately how many of your family members are WMA members? ____________ members

32. Have you met new friends through your involvement with the WMA? [ ] Yes [ ] No
    IF YES, approximately what percentage of your friends are members? _____________ %

33. What percentage of properties that border your land are WMA members? _____________ %

34. In the table below, please circle the number that best indicates the extent to which you agree or disagree with each statement about *the wildlife management association (WMA)*.

1 =Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
I feel that my WMA provides me with choices and options regarding my land management	1	2	3	4	5
It is important that people in the area view me as a WMA member	1	2	3	4	5
It is important to me that I am a WMA member	1	2	3	4	5
My WMA allows me to manage my property well	1	2	3	4	5
My WMA allows me to do things how I would like to do them	1	2	3	4	5
My WMA helps me to manage effectively for wildlife	1	2	3	4	5
In the next 5 years, I will continue to be a WMA member	1	2	3	4	5

SECTION F. OIL GAS AND ENERGY PRODUCTION AND INFRASTRUCTURE

In section F, we seek information about oil and energy production and infrastructure and the view of landowners. Oil and gas development can affect ranching and farming operations in many ways. Numerous actions and management practices have been proposed by the industry and management agencies to limit these effects. We will use this information to help understand the use of and needs for these practices. The information you provide will be aggregated and not used in any way that you can be identified.

35. Please answer each of the following questions about oil and gas energy related aspects pertaining to you land. ***In each row below, please check the one box that best corresponds to your experience with oil and gas development.***

	Yes	No	Don't Know	N/A
Do any family members or close friends work for an energy company or contractor?	☐	☐	☐	☐
Do you own the mineral rights for your land?	☐	☐	☐	☐
Do you own mineral estates without surface rights for any properties?	☐	☐	☐	☐
Do you have an actively producing oil and/or gas well on your land?	☐	☐	☐	☐
Do you have an inactive oil and/or gas well on your property?	☐	☐	☐	☐
Do you have a pipeline or transmission line easement on your property?	☐	☐	☐	☐
Do you earn income from oil and/or gas production?	☐	☐	☐	☐
Has income from oil and/or gas increased the amount of money you spend on wildlife habitat management?	☐	☐	☐	☐
Has income from oil and/or gas decreased your reliance on farm or ranch-based income?	☐	☐	☐	☐
Have you lost laborers due to competition from jobs in the oil and gas industry?	☐	☐	☐	☐
Are you familiar with the Environmentally Friendly Drilling initiative?	☐	☐	☐	☐
Have environmentally friendly drilling practices been used on your land?	☐	☐	☐	☐
Are you interested in learning more about environmentally friendly drilling?	☐	☐	☐	☐

36. How many years have you had oil & gas wells on your property? ___________ years [ ] N/A

37. How many years have you had pipeline/transmission easements on your property?

___________ years [ ] N/A

38. In the following table, please indicate: (Column 1) *If you currently have oil/gas developments* on your land, check each action/practice that has been applied on your land; (Column 2) *If you do not have oil and gas developments*, please check each action/practice you might apply if oil and gas developments were to occur on your land; and (Column 3) Please circle the number that best indicates how important you think each action/practice is for addressing your concerns about effects of oil and gas development on your land.

1 = Very Unimportant 2 = Unimportant 3 = Neutral 4 = Important 5 = Very Important	**Column 1 Already applied**	**Column 2 Would apply**	**Column 3 See measures on left**				
Program/fund developed to respond to unintended *social impacts* from extraction activities	□	□	1	2	3	4	5
Program/fund developed to respond to unintended *environmental impacts* from extraction activities	□	□	1	2	3	4	5
Voluntary offsite mitigation is conducted for *lands impacted by extraction activities*	□	□	1	2	3	4	5
Operations conducted with specified reclamation goals and actions (short-, medium, long-term-)	□	□	1	2	3	4	5
At completion, infrastructure is removed, wells are plugged, pads reclaimed and sites re-contoured	□	□	1	2	3	4	5
Baseline and follow-up surveys are conducted to assess ecological impacts and reclamation efforts	□	□	1	2	3	4	5
Reintroduction of species and reestablishment of habitat after disturbance	□	□	1	2	3	4	5
Livestock grazing is deferred to permit plant reestablishment	□	□	1	2	3	4	5
Reseeding done with locally-adapted, native species and appropriate planting techniques	□	□	1	2	3	4	5
Infrastructure's footprints (roads, pads) minimized and only single lane roads used	□	□	1	2	3	4	5
Steps are taken to control introduction of exotic species	□	□	1	2	3	4	5
Exotic species are monitored and controlled in disturbed areas	□	□	1	2	3	4	5
A formal surface use agreement (with compliance reporting) is negotiated between myself and industry	□	□	1	2	3	4	5
A dispute resolution plan between myself and industry is agreed upon	□	□	1	2	3	4	5
Collective bargaining to help landowners receive fair compensation for royalties, damages and losses	□	□	1	2	3	4	5
An environmental monitoring plan is created that allows adaptation in response to changing conditions	□	□	1	2	3	4	5
Controls are implemented to limit production activities' disturbance (noise and light) on wildlife	□	□	1	2	3	4	5
Traffic is minimized and controlled during sensitive times for wildlife	□	□	1	2	3	4	5
Air pollution controls are implemented	□	□	1	2	3	4	5
Local first responders are trained for specific emergency scenarios	□	□	1	2	3	4	5
Disturbance to my agricultural operations is considered and minimized	□	□	1	2	3	4	5
Infrastructure sited to reduce its visual impact	□	□	1	2	3	4	5
Infrastructure sited to protect sensitive areas (streams, etc) and areas with a high wildlife value	□	□	1	2	3	4	5
Erosion control considered, natural contours and cover crops are used	□	□	1	2	3	4	5
Industry uses water conservation measures on my land to ensure I have water for agricultural use	□	□	1	2	3	4	5

39. In the table below, please circle the number that best indicates the extent to which you agree or disagree that each item below is cause for <u>*concern due to impacts from oil and gas development*</u>.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
My health and wellbeing	1	2	3	4	5
My rural lifestyle	1	2	3	4	5
My future farm/ranch operations	1	2	3	4	5
The health and wellbeing of other people in my community	1	2	3	4	5
The general health of the environment	1	2	3	4	5
The wellbeing of future generations	1	2	3	4	5
Stresses placed on local roads and infrastructure	1	2	3	4	5
Reduction in water available for agricultural uses	1	2	3	4	5
Loss of available labor for farm/ranch operations	1	2	3	4	5
Loss of prairies without roads or other development	1	2	3	4	5
Loss of biodiversity within the coastal prairies	1	2	3	4	5
Increase in the prevalence of invasive species	1	2	3	4	5
Decrease in rural property values	1	2	3	4	5
Damage to farm/ranch land from extraction activities (erosion, etc.)	1	2	3	4	5
Inadequate compensation for damages from extraction	1	2	3	4	5
Loss of landowner control over decisions on their land	1	2	3	4	5
Decrease in the benefits landowners receive from the ecosystem	1	2	3	4	5
Change in my community due to influx of outsiders	1	2	3	4	5
Conversion of lands to industrial/urban use	1	2	3	4	5
Lack of public input during development projects	1	2	3	4	5
Poor public knowledge of oil and gas development plans	1	2	3	4	5
Lack of coordinated regional planning to address ecological impacts of development projects	1	2	3	4	5

SECTION G. VIEWS TOWARD THE ENVIRONMENT AND CONSERVATION

In section G, we are interested in learning about landowner perspectives about the environment. Landowner views and about the environment and conservation can help understand ways to improve the conservation of the Gulf Coast Prairie in ways that are most meaningful for landowners.

40. In the table below, please circle the number that best indicates the extent to which you agree or disagree with each of the following statements about *conservation of the Gulf Coast Prairie.*

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
The Gulf Coast Prairie is a valuable resource that is unique and irreplaceable	1	2	3	4	5
The biodiversity of the Gulf Coast Prairie is worth saving	1	2	3	4	5
Gulf Coast Prairie landowners are not doing enough to conserve biodiversity	1	2	3	4	5

41. In the table below, please circle the number of the category that best corresponds to how much you agree or disagree with each of the statements about your *relationship with the natural environment*.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
I often have the feeling that being connected to nature is more important than my own endeavors	1	2	3	4	5
When faced with a difficult management problem, it is better to decide what to do yourself rather than "look to nature" for lessons or guidance	1	2	3	4	5
People should be aware that if they are going to be part of a nature, they sometimes will have to do things they don't want to	1	2	3	4	5
My happiness depends a lot on the quality of my natural environment	1	2	3	4	5
I enjoy being unique and separate from nature in many ways	1	2	3	4	5
It is important to me to respect natural processes	1	2	3	4	5
What happens to me is my own doing, not nature's	1	2	3	4	5
To me, pleasure is spending time in nature	1	2	3	4	5
I feel good when I "work with nature"	1	2	3	4	5
Being part of nature is important to my sense of the kind of person I am	1	2	3	4	5
I usually forgo my self-interest for the benefit of nature	1	2	3	4	5
I am different and unique from nature	1	2	3	4	5

42. Regardless of their motivations for doing so, people who engage in activities that benefit the environment can be called conservationists. Please indicate the extent to which you agree or disagree with the following statements.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree					
It is important that my friends and family view me as a conservationist	1	2	3	4	5
It is important to me that I am a conservationist	1	2	3	4	5
It is important that people in the area view me as a conservationist	1	2	3	4	5
Government, organizations and landowners can form productive partnerships for conservation	1	2	3	4	5
Conservation in the Gulf Coast Prairie could best be characterized as conservationists versus landowners.	1	2	3	4	5
Landowners can do a better job of conserving the Gulf Coast Prairie than anyone else	1	2	3	4	5
I have enacted or am willing to enact a *conservation easement* or retire the development rights for my land	1	2	3	4	5
I have engaged or am willing to engage in a cooperative conservation agreement (cost share, etc.) with a *government agency*	1	2	3	4	5
I have engaged or am willing to engage in a cooperative conservation agreement (cost share, etc.) with a *conservation organization*	1	2	3	4	5

Continued on next page ➔

SECTION H. ADDITIONAL INFORMATION

In this final section we ask for some information about you and you property in order to characterize different categories of landowners, managers and rural properties that are included in our study. We use codes not associated with individuals when we enter the data and none of this information will be published or used in any way that can identify individual landowners.

43. In what year were you born? 19__________

44. What is your gender? [ ] Male [ ] Female

45. Did you grow up in a farming or ranching household? [ ] Yes [ ] No

46. Does any member of your immediate family currently farm or ranch? [ ] Yes [ ] No

47. How long have you or your family owned the land?
(If multiple tracts are owned, please provide the longest ownership) _______________ years

48. How did you acquire your land? [ ] inheritance; [ ] purchase; [ ] trade; [ ] other ____________

49. Of the land that you manage, approximately how many acres:
Do you own? _______________ acres
Do you lease? _______________ acres
Have a wildlife (1-d-1) tax appraisal? _______________ acres

50. How many years of formal education do you have, including school, university and/or vocational training? _______________ years

51. In a typical week, how many hours do you spend at your land? _______________ hours

52. What is your primary occupation? (please check one)
[ ] Full time rancher/farmer
[ ] Full time employed off the ranch/farm
[ ] Part time employed off the ranch/farm
[ ] Self-employed (other than farming/ranching)
[ ] Unemployed
[ ] Retired

53. Approximately what percent of your average annual household income is derived from activities related to your agricultural property? _______________ %

Thank you for taking the time to participate in this important study. Please return the completed questionnaire and address card in the self-addressed return envelope. If there is anything you would like to add, please do so on the next page.