Ecosystem Transformation Across a Changing Social Landscape: Landowner Perceptions and Responses to Woody Plant Encroachment

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Academic Abstract

The conversion of grasslands to woodlands is an ecosystem transformation that threatens grassland biodiversity, the provision of important ecosystem services, and the sustainability of rural livelihoods. A global phenomenon, woody plant encroachment (WPE) has been particularly problematic in the Southern Great Plains of the United States where the actions of private landowners are integral to sustaining grasslands. Increased diversity in landowners' motivations for owning land have shifted the social landscape of rural areas necessitating a better understanding of landowners' perspectives about WPE and their subsequent management actions. Towards this purpose, I employed a mail survey to private landowners in the Edwards Plateau of Texas, Central Great Plains of Oklahoma, and Flint Hills of Kansas to investigate landowner perceptions and management responses to WPE. First, I assessed landowners' acceptance of WPE as a function of how they relate to their land (i.e., sense of place), their beliefs about the positive and negative consequences of woody plants, and their perceived threat of grassland conversion. Then, I examined the drivers of landowners' goal intentions to manage woody plants and their current use of five adaptive management practices that prevent WPE. My results demonstrate that landowners vary in their sensitivity to WPE based on how they feel connected to their land. This was true even though most landowners had low acceptance thresholds for WPE, believed it led to numerous negative outcomes, and perceived it as increasingly threatening at greater levels of encroachment.

Most landowners wanted to control or remove woody plants and were actively engaged in management practices to do so. These findings address uncertainties about landowners' acceptance of WPE and grassland conservation actions and provide broad implications for how people perceive and respond to ecosystem transformation.

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General Audience Abstract

Around the world, grasslands are converting to tree and shrub woodlands at an unprecedented rate. This transformation profoundly reduces habitat available for grassland plants and animals and diminishes many ecosystem services that people and rural communities rely on. This loss of grasslands has been especially far-reaching throughout the Southern Great Plains of the United States. Because most of this region is privately owned, the management actions of landowners play a crucial role in preventing or allowing this conversion to continue. Recent shifts in land ownership motivations expanding beyond traditional agricultural production have created increased uncertainty about how private landowners view and react to this change. To investigate how landowners perceive and respond to this woody plant encroachment (WPE) phenomenon, I conducted a mail survey of landowners in the Edwards Plateau of Texas, the Central Great Plains of Oklahoma, and the Flint Hills of Kansas. Using sense of place, landowners' beliefs about the potential positive and negative consequences of woody plants, and their perceptions of how threatening grassland conversion is, I assessed the thresholds at which landowners' do or do not accept WPE. Then, I examined how acceptance of WPE relates to landowners' management goals and current use of management practices to control or reduce woody plants. I found that most landowners believed that woody plants had many negative consequences and perceived increasing levels of threat at greater levels of encroachment. This related to low levels of acceptance

for woody plants in grasslands. However, landowners' threat perceptions and acceptance of WPE varied based on their sense of place. Finally, most landowners wanted to control or remove woody plants and were actively engaged in management practices to do so. My results provide critical information regarding how current landowners' view and respond to grassland conversion and offer broad implications for how people perceive and respond to large-scale environmental change.

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Thesis Introduction

Grasslands are one of the most imperiled ecosystems in North America and worldwide (Archer et al., 2017; Leis et al., 2017). Among numerous pressures, one of the greatest threats to grasslands is the expansion of trees and shrubs and the subsequent transformation of grass-dominated landscapes to those dominated by woody species (Wilcox et al., 2018). This phenomenon, known as woody plant encroachment (WPE), has complex causes and far-reaching social and ecological consequences. WPE not only alters ecosystem composition and function to the detriment of grassland dependent plant and animal species, but also changes the type and delivery of ecosystem services that support many human livelihoods, cultures, and local economies (Wilcox et al., 2018).

Although this is a global phenomenon, WPE has been particularly extensive in the Southern Great Plains of the United States (Texas, Oklahoma, and Kansas). While previous research has examined the ecological and social aspects of encroachment separately, my research is part of a multi-disciplinary project approaching WPE as a social-ecological system (Figure 1). The dynamics of WPE are best understood as a social-ecological system because people facilitate WPE and environmental changes in grasslands and in turn, experience and are influenced by the effects of a changing environment (Collins et al., 2011). Within this lens, ecosystem services influence the human outcomes and behaviors that drive human-caused disturbances to the biophysical components of the system. Cumulatively, individual land management practices create disturbance patterns that can alter ecosystem structure, function, and the feedback of services leading to a range of possible human and environmental outcomes.

The purpose of my thesis is to investigate the social aspects of woody plant encroachment as part of a larger research team blending social sciences, biophysical sciences such as ecology and ecohydrology, remote sensing, and systems dynamics to study the entire social-ecological system. Specifically, my research explores private landowners' threat perceptions and acceptability of WPE as a foundation to understand their management actions in response to grassland conversion. Although there are many woody species expanding into grasslands, I focus on three *Juniperus* species prominent in WPE throughout the region; eastern red cedar (*Juniperus virginiana*), Ashe juniper (*Juniperus ashei*), and redberry juniper ((*Juniperus pinchotii*). A thorough understanding of how and why people respond to WPE as part of the overall social-ecological system can enhance the efforts of local landowner collaboratives, practitioners, and policy makers in implementing land management practices and conservation strategies that promote both human and environmental well-being.

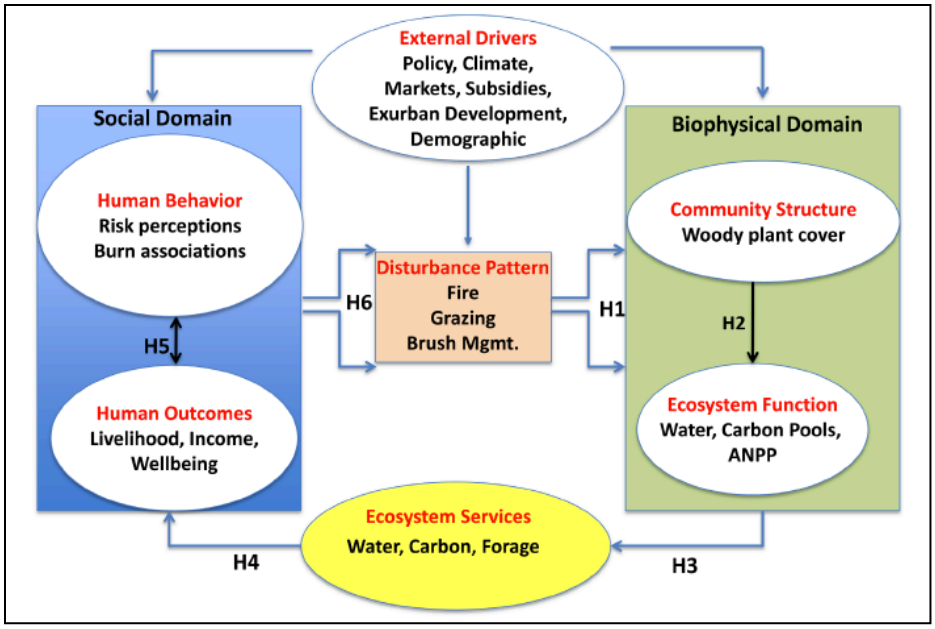

Figure 1. Woody plant encroachment as a social-ecological system where the social and biophysical domains are linked through human-driven disturbances (land management) and the provision of ecosystem services (Wilcox et al., 2018).

Understanding WPE as a Social-Ecological System

Grasslands are ecosystems common in semiarid and subhumid drylands, in which grasses and grass-like plants (graminoids), forbs, and shrubs form a relatively continuous layer of herbaceous vegetation that accounts for the majority of plant diversity in the system (Safriel & Adeel, 2005; Veldman et al., 2015). While people have both created and accelerated the expansion of secondary grasslands, many grasslands are considered "old growth" ecosystems with high biodiversity and unique species assemblages formed over hundreds of years (Veldman et al., 2015; Wilcox et al., 2018). Although grassy biomes can support low levels of tree densities ranging from grasslands without trees to savannas and open-canopy woodlands, the growth of woody plant species in grasslands is limited by low water availability, constrained by soil properties, and further inhibited by frequent disturbances from fire and herbivory (Archer et al., 2017; Safriel & Adeel, 2005; Veldman et al., 2015). Within the last 200 years, however, human-driven changes to the evolutionary processes that maintained grasslands (e.g., fire regimes, grazing patterns) have enabled the proliferation of trees and shrubs in grasslands resulting in large-scale conversions of grasslands to shrub-dominated woodlands (Eldridge et al., 2011; Naito & Cairns, 2011). Woody plant encroachment occurs as native woody species increase in abundance within their historic ranges or expand their geographic range and as non-native species establish and become dominant (Archer et al., 2011; Archer et al., 2017).

The transformation of grasslands to woodlands through WPE does not simply substitute one thriving ecosystem for another. Many woodlands resulting from WPE are monocultures with minimal understory and greatly reduced biodiversity (Archer et al., 2017). In some regions, the conversion of grassland to shrubland represents a from desertification characterized by accelerated rates of wind and water erosion and reduced primary productivity (Archer et al.,

2011). As much of the world's grasslands are rangelands managed as natural systems to support livestock grazing and pastoralism, the expansion of trees and shrubs at the expense of perennial grasses is of great concern to rangeland managers and people whose livelihoods are based on livestock production (Archer et al., 2017; Safriel & Adeel, 2005). Further, WPE is a major conservation issue as the phenomenon has been associated with dramatic declines in plant and animal biodiversity (Archer et al., 2011, Twidwell et al., 2013). Reduced or altered grassland habitat threatens many grassland-obligate species, particularly native grassland birds (Engle, Coppedge, & Fuhlendorf, 2008; Leis et al., 2017). The loss of grasslands to shrub encroachment is a threat on par with exurban development and agricultural conversion (Archer et al., 2011).

In the United States, the most dramatic woody plant encroachment into grasslands has been within the Southern Great Plains (Kansas, Oklahoma, and Texas). The short, mixed, and tallgrass ecosystems of this region formed 10,000- 15,000 years ago and prior to European settlement, existed as grasslands and open savannahs devoid of dense stands of trees or shrubs except along riparian corridors and in rocky outcroppings isolated from fire (Engle et al., 2008). Major Euro-American settlement in the 1800's reduced and degraded much of the region's grasslands through cultivation for agriculture, fire suppression, and overgrazing (Leis et al., 2017; Wilcox et al., 2018). These factors, within a larger context of landscape fragmentation, dissemination of seeds by wildlife and livestock, the elimination of native browsers, and increased atmospheric CO_2, have driven the expansion of woody plant species within the region (Archer et al., 1995; Archer et al., 2017; Briggs et al., 2005; Pyne, 2001). Within the Southern Great Plains, the social and environmental consequences of WPE are considered an ecological disaster second only to the Dust Bowl (Engle et al., 2008; Leis et al. 2018).

In the Southern Great Plains, the importance of people's perceptions of and responses to WPE is amplified as the vast majority of this region is privately owned and managed and private landowners can thus steer the trajectory of grassland transformation (Assal et al., 2015). The social landscape of the Southern Great Plains is influenced by external drivers such as exurban migration, development, and demographic change leaving many unknowns regarding the human role in this system. Landowners in rural rangelands of the region have shifted from a predominantly agricultural-orientation to encompass broader land use preferences and subsequent land management practices (Brown et al., 2005; Sorice et al., 2014). These diverse, or heterogeneous, landowners may have varied land management goals and priorities in regards to grasslands and woody plant management. Consequently, understanding the implications of land ownership change in terms of landowners' landscape preferences, acceptance of woody species in grasslands, and use of management practices that prevent WPE are critical research priorities essential to sustaining grasslands (Leis et al., 2017; Wilcox et al., 2018).

Research Summary

People are not equally susceptible to harms or potential benefits of changing environmental conditions, thus private landowners' management responses to WPE depend largely on how they experience, perceive, and accept grassland transformation. In Chapter 1, I explored landowners' thresholds of acceptability for woody plant species in grasslands based on how they relate to their land (i.e., their sense of place) and their beliefs about the consequences of WPE. Human relationships with nature produce unique values and ecosystem service benefits that can be imperative to individual and collective well-being (Chan et al., 2016). While many types of human-environment relationships have been identified, I conceptualized landowners'

relationships with their land through sense of place (e.g., Trentelman, 2009; Masterson et al., 2017) and resource dependency (e.g., Marshall, 2011) to capture to the unique ties between people, places, and livelihoods within a rural working landscape. Thresholds of acceptability may serve as critical tipping points that drive adaptive, place-protective behavior (Devine-Wright & Howes, 2010; Zajak, Wilson, & Prange, 2012). Therefore, the drivers of landowners' differential thresholds for WPE provide the underlying context for their management goals and behaviors that either sustain grasslands or enable further conversion.

To fully understand the human role in the woody plant encroachment system, it is crucial to examine how landowners' thresholds for woody plants actually relate to the implementation of specific management actions. Thus, in Chapter 2 I examined the role of social-psychological factors in landowners' use of management practices to remove or reduce woody plants. These practices include prescribed fire, mechanical removal, prescribed browsing by goats, and the application of chemical herbicides (Archer et al., 2011). Using a goal-directed behavioral framework (Bamberg, 2013), I assessed how thresholds and the activation of personal norms (Schwartz, 1977) serve as drivers of landowners' management goals for woody plants. Then, I explored how these goal intentions and landowners' goal-frames (Lindenberg & Steg, 2007) translate into the use of behaviors that sustain grasslands and prevent WPE.

The two chapters of thesis investigated how and why people respond to ecological transformation. Given the shifting social landscape of the Southern Great Plains, understanding the drivers of landowners' thresholds for WPE and how these thresholds manifest into goal intentions and specific management behaviors provides much needed insight into the dynamics of private lands conservation and grassland management in the Southern Great Plains. Beyond the direct importance for rangeland managers and practitioners facilitating woody plant

management and grassland restoration among private landowners, this research has broad implications for understanding the social-psychological processes that underlie how people perceive and respond to ecosystem transformation.

Definitions

Throughout this thesis, I used the term "cedar" in reference to the three *Juniperus* woody plant species under study; *Juniperus virginiana (*eastern redcedar), *Juniperus ashei* (Ashe juniper), and *Juniperus pinchotii* (redberry juniper). These species have a number of common names throughout the study region and are referred to alternatively as cedar or juniper within the region and in ecological literate. Additionally, I used the term "place" in reference to all of the rural land that respondents owned within the study area. While a number of terms like "ranch", "farm", or "homeplace" are used by landowners to describe the land they own, "place" is a regional colloquialism that is commonly understood across the three study regions (e.g., Sorice et al., 2012).

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Chapter 1. Expanding the Vulnerability Concept Through Sense of Place to Understand Individual Thresholds for Ecological Transformation

Abstract

Responses to ecosystem transformation depend largely on how people experience, perceive, and accept changing conditions. Combining sense of place and beliefs about consequences of change to understand vulnerability, we explored private landowners' thresholds of acceptability for woody plant encroachment (WPE) in the Southern Great Plains as a first step in understanding how people and social systems adapt. Based on mail survey responses from 877 private landowners in Texas, Oklahoma, and Kansas, I examined landowners' acceptability of *Juniperus* spp. using a photo-analysis approach. Sense of place, measured through place meanings, represents the symbolic connections landowners have with their land. I used K-means cluster analysis to group landowners based on their sense of place and employed a series of mixed regression models to explore the pathways by which sense of place, beliefs about consequences, and perceptions of threat relate to landowner thresholds of acceptability for woody plants. Most landowners believed that woody plants led to negative outcomes and had low thresholds of acceptability for it; however, sensitivity varied across six landowner groups. Group membership was directly related to threshold of acceptability, whereby landowners who emphasized production-oriented and heritage meanings expressed greater sensitivity to WPE. Sense of place was also indirectly related to thresholds via beliefs about consequences and perceived threat. Beliefs about beneficial outcomes (e.g., wildlife habitat) were associated with lower sensitivity to WPE while high threat perceptions were associated with higher sensitivity.

Acceptability thresholds can identify critical tipping points that drive adaptive, place-protective behavior, which is important to understand the trajectory of ecological transformations. The drivers of landowners' perceptions of and thresholds for WPE provide the underlying context for management actions that either sustain grasslands or enable further encroachment.

Introduction

People are often "at the core of both the problems and solutions" to many environmental issues (Corlett, 2015, p. 39). The dynamic nature of social-ecological systems is evident across biomes and cultures worldwide, where people contribute to and must contend with ecosystem transformations such as the eutrophication of freshwater lakes and marine areas (Smith, 2003), coral-algal phase shifts within coral reefs (Nystrom, Folke, & Moberg, 2000), major disturbance events leading to unprecedented tree mortality in temperate forests (Miller & Stephenson, 2015), and woody plant encroachment into grasslands and savannas (Archer et al., 2017; Eldridge et al., 2011). In each of these systems, people evaluate and respond to transformation based on how compatible each system state is with human needs, values, and sense of place (Carpenter et al., 2001; Marshall et al., 2014; Masterson et al., 2017).

One global phenomenon transforming ecosystems on every inhabitable continent is woody plant encroachment (WPE) into grasslands and the subsequent conversion of grasslands to woodlands. This conversion is a nearly irreversible transformation within dryland ecosystems driven by complex social and ecological dynamics. Drylands account for 40% of the Earth's landmass and include desert, grassland, and woodland ecosystems (Stafford Smith et al., 2009). They are home to one-third of the world's population and have historically been biological and

cultural hotspots where human livelihoods and well-being are tightly linked with the biophysical environment. Today, 90% of global drylands are used as either rangeland for grazing or cropland for agriculture leading to a high degree of human dependence on these systems (Safriel & Adeel, 2005). However, human disruption of historic fire regimes through active fire suppression and overgrazing has driven WPE in grasslands worldwide (Briggs et al., 2005; Eldridge et al., 2011; Walker & Meyers, 2004). Additionally, WPE is enabled by other factors such as landscape fragmentation, wildlife and livestock dissemination of seeds, the elimination of native browsers, and increased atmospheric CO_2 that favors C_3 shrubs over C_4 grasses (Archer et al., 1995; Archer et al., 2017; Briggs et al., 2005).

Responses to WPE depend largely on how people experience and perceive this ecosystem change. As most human livelihoods in drylands have developed around the suite of ecosystem services from grasslands, this state is usually desired and valued as productive by people within the system, whereas shrub-encroached woodlands are typically considered a degraded and undesirable state of former grasslands (Eldridge et al., 2011). Woodlands resulting from WPE are often monocultures characterized by accelerated rates of wind and water erosion as well and reduced primary productivity; a form of desertification (Archer et al., 2011; Archer et al. 2017). The conversion from grasslands to woodlands reduces plant productivity and biological diversity, and alters biogeochemical cycles, land-atmosphere interactions, and global carbon balances (Naito & Cairns, 2011; Wilcox, Sorice, & Young, 2011). These changes occur to the detriment of grassland dependent plant and animal species and modify the type and delivery of ecosystem services that support many people's livelihoods, cultures, and local economies. People's likelihood to be negatively affected by the consequences of WPE (i.e., their vulnerability) likely influences their management responses to this change (Adger, 2006). While

some human actions may be considered maladaptive, propelling the expansion of woody plants in grassland systems, adaptive responses leading to the use of management practices such as frequent prescribed fire and other forms of brush management can decrease or prevent further encroachment and are considered essential for maintaining healthy grasslands (Twidwell et al., 2013).

The complex social and ecological dynamics of woody plant encroachment are readily apparent in the Southern Great Plains of the United States. Grassland transformation through WPE has different origins throughout the Southern Great Plains and has continued at different rates. Parts of Texas and Oklahoma have experienced the highest rates of woody plant encroachment in the United States while areas of Kansas contain some of the largest, most intact grasslands in the county (Archer, 2017; Briggs et al., 2005; Pyne, 2001; Walker & Meyers, 2004). The social context of woody plant encroachment in the Southern Great Plains has become increasingly variable as the motivations for owning land in this region have shifted from predominately agricultural production to include an increased value for natural and cultural amenities such as recreation, aesthetics, and the rural lifestyle (Gosnell & Abrams, 2011; Sorice et al., 2014). This shift occurs as amenity migrants move into rural areas, but also as the values of long-term production-oriented residents shift to encompass a greater importance for rural lifestyles (Huntsinger et al., 2010). Additionally, rural landowners increasingly have a range of livelihoods and occupations that may or may not be central to their lifestyle and sense of self (i.e., identity) (Sorice et al., 2012_a; Groth et al., 2016). They may have varying levels of dependence on their land to support their well-being (e.g., Marshall et al., 2014; 2016). Further, landowners' identities and dependence on their land may be based on a wide range of descriptive and symbolic beliefs, underscoring each person's sense of place and the ways that they relate to

their land (Davenport & Anderson 2005; Stedman, 2002; Wynveen et al., 2012). These differences among landowners likely result in different perceptions, experiences, and reactions to grassland conversion.

Given the expanding range of land ownership motivations and land use values across social landscape of the Southern Great Plains, further research into how human perceptions of this ecosystem transformation influence management responses to WPE is needed (Leis et al., 2017; Wilcox et al., 2018). Because people are the primary drivers of modern fire regimes (Wilcox et al., 2018) and over 90% of the Southern Great Plains is privately owned (Assal et al., 2015), the fate of remaining grasslands in this region rests on the management actions of private landowners. Towards this purpose, I investigated the factors that influence landowners' perceptions of WPE. Drawing from the social-ecological literature on vulnerability to environmental change and sense of place research regarding place-change (Adger, 1999; Adger, 2006; Devine-Wright, 2009; Masterson et al., 2017; Smit & Wandel, 2006), I explored landowners' sensitivity to this transformation through their individual thresholds of acceptability for woody plants. Such thresholds are potential tipping points that when surpassed, may compel adaptive action towards sustaining grassland ecosystems (Walker & Meyers, 2004). I examined how landowners' acceptance of woody plants varies as a function of their perceived threat of grassland conversion, their sense of place as a relationship with their land, and their beliefs about the consequences of woody plant expansion. Understanding people's ecosystem preferences and thresholds for action provides the foundation for understanding the implementation of land management actions that either facilitate or constrain grassland conversion.

Conceptual Framework

While much social-ecological systems research has focused on the ecological thresholds involved in ecosystem transformations, the thresholds that constrain or enable human action to cope with environmental change are critically important, yet often poorly understood. A threshold represents the tipping point in a system's trajectory between alternate regimes (Walker & Meyers, 2004). A system's social thresholds are inherently complex as the variation in human-nature relationships and consequent diversity for preferred ecosystem services leads to a spectrum of choices and behaviors that drive different ecological outcomes (Liu et al., 2007). Variation in people's acceptance or intolerance of changing ecological conditions can lead to shifts in the social system (i.e., different norms, rules, or regulations on the use of management practices) designed to prevent undesirable ecosystem changes (Walker & Meyers, 2004).

System thresholds and regime shifts are usually examined on larger scales, however, they exist at the individual level as well (Marshall & Stokes, 2014). An individual's threshold of acceptability marks the point at which something that was previously acceptable becomes unacceptable, prompting an individual to take action to regain acceptable conditions (Devine-Wright & Howes, 2010; Zajac et al., 2012). Whether or not an individual is accepting of an ecological change is based on their preferences and perceptions of the change (Zajac et al., 2012). Understanding these thresholds of acceptability is essential to explain the subsequent action or inaction of individuals.

People differ in how they sense and understand ecological changes because people are not equally informed, nor are they equally susceptible to the potential harms or benefits of changing environmental conditions. This differential vulnerability to environmental change

varies based on differences in people's exposure to an environmental stress or hazard, their sensitivity to the effects of this exposure, and their ability to adapt or cope with the overall change (Adger, 2006). While some environmental hazards are acute (e.g., air pollution in a crowded tunnel, extreme weather events), many are chronic stressors that effect individuals through frequent or long-term exposure (Gatersleben & Griffin, 2017). Chronic environmental stressors can have greater negative consequences for human well-being if people cannot escape or remove them (Steg, van den Berg, & De Groot, 2013). Characteristics such as settlement type and location, land uses, and livelihoods reflect the broader social, economic, cultural and environmental determinants of exposure and sensitivity that can lead to variations in vulnerability (Smit & Wandel, 2006).

Vulnerability is often studied at the community or regional scale; however, researchers have adapted exposure, sensitivity, and adaptive capacity constructs to understand individual level differences in vulnerability and response to change (e.g., Marshall et al., 2014; 2015; 2016). Marshall and colleagues' framework for the vulnerability of individuals focuses on resource dependency, which evaluates an individual's sensitivity to the effects of an environmental change based on how dependent, economically, socially and culturally, they are on the resource that is changing. Resource dependency is commonly used to understand the relationship that producers (e.g., farmers and ranchers) have with their land and how they may depend on a natural resource through distinct social, economic, environmental, and cognitive dimensions to maintain their overall well-being. As a resource-dependent livelihood becomes embedded in multiple aspects of a person's life, they have a greater degree of dependence on the natural resource, which leads to a greater susceptibly to be harmed if the resource is degraded or depleted by some environmental change (Marshall et al., 2016).

Although resource dependency is useful to understand the sensitivity of agricultural producers, its application is relevant to only a specific subsample of the rural population. Consequently, resource dependency is limited in its ability to capture the myriad ways that non-production-oriented landowners relate to their land and may subsequently be affected as it changes. Landowners may relate to and derive meaning from their land in numerous ways in addition to livelihood dependence. For example, relationships formed through agricultural production, and rooted in work and economic dependence, are fundamentally different than those formed by second-home owners in the same rural areas (Cross et al., 2011). Regardless of connections to livelihood, relationships with nature can hold unique 'relational values' as people fulfill the specific responsibilities of their perceived relationship with the environment (Chan et al., 2016). Relational values are neither extrinsic nor intrinsic, but are an emergent property of a person's connections to a place (Cundill et al., 2017; Tadaki, Sinner, & Chan, 2017).

I expanded Marshall's vulnerability framework through an increased emphasis on sense of place, and specifically place meanings, to better explain drivers of behavior in rural lands that are characterized by both production and amenity or lifestyle-oriented landowners. 'Sense of place', based on the meanings and attachment a person has for a setting (Relph, 1976; Tuan, 1977), has been used to describe the range of possible connections between people and places (see Lewicka, 2011 or Trentelman, 2009 for an excellent overview). This approach has been used by disciplines such as human geography, sociology, psychology, social-psychology, and natural resource social sciences (Trentelman, 2009) and applied to various groups of people including rural residents (Davenport & Anderson, 2005), urban residents (Manzo, 2005), vacation homeowners (Jaakson, 1986), residents in working landscapes (Smith et al., 2011), visitors to natural areas (Wynveen et al., 2012), and outdoor recreationists (Williams & Vaske,

2003) to better understand the role of place in people's lives across numerous contexts and for different disciplinary purposes.

Integrating sense of place into the vulnerability framework, I proposed that all landowners have connections with their land based on the symbolic or descriptive beliefs they create and instill in their land, and the degree to which they rely on their land to maintain these place meanings and support their overall well-being (Davenport & Anderson, 2005; Marshall, 2011; Marshall et al., 2014; 2015; 2016; Smith et al., 2011; Masterson et al., 2017). Place meanings form the essence of the person-place relationship and underpin why people value places and what specifically about a place people become attached to (Stedman, 2002; Wynveen et al., 2012; Masterson et al., 2017). Because sense of place can encapsulate the human values, cognitions, and perceptions that underscore the feedbacks between people and nature, researchers have highlighted place meanings as a valuable but underutilized construct for the study of human responses to social-ecological change (Masterson et al., 2017).

Previous approaches to understand people and differentiate landowners based on livelihood and place-based identities (Groth et al., 2016; Sorice et al. 2012_a; Stedman, 2002), resource dependence (Marshall, 2011; Marshall et al. 2014; 2016), and place-based constructs (Jorgensen & Stedman, 2001; Williams & Vaske, 2003) are rooted in place meanings. These meanings, which may or may not be tied to one's livelihood, can inform a person's identity, or role in social life, when they become crucial to a person's self-definition (Stedman, 2002). Along with place identity, the affective aspects of place attachment such as deriving happiness from a place, or missing it when away (Stedman, 2002; Vaske & Korbin, 2001) can be considered as place meanings. Both resource dependency and place dependence, the functional utility of a place to provide opportunities for specific goals or activities (Jorgensen & Stedman, 2001;

Williams & Vaske, 2003), are based on the meanings ascribed to place. A landowner need not be a producer to be dependent on their land for the specific place meanings they hold; their land may also facilitate aspects of their life such as their identity, social networks, or membership and involvement in the community.

Place dependence represents the goal-oriented aspects of people's relationships with places: "the belief that a place directly or indirectly satisfies certain physical or psychological needs" (Davenport & Anderson, 2005, p.628). Qualitative research has found that people depend on places for multiple reasons such as literal and economic sustenance and for restorative recreational experiences like enjoyment, solitude, and freedom (Davenport & Anderson, 2005). Although place dependence can influence the interpretation and evaluation of environmental changes (Mihaylov & Douglas, 2014), most quantitative measures of place dependence are narrow in their framing around measures of whether or not a place is the best place for one specific activity (Jorgensen & Stedman, 2001; Williams & Vaske, 2003). Incorporating aspects of resource and place dependence with the study of a broad range of place meanings can better capture the unique ties between people, places, and livelihoods while accounting for the diverse ways in which landowners in a rural working landscape may relate to their land.

Protecting important place meanings can be a significant driver of human behavior to protect places or prevent unwanted place-change (Twigger Ross & Uzzell, 1996; Stedman, 2002; Devine-Wright, 2009; Jacquet & Stedman, 2014). Traditionally, researchers emphasized the strength of people's attachment (emotional bond) to place to understand reactions to change. This approach has been reconsidered, however, as "people do not simply engage in places they are attached to; their particular forms of engagement rest on place meanings they hold dear and perceive as threatened" (Masterson et al., 2017, p.49). Ecological and human-caused place

changes can threaten the livelihoods of resource dependent users (Marshall et al., 2014) and cause intense emotional reactions and psychological distress when changes threaten important meanings and disrupt people's connections to place (Devine-Wright, 2009). Even the anticipated threat of change can negatively impact people if it influences how they see themselves, their families, their home, and/or their environments (Jacquet & Stedman, 2014).

If certain ways of relating to the land are more or less jeopardized by environmental change, then the perception of threat may be an important factor in determining a landowner's acceptance of change. Perceived threat captures an individual's sensitivity to the effects of exposure to some environmental stress or hazard (Bockarjova & Steg, 2014; Jacquet & Stedman, 2014). While the evaluation of an environmental stress as a threat is analogous to an attitude, it is likely informed by beliefs about the consequences of the landscape change (Ajzen, 1991). Beliefs are salient information thought to be true, although they can include both true facts and misconceptions formed through experiences (Ajzen, 1991; Ajzen, 2002). In this case, landowners' beliefs about the consequences of woody plant encroachment likely influence their perceived threat. The evaluation of threat may be directly related to an individual's threshold of acceptability for change (Devine-Wright, 2010). Given that there may be multiple ways landowners relate to their land, it is possible that the variation in relationship directly accounts for the way that different landowners evaluate the consequences of change. This evaluation may also be partially or fully mediated by beliefs about the consequences of ecological transformation.

Prior research has found that the meanings people ascribe to places can shape their beliefs and attitudes about landscape change and preferences for management outcomes (Smith et al. 2011; Stedman, 2002). While conceptually strong, the direct and indirect pathways from place

meanings to some threshold for action have not been explored. I examined the role of place meanings as the foundation of an individual's sensitivity and reaction to ecological change (Figure 1). A landowner's relationship with their land, based on place meanings, may directly affect their threshold of acceptability for change. Alternatively, beliefs about consequences of change may mediate the association between relationship with land and threshold of acceptability. Perceived threat is an evaluation informed by place meanings and beliefs about consequences that may subsume the influence of relationship and beliefs, thus serving as an important determinant of whether or not change is acceptable. The level at which landscape change becomes unacceptable can be seen as an individual threshold that when surpassed, motivates an individual to take adaptive or protective action.

Although there is much support for using a place-based approach to understand an individual's vulnerability to change, there is no expectation that sense of place would be directly related to the specific management behaviors chosen to address unacceptable ecosystem transformation. Therefore, I used this conceptual framework to understand how landowners in the Southern Great Plains perceive and evaluate the expansion of woody plants into grasslands. As such, landowners' threshold of acceptability for ecological change is a function of their evaluation of threat, which is informed by their relationship with the land and beliefs about the consequences of change (Figure 1). Although some scholars have looked at the direct associations between landowners' place meanings and their land management behaviors (e.g., Lai & Lyons, 2011), the relationship between sense of place and behavior is likely indirect and mediated a number of intervening variables (e.g., Bamberg, 2013). Exploring how the threshold of acceptability relates to the actual use of land management practices to remove or control woody plants is the subject of Chapter 2.

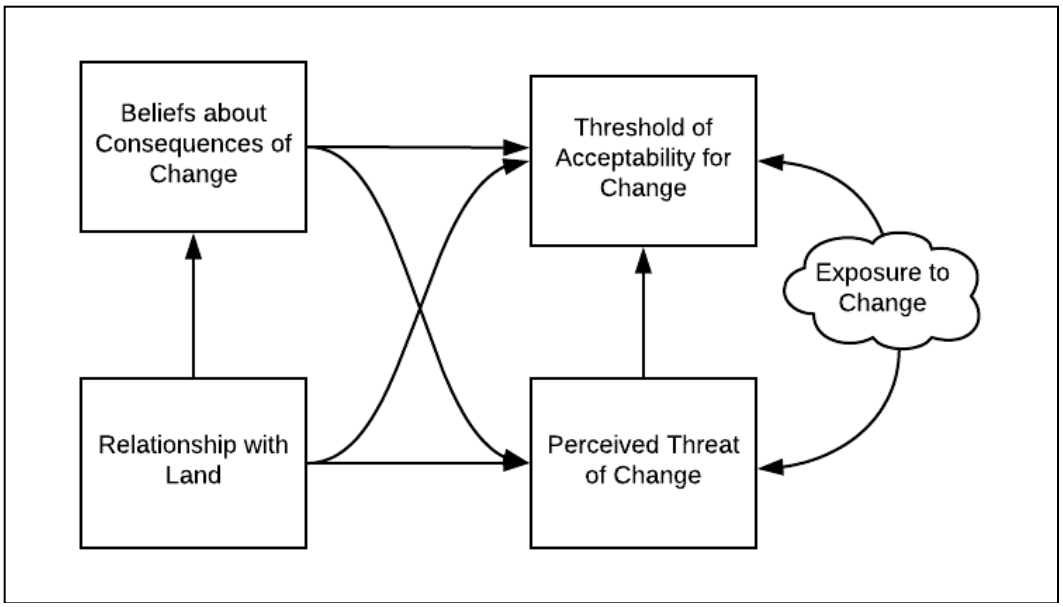


Figure 1. Conceptual framework for hypothesized pathways by which a person's relationship with the land (sense of place) may relate to their threshold of acceptability for ecological change. In my research, these concepts are applied to private landowners experiencing woody plant encroachment into grasslands.

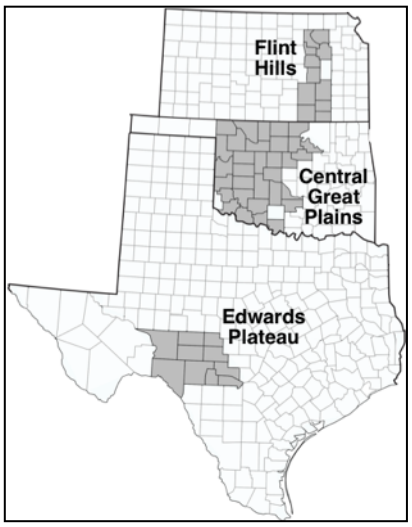
Study Area

Between the Mississippi River and Rocky Mountains, the short, mixed, and tallgrass prairies of the Great Plains once comprised the largest continuous ecosystem in North America (Engle, Coppedge, & Fuhlendorf, 2008; NPS, 2016). They were drastically reduced following Euro-American settlement encouraged by the 1862 Homestead Act, where after settlers began converting open rangeland into row-crop agriculture and pasture for livestock grazing (Assal et al., 2015). Grasslands continue to face many anthropogenic pressures and currently, grassland conversion to shrubland in the Southern Great Plains states of Kansas, Oklahoma, and Texas is 5-7 times greater than any other region of the United States (Wilcox et al., 2018). The largest intact grasslands within this region are in parts of Kansas and Oklahoma where people have maintained frequent fire regimes through the use of prescribed fire (Briggs et al., 2005). Still, fire

faces many social constraints (e.g., legal liability and risk perceptions) and is not widely used throughout the region as a whole (Harr et al., 2014; Krueter et al., 2008; Toledo et al., 2013; Twidwell et al., 2013).

Although rural areas in the Southern Great Plains have tended to decrease in population following the Dust Bowl and Great Depression, urban centers have grown (Assal et al., 2015) and rangelands have recently experienced increased amenity and exurban migration to rural areas (Berg et al., 2015; Brown et al., 2005; Sorice et al., 2012$_b$; 2014) similar to the "New West" transformation documented in the western United States (Robbins et al., 2009). This has produced an increase in both the number of very large and very small properties through consolidation of smaller tracts into large properties and increased subdivision of land into small ranchette-like parcels (Wilcox et al., 2018).

My research focuses on three ecoregions in the Southern Great Plains; the Flint Hills in eastern Kansas; the Central Great Plains in western and central Oklahoma; and the Edwards Plateau in central Texas (Figure 2). These ecoregions are spatially defined areas delineated by the Environmental Protection Agency (EPA) based on unique biotic and abiotic interactions that produce distinctive ecosystems (Omernik, 1987; Omernik and Griffith, 2014). The specific counties included in this research were selected based on ecoregion boundaries, existing ecological data regarding WPE, and expert opinion from project collaborators about woody plant cover and species relevant to this research.



A) Flint Hills, Kansas
11 counties: Butler, Chase, Chautauqua, Cowley, Elk, Geary, Greenwood, Morris, Pottawatomie, Riley, and Wabaunsee

B) Central Great Plains, Oklahoma
32 counties: Alfalfa, Beckham, Blaine, Caddo, Canadian, Comanche, Cotton, Custer, Dewey, Ellis, Garfield, Garvin, Grady, Grant, Greer, Harper, Jackson, Jefferson, Kay, Kingfisher, Kiowa, Logan, McClain, Major, Noble, Pawnee, Payne, Roger Mills, Tillman, Washita, Woods, and Woodward

C) Edwards Plateau, Texas
10 counties: Bandera, Crockett, Edwards, Kerr, Kimble, Menard, Real, Schleicher, Sutton, and Val Verde

Figure 2. The 53 counties in 3 ecoregions of the United States' Southern Great Plains that comprise the study area for this research.

Edwards Plateau, Texas

The Edwards Plateau is a limestone plateau in central Texas that experienced the earliest onset of woody plant encroachment as grassland conversion followed major settlement, fire suppression, and overgrazing in the early 20th century (Box, 1967; Griffith, 2007; Hennessey et al., 1983). While historically a fire-maintained post oak grassland savanna (Chapman & Bolen, 2015; Griffith et al., 2007), most open land has converted to woodlands of juniper-oak and mesquite-oak (Diamond & True, 2008; Ansley & Wiedemann, 2008). Woody plant expansion on the Edwards Plateau's remaining two percent of intact grassland is driven by concurrent overgrazing and soil loss (Chapman & Bolen, 2015). Along with shrub encroachment from species such as Ashe juniper (*Juniperus ashei*) and redberry juniper (*Juniperus pinchotii*), viable rangelands have shrunk due to fragmentation and land conversion from urban expansion and amenity migration (Griffith et al., 2007; Lai & Lyons, 2011). Land use in the area is primarily agricultural grazing for cattle, sheep, goats, and exotic game animals (Griffith et al., 2007). To

supplement and diversify agricultural economies, the state of Texas has encouraged landowners to engage in nature-based tourism and recreation ventures (Lai & Lyons, 2011) and the sale of hunting leases on private lands has become a major source of income for many landowners (Griffith et al., 2007).

Central Great Plains, Oklahoma

The Central Great Plains in western and central Oklahoma was historically mixed and short grass prairie. In general, precipitation increases towards the east and growing seasons increase to the south of the Central Great Plains (Woods et al., 2005). Much of the region contains extensive cropland; however, rangelands found in more rugged areas are predominately used for grazing livestock (Woods et al., 2005). These open-range grasslands are experiencing dramatic advances in woody plant encroachment from *Juniperus* species such as eastern redcedar (*Juniperus virginiana*), mesquite (*Prosopis* spp.), and creosote bush (*Larrea tridentate*) (Archer et al., 2011; Assal et al., 2015; Briggs et al., 2005; Knapp et al., 2008). Compared to the Edwards Plateau, shrub encroachment in the Central Great Plains is more recent, likely because much of the region was previously cultivated for agriculture and returned to grassland after cultivation proved unviable (Wilcox et al., 2018). Although grasslands in the Central Great Plains have undergone accelerated conversion to juniper woodlands within the last 40 years, some large areas of grassland remain (Ansley & Wiedemann, 2008; Barger et al., 2011).

Flint Hills, Kansas

The Flint Hills in eastern Kansas and northeastern Oklahoma is the largest functional remnant of tallgrass prairie in the Southern Great Plains and greater North America (Chapman et al., 2001). The Flint Hills are characterized by rolling hills of tallgrass prairie with rocky surfaces, preventing substantial cultivation for agriculture and perpetuating range and pasture for livestock grazing as the predominant land use. The unsuitability for agricultural conversion has kept the Flint Hills relatively untouched by the plow and this region remains a prairie island within a sea of surrounding row-crop agriculture (Chapman & Bolen, 2015). The frequent use of prescribed fire has become deeply engrained within the strong ranching culture of this region as a tool to promote forage growth for livestock and limit undesirable forbs and brush (Hoy, 1989). As such, the Flint Hills have remained predominantly grasslands despite expanding wooded areas due to encroachment from species such as eastern redcedar (*Juniperus virginiana*) (Briggs et al., 2005; Hoy, 1989; Twidwell et al. 2016).

Materials and Methods

Sampling

I developed the sampling frame for the 53 counties included in this study by aggregating 2017 public property records that I obtained from each county's tax appraisal district. From these records, I filtered the list to include only private landowners who owned at least 30 acres of rural land, either contiguously or in separate parcels. Parcels owned by multiple landowners (e.g., spouses, business partners, etc.) were considered as a single entity in the sampling frame if owners shared the same mailing address in the property record. Landowners who owned land

through trusts or licensed businesses were retained in the list if their name and mailing address was available in the property record or through an online public search of the trust/business. Based on prior research with this population, the 30-acre threshold affords both the inclusion of small acreage landowners and ensures that the land ownership and management questions would be salient and applicable (Sorice et al., 2012; Toledo, Sorice, & Kreuter, 2013).

From the final list (N = 84,871), I selected a simple random sample of landowners from each county using a sampling fraction proportionate to the size of the county's eligible rural landowning population. I selected a total of 1,000 landowners from each ecoregion for an overall sample of 3,000 people. See Appendix A for further information on sampling fractions per county. This form of sampling (probability proportionate to size) ensures that each landowner in the sampling frame has an equal chance of selection regardless of differences in size of the rural population of each county, which is an efficient and effective method for selecting large samples (Babbie, 2007). I selected the overall sample size of 3,000 landowners based on population size and response rate calculations needed to achieve a 95% confidence interval with +/- 3% margins of error (Dillman, Smyth, & Christian, 2014) given prior response rates (36.7% - 76.2%) from this population (Krueter et al., 2008; Sorice et al., 2012; Toledo et al., 2013). Address verification through the USPS resulted in a final sample size of 2,993 landowners from the 53 counties in the three ecoregions of the study.

Survey Design and Administration

I selected a mail survey for this research as an economically and logistically feasible approach to reach a large sample size from a geographically expansive study area. Further, the population for this study is educated, literate, and has been responsive to mail surveys in recent

research (Sorice et al., 2012; Toledo et al., 2013). Survey development was grounded in social science theory and findings from relevant prior research. The survey was adapted to this specific landowning population through interviews with landowners (n = 34) and practitioners and subject matter experts (n = 8) in the Southern Great Plains between July and September 2017. The survey was pre-tested with landowners (n = 8) and reviewed by committee members and project partners (n = 5) between October 2017 and January 2018.

The questionnaire instructed the primary decision maker (i.e., the person responsible for making most of the day-to-day decisions about the land) to complete the survey. The survey used the term "cedar/juniper" in reference to the following species of woody plants, known by a variety of common names; *Juniperus virginiana* (i.e., cedar, eastern red cedar), *Juniperus ashei* (i.e., blueberry juniper, Ashe juniper, mountain cedar), *Juniperus pinchotti* (redberry juniper). The survey instructed respondents to think of all the rural land they owned within the study area in terms of one overall "place", which is a colloquialism that is well understood across the three regions in the study. The words "place," "land," and "grassland/rangeland" were deliberately used throughout the survey based on the context of the question. The survey requested information about land use and landowner characteristics, sense of place, exposure to and preferences for cedar/juniper, beliefs about the potential consequences of cedar/juniper encroachment, land management practices commonly used to control cedar/juniper, and basic demographics (full survey is provided in Appendix B).

Beginning in February 2018, I mailed the questionnaire to selected research participants following Dillman's modified repeat mail procedure that incorporates multiple contacts with varied content to encourage respondent participation (Dillman et al., 2014). Over the course of nine weeks, I mailed all participants an introductory letter (Day 1), survey packet with cover

letter, survey, and pre-paid business reply envelope (Day 7), and a thank you/reminder postcard (Day 14). After removing people who had completed the survey and those who did not wish to participate or were ineligible, I mailed replacement survey packets with cover letter, survey, and pre-paid business reply envelope to remaining participants (Day 43). Finally, I mailed a reminder letter to the remaining participants who had not yet completed the survey or expressed that they wanted to withdraw (Day 63). The documents used to contact landowners and further details about each mailing are provided in Appendix C.

Data Collection and Data Reduction

Relationship with the Land

Based on existing literature and the interviews conducted during survey development, I used 46 indicators to measure 26 unique place meanings. The place meanings were comprised of four categories: 1) place characteristic meanings regarding the physical attributes of a place, 2) functional or utilitarian meanings based on desired activities or uses, 3) experiential meanings from individually oriented experiences, and 4) interpersonal meanings representing social aspects and interactions with others in the setting (Davenport & Anderson, 2005; Smith et al., 2011; 2012, van Riper et al., 2012; Williams & Vaske, 2003; Wynveen & Kyle, 2015). For each place meaning indicator, I asked landowners the degree to which they felt the meaning described their place using a five-point response scale in which *1 = Not at all*, and *5 = Completely describes* to measure the strength of belief in said place meaning. I also asked landowners to indicate the degree to which they relied or counted on their land to provide or maintain each place meaning indicator (*1 = Not at all*, and *5 = Completely* or *Completely rely*). This measured a landowner's dependence on their land for each specific place meaning. For instance, the item:

"*My place is a source of personal pride*," represents the self-esteem one derives from their land. Respondents were asked to indicate the degree to which this described their beliefs and the degree to which they depended on their land to supply their self-esteem. I then used exploratory factor analysis (EFA) with promax rotation to reduce a select number of meanings indicators that represented nine larger constructs and were thus highly correlated.

To categorize landowners into unique groups representing distinct ways that people related to their land, I conducted a K-means cluster analysis on the responses to the place meaning and dependence items (Rose & Dierker, 2018). To determine the final number of landowner groups, I reviewed 50 random iterations of 2-20 group cluster solutions and examined the results of each using the elbow method (Acock, 2016; Makles, 2012) for model selection (see Appendix D). Because this did not provide clear guidance, I considered how meaningful and interpretable a small number of cluster solutions were in terms of differentiating landowners into distinct groups based on their patterns of place meanings and identifying known landowner types (e.g. farmers). I also considered parsimony and the number of landowners categorized within each group. I further characterized the resulting groups using socio-demographic and descriptive data collected elsewhere in the survey but not used in the cluster analysis (see Appendix E) as is commonly done to assess K-means cluster solutions and typologies in general (Dayer, Allred, & Stedman, 2014; Rose & Dierker, 2018).

Beliefs about Consequences

I measured beliefs about the ecosystem services and consequences of cedar/juniper, hereafter referred to as cedar, by asking landowners to indicate their level of agreement with nine statements about potential benefits and six statements about potential negative outcomes of cedar

in grasslands (*1 = Strongly disagree* to *7 = Strongly agree*). These statements included established facts, common beliefs, and misconceptions about cedar (e.g., provides useful windbreaks, reduces the amount of forage available for livestock). Using Cronbach's alpha, I explored if multiple statements pertaining to similar beliefs, such as *enhances wildlife habitat* and *increases the types of wildlife species present*, could be combined into reliable single indices.

Exposure, Perceived Threat, and Threshold of Acceptability

I used a series of three photos to represent a grassland with low, medium, and high densities of cedar (Figure 3) to measure landowners' current exposure to cedar, their perceived threat of cedar, and their threshold of acceptability for cedar on their land. I asked them to consider the landscape in each photo as a view of their own place. Landowners indicated which photo best represented the amount of cedar currently on their land (*1 = Not at all* to *5 = Almost completely)* providing their perception of their current degree of exposure. Landowners then rated each photo on acceptability, desirability, and the level of threat they perceived. These three scales were averaged into a single item, perceived threat, based on exploratory factor analysis and Cronbach's alpha. Finally, landowners used the photos to indicate their preference for the level of cedar on their own place using a five-point scale (*1 = Much too low*, *3 = About right*, *5 = Much too high*). I used this rating to determine each landowner's threshold of acceptability. Photos that were rated as *too high* or *much too high* were scored as a *1* and all other ratings were scored as a *0*.

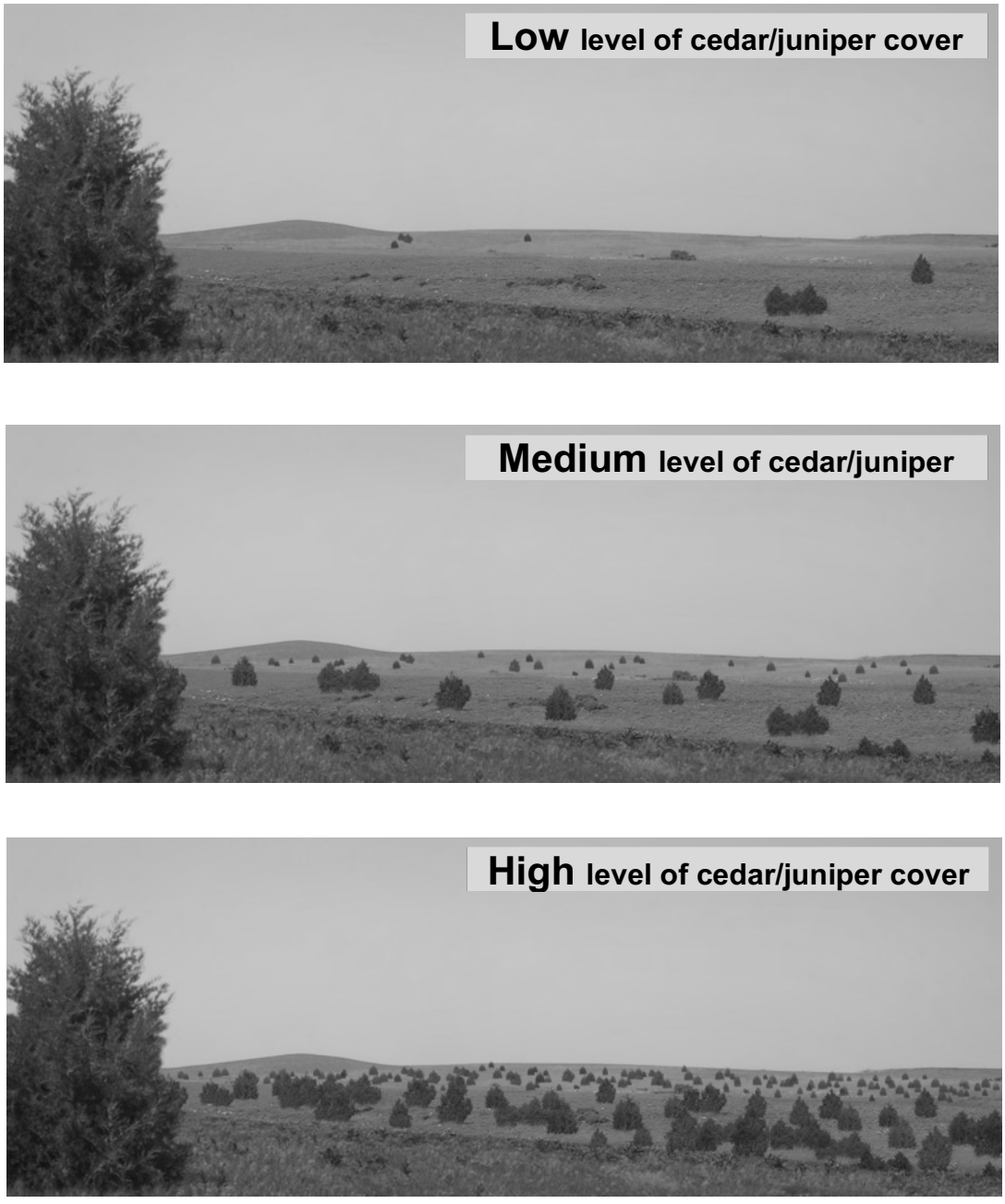


Figure 3. Photo series depicting low, medium, and high levels of cedar/juniper in a grassland. Landowners' responses to questions referencing these photos were used to measure exposure to cedar, perceived threat of cedar, and threshold of acceptability for cedar.

Descriptive Analysis

I used descriptive statistics in Stata 14.2 to characterize the land uses, land ownership characteristics, and basic demographics of respondents. Prior to explanatory analyses, I summarized landowners' exposure, thresholds, and perceived threat of cedar as well as their beliefs about the ecological outcomes of cedar and the defining characteristics of the meanings-based relationships resulting from the K-means cluster analysis.

Modelling Factors Related to Threshold of Acceptability

I used an ordinal logit to examine how landowners' beliefs about cedar varied based on how landowners related to their land. In these models, the level of agreement with each belief was treated as an ordinal variable because the assumption of normality was not met for OLS regression. I used multilevel mixed-effects regression models to explain variation in perceived threat and acceptance for ecosystem transformation among landowners. Specifically, I used multilevel mixed-effects linear regression to model perceived threat, which has a continuous outcome, and multilevel mixed-effects logistic regression to model threshold of acceptability, which has a binary outcome. All cases with missing data were removed from analyses. Because the questions based on the 3-photo series are repeated measures from the same individual, my data were nested within individuals. Additionally, landowners themselves were nested within regions that are known to vary based on rules, norms, and culture. Both levels of nesting violate the independence of observations assumption making the mixed model best suited for the structure of this data (Robson & Pevalin, 2016). The mixed model enables estimating the fixed effects of explanatory variables on perceived threat and acceptability threshold, while controlling for the random effects of individuals and regions by allowing their intercepts to vary (Robson &

Pevalin, 2016). As the purpose of this research was to understand how vulnerability varies among respondents throughout the Southern Great Plains as a whole, not to compare regional differences, the mixed model enabled the consideration of context (i.e., an individual's ecoregion) through accounting for the variations from nested data.

My mixed models had three levels. As with single-level regression, I analyzed the dependent and independent variables of interest as level one. Using each respondent's ID number, I included the individual as a level two variable to control for the repeated measures from individuals. I used the county where each respondent owned land as a level three variable to control for the influence of within region similarities. Using counties to represent regions, instead of the three ecoregions, allowed for greater control over potential contextual influences (e.g., level of urbanization) and resulted in more groups (53 counties vs. 3 regions) providing better model estimation (Robson & Pevalin, 2016). Along with conceptual considerations of how the data was structured, the intraclass correlation (ICC), which indicates the variance of the dependent variable captured by nesting effects at higher levels, indicated that nesting effects within the individual and an individual given their region accounted for a non-trivial amount of variance in landowners' thresholds (see Appendix F). This provided further statistical support for using a multilevel modeling approach for this data (Robson & Pevalin, 2016).

As the study areas are known to have differing levels of woody plant encroachment, I tested the utility of using exposure to cedar as a co-variate in the models to account for the differing baselines landowners may have in regards to their judgements about cedar. Models were evaluated in terms of individual hypotheses and comparatively through the intraclass correlation (ICC) and Akaike's Information Criterion (AIC). As explanatory variables are added in level one of the model, reductions in the ICC of level two and level three variables indicate

that more variance is being explained by independent variables and less is accounted for by the random variables at higher levels (Robson & Pevalin, 2016). The AIC is a relative measure of model fit that balances goodness of fit with parsimony, attempting to avoid information loss without overfitting a model to the data (Acock, 2016).

Results

Of the 2,993 initial surveys mailed out, 1,231 were returned. Of these, 210 were mailed back blank to indicate that the landowner did not wish to participate and 11 others indicated that the intended recipient was ineligible (e.g., had sold land, was deceased, etc.). Of the 1,010 surveys completed, 16 surveys were removed because the landowner owned less than 30 acres and 3 more were removed because they were duplicates. The final sample contained 991 landowners. After accounting for 154 additional ineligible respondents (e.g., undeliverable addresses, respondents who contacted me to indicate their ineligibility, etc.), the adjusted response rate was 35% (991 eligible surveys/2812 adjusted sample). This is comparable to other response rates (36.7%) from general population surveys of landowners within this region (Kreuter et al., 2008). After removing 114 landowners who were not primary decision makers for their land, there was a total of 877 landowners included in this study. Allowing for maximum heterogeneity in responses (e.g., a 50/50 split on a binary question), 877 completed responses from a population of around 85,000 should yield a 95% confidence level with margins of error between +/- 3% and +/-5 % (Dillman et al., 2014). Of the 877 primary decision makers, 38% owned land in the Edwards Plateau (n = 334), 28% in the Central Great Plains (n = 247), and

34% in the Flint Hills (n = 296). The number of observations varied per analysis due to item nonresponse throughout the survey.

Landowner Demographics and Land Ownership Characteristics

Most responding landowners were male (77%), 60 years old or older (75%) and indicated that their race and ethnicity was white (98%), non-Spanish or Hispanic (97%). On average, respondents were 66 years old (standard deviation (SD) = 12.10, median (MD) = 67; range = 21-97). More than half of landowners had received a 4-year college degree or higher level of education (58%), reported annual household incomes above $75,000 (61%) and were still in the work force (57%). Only 18% of respondents listed farmer, rancher, or farmer and rancher as their sole primary occupation, although 33% indicated that their occupation was part of, or connected to, the farming and ranching industry.

On average, respondents owned 958 acres of land (SD = 2401, MD = 250, range = 30-26,000). Across the regions, landowners had owned their land for an average of 23 years (SD = 15.5, MD = 20, range = 0-80) and 47% had inherited or acquired their land from their family. Overall, 45% of landowners lived on their land full-time and those who were not full-time residents lived an average 235 miles away (SD = 349, MD = 120, range = 0.25-3500). Less than half of landowners indicated that they used their land primarily for farming and/or ranching (42%) whereas 22% stated that they primarily used their land for the rural lifestyle, outdoor recreation, or wildlife. The remaining 36% of landowners indicated other primary land uses (e.g., for commercial hunting, as a financial investment, etc.) or combinations of many uses as their 'primary' land use (e.g., for livestock, recreation, financial investment, and the rural lifestyle).

Relationship to Land

The nine individual EFA's of indicators that represented larger place meaning constructs yielded 11 multi-item indices (see Appendix G) that showed strong inter-item reliability and validity indicated by Cronbach's alpha's above 0.70 and individual item factor loadings above 0.40 (Acock, 2016). Combined with 15 single-item indicators, there were a total of 26 place meanings with landowners' rating for their strength of belief and dependence on each, resulting in the 52 place meaning variables I used in the cluster analysis. These place meanings included place characteristic meanings regarding physical attributes, functional or utilitarian meanings based on desired activities or uses, experiential meanings from individually oriented experiences, and interpersonal meanings representing social aspects and interactions with others (Table 1). In terms of both belief and dependence, the strongest held place meanings for landowners were not based on the physical characteristics (apart from aesthetics) or functional uses of land but represented experiential and interpersonal aspects of how landowners connected with and related to their land.

Table 1. The mean (*M*) and standard deviation (*SD*) for belief in and dependence on each place meaning concept. Due to item non-response, the number of respondents for each meaning ranges from 743 to 865. Responses were on a scale from *1 = Not at all* to *5 = Completely*.

Place Meaning	Belief in Place Meaning		Dependence on Place Meaning	
	M	***SD***	***M***	***SD***
Place Characteristics Meanings				
Grassland	3.15	1.22	2.81	1.39
Aesthetics (scenic beauty)	3.92	1.10	3.16	1.46
Naturalness	2.59	1.24	2.13	1.28
Food production	2.52	1.49	2.30	1.45
Wildlife habitat	3.45	1.18	2.61	1.40
Functional Meanings				
For grazing livestock	3.21	1.52	2.99	1.40
For growing crops	1.98	1.35	1.94	1.35
For hunting/fishing	2.93	1.27	2.56	1.40
For outdoor recreation	2.20	1.24	2.11	1.28
Economics[a] $\alpha = 0.92$	2.71	1.47	2.55	1.45
Professional connections	1.89	1.20	1.83	1.18
Experiential Meanings				
Individual identity 1 (reflects/shaped me)[a] $\alpha = 0.84$	3.64	1.00	3.51	1.10
Individual identity 2 (pride/expression)[a] $\alpha = 0.81$	3.86	1.18	3.77	1.22
Autonomy[a] $\alpha = 0.79$	3.77	1.10	3.65	1.17
Restorative 1 (stress relief/recovery)[a] $\alpha = 0.83$	3.55	1.05	3.37	1.12
Restorative 2 (perspective/inspiration)[a] $\alpha = 0.86$	3.57	1.17	3.40	1.21
Restorative-escape	3.23	1.51	3.12	1.50
Psychological Flow[a] $\alpha = 0.88$	3.66	1.14	3.57	1.19
Attachment[a] $\alpha = 0.92$	3.79	1.24	3.70	1.18
Livelihood	3.65	1.29	3.60	1.33
Stewardship/conservation[a] $\alpha = 0.84$	3.67	1.11	3.59	1.11
Interpersonal Meanings				
Family identity[a] $\alpha = 0.84$	3.50	1.18	3.43	1.23
Purpose/legacy[a] $\alpha = 0.86$	3.70	1.23	3.57	1.26
Rootedness	2.96	1.77	2.91	1.75
Community belonging	3.04	1.34	2.82	1.37
Social connections	3.62	1.27	3.41	1.37

[a] Cronbach's alpha (α) indicates the internal consistency for concepts measured through multi-item indices.

A 6-cluster solution to the K-means cluster analysis provided the most meaningful and interpretable solution to differentiate the distinct ways that landowners related to their land. Although the goodness of fit tests that I explored to aid in model selection did not provide definitive guidance, the 6-cluster solution performed as well or better than the other models (see Appendix D). The relationships identified by the cluster analysis indicated a wide range in how

landowners view and connect with their land. The relationships are distinguished not only by landowners' meanings and dependencies on place characteristics and functional uses of their land, as is common in landowner typologies, but also through the degree of experiential and interpersonal meanings that they hold for and rely on their land to provide. Table 2 provides the average belief (M_b) and average dependence (M_d) score for each place meaning, per cluster. The following descriptions characterize the way landowners in each group related to their land.

Cluster 1 (n = 77, 13%) were crop-oriented productivists with moderate-to-high experiential and interpersonal connections based around their individual and family identity. They were distinct from other groups through their moderate-to-high belief (M_b = 3.8) and dependence (M_d = 3.7) on their place as somewhere for growing crops, which were the highest ratings for crop production of any relationship group. They also viewed their place as somewhere that provided food for people (M_b = 3.5) and moderately depended on their place for economic purposes (M_d = 3.4). Although they believed their land has some scenic beauty (M_b = 3.3), they tended not to consider it as a place that reflected naturalness (M_b = 1.9) or provided wildlife habitat (M_b = 2.4) and gave limited consideration of their place as somewhere for hunting or fishing (M_b = 2.2) or other forms of outdoor recreation (M_b = 1.5). Experientially, their place was a moderately-to-very important part of their self-concept (individual identity 1: M_b = 3.6, individual identity 2: M_b = 3.9) and livelihood (M_b = 3.9). They were moderately-to-highly attached to their land (M_b = 3.8) and experienced autonomy (M_b = 3.7), psychological flow (M_b = 3.7) and some aspects of mental restoration (restorative 2: M_b = 3.5). However, their land was less a place where they could escape (M_b = 2.7). They expressed high rootedness (M_b = 4.2) and indicated that their place was a large part of their family's identity (M_b = 3.9) and the legacy they wanted to pass on to future generations (M_b = 4.1).

Cluster 2 (n = 101, 17%) were nature/wildlife appreciators with moderate experiential meanings and low familial connections to their land. They viewed their land as somewhere with much scenic beauty (M_b = 4.1) and wildlife habitat (M_b = 4.1), which they had moderate-to-high reliance on (beauty M_d = 3.6; habitat M_d = 3.5). They tended not view their place as a grassland (M_b = 2.4) or as being very natural (M_b = 2.4). This group moderately related to their land through hunting/fishing (M_b = 3.6) and other forms of outdoor recreation (M_b = 3.0), which was higher than their responses to grazing livestock (M_b = 2.1), growing crops (M_b = 1.2) or economics (M_b = 1.4). They expressed moderate beliefs and dependence on most experiential meanings of their place such as autonomy (M_b = 3.7), escape (M_b = 3.4), and stress relief (restoration 1: M_b = 3.4); however, held lower beliefs about the inspirational aspects of restoration (restoration 2: M_b = 2.7) and that their place was part of their way of life (M_b = 2.7). Landowners with this relationship felt that their place was somewhere for social connections with friends and/or family to a moderate-to-high degree (M_b = 3.6), although they held few other interpersonal meanings as their place was only a slight part of their family identity (M_b = 2.2) and personal legacy (M_b = 2.4). Landowners in this group did not feel that their place represented their family's history in the area (M_b = 1.2), which was the lowest degree of rootedness expressed by any group.

Cluster 3 (n = 95, 16%) were grassland and grazing-oriented landowners with moderate-to-high psychological connections to their land through experiential and interpersonal meanings. They largely considered their place to be a grassland (M_b = 4.0) with high scenic beauty (M_b = 4.0) and moderate wildlife habitat (M_b = 3.3); however, their dependence on their land as grassland (M_d = 3.7) was somewhat higher than for aesthetics (M_d = 3.0) or wildlife habitat (M_d = 2.4). Although they tended not to see their place as somewhere that produces food (M_b = 2.5),

they expressed strong beliefs and dependence on their place as somewhere for grazing livestock (M_b = 4.3; M_d = 4.2). Despite grazing as a strong functional meaning, they indicated only moderate economic meanings for their place (M_b = 2.9; M_d = 2.7). The pattern of experiential meanings they held for their land was very similar to Cluster 1, with moderate-to-high ratings for individual identity (1: M_b = 3.7; 2: M_b = 4.0), autonomy (M_b = 3.7), and attachment (M_b = 3.9). Compared to Cluster 1 in terms of interpersonal meanings, landowners in Cluster 3 held slightly lower meanings for family identity (M_b = 3.5), legacy (M_b = 3.7), and rootedness (M_b = 3.2) and slightly higher meanings for community belonging (M_b = 3.2) and social experiences with friends or family (M_b = 3.5).

Cluster 4 (n = 126, 21%) were nature/wildlife enthusiasts that derived high psychological benefits from their place through many experiential and interpersonal meanings. These landowners related to their land through place characteristic meanings based on natural amenities such as scenic beauty (M_b = 4.4) and wildlife habitat (M_b = 4.2), and functional meanings such as opportunities for hunting/fishing (M_b = 3.5) and other forms of outdoor recreation (M_b = 3.4). They indicated the highest level of dependence of any group on their land for aesthetics (M_d = 4.0) and expressed the same degree of dependence on wildlife habitat (M_d = 3.5), hunting/fishing (M_d = 3.0), and other recreation (M_d = 3.0) as Cluster 2. As with Cluster 2, they only slightly viewed their place as a grassland (M_b = 2.4) and held minimal agricultural or economic meanings. While they were similar to Cluster 2 in regards to place characteristic and functional meanings, this group derived far stronger experiential and interpersonal connections to their land. For instance, they expressed high dependence on their land for restorative experiences of stress relief (restorative 1: M_d = 4.3), perspective/inspiration (restorative 2: M_d = 4.3) and escape (M_d = 4.4) as well as meanings related to their sense of stewardship/conservation (M_d = 4.3). They also

felt that their land was a significant part of their individual identity, as a reflection of who they are (identity 1: $M_b = 3.9$) and as a source of pride (identity 2: $M_b = 4.5$), and considered their land to represent their way of life ($M_b = 4.2$). The only interpersonal meanings for which they did not indicate strong beliefs or dependence were community belonging ($M_b = 3.2$; $M_d = 3.0$) and rootedness ($M_b = 2.1$; $M_d = 2.1$).

Cluster 5 (n = 115, 19%) were grassland and grazing-oriented productivists with high economic and livelihood dependence as well as strong psychological connections based on many experiential and interpersonal meanings. This group held strong beliefs and dependence on their land as a grassland ($M_b = 3.9$; $M_d = 4.0$) and moderately-to-highly as place of food production ($M_b = 3.7$; $M_d = 3.5$). Functionally, their place was somewhere for grazing livestock ($M_b = 4.5$; $M_d = 4.5$) but minimally for growing crops ($M_b = 2.2$; $M_d = 2.4$). They had strong economic dependence on their land ($M_d = 3.8$) and were the only group to indicate that their place was moderately important in terms of their professional network ($M_b = 2.9$). They saw their place as somewhere with much scenic beauty ($M_b = 4.2$) and a moderate degree of wildlife habitat ($M_b = 3.2$). Although this group related to their land through agricultural meanings along with some natural amenities, they were very similar to Cluster 4 in terms of their strong belief and dependence on experiential and interpersonal meanings. Of all groups, they expressed the highest belief and dependence on meanings related to their individual identity (identity 1: $M_b = 4.5$; $M_d = 4.5$, identity 2: $M_b = 4.8$; $M_d = 4.7$) psychological flow ($M_b = 4.6$; $M_d = 4.6$), attachment ($M_b = 4.7$; $M_d = 4.7$), livelihood ($M_b = 4.7$; $M_d = 4.7$) and stewardship/conservation ($M_b = 4.4$; $M_d = 4.4$). Compared to Cluster 4, this group expressed lower, but still moderate-to-high meanings for stress relief and recovery (restorative 1: $M_b = 3.9$) and escape ($M_b = 3.4$). Their place was a very strong part of their family's identity ($M_b = 4.6$) and personal legacy ($M_b = 4.8$) and they

expressed strong rootedness (M_b = 4.1), community belonging (M_b = 4.1) and social connections (M_b = 4.2) associated with their land.

Cluster 6 (n = 81, 14%) were moderate nature/wildlife appreciators with a grassland and grazing orientation and few psychological connections to their place. They were distinct from all other clusters through their lack of any strong characteristic, functional, experiential, or interpersonal meanings for their land. Although they held moderate beliefs that their place was a grassland (M_b = 3.2) with scenic beauty (M_b = 3.3) and wildlife habitat (M_b = 3.0), they expressed low dependence on their land for these meanings (grassland: M_d = 2.4; beauty: M_d = 2.2; habitat: M_d = 1.9). While moderate, their strongest functional meaning for their place was as somewhere for grazing livestock (M_b = 3.1), although they indicated lower dependence on grazing (M_d = 2.5) as well as economic aspects related to their land (M_d = 2.2). They held little to no beliefs or dependence on most of the potential experiential or interpersonal meanings of their place, the lowest scores of any group. While they expressed that their place only somewhat represented generations of their family's history (M_b = 2.8), this moderate degree of rootedness was greater than that for those in Cluster 2 or Cluster 4.

Table 2. The mean of belief in (M(B)) and dependence on (M(D)) each place meaning concept for each relational group identified through the K-means cluster analysis (n = 595). Responses were on a scale from 1 = *Not at all* to *5 = Completely*.

Place Meaning	**Cluster 1** 13% (n = 77)		**Cluster 2** 17% (n = 101)		**Cluster 3** 16% (n = 95)		**Cluster 4** 21% (n = 126)		**Cluster 5** 19% (n = 115)		**Cluster 6** 14% (n = 81)	
	M_b	M_d	M_b	M_d	M_b	M_d	M_b	M_d	M_b	M_d	M_b	M_d
Place Characteristics Meanings												
Grassland	2.6	2.4	2.4	2.0	4.0	3.7	2.6	2.1	3.9	4.0	3.2	2.4
Aesthetics (scenic beauty)	3.3	2.1	4.1	3.6	4.0	3.0	4.4	4.0	4.2	3.4	3.3	2.2
Naturalness	1.9	1.4	2.4	1.9	2.7	2.1	2.9	2.5	2.7	2.4	2.5	1.7
Food production	3.5	3.0	1.6	1.5	2.5	2.3	1.6	1.5	3.7	3.5	2.4	2.0
Wildlife habitat	2.4	1.6	4.1	3.5	3.3	2.4	4.2	3.5	3.2	2.5	3.0	1.9
Functional Meanings												
For grazing livestock	2.8	2.6	2.1	1.8	4.3	4.2	2.2	2.0	4.5	4.5	3.1	2.5
For growing crops	3.8	3.7	1.2	1.2	1.5	1.4	1.4	1.3	2.2	2.4	2.0	1.7
For hunting/fishing	2.2	1.6	3.6	3.3	2.8	2.4	3.5	3.3	2.8	2.4	2.5	1.8
For outdoor recreation	1.5	1.5	3.0	3.0	1.8	1.7	3.1	3.0	1.8	1.8	1.6	1.3
Economics	3.7	3.4	1.4	1.4	2.9	2.7	1.6	1.4	3.9	3.8	2.6	2.2
Professional connections	1.9	1.8	1.3	1.2	1.9	1.8	1.5	1.5	2.9	2.9	1.2	1.2
Experiential Meanings												
Individual identity 1 (reflects/shaped me)	3.6	3.6	3.0	2.8	3.7	3.5	3.9	3.9	4.5	4.5	2.6	2.2
Individual identity 2 (pride/expression)	3.9	3.9	3.3	3.2	4.0	3.8	4.5	4.4	4.8	4.7	2.0	1.8
Autonomy	3.7	3.7	3.7	3.2	3.7	3.5	4.5	4.4	4.3	4.3	2.4	2.0
Restorative 1 (stress relief/recovery)	3.2	3.0	3.4	3.4	3.3	3.3	4.4	4.3	3.9	3.9	1.7	1.7
Restorative 2 (perspective/inspiration)	3.5	3.3	2.7	2.7	3.3	3.3	4.4	4.3	4.4	4.3	1.6	1.6
Restorative-escape	2.7	2.6	3.4	3.2	2.9	2.8	4.5	4.4	3.4	3.3	1.6	1.4
Psychological flow	3.7	3.6	3.2	3.2	3.6	3.5	4.3	4.3	4.6	4.6	1.9	1.7
Attachment	3.8	3.8	3.2	3.1	3.9	3.8	4.4	4.3	4.7	4.7	1.9	1.7
Livelihood	3.9	3.9	2.7	2.6	3.6	3.5	4.2	4.2	4.7	4.7	2.0	1.8
Stewardship/conservation	3.4	3.4	3.4	3.3	3.5	3.4	4.3	4.3	4.4	4.4	2.4	2.2
Interpersonal Meanings												
Family identity	3.9	3.8	2.2	2.1	3.5	3.4	3.8	3.8	4.6	4.6	2.7	2.4
Purpose/legacy	4.1	4.1	2.4	2.3	3.7	3.6	4.0	3.9	4.8	4.7	2.5	2.3
Rootedness	4.2	4.1	1.2	1.2	3.2	3.2	2.1	2.1	4.5	4.5	2.8	2.6
Community belonging	2.8	2.7	2.3	2.0	3.2	2.9	3.2	3.0	4.1	4.0	1.9	1.5
Social connections	2.9	2.8	3.6	3.2	3.5	3.2	4.5	4.3	4.2	4.2	2.1	1.8

Beliefs about Consequences

Two sets of positive belief indicators about cedar were combined to create two two-item indices (aesthetic benefits and wildlife benefits) based on reliable Cronbach's alpha. This resulted in seven variables representing respondents' beliefs about positive outcomes of cedar and six variables regarding negative outcomes of cedar (Table 3). Overall, landowners believed that cedar led to a number of negative consequences and provided very few positive services. On average, however, landowners did slightly agree that cedar provided useful windbreaks, and did not commonly believe that cedar increased soil erosion.

Table 3. The uncentered mean (*M*), standard deviation (*SD*), and median (*MD*) of landowners' beliefs about potential positive and negative consequences of cedar. Responses were given on a 7-point scale where *1 = Strongly disagree*, *4 = Neutral*, and *7 = Strongly agree*. Due to item non-response, the number of respondents for each belief ranged from 821 to 845.

	M	***SD***	***MD***
Positive ecosystem beliefs about cedar			
Provide aesthetic benefits [a] $\alpha = 0.79$	3.09	1.79	3
Provide wildlife benefits [a] $\alpha = 0.77$	4.26	1.80	5
Increase my sense of privacy	3.82	2.06	4
Are a source of products I can use or sell	2.22	1.77	1
Are an important source of shade	3.30	2.08	3
Increase soil quality	2.34	1.59	2
Provide useful windbreaks	4.95	1.85	5
Negative ecosystem beliefs cedar			
Reduce the amount of water flowing in springs and creeks	5.71	1.79	7
Cause allergies	5.59	1.86	7
Reduce the amount or quality of forage available for livestock	5.91	1.81	7
Reduce the number and types of other plant species	5.82	1.69	7
Increase risk of wildfires	5.83	1.65	7
Increase soil erosion	3.44	1.88	3

[a] Cronbach's alpha (α) indicates the internal consistency for concepts measured through multi-item indices.

Exposure, Perceived Threat, and Threshold of Acceptability

Exposure to cedar was bimodal as 40% of landowners indicated that their land looked most similar to the low level of cedar, 14% indicated the medium level of cedar, and 34% indicated the high level of cedar (n = 819). The remaining 12% of respondents were not classified because they indicated that all three photos did not look *at all* like their land.

Landowners' threshold of acceptability for cedar reflected a preference for little to no cedar as 76% indicated that the low level of cedar was within their threshold of acceptability, but that anything above the low level of cedar pictured was "*too high*" (n = 789). For greater levels of cedar, 74% of landowners indicated that the medium level had surpassed their threshold of acceptability (n = 770) and 87% responded that the high level had surpassed their threshold (n = 775).

I constructed an index of perceived threat for each photo based on high reliability and EFA results showing that the evaluations of desirability, acceptability, and threat loaded on a single factor (see Appendix H for individual items and EFA factor loadings). On average, landowners appraised the threat imposed by a low degree of cedar as neutral, while medium and high cedar were perceived as moderately and extremely threatening, respectively (Table 5).

Table 5. The mean (M), standard deviation (SD), and median (MD) for landowners' perceived threat of low, medium, and high cedar based on their preferences for their own land. Cronbach's alpha (α) is presented for each index. The number of respondents ranged from 742 to 772.

Perceived threat of cedar	***M***	***SD***	***MD***
Low cedar photo $\alpha = 0.83$	4.07	1.92	4
Medium cedar photo $\alpha = 0.85$	5.36	1.69	6
High cedar photo $\alpha = 0.84$	6.31	1.36	7

Note: Responses were transformed to a 7-point scale where evaluation of cedar was *1 = Extremely desirable*, *4 = Neutral*, and *7 = Extremely threatening*.

Modelling Factors Related to Threshold of Acceptability

To explore landowners' thresholds for ecological change, I estimated multiple logistic, ordered logit, and OLS regression models that examined the direct and indirect relationships between factors that may influence perceptions of change (Table 6, Table 7, and Table 8). Building consecutive models to examine the associations between landowners' relationship with their land, beliefs about ecological outcomes, perceived threat, and threshold of acceptability for

cedar enabled the statistical examination of multiple cognitive pathways that may predict and explain how people evaluate landscape changes.

Table 6. Summary of logistic regression models predicting the likelihood of surpassing threshold of acceptability for cedar. The unstandardized coefficients (*b*), standard error of coefficient (SE (*b*)), and the p-value (p) are presented for variables in each model. Significant variables are shown in bold. Fit statistics for each model are shown in *Model Fit Statistics* section.

	1. Exposure (n = 482)			**2. Relationship only** (n = 482)			**3. Beliefs only** (n = 456)			**4. Relationship & Beliefs** (n = 456)			**5. Threat only** (n = 482)			**6. Relationship, Beliefs, Threat** (n = 456)		
Variable	***b***	**SE (*b*)**	**p**	***b***	**SE (*b*)**	**p**	***b***	**SE (*b*)**	**p**	***b***	**SE (*b*)**	**p**	***b***	**SE (*b*)**	**p**	***b***	**SE (*b*)**	**p**
Exposure	-0.89	0.17	<0.01	-0.76	0.17	<0.01	-0.58	0.16	<0.01	-0.53	0.16	<0.01	-0.15	0.24	0.53	-0.04	0.23	0.80
Exposure x Exposure	**0.19**	**0.45**	**<0.01**	**0.17**	**0.04**	**<0.01**	**0.12**	**0.04**	**<0.01**	**0.11**	**0.04**	**0.01**	0.04	0.06	0.52	0.02	0.06	0.80
Relationship with land																		
Cluster 1[a]				-	-	-				-	-	-				-	-	-
Cluster 2				**-1.40**	**0.30**	**<0.01**				**-0.90**	**0.30**	**<0.01**				-0.89	0.52	0.09
Cluster 3				**-0.69**	**0.28**	**0.01**				**-0.54**	**0.27**	**<0.05**				-0.64	0.51	0.20
Cluster 4				**-1.45**	**0.29**	**<0.01**				**-0.89**	**0.27**	**<0.01**				-0.92	0.50	0.06
Cluster 5				-0.27	0.29	0.35				-0.30	0.28	0.29				-0.54	0.52	0.30
Cluster 6				-0.61	0.32	0.06				-0.53	0.31	0.09				-0.53	0.54	0.33
Beliefs																		
Aesthetic benefits							**-0.11**	**0.04**	**0.04**	-0.10	0.05	0.07				0.05	0.09	0.60
Wildlife benefits							**-0.12**	**0.05**	**<0.01**	**-0.13**	**0.45**	**<0.01**				-0.13	0.07	0.08
Increase privacy							**-0.11**	**0.04**	**0.01**	-0.07	0.04	0.10				-0.07	0.07	0.34
Source of products							0.06	0.04	0.15	0.06	0.04	0.13				0.10	0.07	0.14
Source of shade							**-0.17**	**0.04**	**<0.01**	**-0.15**	**0.04**	**<0.01**				**-0.18**	**0.06**	**<0.01**
Increase soil quality							**-0.12**	**0.04**	**<0.01**	**-0.13**	**0.04**	**<0.01**				-0.07	0.08	0.33
Useful windbreak							<0.01	0.04	0.91	-0.01	0.05	0.75				**-0.15**	**0.08**	**0.04**
Reduce water							0.01	0.05	0.84	0.03	0.05	0.60				0.04	0.07	0.61
Causes allergies							-0.69	0.04	0.13	-0.07	0.04	0.13				-0.10	0.07	0.17
Reduce forage							**0.14**	**0.05**	**<0.01**	**0.11**	**0.05**	**0.04**				0.08	0.08	0.29
Reduce other plants							-0.7	0.06	0.25	-0.07	0.06	0.26				-0.03	0.09	0.71
Increase wildfire risk							-0.01	0.05	0.79	-0.01	0.05	0.77				<-0.01	0.23	0.99
Increase soil erosion							-0.05	0.04	0.14	-0.04	0.04	0.22				-0.09	0.06	0.15
Perceived threat													**1.29**	**0.13**	**<0.01**	**1.14**	**0.12**	**<0.01**
Model constant	1.21	0.12	<0.01	1.94	0.24	<0.01	0.73	0.20	<0.01	1.34	0.29	<0.01	-0.35	0.20	0.08	0.52	0.52	0.32
Model Fit Statistics																		
Wald X^2 =	32.67			80.67			151			162			106			111		
Prob > X^2 =	<0.01			<0.01			<0.01			<0.01			<0.01			<0.01		
Individual ICC	0.13	0.04		0.06	0.05		0.04	0.02		0.02	0.03		0.24	0.04		<0.01	<0.01	
Region ICC	0.25	0.05		0.20	0.05		0.07	0.05		0.05	0.06		0.44	0.09		0.33	0.10	
Model AIC =	1799			1758			1570			1563			1166			1085		

[a] Indicates reference category thus no values are available.

Model of Exposure to Threshold of Acceptability

Because landowners' judgements occur in the context of the current amount of cedar on their land, I first examined the role of exposure to cedar as a potential control variable for the regression models (Model 1 in Table 6). This model shows a non-linear, inverse relationship between exposure and threshold ($b^2 = 0.19$, $z = 4.22$, $p<0.001$) indicating that, as exposure to cedar increases the probability of a landowner rating the photos as *too high* decreases; but, this relationship flattens out at a moderate level of exposure. While exposure had a significant influence on the likelihood of exceeding one's threshold, the intraclass correlations indicated that a fair amount of error was being explained by individual (ICC = .13) and regional (ICC = .25) differences in the second and third levels of the mixed model.

Model of Relationship to Land to Threshold of Acceptability

Next, I explored whether a landowner's relationship with their land directly influences their threshold of acceptability for landscape change (Model 2 in Table 6). Controlling for the effect of a landowner's current exposure, the way a person related to their land had a significant influence on their threshold for cedar in grasslands (Wald $X^2_{(7)} = 80.86$, $p < = 0.001$). Compared to Cluster 1 who identified as crop-oriented productivists with strong experiential connections and familial ties to their land, Cluster 2 ($b = -1.40$, $z = -4.6$, $p<0.01$), Cluster 3 ($b = -0.69$, $z = 2.46.6$, $p = 0.01$), and Cluster 4 ($b = -1.45$, $z = -5.08$, $p<0.01$), had significantly higher thresholds for cedar. Cluster 5 and Cluster 6 did not significantly vary from Cluster 1, and all three groups were likely to exceed their cedar threshold (Figure 4). In terms of acceptability, the two amenity-based relationship types (Cluster 2 and Cluster 4) were the least likely to view cedar as unacceptable while the two landowner types strongly involved in agriculture (Cluster 1 and

Cluster 5) were the most likely to view cedar as unacceptable. Using a postestimation test, landowners' relationship with the land contributed significantly to the overall fit of the model while accounting for the significant effects of exposure ($X^2_{(5)} = 45.14$, $p < 0.001$). Compared to only knowing a landowner's exposure to cedar, knowing their relationship with the land explained 54% more variance at the individual level (ICC = 0.06) and 20% more at the regional level (ICC = 0.20) and provided a better overall fit to the data (AIC = 1758, $\Delta = -41$).

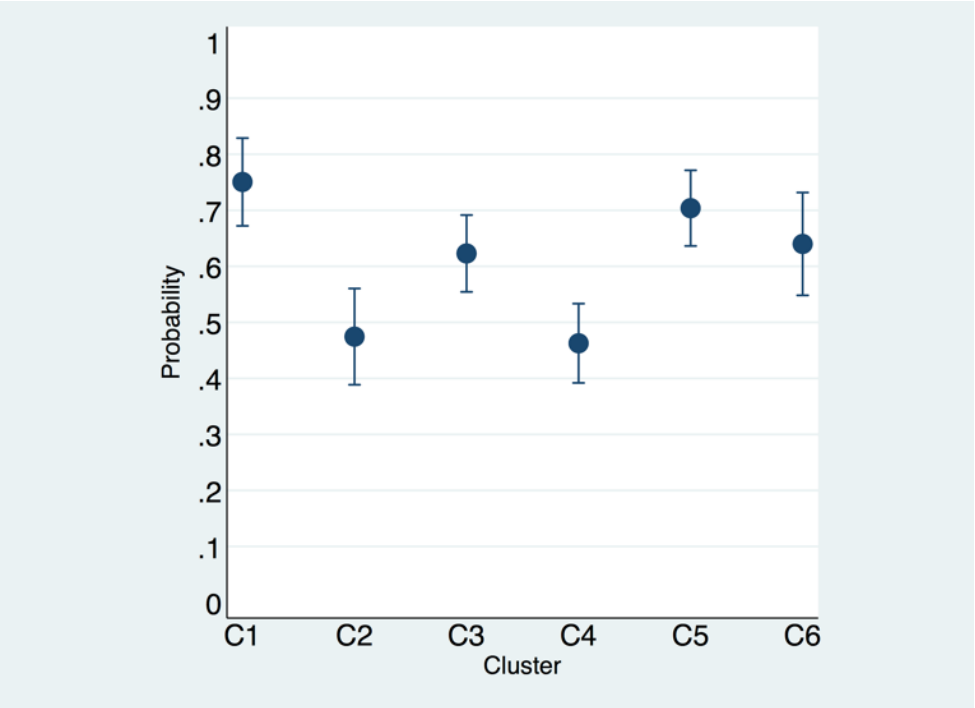


Figure 4. The predicted probability that threshold of acceptability for cedar is exceeded (y-axis) based on a landowner's relationship with the land (x-axis), when exposure is held at its mean.

Model of Relationship to Land to Beliefs about Consequences

A landowner's relationship with their land is the context in which they use and interact with their immediate environment and may be related to the ecosystem services that they value, rely on, or are even aware of. To understand how positive and negative beliefs about cedar related to thresholds for cedar, I first explored how landowners' beliefs about cedar varied based

on their relationship with the land (Table 7). Compared to Cluster 1, other landowner groups held significantly different beliefs about most of the positive services provided by cedar such as aesthetics ($X^2 = 33.87$, $p<0.01$), wildlife benefits ($X^2 = 14.15$, $p = 0.01$), privacy ($X^2 = 48.03$, $p<0.01$), products ($X^2 = 13.58$, $p<0.02$), and shade ($X^2 = 33.87$, $p<0.01$). Of these, Cluster 2, Cluster 3, and Cluster 4 tended to have a greater liklihood of agreeing that cedar provided these positive outcomes than did Cluster 1. Although there was more agreement among landowner groups about the potential negative outcomes of cedar, Cluster 2 and Cluster 4 were significantly less likely to agree that cedar reduced forage and Cluster 5 was more likely to agree that cedar reduced other plant species at a marginally significant level ($p = 0.052$).

Table 7. The log odds (*b*) and standard error (*SE*) of ordinal logits showing different relationships' beliefs about cedar, using Cluster 1 as the reference group. Beliefs were rated *1 = Strongly disagree*, *4 = Neutral*, *7 = Strongly agree* (n = 457).

Belief about cedar/juniper	**Relationship with Land**								
	Cluster 1 [a]	**Cluster 2** ***b* (*SE*)**	**Cluster 3** ***b* (*SE*)**	**Cluster 4** ***b* (*SE*)**	**Cluster 5** ***b* (*SE*)**	**Cluster 6** ***b* (*SE*)**	**X^2**	**p**	**Pseudo R^2**
Positive outcomes									
Aesthetic benefits	-	**1.13 (0.30)****	**0.81 (0.29)****	**1.33 (0.31)****	0.18 (0.31)	0.51 (0.33)	**33.87**	**<0.01**	**0.02**
Wildlife benefits	-	**0.59 (0.30)***	0.09 (0.29)	**0.64 (0.28)***	-0.23 (0.29)	0.20 (0.28)	**14.15**	**<0.02**	**0.01**
Increase privacy	-	**1.30 (0.32)****	**0.60 (0.27)***	**1.62 (0.30)****	0.14 (0.31)	0.30 (0.34)	**48.03**	**<0.01**	**0.03**
Source of products	-	**0.74 (0.36)***	**0.76 (0.34)***	**0.90 (0.34)****	0.35 (0.36)	0.03 (040)	**13.58**	**<0.02**	**0.01**
Source of shade	-	**1.42 (0.33)****	**0.88 (0.31)****	**1.37 (0.30)****	0.38 (0.31)	0.49 (0.36)	**33.87**	**<0.01**	**0.02**
Increase soil quality	-	0.36 (0.31)	-0.07 (0.32)	0.39 (0.32)	-0.35 (0.32)	0.10 (0.34)	9.87	0.08	<0.01
Useful windbreaks	-	-0.03 (0.30)	0.13 (0.27)	0.45 (0.29)	-0.05 (0.32)	-0.35 (0.32)	8.14	0.15	<0.01
Negative outcomes									
Reduce water	-	0.48 (0.31)	0.54 (0.31)	**0.70 (0.30)***	0.57 (0.31)	0.25 (0.30)	7.12	0.21	<0.01
Cause allergies	-	0.13 (0.31)	0.44 (0.33)	0.29 (0.30)	0.11 (0.32)	-0.11 (0.34)	3.88	0.57	<0.01
Reduce forage	-	**-1.17 (0.38)****	0.11 (0.42)	**-0.86 (0.37)***	0.31 (0.42)	-0.57 (0.32)	**30.71**	**<0.01**	**0.03**
Reduce other plants	-	-0.59 (0.37)	-0.17 (0.36)	-0.04 (0.35)	**0.75 (0.39)**$^{+}$	-0.27 (0.37)	**17.49**	**<0.01**	**0.02**
Increase wildfire risk	-	-0.34 (0.33)	0.25 (0.33)	-0.01 (0.31)	0.20 (0.34)	-0.33 (0.25)	6.64	0.25	<0.01
Increase soil erosion	-	0.09 (0.29)	-0.04 (0.29)	0.03 (0.30)	0.45 (0.31)	-0.04 (0.32)	4.19	0.52	<0.01

Relationships with beliefs that were significantly different from Cluster 1 are shown in bold; $^{+}$ $p<0.06$, * $p<0.05$, **$p<0.01$.
[a] Indicates reference category thus no values are available.

Model of Beliefs about Consequences to Threshold of Acceptability

As landowners with different relationships to the land hold different beliefs about the consequences of cedar (Table 7), I next examined the association between beliefs and the threshold of acceptability for cedar (Model 3 in Table 6). Again, controlling for exposure, landowners' beliefs about the ecosystem services and disservices of cedar were significant in explaining thresholds for cedar on their land (Wald $X^2_{(15)} = 152.59$, $p < 0.001$, $n = 458$). Specifically, believing in positive outcomes such as aesthetics ($b = -0.11$, $z = -1.53$, $p = 0.04$), wildlife benefits ($b = -0.12$, $z = -2.67$, $p<0.01$), privacy ($b = -0.11$, $z = -2.58$, $p = 0.01$), shade ($b = -0.17$, $z = -4.42$, $p<.01$) and improved soil quality ($b = -0.12$, $z = -2.70$, $p<0.01$) all significantly decreased the liklihood that a given level of cedar would exceed one's threshold of acceptability. Believing that cedar decreased available forage was the only negative outcome belief that significantly increased the likelihood of surpassing one's threshold for cedar ($b = 0.13$, $z = 2.72$, $p<0.01$). Understanding the perceived consequences of cedar reduced the residual variation explained by random individual differences (ICC = 0.04) and regional differences (ICC = 0.07). This model also provided a large reduction in the AIC (1570, $\Delta = -188$) as compared to the previous two models indicating that landowners' threshold of acceptability is better modeled by their beliefs about consequences than just their exposure and/or relationship with the land.

Model of Relationship to Land and Beliefs about Consequences to Threshold of Acceptability

Landowners' threshold of acceptability for cedar varied based on how they related to their land. Acceptance also varied according to the beliefs they had about cedar, which differed based on their relationship to the land. Given these associations, I assessed if relationship with the land was still directly related to threshold when considering landowners' beliefs (Model 4 in

Table 6). I found that beliefs about cedar partially mediated the influence of relationship on thresholds (Wald $X^2_{(20)} = 161.97$, $p < 0.001$, $n = 456$). Similar to the previous model, believing that cedar provided the positive outcomes of wildlife benefits ($b = -0.12$, $z = -2.84$, $p<0.01$), shade ($b = -0.15$, $z = -3.94$, $p<0.01$), and improved soil quality ($b = -0.13$, $z = -2.99$, $p<0.01$) significantly decreased the likelihood of perceiving cedar as too high, while believing that cedar had the negative outcome of reducing available forage significantly increased the likelihood of perceiving cedar as too high ($b = 0.11$, $z = 2.11$, $p<0.04$). When accounting for the effects of exposure and beliefs, all groups were more than 50% likely to surpass their thresholds for cedar (Figure 5). Based on Cluster 1 as the reference group, however, landowners with Cluster 2 ($b = -0.90$, $z = -3.04$, $p<0.01$), Cluster 3 ($b = -0.54$, $z = -1.98$, $p<0.05$), and Cluster 4 ($b = -0.89$, $z = -3.34$, $p<0.01$) relationships remained significantly less likely to exceed their threshold of acceptability for cedar (Model 4 in Table 6). This model provided a better fit to the data as compared to the previous belief-only model (Model 3) as indicated by the reductions in individual ICC (0.02), region level ICC (0.05), and the AIC (1563, $\Delta = -7$). A postestimation test confirmed that relationship to the land makes a significant contribution to the fit of the model when accounting for exposure and beliefs (Wald $X^2_{(5)} = 17.03$, $p < 0.001$).

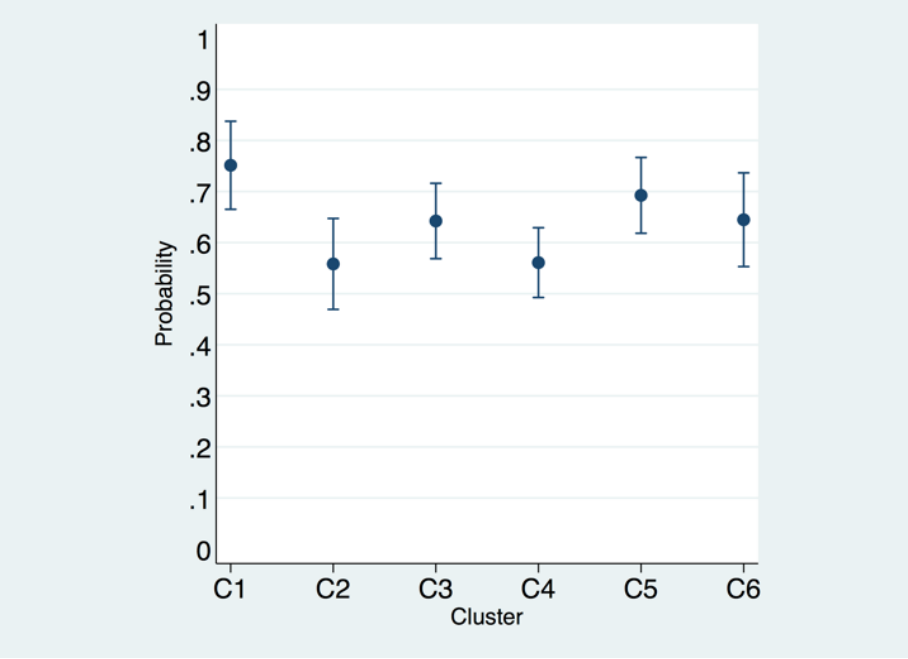


Figure 5. The probability of exceeding threshold of acceptability for cedar (y-axis) based on relationship to land (x-axis), while controlling for exposure and holding beliefs about cedar at their means.

Model of Relationship to Land and Beliefs about Consequences to Perceived Threat

Because perceived threat is considered a major driver of reactions to change, threat may subsume the influence of relationship and beliefs on one's acceptance of cedar in grasslands. To explicitly understand the role of threat perceptions in one's thresholds for ecosystem transformation, I first examined how relationship to land and outcome beliefs related to perceived threat (Table 8). I found that certain positive beliefs about cedar- that it had aesthetic benefits ($b = -0.14$, $z = -3.35$, $p<0.01$), provided shade ($b = -0.07$, $z = -2.38$, $p = 0.02$), and improved soil quality ($b = -0.12$, $z = -3.41$, $p<0.01$) were related to perceptions of cedar as significantly less threatening (Wald $X^2_{(21)} = 410.\ 88$, $p < 0.001$). Similar to the threshold models, the belief that cedar has the negative outcome of decreasing forage significantly increased the evaluation of cedar as a threat ($b = 0.07$, $z = 2.06$, $p = 0.04$). While accounting for exposure and holding beliefs at their means, landowners in Cluster 2 ($b = -0.50$, $z = -2.84$, $p<0.01$) and Cluster

4 (b = -0.45, z = -2.70, p<0.01) perceived significantly less threat from cedar than did Cluster 1, the reference group. The residual ICC's were again close to zero meaning that this model accounted for most of the variance at the individual (ICC = 0.02) and regional (ICC = 0.02) levels. While controlling for exposure and beliefs, a postestimation test indicated that relationship with the land provided a significant benefit to understanding threat (Wald $X^2_{(5)}$ = 14.41, p = 0.013). In isolation, the relationship between perceived threat and threshold of acceptability was significant (Wald $X^2_{(3)}$ = 106.06, p<0.001) and accounted for the influence of exposure seen in previous models (Model 5 in Table 6). While it produced a major reduction in the AIC (1166, Δ = -397) from the belief-and-relationship model (Model 4), the threat-only model left the greatest amount of unexplained variance to be accounted for by individual (ICC = 0.24) and regional (ICC = 0.44) differences.

Table 8. Summary of regression model explaining perceived threat showing the unstandardized coefficients (*b*), standard error of coefficients (SE (*b*)), and the p-value (p) for variables in the model (n = 456). Significant variables are shown in bold.

Variable	***b***	**SE (*b*)**	**p**
Exposure	-1.22	0.26	<0.01
Exposure x Exposure	**0.56**	**0.18**	**<0.01**
Relationship with land			
Cluster 1 [a]	-	-	-
Cluster 2	**-0.50**	**0.18**	**<0.01**
Cluster 3	-0.20	0.16	0.21
Cluster 4	**-0.45**	**0.17**	**<0.01**
Cluster 5	-0.03	0.15	0.85
Cluster 6	-0.27	0.17	0.11
Beliefs about cedar			
Aesthetic benefits	**-0.14**	**0.04**	**<0.01**
Wildlife benefits	-0.05	0.03	0.12
Increase privacy	-0.05	0.03	0.07
Source of products	0.02	0.03	0.57
Source of shade	**-0.07**	**0.03**	**0.02**
Increase soil quality	**-0.12**	**0.03**	**<0.01**

Useful windbreak	0.05	0.03	0.08
Reduce water	0.01	0.03	0.74
Causes allergies	-0.2	0.03	0.51
Reduce forage	**0.07**	**0.04**	**0.04**
Reduce other plants	-0.04	0.04	0.36
Increase wildfire risk	-0.01	0.04	0.84
Increase soil erosion	<0.01	0.03	0.97
Model constant	5.49	0.18	<0.01
Model Fit Statistics			
Wald X^2	410.88		
Prob > X^2	<0.01		
Individual ICC	0.01	0.01	
Region ICC	0.01	0.03	

[a] Indicates reference category thus no values are available.

Model of Relationship to Land, Beliefs about Consequences, and Perceived Threat to Threshold of Acceptability

When threshold of acceptability was modeled with perceived threat, beliefs, relationship, and exposure (Model 6 in Table 6), perceived threat captured most of the variance previously explained by other variables (Wald $X^2_{(22)} = 13.75$, $p = 0.017$). Perceived threat was significantly related to an increased likelihood of threshold exceedance ($b = 1.13$, $z = 9.31$, $p<0.01$) whereas the beliefs that cedar was a useful source of shade ($b = -0.17$, $z = -2.79$, $p<0.01$) and windbreak ($b = -0.15$, $z = -2.04$, $p = 0.04$) both significantly decreased the likelihood of surpassing the threshold of acceptability (Model 6 in Table 6). The Cluster 4 relationship was marginally significant at the $\alpha = 0.05$ ($b = -0.92$, $z = -1.86$, $p = 0.063$) when controlling for other variables and using Cluster 1 as a reference group; yet, the postestimation test indicated that relationship to land did not significantly contribute to understanding cedar thresholds when perceived threat was also included (Wald $X^2_{(5)} = 4.53$, $p = 0.48$). This model accounted for nearly all the residual

variation at the individual level (ICC<0.001), but left more variation at the regional level than most prior models (ICC = 0.33). However, incorporating perceived threat as well as beliefs, relationship, and exposure provided the best fitting model for understanding landowners' thresholds for cedar as indicated by the lowest AIC (1085) of all models. For all ways that landowners related to their land, high threat perceptions of cedar lead to a near certain expected probability of exceeding one's threshold for cedar, while strong positive perceptions lead to extremely low likelihoods of exceeding one's threshold (Figure 6).

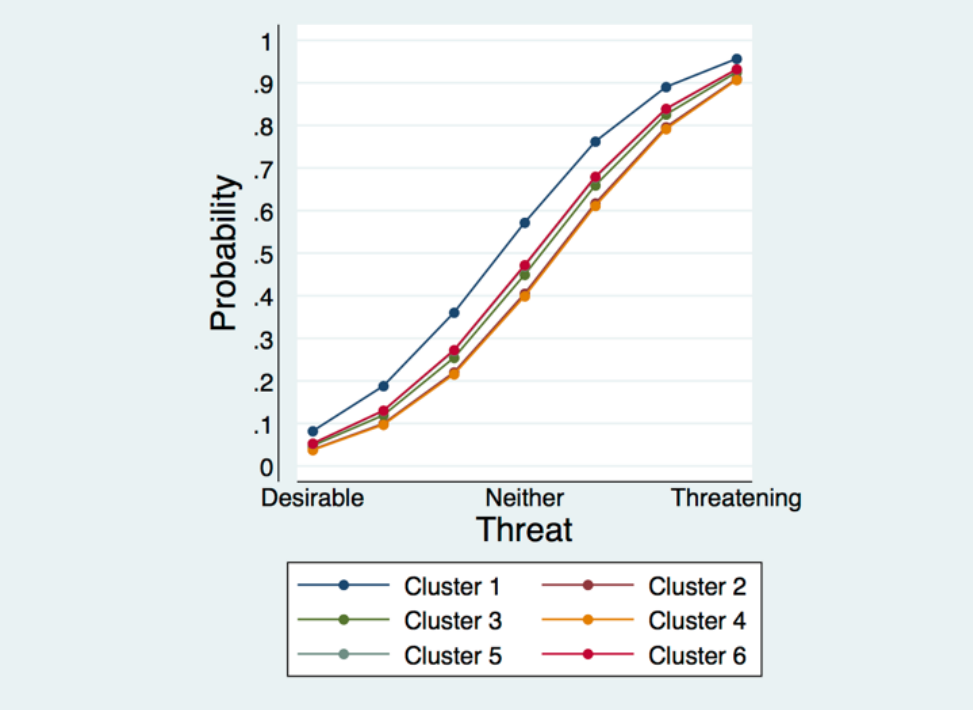


Figure 6. The predicted probability of each relationship type exceeding their threshold of acceptability for cedar as perceived threat increases, while controlling for exposure and all of the beliefs about consequences at their means.

Discussion

The respondents from the Edwards Plateau, Central Great Plains, and Flint Hills reflect the diversification of the social landscape beyond traditional production agricultural that has been documented in the Southern Great Plains and throughout rural lands worldwide (Berg et al., 2015; Brunson & Huntsinger, 2008; Gill et al., 2010; Gosnell & Abrams, 2011; Mendham & Curtis, 2010; Sorice et al., 2012_b). Not only is this heterogeneity expressed through varied land uses and personal characteristics of landowners, but also and perhaps more so, through the plethora of different meanings that comprise the distinct ways landowners related to their land. This is reflected in how landowners perceived WPE given that it is salient throughout the Southern Great Plains: most landowners believed that cedar led to numerous negative outcomes and provided very few ecosystem services. As such, landowners in general had low thresholds of acceptability for cedar in grasslands, which they perceived as increasingly threatening at greater degrees of encroachment.

Given respondents' predominant dislike of cedar at varying degrees of encroachment throughout the three regions in the study area, I first explored the influence of landowners' current exposure to cedar. The level of exposure had a significant influence on landowners' perceived threat and threshold of acceptability for cedar. Most landowners in this study indicated that they were exposed to either high or low levels of cedar; however, people who had higher levels of cedar on their land were *more*, not *less*, likely to be tolerant of cedar. As my study was cross-sectional, I cannot determine causation between landowners' exposure and thresholds, however, different plausible interpretations of these findings may represent shifting baselines either within individuals or at a collective level through land ownership change (Papworth et al.,

2008). Shifting baselines syndrome (Pauly, 1995) refers to the gradual lowering of baselines for environmental conditions as norms of what is acceptable change in response to reference points based on higher levels of degradation (Soga & Gaston, 2018). Shifting baselines can occur when people are unaware of previous environmental conditions due to a lack of information about past conditions, have diminished interactions with the environment, or through lack of familiarity with the natural environment (Soga & Gaston, 2018). This presents major challenges for conservation and efforts to combat environmental degradation as people become more tolerant of degraded conditions and change their preferences for desired states of nature (Soga & Gaston, 2018).

The current state of encroachment may influence landowners' perceptions of change as people often develop different reference points in relation to environmental stressors to which they are frequently exposed (Gatersleben & Griffin, 2017). In such cases, people with long-term or greater exposure to chronic environmental stressors can develop higher baselines as the reference point from which they evaluate the stress (Gatersleben & Griffin, 2017). This may represent successful adaptation to altered conditions; however, shifting baselines within individuals is often indicative of a negative habituation with adverse psychological consequences through "learned helplessness and exhaustion" as a result of lack of control or repeated failures at removing or reducing the stress (Gatersleben & Griffin, 2017, p. 470). In terms of ecosystem transformation, this is an important lesson as people may adjust to changing conditions at the expense of their psychological health and overall well-being (e.g., loss of connections to place, diminished relational values) if they feel incapable of combatting the unwanted change (Gatersleben & Griffin, 2017; Steg et al., 2013). Further research is needed to explore if baselines for WPE are shifting within individuals and/or collectively as land ownership turns

over to new generations or landowners less familiar or knowledgeable about grassland environments.

Despite landowners' general negative disposition toward woody plants, the relationships identified through patterned meanings of place are a useful lens to understand how perceptions of ecological change vary as function of an individual's vulnerability. Landowners among the six relationship types identified in this study demonstrated different degrees of sensitivity to the ecosystem transformation of grasslands reflecting that "people respond to change differently depending on how their respective meanings are affected by this change" (Masterson et al., 2017, p.49). Although there was near-consensus (87%) that high densities of cedar were unacceptable in grasslands, landowners who held strong meanings related to farming or ranching livelihoods and their family's heritage (i.e., rootedness in the area) were more likely to view cedar as unacceptable than landowners whose sense of place was based on natural amenities like wildlife habitat, hunting, and recreation and a low degree of familial rootedness. This difference in thresholds held true for the two groups that expressed the highest belief and dependence on meanings related to place attachment reinforcing the assertion that the meanings of a place, not simply the strength of attachment, drive how individuals interpret and respond to place change (Devine-Wright & Howes, 2010; Masterson et al., 2017). Person-place relationships thus play an important role in understanding perceptions of ecological change.

It has been proposed that people are more likely to protect psychologically restorative, 'natural' places to which they are attached (Devine-Wright & Howes, 2010). Although two landowner groups expressed strong restorative meanings for their place (e.g., stress recovery, escape), the group that also held meanings related to grazing livestock, food production, and economics was more threatened and less likely to accept woody plant encroachment. This

corroborates Wilcox et al.'s (2018) hypothesis that resource-dependent grassland owners would show greater preference for grasslands than landowners who use their land in other ways, such as for hunting opportunities. Landowners who relate to their land through meanings dependent on grasslands may serve as the best stewards of the resource acting as first responders against potential threats or drivers of policy to sustain grassland health, supporting utility of ranching and working landscapes as a conservation strategy for private rangelands (Brunson & Huntsinger, 2008). Given the heterogeneity of landowners, however, it is difficult to say whether these likely stewards and their potential responses would be sufficient to arrest unwanted grassland transformation.

A number of individual studies have separately assessed how the meanings people ascribe to places can influence their landscape preferences, beliefs and attitudes about a place, and evaluations of place-change (Devine-Wright & Howes, 2010; Smith et al. 2011; Stedman, 2002). Building on their findings, I examined these multiple pathways and found that the association between a landowner's relationship with their land and their threshold of acceptability for change was further explained through knowing their beliefs about the consequences of change and their perceptions of threat. Landowners' responses to natural hazards are largely shaped by beliefs about the hazard (Arbuckle, Morton, & Hobbs, 2015). Place-research suggests that these beliefs are then used to interpret the implications of change for importantly held place meanings, not necessarily the objective effects of change on a place itself (Devine-Wright, 2009; Jacquet & Stedman, 2014). Applied to WPE in the Southern Great Plains, landowner's beliefs about cedar likely influence their beliefs about the implication's cedar expansion will have for the way they relate to their land, leading to some level of perceived threat as an attitude towards WPE (Ajzen, 2002; Fishbein & Ajzen, 2010). Landowners who felt

more threatened by this landscape change were far more likely to feel that this change was unacceptable, crossing a threshold where they are more likely to engage in adaptive actions to restore acceptable conditions (Zajac et al., 2012). As the data collected in this study was cross-sectional, the series of models tested are not causal, but do follow known psychological processes and accepted conceptualizations to provide a plausible explanation of the pathways by which people evaluate change (Ajzen, 1991; Fishbein & Ajzen, 2010; Devine-Wright, 2009).

Categorizing people through typologies is commonly used in private landowner research to distil the similarities and differences among a potentially diverse population into recognizable groups. Any typology, and the utility of resulting groups, likely has strengths and weaknesses based on the approach from which it was created and the purposes for which it will be used (Dayer et al., 2014). The different meanings and dependencies that comprise the landowner relationships found in this study provide more detail than typical characterizations of the 'production' versus 'lifestyle' landowner. This is a continuation of efforts in private landowner research to move from understanding landowners through basic demographics to more in-depth methods that better portray the motivations and meanings of land ownership (e.g., Sorice et al. 2012; 2014). Although the relationships I found reflect some common archetypes of landowners identified in the literature (e.g., rancher, farmer, lifestyle landowner), these relationships transcend roles and holistically capture relational values of people's connections to places that can contribute to the sense of a fulfilling, meaningful life (Chan et al., 2016). While notably complex, these relationships illustrate the importance of not oversimplifying the way landowners connect with and relate to their land (Sorice, Rajala, & Kreuter, 2018).

For example, the landowner group that most strongly relied on their land as a grassland and for economic and livelihood aspects related to livestock production also strongly believed

that their land provided recreation and psychological benefits such as mental restoration and optimal, immersive experiences (i.e., psychological flow). This group expressed high reliance on their land for these experiences; however, research on place tends to reserve the measurement of these meanings for recreational visitors or amenity-oriented landowners (e.g., Williams & Vaske, 2003; Wynveen & Kyle, 2015). One of the two groups of landowners that related to their land based on place character and functional meanings associated with natural amenities, as opposed to agricultural production, indicated that they also strongly relied on their land as an important part of their identity, way of life, and the legacy that they wanted to pass on to future generations. The social vulnerability of this type of landowner would be missed by frameworks like resource dependency that consider only the specific subset of landowners that are engaged in agricultural production. Not only did landowners hold a wide array of place meanings, most indicated that they depended on their land to supply many of these meanings. By expanding Marshall's concepts of social vulnerability and resource dependency to apply to a wider range of landowners and the ways they relate to their land, research can better capture heterogeneity on the landscape and thus better explain behaviors of landowners in response to environmental change.

While increasingly important given the scope and scale of environmental changes, human relationships with nature are rarely simple (Chan et al., 2016; Masterson et al., 2017). Careful design of quantitative studies can represent rich human experiences through data. My survey instrument included a wide range of potentially salient place meanings, derived from a number of literatures and interviews with landowners, and allowed respondents to indicate their belief and dependence on meanings independently. Measuring meanings along these two dimensions enabled nuance and depth that more closely approximates qualitative research on sense of place

(e.g., Davenport & Anderson, 2005). The relationships identified in this study have stand-alone value as they provide descriptive portraits of the people that comprise the shifting social landscape of rural rangelands in the Southern Great Plains. My approach to measuring belief in and dependence on place meanings in this study provides a template for future quantitative research to better convey the breadth of human experiences with nature and the relational values that these connections produce.

Conclusion

Within social-ecological systems, the vulnerability of system components to perturbations and change can determine the sustainability or collapse of the system. In regards to social vulnerability, people's sensitivity to ecological change is tied to how they relate to the place undergoing change and their beliefs about the implications of the place-change. Measured through perceived threat and acceptance of WPE, thresholds can be critical tipping points that drive adaptive, place-protective behavior by changing human feedbacks and the potential trajectory of the social-ecological transformation.

By applying this framework to woody plant encroachment in three regions of the Southern Great Plains, I found that landowners in my sample were more likely to view cedar (*Juniperus* spp.), a woody plant species predominant in grassland transformation, as unacceptable based on their beliefs about cedar and how the consequences of this landscape change may threaten the ways in which they related to their land. A "new normal" may be emerging wherein landowner baselines for WPE are shifting, which may indicate either positive adaptation or negative habituation to this change. Understanding what drives landowners'

differential perceptions and thresholds for woody plants provides the underlying context for the subsequent study of specific management actions that either sustain grasslands or enable further conversion. A next step is to understand the cognitive processes that leads landowners to engage in adaptive behaviors to enhance the resilience of grasslands.

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Chapter 2. Woody Plant Management in the Southern Great Plains: Understanding the Goal Intentions and Management Actions of Private Landowners

Abstract

Conversion of grasslands through the expansion of trees and shrubs is a global phenomenon that threatens the integrity of grassland ecosystems, provision of important ecosystem services, and sustainability of many rural livelihoods. In the Southern Great Plains of the United States, the actions of private landowners are paramount to sustaining grasslands and preventing woody invasions. Understanding the drivers of adaptive woody plant management is increasingly important given the diversification of land uses and land ownership motivations shifting the social landscape of rural rangelands in the Southern Great Plains. Through a mail survey of 2,993 private landowners in 53 counties across Texas, Oklahoma, and Kansas, I examined the drivers of landowners' management goals for cedar (*Juniperus* spp.) and their current use of five adaptive, environmentally relevant management practices. The survey received a 35% response rate and most landowners (75%) had the goal intention to lower cedar on their land and were currently engaged in management actions to do so (73%). Using a series of regression models, I found that the goal intention to reduce cedar was driven by dissatisfaction with unacceptable levels of change, followed by the perceived feasibility of this goal, and personal and social norms. In turn, landowners' goal intentions to lower cedar were a significant predictor of their use of management practices, followed by the degree of their normative goal-frame. Despite uncertainty regarding landowners' orientation towards grassland conversion and woody plant expansion, this research demonstrates that most landowners in the Southern Great

Plains want to control or remove cedar and are actively engaged in management behaviors to achieve this goal. For application to other environmental issues or unwanted ecosystem transformations, these results suggest that dissatisfaction and normative influences play a large role in people's goal intentions to intervene or prevent unwanted change, and that goal intentions and normative considerations of what is appropriate relate to higher levels of adaptive engagement.

Introduction

Adaptive, environmentally relevant behaviors are of critical importance in preventing unwanted ecosystem transformations such as grassland conversion to woodlands through the proliferation of woody shrubs and trees. Woody plant encroachment (WPE) is a global phenomenon with far-reaching social and ecological consequences (Archer et al., 2017; Naito & Cairns, 2011; Eldridge et al., 2011). This transformation not only alters ecosystem composition and function to the detriment of grassland dependent plant and animal species but also changes the type and delivery of ecosystem services that support people's livelihoods, connections to place, and sustain many rural communities and local economies (Wilcox et al. 2018). WPE often parallels human settlement (Pyne, 2001) and exurban migration to rural rangelands (Brown et al., 2005) as active fire suppression and overgrazing have dramatically reduced the frequency of historic fire regimes, driving WPE in grassland systems (Walker & Meyers, 2004; Briggs et al., 2005). Other human-related factors such as the elimination native browsers, landscape fragmentation, and increased atmospheric CO_2 further enable the expansion of woody plants into grasslands (Briggs et al., 2005; Archer et al. 1995).

In the Southern Great Plains of the United States, the management actions of private landowners are integral to sustaining grasslands. The tall, mixed, and short grass prairies of this region evolved through frequent natural and human-driven disturbances from expansive fire and the migratory grazing patterns of large mammals (Assal et al., 2015). While these grasslands were once part of the largest continuous ecosystem in North America (NPS, 2016), they were drastically reduced following Euro-American settlement, land use, and development. Today, the remaining grasslands of the Southern Great Plains continue to face anthropogenic pressures and have experienced woody plant encroachment at rates 5-7 times greater than anywhere else in the United States (Wilcox et al., 2018). Multiple *Juniperus* species (e.g., eastern redcedar, Ashe juniper, redberry juniper) have expanded their range 60-70% over millions of acres of northwest Texas and Oklahoma (Ansley & Wiedemann, 2008) and functional tallgrass prairie exists in Kansas as only 4% of its historic range (NPS, 2016).

While human actions drive the expansion of woody plants in grassland systems, land management can decrease or prevent further encroachment. Natural and human-caused fire is an integral part of grassland ecosystems and is the most effective management tool to prevent woody plant encroachment as illustrated in areas where periodic fire regimes have been maintained, which contain the most intact grasslands in the United States (Assal et al., 2015; Briggs et al. 2005). Mechanical removal of woody plants is common and very effective at thinning areas where dense stands have established; however, physical removal with heavy equipment is not always practical or economical (Archer et al., 2011; 2017). Manual removal through the use of hand tools can be a successful preventative measure at early stages of woody plant encroachment and as a part of a more comprehensive brush management strategy (Simonsen et al., 2015). Spot treatments and broad application of chemical herbicides are

effective controls for certain woody plant species. Additionally, prescribed browsing by goats (i.e., at high densities in specific areas for a set duration) can a provide biological control on woody species and preventing the establishment of woody seedlings and precluding woody plant invasions (Archer et al., 2011; Taylor, 2008). At high densities, woody plant stands may require successive or multiple treatments such mechanical thinning to break up continuous canopies and encourage herbaceous growth prior to the application of prescribed fire or other treatments (Ansley & Wiedemann, 2008). Current best practices to control or reduce woody plant expansion recommend integrating these different management techniques spatially and temporally across the landscape to mimic natural patterns of disturbance (Archer et al., 2011).

Despite the availability of different potential management solutions to prevent the expansion of woody plants, WPE continues to be a pervasive problem. Some management practices, such as prescribed fire, face social constraints due to concerns about safety and legal responsibility, lack of training and equipment, or culturally entrenched negative attitudes regarding its use (Krueter et al., 2008; Toledo et al., 2013; Harr et al., 2014). Additionally, rural rangelands in the Southern Great Plains have experienced growing populations of landowners who emphasize natural and cultural amenities over production-oriented land uses dependent on grasslands (Berg et al., 2015; Brown et al., 2005; Gosnell & Abrams, 2011; Sorice et al. 2012; 2014). Every landowner has an individual personal history (Hurst, Ramsdell, & Sorice, 2017) and motivation for land ownership (VanWey et al., 2005), which drives their land use goals and use of different land management practices (Sorice et al., 2014). The variation in individual land management practices can shape ecosystem dynamics and alter landscape-scale ecosystem services (Gosnell & Travis, 2005; Theobald, 2001); however, the implications of land ownership change for the prevention or expansion of woody plants in the Southern Great Plains is unknown.

The shifting social landscape of the Southern Great Plains complicates assumptions that rural landowners universally perceive woody plants as a problem to be actively managed. Thus, understanding landowners' acceptance of trees and shrubs in grasslands and their orientation towards grassland conversion is a critical research need (Leis et al. 2017).

Landowners have different perceptions of, and acceptance levels for grassland conversion based on their vulnerability to the consequences of this landscape change, which varies according to how landowners relate to their land (see Chapter 1). The tipping point where the level of woody plants threatens a landowner's relationship with their land and is considered unacceptable, is hypothesized to motivate adaptive land management behaviors aimed at preventing or reversing this unwanted change (Zajac et al., 2012). In this research, I explored people's behavioral responses to ecological change, from forming a goal to intervene in the ecological transformation to actually implementing land management behaviors aimed at preventing unwanted ecosystem change. To investigate how thresholds related to actual behavior, I examined the role of social-psychological factors in landowners' goal-directed management actions towards woody plants. My objectives were to understand the drivers of landowners' goals for woody plants and how these goals translate into the use of five management practices that prevent woody plant encroachment and sustain grasslands: prescribed fire, mechanical removal, manual removal, biological controls through prescribing browsing by goats, and the application of herbicides.

Conceptual Framework

In social-ecological systems, human behaviors provide feedbacks to the biophysical domain that can steer the trajectory of the system and influence the provision of important ecosystem services leading to a range of both human and environmental outcomes (Collins et al., 2011; Wilcox et al., 2018). Given heightened awareness about people's role in modern environmental issues, much research has characterized what drives people to adopt or engage in actions that minimize ecological impacts or promote and enhance the natural environment (Bamberg 2013; Bamberg & Moser, 2007; Larson et al., 2015; Steg et al., 2014). Land management practices that enable the sustainable use and conservation of natural resources are an important dimension of pro-environmental behavior (Larson et al., 2015) and are of critical importance on private lands. This is accentuated in the Southern Great Plains as 90% of the land in this region is privately owned (Assal et al., 2015). As such, the land management practices that prevent woody plant expansion and sustain grasslands are adaptive, environmentally relevant behaviors.

An individual's intentions to act are considered the most important determinant of actual behavior, yet, on average, behavioral intentions account for only 30% of the variance in observed behavior (Bamberg, 2013; Bamberg & Moser, 2007). To better explain this noticeable gap between behavioral intentions and implementation, scholars have posited that engaging in a behavior is a goal-directed cognitive process whereby individuals progress through multiple stages: setting a goal, choosing a specific behavior to achieve that goal, forming a plan to implement the behavior, and engaging in the behavior (e.g., Bamberg, 2013). Progression from one stage to another is based on the sequential influences of social-psychological constructs

related to the activation of personal norms through the Norm Activation Model (Schwartz, 1977) and the values people attach to the outcomes of potential behavior as explained by Theory of Planned Behavior (Ajzen, 1991; Ajzen, 2002). Bamberg (2013) proposes that these theories are more or less influential at certain stages of goal-directed behavior, building on meta-analyses that advocate for combining aspects of these two theories to improve predictions of pro-environmental behavior (e.g., Bamberg & Moser, 2007).

To understand the determinants of landowners' goals for woody plants, I borrowed from Bamberg's (2013) conceptualization of behavior originating in a predecisional phase where an individual forms a personal commitment to achieve some objective, referred to as a "goal intention". In this phase, the activation of personal norms provides the initial impetus to invest the cognitive effort to reflect on and form goals, which are mental representations of some desired future state (Steg, van den Berg, & de Groot, 2013). Following Schwartz's (1977) Norm Activation Model, when a person feels responsible (ascription of responsibility) for something that has harmful consequences they may experience negative emotions that activate a sense of obligation stemming from their personal standards (personal norms). Additionally, internalizing the responsibility for some harm may prompt concern about what other people in similar situations do (social norms) and further engage one's personal norms to avoid social disproval. This pathway creates an incentive to form a goal intention, but committing to a goal is also influenced by the perceived feasibility of that goal (Bamberg, 2013). Although some scholars have conflated feeling responsible for a problem with the perception that one can effectively contribute to solutions, research has shown that ascription of responsibility and perceptions of goal feasibility are conceptually unique (Steg & de Groot, 2010).

Negative emotions associated with the activation of personal norms are often considered as stress or guilt; however, other emotional responses have also been linked to pro-environmental behaviors (Lindenberg & Steg, 2007). Emotional, or affective responses, are based on the degree of "goodness" or "badness" felt in relation to the positive or negative qualities of some stimuli and can yield important, but often underappreciated, influences on people's judgements and decision-making process (Slovic et al., 2005; Steg et al., 2013). Dissatisfaction may adequately capture landowners' emotions towards their exposure to environmental hazards or stressors producing undesirable changes on their land. Place-based research indicates that dissatisfaction with the quality of an area may compel protective, environmentally relevant behavior when that place is "important but threatened" (Stedman, 2002, p.576). Based on my previous findings (see Chapter 1), when exposure to an environmental stressor threatens how people relate to their land, their likely dissatisfaction with unacceptable conditions from "forced change" should encourage them to take action. Understanding landowners' satisfaction or dissatisfaction with the level woody plants on their land, based on their exposure and tolerance, incorporates antecedent evaluations of ecological change and can assist in explaining the formation of goal intentions and the implementation of actual behavior.

Along with the activation of personal norms, a person's goal for environmental change may also be related to their goal-frame; the abstract, overarching goal that "frames" the way a person comprehends given situations and guides a larger set of relevant subgoals (Lindenberg & Steg, 2007; Steg et al., 2013). A person's active goal-frame may be hedonic (to seek pleasure and avoid discomfort), gain (to maintain one's resources and seek self-enhancement), or normative (to act appropriately based on one's personal and social norms). As such, goal-frames influence how information is interpreted and acted upon providing motivation that steers the decision to

change or engage in some behavior (Lindenberg & Steg, 2007). Goal framing theory proposes that while people have multiple, and often competing goals, one goal-frame is active and dominant at any one point, and that certain situations prompt the dominance of one goal-frame over another.

Similar to Bamberg's (2013) argument that certain behavioral theories are more applicable to people in certain stages of goal-driven behavior, Lindenberg and Steg (2007) posit that the actions of people with different goal-frames are best explained by specific behavioral theories. For example, situations with high-cost actions are likely to invoke a gain-dominant goal-frame in which people's environmental behavior is motivated by rational self-interest and may be best understood through Ajzen's (1991, 2002) Theory of Planned Behavior. Situations that influence the way a person feels in the moment likely enhance the hedonic goal-frame and theories on affect, which assess the roles of emotions and risk perceptions, may be most relevant to people's subsequent behaviors. And finally, situations in which people are aware of environmental problems and concerned about their consequences likely promote normative goal-frame, where pro-environmental behavior is best explained through Schwartz's (1977) Norm Activation Model. Research suggests that gain and hedonic goal-frames may inhibit engaging in pro-environmental behaviors when behaviors are costly or difficult whereas the normative goal-frame may facilitate environmentally conscious actions as people are more sensitive to what they think they ought to do (Steg et al., 2014). Goal framing theory dovetails into Bamberg's (2013) stage model of goal-driven behavior as a person's overarching goal-frame may influence both their goal intention towards woody plants and their subsequent behavior as hypothesized through the behavioral theories linked to each goal-frame.

I applied Bamberg's (2013) conceptualization of goal intentions, Lindenberg & Steg's (2007) goal framing theory, and insights from vulnerability and place change research (see Chapter 1) to understand landowners' use of environmentally relevant land management practices that prevent woody plant expansion. I conceptualized this cognitive process as a progression from dissatisfaction resulting from the unacceptability of current exposure to woody plants, to forming a goal towards woody plants, to implementing specific management actions to achieve this goal (Figure 1).

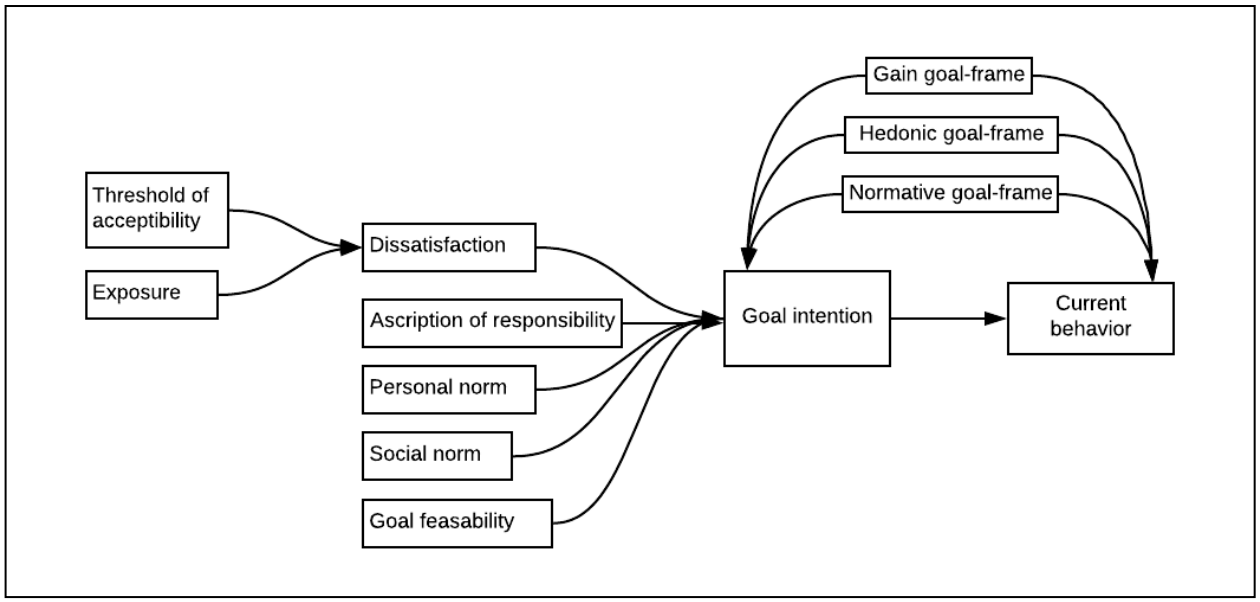
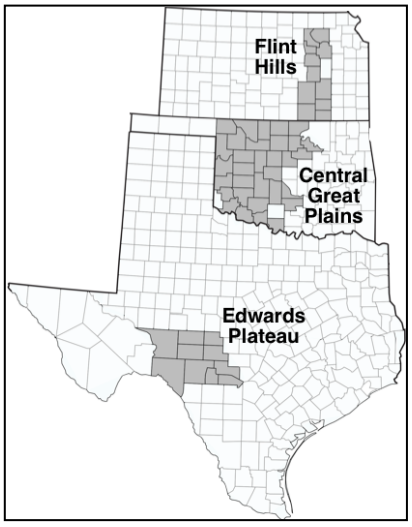


Figure 1. Conceptual framework for understanding goal-directed environmentally relevant behavior in response to unwanted ecological change. In my research, these concepts are applied to private landowners experiencing woody plant encroachment into grasslands.

Study Area

My research examines three specific ecoregions within the Southern Great Plains; A) the Flint Hills in eastern Kansas, B) the Central Great Plains in western and central Oklahoma, and

C) the Edwards Plateau in south central Texas (Figure 2). These ecoregions are spatially defined by the Environmental Protection Agency (EPA) based on distinct biotic and abiotic ecosystem components (Omernik, 1987; Omernik and Griffith, 2014). Further, these regions are socially, culturally, and ecologically unique in their histories and in their management responses to woody plant encroachment (Wilcox et al., 2018). Together, they provide the opportunity to study the complex social-ecological dynamics of woody plant encroachment and land ownership change along both a societal and ecological gradient. The specific counties included in this research were selected based on ecoregion boundaries, existing ecological data regarding WPE, and expert opinion from project collaborators about woody plant cover and species relevant to this research.



A) Flint Hills, Kansas
11 counties: Butler, Chase, Chautauqua, Cowley, Elk, Geary, Greenwood, Morris, Pottawatomie, Riley, and Wabaunsee

B) Central Great Plains, Oklahoma
32 counties: Alfalfa, Beckham, Blaine, Caddo, Canadian, Comanche, Cotton, Custer, Dewey, Ellis, Garfield, Garvin, Grady, Grant, Greer, Harper, Jackson, Jefferson, Kay, Kingfisher, Kiowa, Logan, McClain, Major, Noble, Pawnee, Payne, Roger Mills, Tillman, Washita, Woods, and Woodward

C) Edwards Plateau, Texas
10 counties: Bandera, Crockett, Edwards, Kerr, Kimble, Menard, Real, Schleicher, Sutton, and Val Verde

Figure 2. The 53 counties in 3 ecoregions of the Southern Great Plains that comprise the study area for this research.

Edwards Plateau, Texas

Of the three regions in this study, the Edwards Plateau experienced the earliest onset of woody plant encroachment, following the major settlement and subsequent fire suppression and overgrazing of the early 20th century (Box, 1967; Hennessey et al., 1983). Historically, this limestone plateau was a fire-maintained post oak grassland savanna (Chapman & Bolen, 2015; Griffith et al., 2007); however, most open rangeland has now converted to woodlands of juniper-oak and mesquite-oak (Diamond & True, 2008; Ansley & Wiedemann, 2008). Viable grasslands have been reduced to only two percent of the ecoregion through shrub encroachment from species such as Ashe juniper (*Juniperus ashei*) and redberry juniper (*Juniperus pinchotii*) as well as fragmentation and land conversion related to urban expansion and amenity migration (Chapman & Bolen, 2015; Griffith et al., 2007; Lai & Lyons, 2011). Although land use in the area is primarily agricultural grazing for cattle, sheep, goats, and exotic game animals, the state of Texas has begun encouraging landowners to supplement and diversify agricultural incomes through the sale of hunting leases and nature-based recreation/tourism enterprises (Griffith et al., 2007; Lai & Lyons, 2011). Although goats have gone through cycles of popularity as a livestock species in this region (Hurst et al., 2017), they are a low-cost alternative or supplement to other forms of woody plant management used in this region (Taylor, 2008). Landowners in the Edwards Plateau have historically had an anti-fire perspective; however, there has been a recent cultural shift towards prescribed fire recognizing the benefits of fire in reducing the adverse effects of woody plant encroachment (Twidell et al., 2013). Prescribed Burn Associations have developed in this region to provide members with social support and increase their experience with fire, which has influenced attitudes towards prescribed burning as it becomes a more socially acceptable management practice (Toledo et al., 2013).

Central Great Plains, Oklahoma

The Central Great Plains are the historically mixed and short grass prairies of central and western Oklahoma. While much of the eastern and southern portions of the region contain extensive crop land, the rangelands in more rugged areas are predominately used for livestock grazing (Woods et al., 2005). Woody plant encroachment is more recent in the Central Great Plains than in the Edwards Plateau and this region has some large remaining grasslands despite dramatic advances of woodlands from species such as juniper (*Juniperus* spp.), eastern redcedar (*Juniperus virginiana*), mesquite (*Prosopis* spp.), and creosote bush (*Larrea tridentate*) over the last 40 years (Ansley & Wiedemann, 2008; Assal et al., 2015; Archer et al. 2011; Barger et al. 2011; Briggs et al., 2005; Knapp et al., 2008). As with the Edwards Plateau, Prescribed Burn Associations have proliferated throughout the Central Great Plains to promote and assist with the use of prescribed fire as a management tool to prevent woody plant encroachment sustain healthy grasslands (Twidwell et al., 2013).

Flint Hills, Kansas

The Flint Hills in eastern Kansas is the largest intact tallgrass prairie in the Southern Great Plains and greater North America (Chapman et al., 2001). This region is characterized by rolling hills with rocky surfaces that are largely unsuitable for row-crop agriculture, perpetuating land use as range and pasture for livestock grazing as opposed to the substantial agricultural conversions evident throughout much of Kansas (Chapman & Bolen, 2015). Landowners in the Flint Hills commonly use fire as a land management tool to promote forage growth and prevent the expansion of undesirable weeds and brush (Hoy, 1989). Despite expanding wooded areas from the encroachment of species like eastern redcedar (*Juniperus virginiana*), the Flint Hills has

remained predominately grasslands through the frequent application of prescribed fire, which has become an integral aspect of the region's strong ranching culture (Briggs et al., 2005; Hoy, 1989, Twidwell et al., 2016). Compared to the other ecoregions in the study region, encroachment in the Flint Hills is the most recent and the most minimal (Wilcox et al., 2018).

Materials and Methods

Sampling

To develop the sampling frame for the 53 counties in this study, I obtained the 2017 public property records from each county's tax appraisal district. I aggregated and filtered these records to include only private land owners who owned at least 30 acres of rural land. This size threshold allowed for the inclusion of small-acreage landowners while also ensuring that the land management questions would be relevant (Sorice et al., 2012; 2014; Toledo et al., 2013). Parcels owned by multiple landowners (e.g., spouses, business partners, etc.) were considered as a single entity in the sampling frame if owners shared the same mailing address in the property record. Trusts and licensed businesses were retained in the sampling frame if the name and mailing address of a specific landowner was available in the property record or through a publicly available online search.

From the final sampling frame (N = 84,871), I selected a simple random sample of landowners from each county to reach 1,000 landowners per ecoregion for a total sample of 3,000 people. Landowners were selected from each county based on the proportion of the total number of eligible landowners in the county. See Appendix A for further information on sampling fractions per county. Sampling a fraction of landowners per county based on the

probability proportionate to the size of each county's eligible population is an efficient method for selecting large samples and ensures that landowners from large or small population counties are not over or under sampled, but that each landowner has an equal chance of selection (Babbie, 2007). Given estimated response rates for this survey based on prior response rates (36.7% - 76.2%) from this population (Kreuter et al., 2008; Sorice et al., 2012; Toledo et al., 2013), a sample of 3,000 landowners should yield a 95% confidence interval with +/- 3% margins of error and effectively represent the landowner population within the study area (Dillman, Smyth, & Christian, 2014). After USPS address verification of selected respondents, there were 2,993 landowners in the final sample.

Survey Design and Administration

Based on my large study area and target sample size, I selected a mail survey as the most logistically and economically feasible method of data collection and because mail surveys have received favorable response rates (36.7% - 76.2%) with this population in recent research (Kreuter et al., 2008; Sorice et al., 2012; 2014; Toledo et al., 2013). Survey development was based on prior research about WPE and private landowners and was grounded in social science behavioral theories. Between July and September 2017, I conducted interviews with landowners (n = 34) and conservation practitioners and subject matter experts (n = 8) in the Southern Great Plains to further inform the survey and refine specific questions and phrasing to this population. Prior to distribution, the survey was reviewed by committee members and project partners (n = 5) and pre-tested with landowners in the study population (n = 8) between October 2017 and January 2018.

I used a slightly modified Dillman approach to mail the questionnaire to selected participants beginning in February 2018. This method included five mailings between February and May of 2018 using varied content to encourage participation (Dillman et al., 2014). The contact documents and additional details about each mailing are provided in Appendix C. In the survey, I used the term "cedar/juniper*"* in reference to the following species; *Juniperus virginiana* (i.e., cedar, eastern red cedar), *Juniperus ashei* (i.e., blueberry juniper, Ashe juniper, mountain cedar), *Juniperus pinchotti* (redberry juniper). I instructed respondents to think of all the rural land they owned within the study area in terms of one overall "place", which is a colloquial term for all of one's land that is well understood across the three study regions. Depending on the context of the question, the words "place," "land," and "grassland/rangeland" were used in the survey. The questionnaire requested information about landowner characteristics; sense of place; exposure to, preferences for, and beliefs about cedar/juniper; land management practices related to cedar/juniper; and basic demographics (full survey is provided as Appendix B).

Data Collection

Exposure, Threshold of Acceptability, and Dissatisfaction

I used a series of three photos showing a successively encroached grassland with low, medium, and high densities of cedar/juniper (hereafter referred to as cedar) to measure each respondent's perception of their current exposure to cedar and their threshold of acceptability for cedar on their land. To measure exposure, I asked landowners to indicate how well each photo represented the amount of cedar currently on their land (*1 = Not at all* to *5 = Almost completely*). For each individual, I took the highest rating for the three photos and created a new variable to

indicate which photo best represented their current degree of exposure to cedar, where *1 = Low exposure*, *2 = Medium exposure*, and *3 = High exposure*.

For threshold of acceptability, landowners rated each of the three photos based on their preference for the level of cedar they desired on their place (*1 = Much too low*, *3 = About right*, *5 = Much too high*). I used these rating to create a new variable measuring landowners' threshold of acceptability for cedar; landowners were considered accepting of cedar levels they rated as *much too low*, *too low*, or *about right* and not accepting of levels that were rated as *too high* or *much too high*. Corresponding to the pictures, landowners' threshold for cedar was either *1 = Low cedar*, *2 = Medium cedar*, or *3 = High cedar.*

Using a 5-point scale, I asked landowners to indicate how satisfied or dissatisfied they were with the current level of cedar/juniper on their place (*1 = Extremely dissatisfied, 3 = Neither dissatisfied or satisfied, 5 = Extremely satisfied*). I reverse coded these responses to aid in interpreting dissatisfaction.

Goal Intention

I asked respondents which of four options best described their management goal for cedar on their place: either *increase*, *maintain*, *decrease*, or *no goal*. From these responses, I created a goal intention variable to capture whether landowners indicated that they wanted to reduce cedar at any level of exposure or maintain cedar at the low level. For the goal intention variable, landowners were categorized as having the goal intention to lower cedar if they stated that they wanted to decrease cedar at any level of exposure, or if they wanted to maintain cedar and had indicated that they had the low level of exposure. The new binary variable was scored *1 = Lower or maintain low level*, *0 = Other*.

Goal-Frames

To measure landowners' goal-frames, I asked landowners to indicate how well 14 goal-frame oriented statements described their philosophy for making land management decisions using a 5-point scale in which *1 = Does not describe my beliefs* and *5 = Completely describes my beliefs*. The battery included four hedonic, five normative, and six gain frame statements derived from the conceptualizations of each goal-frame outlined in goal framing theory (Lindenberg & Steg, 2007). Each item was adapted to fit the context of land management and further refined through survey pretesting with landowners. For example, an indicator for the gain goal-frame, characterized by the goal to protect or enhance personal resources was, "*When I make a decision about what to do with my land, I do things that have potential to increase my income*" (see Table 4 for items).

Normative Constructs

To measure ascription of responsibility for controlling cedar, I asked landowners the degree to which they agreed or disagreed that, on their own land, cedar was their "*personal responsibility to control*" (*1 = Strongly disagree*, *4 = Neutral*, *7 = Strongly agree*). I measured the personal norm of controlling cedar by asking landowners to indicate their level of agreement or disagreement with the statement that, "*regardless of what other people do, my personal values oblige me to control cedar/juniper on my place*" (*1 = Strongly disagree*, *4 = Neutral*, *7 = Strongly agree*). To measure the informational social norm of controlling cedar, I asked landowners how often other people with cedar/juniper on their land controlled these species (*1 = Never* to *5 = Always*). I measured goal feasibility of controlling cedar by asking respondents how possible controlling cedar was on their place (*1 = Not possible* to *5 = Extremely possible*).

Current Environmentally Relevant Behaviors

To examine current management practices, I asked landowners to indicate their use of each of the following five land management practices, specifically for the purpose of removing or controlling cedar on their land: prescribed fire, mechanical removal, handheld tools, browsing by goats, and chemical herbicides. For each management practice, respondents indicated whether or not they currently used each practice. For this analysis, I combined the current use of all practices into a single variable where *1 = Current use* of any form of brush management to control or remove cedar on their land, and *0 = Other*.

Data Analysis

I used Stata version 14.2 to characterize respondents through demographics and land ownership characteristics. I also summarized landowners' exposure, thresholds of acceptability, dissatisfaction, and current use of management practices at the descriptive level. To examine the role of goal-frames in goal setting and action, I used confirmatory factor analysis (CFA) in Mplus version 6.11 and Cronbach's alpha to determine if the normative, gain, and hedonic goal-frame statements could be reduced to their respective underlying goal-frame constructs.

Then, I tested a series of regression models to explore the factors related to the goal intention of lowering cedar and the self-reported use of management practices to achieve this goal. First, I used linear regression to model dissatisfaction with cedar as a function of a landowner's current exposure to cedar and their threshold of acceptability for cedar. Then, I used a logistic regression model to determine how normative factors (ascription of responsibility, personal norm, informational social norm, goal feasibility) and goal-frames (normative, gain, hedonic) along with cedar dissatisfaction related to landowners' goal intention to lower or

maintain low levels of cedar. With a final logistic regression model, examined how landowners' goal-frames and goal intentions related to the likelihood of currently using the environmentally relevant management practices.

Because the three regions in this study are known to have different levels of woody plant encroachment and different cultural orientations towards certain land management practices, I accounted for error attributable to regional similarities and differences by allowing intragroup correlation within each region (based on the county in which a respondent owned land) in the models (StataCorps, 2013). This adjusts the standard error estimates and relaxes the assumption of independent observations within each group, while still treating observations as independent across groups.

Results

Overall, 1,231 of the initial 2,993 surveys mailed out were returned. Of these, 1,010 were completed while 210 were mailed back blank indicating that the landowner did not wish to participate and 11 others indicated that the intended recipient was ineligible (e.g., had sold land, deceased, etc.). From the 1,010 surveys completed, 16 surveys were removed because the landowner indicated that they owned less than 30 acres and 3 were removed because they were duplicates. The final sample contained 991 landowners. The adjusted response rate was 35% after accounting for 154 additional ineligible respondents who contacted me to indicate their ineligibility or had undeliverable addresses (991 eligible surveys/2812 adjusted sample). This is comparable to other response rates (36.7%) from general population surveys of landowners within this region (Kreuter et al., 2008). I removed all respondents who were not the primary

decision makers for their land, either solely or with others, for a total of 877 landowners included in this study. Allowing for maximum heterogeneity in responses (e.g., a 50/50 split on a binary question), the final sample of 877 respondents from a population of around 85,000 (the final sampling frame) should yield a 95% confidence level with margins of error between 3% and 5% (Dillman et al., 2014). Of the 877 primary decision makers, 38% owned land in the Edwards Plateau (n = 332), 28% in the Central Great Plains (n = 247), and 34% in the Flint Hills (296). Due to item nonresponse throughout the survey, however, the number of observations per analysis is varied.

Landowner Demographics and Land Ownership Characteristics

Three-quarters of landowners were 60 years old or older (75%) and male (77%). Most indicated that they were white (98%) and non-Spanish or Hispanic (97%). Respondents were 66 years old on average (standard deviation (SD) = 12.10, median (MD) = 67); however, ranged in age from 21 to 97 years old. Over half of landowners had received at least 4-year college degree or higher level of education (58%), reported annual household incomes above $75,000 (61%), and were still in the work force (57%). Although 33% of respondents indicated that their occupation was related to the farming and ranching industry, only 18% of respondents listed farmer, rancher, or farmer and rancher as their sole primary occupation.

On average, respondents owned 958 acres of land (SD = 2,401, MD = 250, range = 30-26,000). Across the regions, landowners had owned their land for an average of 23 years (SD = 15.5, MD = 20, range = 0-80). Less than half of landowners lived on their land full-time (45%) or had inherited or acquired their land from their family (47%). Of those who were not full-time residents, respondents lived an average of 235 miles away (SD = 307, MD = 115, range = 0.25-

3,500). Less than half of landowners indicated that they used their land primarily for farming and/or ranching (42%) whereas 22% used their land primarily for rural/natural amenities (either rural lifestyle, outdoor recreation, or wildlife). The remaining landowners (36%) indicated other primary land uses (e.g., for commercial hunting, as a financial investment, etc.) or combination of many uses as their 'primary' land use (e.g., for livestock, recreation, financial investment, and the rural lifestyle).

Exposure, Thresholds of Acceptability, and Dissatisfaction

Landowners were evenly split in their exposure to high and low levels of cedar (low cedar: 42%; medium cedar: 15%; high cedar: 43%). However, exposure varied between regions. The majority of respondents from the Edwards Plateau (73%) indicated exposure to high levels of cedar whereas the majority of the Central Great Plains (58%) and Flint Hills (65%) landowners indicated that their land had a low level of cedar. Overall, most landowners' (75%) threshold of acceptability for cedar was at the low cedar level, meaning that the level of cedar in the low-density picture was acceptable but that levels in the medium and high-density pictures were unacceptable. This low cedar threshold was more pronounced in the Central Great Plains (88%) and Flint Hills (87%) than in the Edwards Plateau (55%), where almost half of landowners would accept either medium levels of cedar (25%) or high levels of cedar (20%).

Landowners expressed a wide range of satisfaction levels with the degree of cedar currently on their land. Although the majority of landowners considered low cedar within their threshold of acceptability, 30% of landowners with a low level of cedar exposure were dissatisfied or extremely dissatisfied with this degree of cedar on their land. Close to half of landowners exposed to medium levels of cedar were dissatisfied (45% dissatisfied or extremely

dissatisfied). Of those exposed to high levels of cedar, 65% were dissatisfied (40% dissatisfied and 25% extremely dissatisfied).

Goal Intention

Overwhelmingly, landowners wanted to decrease the amount of cedar on their land (73%) while the remainder wanted to either maintain (13%) or had no goal (14%) for cedar. Not a single landowner indicated that they wanted to increase the amount of cedar on their land. Cedar reduction was landowners' predominant goal regardless of current exposure levels (71% of landowners with low cedar, 72% of landowners with medium cedar, 80% of landowners with high cedar) or region (80% of Edwards Plateau landowners, 66% of Central Great Plains landowners, 71% of Flint Hills landowners). When accounting for current exposure, 75% of landowners had the management goal intention to lower the amount of cedar on their land or maintain it at currently low levels. Considering landowners' threshold of acceptability for cedar, most landowners who found only the low level of cedar acceptable (78%) or medium level of cedar acceptable (73%) had the goal intention to lower cedar. Half (50%) of landowners who indicated that high levels of cedar were within their threshold of acceptability had the goal intention to lower cedar.

Normative Constructs

Across the three regions, landowners expressed strong personal norms (83% moderately to strongly agreed, M = 6.2, SD = 1.45) and felt responsible to control cedar on their land (80% moderately to strongly agreed, M = 6.16, SD = 1.47). Respondents did not report the presence of a strong social norm about cedar control as only one third thought that other landowners with

cedar usually (30%) or always (1%) controlled these species (Table 1). This social norm was more prominent in the Flint Hills (46% usually or always) than in the Central Great Plains or Edwards Plateau (23% usually or always for both regions). Across all regions, most landowners (87%) felt that controlling cedar on their land was at least moderately possible, with over half (59%) indicating it was very or extremely possible (Table 1).

Table 1. Landowners' informational social norms and goal feasibility for controlling cedar. The percent of landowners who indicated each level of information norm and goal feasibility is provided for each study region and in aggregate.

	All Regions	**Edwards Plateau**	**Central Great Plains**	**Flint Hills**
Social norm about controlling cedar (n = 825)				
Never	3%	3%	3%	2%
Rarely	16%	19%	20%	10%
Sometimes	50%	54%	54%	42%
Usually	30%	23%	22%	44%
Always	1%	<0.5%	1%	2%
Goal feasibility of controlling cedar (n = 839)				
Not possible	4%	6%	4%	<1%
Slightly possible	9%	12%	7%	8%
Moderately possible	28%	38%	23%	20%
Very possible	39%	30%	44%	46%
Extremely possible	20%	14%	23%	26%

Current Environmentally Relevant Behavior

Although some practices for controlling cedar are more widely used in certain regions, such as prescribed fire in the Flint Hills or browsing goats in the Edwards Plateau, most (73%) landowners had currently used at least one of the five management practices to remove or control cedar on their land (Table 2). While still a majority, fewer landowners in the Central Great Plains (57%) indicated that they were currently engaged in any of these practices compared to landowners in the Edwards Plateau (74%) or Flint Hills (83%).

Table 2. The percentage of landowners who currently used management practices to remove or control cedar on their land.

	Any Practice	Prescribed Fire	Mechanical Equipment	Handheld Tools	Goat Browsing	Chemical Herbicides
All Regions (n = 822)	73%	27%	33%	54%	7%	16%
Edwards Plateau (n = 318)	74%	5%	38%	60%	16%	11%
Central Great Plains (n = 225)	57%	11%	25%	43%	1%	16%
Flint Hills (n = 279)	83%	66%	34%	57%	1%	22%

Modelling the Factors Related to Goal Intentions and Current Behavior

Dissatisfaction Model

Given that landowners were exposed to varying degrees of encroachment and had different thresholds of acceptability for cedar, I first examined how landowners' thresholds and exposure related to their satisfaction or dissatisfaction with the amount of cedar on their land. Landowners' dissatisfaction with the amount of cedar on their land was related to both their baseline level of exposure and their threshold of acceptability for cedar, which together accounted for 27% of the variation in landowners' dissatisfaction with cedar ($F = 118.90$, $p<0.01$, $R^2 = 0.27$) (Table 3). Landowners' threshold of acceptability had a negative relationship with their level of dissatisfaction, whereby higher thresholds of acceptability were related to lower levels of dissatisfaction. Compared to landowners with a low threshold for cedar, landowners with a high threshold were one unit less dissatisfied. Conversely, greater exposure to cedar was related to higher levels of dissatisfaction with cedar as landowners with high exposure were 1.33 levels more dissatisfied than landowners with low exposure.

Table 3. Summary of linear regression model predicting landowners' dissatisfaction with cedar on their land (n = 686). The unstandardized coefficients (*b*) are standard errors *(SE(B))* are provided for levels of threshold and exposure which were measured on the same scale. Dissatisfaction was measured on a 5-point scale where *1 = Extremely satisfied* and 5 = *Extremely dissatisfied*.

Independent variables	***b***	***SE (b)***	***t***	***p***
Threshold of acceptability for cedar				
Low	-	-	-	-
Medium	**-0.35**	**0.10**	**-3.83**	**<0.01**
High	**-1.03**	**0.15**	**-6.76**	**<0.01**
Exposure to cedar				
Low	-	-	-	-
Medium	**0.63**	**0.09**	**6.93**	**<0.01**
High	**1.33**	**0.06**	**20.58**	**<0.01**
Model constant	2.79	0.05	58.57	<0.01
Model statistics				
F	118.90			
P> F	<0.01			
R^2	0.27			
RMSE	0.94			

Significant variables ($p<0.05$) are shown in bold.

Goal-Frames

The 14 goal-frame indicators provided adequate model fit when reduced to their respective constructs using confirmatory factor analysis as they were on par or near the assessment criteria of RMSEA below 0.06, CFI above 0.90, TLI above 0.90, and SRMR below 0.08 indicating good model fit (Brown, 2014) (Table 4). One indicator was dropped from each goal-frame index to improve the reliability of each scale. Based on Cronbach's alpha, the normative ($\alpha = 0.81$) and gain ($\alpha = 0.72$) index showed greater internal consistency and thus reliability than the hedonic index ($\alpha = 0.64$) (Acock, 2016). Overall, landowners indicated that the normative goal-frame mostly described their beliefs about land management (M = 3.99, SD = 0.78, MD = 4) while hedonic and gain frames moderately described their beliefs (hedonic: M = 3.45, SD = 0.80. MD = 3.33; gain: M = 3.07, SD = 0.97, MD = 3).

Table 4. Results of confirmatory factor analysis of latent goal-frame constructs for land management. Items were scored on a 5-point scale where 1 = *Does not describe my beliefs* and 5 = *Completely describes my beliefs*. CFA was conducted on responses from all eligible landowners prior to reducing study to primary decision makers (n = 991).

Survey items: "When I make a decision about what to do with my land, I do things that…"	**M**	**SD**	**α**	**RMSEA**	**CFI**	**TLI**	**SRMR**	X^2
Hedonic	3.45	0.80	0.64	<0.01	1.00	1.00	<0.01	<0.01
give me the greatest personal satisfaction	3.93	1.04						
have a predictable outcome	3.49	1.01						
provide relatively fast results	2.77	1.10						
Gain	3.33	0.97	0.72	0.06	0.981	0.942	0.027	<0.01
are best for me	3.57	1.15						
maintain or enhance my reputation	2.52	1.41						
give me a good return on my investment	3.13	1.26						
have potential to increase my income	2.95	1.34						
Normative	3.99	0.78	0.81	<0.05	0.985	0.956	0.022	<0.01
are best for the health of the land	4.11	0.89						
improve conditions for future generations	4.05	0.99						
I think are morally the right thing to do	3.97	1.01						
do not disturb the balance of nature	3.67	1.09						

Goal Intention Model

Next, I explored how these goal-frames along with dissatisfaction and normative factors related to landowners' goal intentions to reduce cedar or maintain it at an already low level (Table 5). Landowners' dissatisfaction, personal and social norms about cedar, and goal feasibility of controlling cedar were all significant factors positively associated with the goal to lower cedar (Wald $X^2_{(8)} = 248.28$, $p<0.01$, Pseudo $R^2 = 0.25$). When standardized to the same measurement scale, dissatisfaction had the largest effect on increasing the liklihood of having this goal ($\beta = 1.59$, SD = 1.18, $p<0.01$), followed by goal feasibility ($\beta = 0.35$, SD = 1.01, $p<0.01$), personal norm ($\beta = 0.29$, SD = 1.40, $p<0.01$) and social norm ($\beta = 0.26$, SD = 1.40, $p<0.01$). The odds of having the goal to lower cedar increased by 282% for every one-level increase in dissatisfaction. The feasibility of controlling cedar played a larger role in the goal to reduce cedar when a landowner was satisfied with the amount of cedar on their land (Figure 3).

As dissatisfaction increases, however, landowners become more likely to hold the goal to lower cedar regardless of how feasible they think this is.

Table 5. Summary of logistic regression model predicting landowners' likelihood of having the goal to lower cedar (n = 757) providing the unstandardized (*b*) and x-standardized coefficients (β). Significant variables (p<0.05) are shown in bold.

Independent variables	***b***	***SE (b)***	***z***	***p***	***β***	***Odds Ratio***	***Percent change***	***X-Standardized Percent Change***
Dissatisfaction with cedar	**1.34**	**0.10**	**13.01**	**<0.01**	**1.59**	**3.82**	**282.1**	**387.9**
Ascription of responsibility	0.08	0.07	1.06	0.29	0.11	1.08	8.1	11.7
Personal norm	**0.21**	**0.08**	**2.47**	**0.01**	**0.29**	**1.23**	**23.4**	**34.1**
Social norm	**0.34**	**0.13**	**2.67**	**<0.01**	**0.26**	**1.40**	**40.5**	**29.5**
Goal feasibility	**0.35**	**0.12**	**3.02**	**<0.01**	**0.35**	**1.42**	**41.7**	**42.2**
Normative goal-frame	-0.13	0.14	-0.89	0.38	-0.10	.88	--11.9	-9.3
Gain goal-frame	-0.03	0.14	-0.18	0.86	-0.02	.97	-2.5	-2.4
Hedonic goal-frame	0.27	0.18	1.56	0.12	0.21	1.32	31.5	23.8
Model constant	-6.93	0.97	-7.14	<0.01				
Model statistics								
Wald X^2	248.28							
P> X^2	<0.01							
Pseudo R^2	0.25							

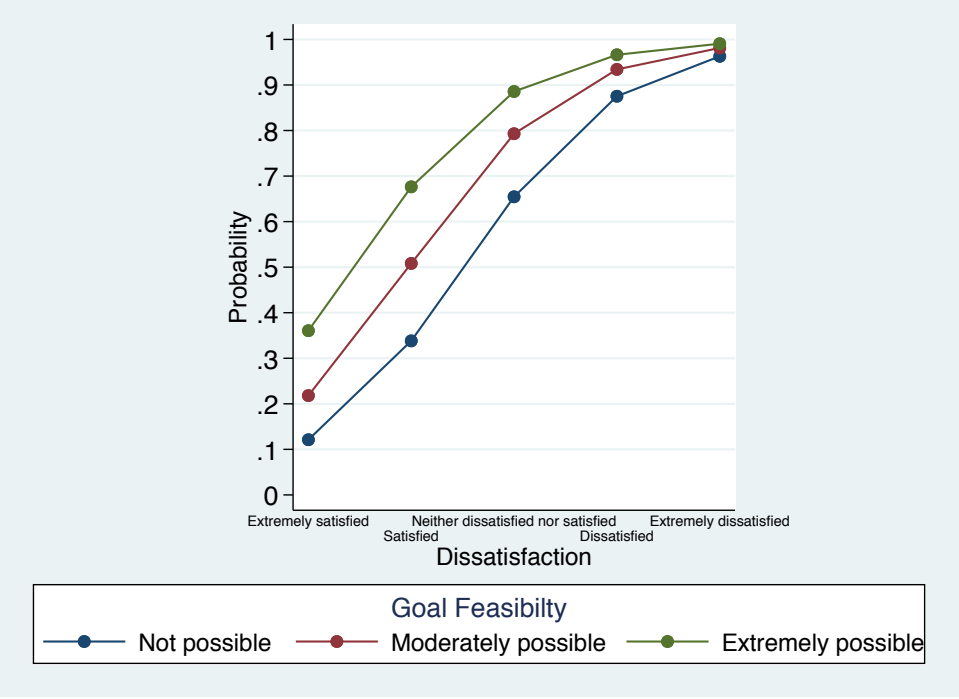


Figure 3. The predicted probability that landowners hold the goal to lower cedar based on their levels of dissatisfaction and goal feasibility, while holding personal and social norms at their means.

Current Environmentally Relevant Behavior Model

Of landowners who expressed the goal to lower cedar, 80% had currently engaged in management actions to achieve this goal. About half (51%) of landowners who did not hold the goal to lower cedar had also currently used management practices to remove or control cedar. I found that landowners' goal to lower cedar ($\beta = 0.58$, SD = 0.43, $p<0.01$) and their degree of normative goal-frame ($\beta = 0.23$, SD = 0.78, $p<0.06$) were both positively related to the current implementation of cedar management practices (Wald $X^2_{(4)} = 38.07$, $P<0.01$, Pseudo $R^2 = 0.07$) (Table 6). When standardized to the same measurement scale, the odds of a landowner currently controlling or removing cedar increased by 79% if they held the goal intention to lower cedar and increased by 26% for every one-level increase in the strength of their normative goal-frame.

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Table 6. Summary of logistic regression model predicting landowners' likelihood to currently use management practices to remove or reduce cedar (n = 776) providing the unstandardized (*b*) and x-standardized coefficients (β) of variables.

Independent variables	***b***	***SE (b)***	***z***	***p***	***β***	***Odds Ratio***	***Percent change***	***X-Standardized Percent Change***
Goal to lower cedar	**1.35**	**0.18**	**5.60**	**<0.01****	**0.58**	**3.87**	**286.7**	**78.9**
Normative goal-frame	**0.29**	**0.13**	**1.92**	**<0.06***	**0.23**	**1.34**	**34.3**	**25.9**
Gain goal-frame	-0.03	0.12	-0.24	0.81	-0.03	0.97	-2.7	-2.6
Hedonic goal-frame	0.08	0.15	0.55	0.58	0.06	1.08	7.7	6.0
Model constant	-1.28	0.48	-2.39	0.02				
Model statistics								
Wald X^2	38.07							
P> X^2	<0.01							
Pseudo R^2	0.07							

Significant variables are shown in bold; *p<0.10, **p<0.05

There was a 51% predicted probability that landowners currently used management practices to lower cedar without having the goal intention to lower cedar, while those with the goal intention had an 80% likelihood of using management practices. While the probability of engaging in some form of cedar management was about 30% higher for landowners' whose goal it was to lower cedar, landowners were more likely to currently implement cedar management if

they possessed a stronger normative goal-frame (Figure 4). As the strength of landowners' normative goal-frame increased, they were 30% more likely to currently control cedar when they did not have the goal to lower cedar or maintain it at a low level and 23% more likely to control cedar when they did hold this goal.

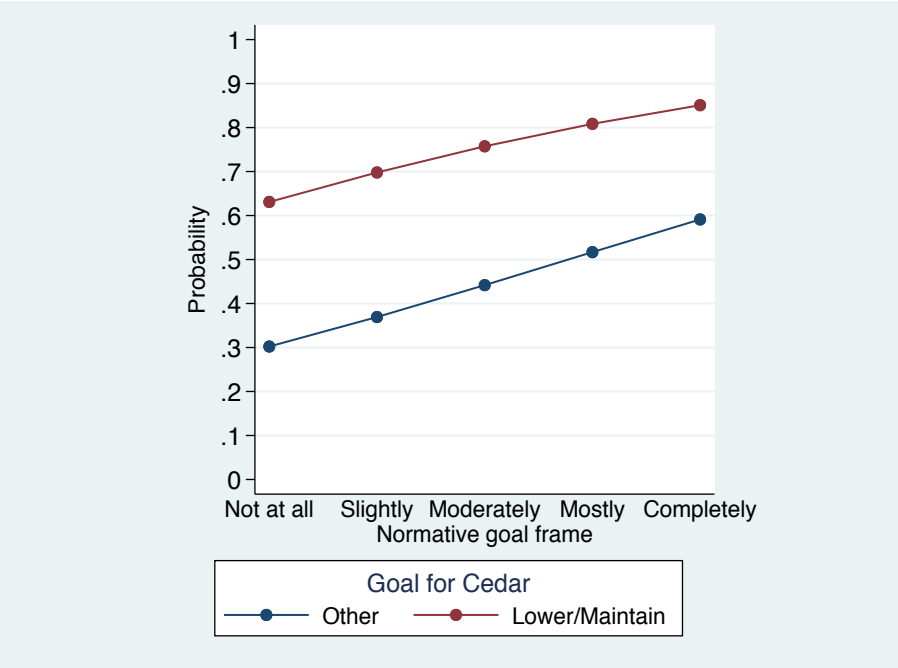

Figure 4. The predicted probability of landowners currently engaged in cedar control or reduction based on having the goal to lower cedar and their degree of normative goal-frame.

Discussion

The salience of woody plant encroachment to respondents from the Edwards Plateau, Central Great Plains, and Flint Hills was evident through the high percentage of landowners in my sample who held the goal to reduce cedar on their land (75%) and were currently employing environmentally relevant land management practices to prevent cedar expansion and restore

grasslands (73%). Although landowners indicated diverse personal connections to and uses for their land (see Chapter 1), as well as varying degrees of cedar encroachment, most expressed low thresholds of acceptability for cedar in grasslands and felt a strong moral obligation and sense of responsibility to control cedar on their land. While a small number of landowners had no goal for cedar or wanted to maintain it at medium or high levels, not a single respondent to this study indicated that they wanted to increase the level cedar on their land. This near-consensus among landowners despite recent patterns in land ownership change is important for rangeland managers and conservation practitioners attempting to promote woody plant management; most landowners *do* want to control or remove cedar in grasslands.

Bamberg's (2013) conceptualization of goal-driven behavior originating with goal intentions and normative constructs from Schwartz's (1977) Norm Activation Model was a valuable framework to understand the drivers of landowners' management goals for cedar. The activation of personal norms is recognized as an important determinant of pro-social and pro-environmental behaviors (Bamberg & Moser, 2007; de Groot & Steg, 2009; Onwezen, Antonides, & Bartels, 2013; Steg & de Groot, 2010) and indeed, I found that personal norms, along with social norms, goal feasibility, and the negative emotion of dissatisfaction were significant predictors of landowners' goal intentions to lower cedar.

Although previous research suggests that goal feasibility is especially important in large-scale problems where the actions of individuals may seem trivial (Lindenberg & Steg, 2007; Steg & de Groot, 2010), I found that high levels of dissatisfaction outweighed landowners' considerations of feasibility in regards to their management goal intentions. Dissatisfaction may be a form of distress, which can be strong predictor of personal efforts toward environmentally conscious behaviors (Lee & Holden, 1999). Emotions related to the environment can drive pro-

environmental behavior through mediating the effects of both objective and subjective knowledge about environmental issues (Carni, Arnon, & Orion, 2015). The importance of landowners' satisfaction or dissatisfaction with the level of cedar on their land illustrates how intolerance of an ecological change and subsequent dissatisfaction with the conditions of a place can motivate people to take protective or restorative actions (Stedman, 2002; Zajac et al., 2012).

While much social science research is focused on understanding the problematic intention-behavior gap, in which people do not follow through with actions to achieve their intentions, I found that 80% of landowners were currently engaged in actions in support of their stated goal. Although my data was cross-sectional and thus cannot demonstrate any sequence of events or cognitions, my results suggest that goal intentions may be a significant driver of landowners' current management behaviors. This reinforces the importance of understanding and targeting the social-psychological determinants of intentions in efforts to understand, influence, or change actual behaviors (Ajzen, 1991; Fishbein & Ajzen, 2010). While 20% of people were not currently engaged in behaviors to achieve their stated goal, a number of compelling questions surround the 51% of people who were engaged in cedar reduction behaviors without holding the explicit end goal to reduce cedar. These findings question the necessity of holding an explicit goal intention as the first step in the cognitive process of implementing behavior as suggested by Bamberg (2013).

Half of landowners who did not have the goal intention to control or reduce cedar had engaged in management practices to do so. While most behavior is thought to be goal-driven by the conscious choice to achieve some desired outcome, a body of recent research suggests that goals can be activated outside of people's conscious awareness (Custers & Aarts, 2010). When activated through social and situation cues, people invest effort and engage in behavior to attain

these unconscious goals without actually being aware of the goal or its operation. This may partially explain the large number of landowners who reported engaging in behavior to reduce or control cedar even though they did not report having the goal intention to reduce or control cedar. Even complex behaviors can develop habit-like aspects when performed frequently, in a stable context, and for the same purpose, thus negating the conscious effort required to form a goal intention when engaging in goal-directed behavior (Danner, Aarts, & de Vries, 2008). As my research assessed landowners' current use of management practices irrespective of their past use, the use of some management practices may have unconscious qualities independent of landowners' explicit goals. For instance, the tradition of annual spring burning in the Flint Hills has become a strong part of local ranching culture in that region (Hoy, 1989; Twidwell et al., 2016) and may be better understood through conceptualizations of social norms rather than goal-directed behavior.

Alternatively, another explanation may be that landowners use of these management practices was driven by some other goal intention not measured (e.g., owning and browsing goats purely as an economic commodity) that still yields the same resulting outcome. Additionally, landowners who expressed the goal to maintain cedar at medium or high levels may have currently used these land management practices simply to prevent cedar from increasing. There are a number of plausible explanations for why most landowners were currently implementing management practices to reduce cedar; yet it is noteworthy that they were 30% more likely to do so if they held the goal intention to lower cedar on their land. Thus, goal-generation approaches such as management plans are likely to increase the use of environmentally relevant management practices and aid in conservation efforts on private lands even when target behaviors are commonly accepted.

In this study, I introduced measures of private landowners' goal-frames (Lindenberg & Steg, 2007) in attempts to better understand their management behaviors. Adapted to the context of land management, the normative and gain goal-frame measures performed well. However, the hedonic measures had lower reliability and would benefit from further refinement to land management through additional pretesting with landowners. While goal-frames were not significant in understanding landowners' goals, the effect of the normative goal-frame, especially, may have been masked by the influence of other normative measures in the goal intention model as goal framing theory predicts that the people with a strong normative goal-frame are best understood through the norm activation model (Lindenberg & Steg, 2007). My findings support previous associations between the normative goal fame and pro-environmental behaviors (Lindenberg & Steg, 2007; Steg et al., 2014; Chakraborty, Singh, & Roy, 2017). Regardless of their goal intentions, landowners were more likely to have engaged in cedar management as the strength of their normative goal-frame increased. However, the significance of the normative goal-frame in the behavior model was marginal at the $\alpha = 0.05$ level ($p < 0.06$).

While there has been an emphasis on increasing adaptive, environmentally relevant behaviors through reducing the perceived costs and increasing the perceived benefits of target behaviors, thus focusing on gain and hedonic goal-frames (Steg et al., 2014), I did not find that gain or hedonic land management goal-frames were related to current behaviors. However, combining all five types of management practices may have concealed the importance of gain and hedonic influences such as cost, difficulty, and convenience that may be specific to each type of behavior. Although the role of landowners' goal-frames in their goal intentions and current behaviors was somewhat inconclusive in this study, further development of goal-frame measures and integration of goal framing theory is a promising tool for private landowner

research. Measuring landowners' goal-frames in regards to land management to understand their goal intentions for cedar and use of management behaviors was consistent with the conceptualization of goal-frames as overarching goals that guide behavior towards a more specific set of subgoals (Steg, van den Berg, & de Groot, 2013). However, developing goal-frame statements that correspond more closely with the goal intention or behaviors in question may improve their utility (Fishbein & Ajzen, 2010). Understanding the motivations underlying landowners' management actions, through the concept of goal-frames, enables targeted and potentially more effective conservation strategies and policies aimed at promoting or changing the use of land management practices.

Most landowners in this study wanted to control or reduce cedar and were currently engaged in some form of cedar management. While encouraging for conservation practitioners and rangeland managers, recent research documents increasing levels of woody plant encroachment throughout the Southern Great Plains indicating a missing piece of this puzzle (Wilcox et al., 2018). As with any suite of potential solutions, certain land management practices and their forms of implementation are more or less effective at preventing woody plant encroachment. Knowing that WPE is increasing despite high levels of current engagement in actions designed to prevent this transformation, a more nuanced understanding of landowners' adoption and use of management practices is needed. This presents two key directions for future social science research. First, future research should examine what catalyzes the specific use of the most effective practices (e.g., prescribed fire) over other possible options. Second, research should investigate landowners' commitment to woody plant reduction through the ongoing use (i.e., past, present, and future intended use) of adaptive management practices and aim to better understand the factors enabling or constraining such ongoing management.

Conclusion

The drivers of private land management actions are paramount in understanding and solving many modern environmental issues. In this study, the use of adaptive, environmentally relevant behaviors by landowners facing ecosystem transformation through the encroachment of woody plants was the outcome of normative feelings about "what one should do" and a person's goal to intervene in the transformation. The goal to engage in actions that sustain grasslands was driven predominantly by dissatisfaction with unacceptable levels of change, followed by the perceived feasibility of goal achievement and personal and social norms. While goal intentions increased the likelihood of implementing actual behaviors, they were not a necessary condition for landowners to engage in adaptive actions.

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Thesis Conclusion

Focusing specifically on woody plant encroachment in the Southern Great Plains, my research examined people's role in perpetuating or preventing large-scale ecological transformation. Necessarily, this required a social-ecological systems perspective and my research on the social aspects of the system was coordinated with the efforts of a larger multi-disciplinary team. Along with contributing to the collaborative research findings of the team, this research has independent practical and theoretical importance. As the single largest and most recent private landowner survey regarding WPE in the Edwards Plateau, Central Great Plains, and Flint Hills, my research provides much needed information on the management of private lands, which in large part shape the sustainability of grasslands throughout the Southern Great Plains. Additionally, this research offers a number of scholarly contributions towards understanding the human roles in social-ecological systems, conceptualizations of sense of place and vulnerability among private landowners, and the drivers of adaptive, environmentally relevant behaviors.

Summary of Findings

In Chapter 1, I focused on understanding the diversity of the social landscape to examine the mechanisms that underlie private landowners' perceptions of woody plant encroachment into grasslands. Specifically, I examined how landowners' sense of place, beliefs about woody plants, and threat perceptions of WPE related to the thresholds at which they viewed woody plants as unacceptable. These tipping points can spur adaptive behaviors to reverse unacceptable levels of change (Zajac et al., 2012). I approached this study by recognizing that people connect with and

relate to their environment in different ways, and likely do not experience or perceive environmental change equally. While previous research has emphasized the vulnerability of production-oriented landowners to environmental changes, I combined aspects of sense of place (e.g., Masterson et al., 2017) and resource dependency (e.g., Marshal, 2011) to account for the diversity of landowners and their possible connections to the landscape to capture how all types of landowners may be affected by WPE and subsequent grassland conversion.

In regards to uncertainty about landowners' orientation towards woody plant species in grasslands given recent changes in land ownership, WPE from *Juniperus* species (e.g., cedar) was a salient issue to the private landowners in my sample despite the different ways that they used and related to their land. Most landowners (76%) in this study viewed woody plants as unacceptable at densities above a low level as depicted by series of comparative photos. Despite general agreement on the problem, I found that landowners' sense of place varied and related to different thresholds of acceptance, indicating varying sensitivities to WPE. Across the different sense of place groups, most landowners believed that cedar led to negative outcomes and had low thresholds of acceptability for their presence in grasslands. Landowners' thresholds for woody plants were further explained by their threat perceptions of WPE, which also varied based on their relationship with the land and beliefs about consequences, but overall tended to increase at greater degrees of encroachment.

In my study, landowners' sense of place provided a rich profile of different ways that people value and are connected with their land. I am unaware of other survey research that has explored place meanings in as much depth. My approach captured the nuances and complexities of human connections to places, meeting the depth at which qualitative research has described intricate human-nature relationships (Chan et al., 2016; Davenport & Anderson, 2005). Future

research is needed to specifically examine the meanings that drive differences in landowners' beliefs, perceptions, and acceptability of woody plants. Doing so may isolate the place meanings most salient to grassland conservation and thus improve practical applications to differentiate landowners based on how they relate to their land. Finally, this chapter was limited to testing direct and indirect psychological pathways as separate models to understand the associations between landowners' relationship with their land and their thresholds for woody plants. A more comprehensive path model exploring the same pathways may improve understanding of the direct and indirect relationships between these concepts.

In Chapter 2, I focused on the cognitive processes related to landowners' engagement in adaptive behaviors that prevent WPE and sustain grasslands. This research began where I left off in Chapter 1 by incorporating landowners' thresholds of acceptability for woody plant as an initial motivation towards action. I borrowed from Bamberg's (2013) framework of goal-driven behavior, the activation of personal norms (Schwartz, 1977), and goal framing theory (Lindenberg & Steg, 2007) to understand the cognitive drivers underlying current implementation of environmentally relevant management behaviors. I found that most landowners had the goal intention to lower woody plants on their land, and this was explained largely by their dissatisfaction with woody plant levels, beliefs about goal feasibility, and normative influences. While much research regarding environmental behaviors is plagued by the "intention-behavior gap", I found that most people were currently engaged in land management practices to control or reduce woody plants. Landowners' current use of management practices was explained by their goal intentions and the strength of their normative goal-frame in regards to land management.

Although woody plant encroachment in the Southern Great Plains is increasing (Wilcox et al., 2018), my findings indicate that continued WPE is likely not due to a simple lack of motivation or action among private landowners. While the widespread engagement in brush management by landowners in this study is an encouraging finding for rangeland managers and conservation practitioners, this necessitates a deeper understanding of landowners' use of management practices. Investigations into landowners' ongoing commitment to woody plant management over time or structural issues that constrain the use of the most effective practices may illuminate disparities in woody plant management that contribute to the increasing conversion of grasslands to woodlands.

Scholarly Contributions

My thesis contributes to social-ecological systems research demonstrating how people's perceptions of ecological transformation, in terms of acceptability and threat, are tied to how they relate to the place undergoing change and their beliefs about the consequences of the place-change. My meanings-based approach using sense of place to measure a landowner's relationship with their land is in response to recent recognition that place-based concepts can enhance social-ecological research (Masterson et al., 2017). To do this, I employed a novel approach to measuring place meanings. Specifically, I re-conceptualized place attachment and place identity as meanings themselves, and I measured a landowner's belief in each meaning along with their dependence on the particular meaning. By itself, this innovative approach to understanding sense of place contributes to the literature. Additionally, it allows for better integration of sense of place into understanding private landowners' vulnerability to ecological change. This approach to landowners' connections to place advances the understanding of how

all landowners may relate to their land; expanding the applicability of Marshall and colleagues' resource dependency framework and enabling future research to better study landowners outside of the traditional agricultural production lens (Chan et al., 2016; Marshall, 2011; Marshall et al., 2014).

While much research has investigated the management and conservation behaviors of private landowners, my research took a new approach to characterize the direct and indirect pathways by which threats to sense of place may lead to tipping points for action and how these thresholds actually relate to environmentally relevant behaviors. For example, the role of dissatisfaction in landowners' goal intentions towards woody plants links place-based research and place-change (Stedman, 2002) with social-psychological models of behavior (Bamberg, 2013). I adapted Lindenberg & Steg's (2007) conceptualizations of goal-frames to better understand adaptive behaviors as the result of a goal-directed cognitive process influenced by overarching land management goals. The normative and gain goal-frame indicators performed well; however, the hedonic indicators could be improved given their lower reliability (Cronbach's alpha = 0.64). As this study is the first that I am aware of to adapt goal-frames to private landowner research, these measures are a starting point for future research to integrate goal framing theory from previous research on pro-social and pro-environmental behaviors in other contexts.

Limitations

Generalizability of findings is always a concern in survey research. My research included a large mail survey effort across 53 counties in three ecoregions of three states. Dillman, Smyth, & Christian (2014) highlight the overall trend of decreasing response rates to single mode survey

research in the past 40 years as technology has provided researchers with greater access to people, but has also enabled people to buffer themselves against unsolicited contacts. I obtained a 35% response rate which is in line with general mail survey efforts that employ multiple contacts without any token incentives (Dillman et al., 2014) and previous survey research efforts in the Great Plains (Kreuter et al., 2008; Sorice et al., 2012; Toledo et al., 2013). Although there are a number of indicators that suggest responses to my survey are aligned with previous research in the region and with survey research itself, I did not conduct a nonresponse survey or bias analyses. I outline the issue of nonresponse below.

Several of factors lend confidence to the responses I received across the study area. Using probability proportionate to size (PPS) sampling from each county ensured that all eligible landowners had an equal chance of being selected (i.e., no over-sampling from larger counties or of larger landowners) (Babbie, 2007); and, I received completed surveys from all counties in the study area (response rates per county ranged from 12% to 58%). The survey design may have also played a role in reducing nonresponse bias. Because I was interested in heterogeneity of landowners, I was concerned that a survey explicitly focused on woody plant encroachment would only appeal to those landowners for whom it was most salient. Compared to similar research that has focused specifically on WPE or certain management practices (e.g., Kreuter et al., 2008; Toledo et al., 2013), I consequently designed my questionnaire and supporting contact materials as a study about landowners' perspectives on their land. The first half of the questionnaire focused on broad questions relevant to all types of landowners and then narrowed into questions specifically about cedar and cedar management (see Appendix B for full survey). I felt that this involved some risk as landowners in the study region receive frequent survey requests and may be less likely to respond to a more 'general' survey; however, I determined that

a broadly framed survey would be more inclusive of the potential range of opinions I aimed to capture.

The respondents were split fairly evenly from each region, which vary in their levels of woody plant encroachment and the length of time for which woody plant expansion has been an issue. Notably, response rates were similar from the Flint Hills region in Kansas, which has the least degree of and most recent WPE, as compared to the Oklahoma and Texas regions where WPE is a more widespread issue. Additionally, I found that most survey respondents were either exposed to high or low levels of cedar in their grasslands. This suggests that respondents did not represent a portion of the eligible landowner population that was biased in terms of region or level of exposure to woody plants.

Further, the socio-demographic characteristics of respondents indicated a wide range of diversity among landowners in terms of landowners' land tenure, acreage owned, residence and involvement on the land, inheritance of the land from family, primary land uses, and primary occupations. This variation is illustrated in Appendix E, which compared the landowner and land ownership characteristics of respondents with different place meanings-based relationships described in Chapter 1. For example, of respondents to this survey who had the Cluster 2 relationship with their land, 20% lived on their land full-time and 5 % had inherited or acquired this land from their family. They owned 323 acres on average, spent an average of 8 hours per week working on their land, and did not hold a strong rancher or farmer identity. On the other hand, 73% of respondents who had the Cluster 5 relationship with their land lived on their place full-time and 75% had inherited or acquired their land from family. Landowners in Cluster 5 owned an average of 1,884 acres, spent an average of 35.6 hours per week working on their land, and held a strong rancher/farmer identity (average of 4.3 out of a 5-point scale).

Previous research with landowners in parts of the Edwards Plateau has found that woody plant encroachment is a salient issue that most landowners are actively combatting regardless of their land ownership motivations (Sorice et al., 2014) or residence and involvement on the land (Sorice, Rajala, Kreuter, 2018). In my research, I found high rates of engagement (73%) in any of five applicable management practices to control woody plants whereas previous research has looked at single practices such as prescribed fire (Kreuter et al., 2008; Toledo et al., 2013) or subsets of practices in which fire is often separated from brush management through mechanical and chemical techniques (Sorice et al., 2014). I present these considerations to provide context for the results of the study; however, as I did not conduct a nonresponse bias analysis I cannot determine if my respondents were any more or less biased towards the woody plant issue than their nonresponding counterparts. Thus, I caution the reader against generalizing the results of my study.

Closing

This research illustrates a mosaic of private land ownership and management of woody plants throughout three ecoregions in the Southern Great Plains. Beyond simply describing *who* is doing *what*, this thesis provides an explanation for *why* landowners perceive and respond to WPE differently. Understanding why landowners do or do not accept woody plants in grasslands and why they engage in management actions to control their expansion reveals possible intervention points in the social-ecological system for policy makers and conservation practitioners to promote the sustainable management of grasslands.

For application to other social-ecological systems, this research demonstrates how ecological change is filtered by individuals based on their beliefs about how change will affect

the place meanings that they hold for their environment. Place meanings are the core of a person's connection to a place, and connections to place may be especially important to understand how private landowners respond to changes occurring on their land. Successful adaptation to environmental change, in terms of altered behaviors, or guided transformation of major change requires understanding the place meanings that exist, and may be threatened, across the landscape.

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Appendix A. Probability Proportionate to Size Sampling Fractions Per County

Sample frame:	84871
Target sample size:	3000
Actual sample size:	2993
Percentage of sample frame:	0.035

Region	Number of landowners (N)	Target sample	Sampling fraction
Flint Hills (KS)	15434	1000	0.065
Central Great Plains (OK)	60297	1000	0.017
Edwards Plateau (TX)	9140	1000	0.109

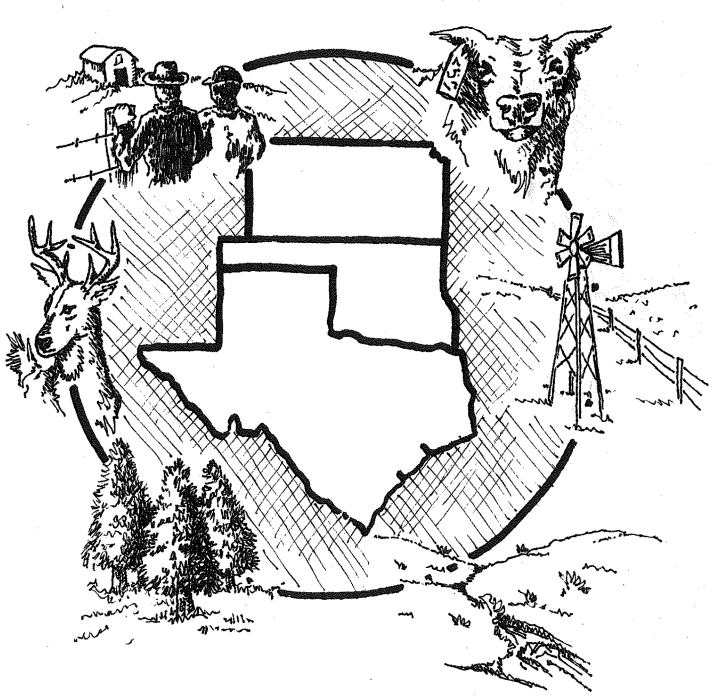
State	County	N	Sampling fraction	Sample
KS	Butler	3563	0.065	231
KS	Chase	592	0.065	38
KS	Chautauqua	1094	0.065	71
KS	Cowley	1811	0.065	117
KS	Elk	1159	0.065	75
KS	Geary	608	0.065	39
KS	Greenwood	1668	0.065	108
KS	Morris	1093	0.065	71
KS	Pottowatomie	1563	0.065	101
KS	Riley	943	0.065	61
KS	Wabaunsee	1340	0.065	87
Total				999

State	County	N	Sampling fraction	Sample
OK	Alfalfa	1746	0.017	29
OK	Beckham	1939	0.017	32
OK	Blaine	1815	0.017	30
OK	Caddo	2575	0.017	43
OK	Canadian	335	0.017	6
OK	Comanche	2676	0.017	44
OK	Cotton	1154	0.017	19
OK	Custer	1602	0.017	27
OK	Dewey	1544	0.017	26
OK	Ellis	1459	0.017	24
OK	Garfield	3401	0.017	56
OK	Garvin	2616	0.017	43
OK	Grady	3162	0.017	52
OK	Grant	2012	0.017	33

State	County	N	Sampling fraction	Sample
OK	Greer	1079	0.017	18
OK	Harper	1244	0.017	21
OK	Jackson	1792	0.017	30
OK	Jefferson	905	0.017	15
OK	Kay	2052	0.017	34
OK	Kingfisher	1891	0.017	31
OK	Kiowa	1488	0.017	25
OK	Logan	2462	0.017	41
OK	Major	1839	0.017	30
OK	McClain	3485	0.017	58
OK	Noble	1557	0.017	26
OK	Pawnee	1525	0.017	24
OK	Payne	2260	0.017	37
OK	Roger Mills	1531	0.017	25
OK	Tillman	1331	0.017	20
OK	Washita	2313	0.017	38
OK	Woods	1875	0.017	31
OK	Woodward	1632	0.017	27
Total				995

State	County	N	Sampling fraction	Sample
TX	Bandera	390	0.109	43
TX	Crockett	776	0.109	85
TX	Edwards	2370	0.109	259
TX	Kerr	1985	0.109	217
TX	Kimble	1520	0.109	166
TX	Menard	850	0.109	93
TX	Real	500	0.109	55
TX	Schleicher	332	0.109	36
TX	Sutton	205	0.109	22
TX	Val Verde	212	0.109	23
Total				999

Your Perspective on your land in the Southern Great Plains



A Survey By:

TEXAS A&M UNIVERSITY

OSU

VirginiaTech
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INTRODUCTION

The Southern Great Plains of Texas, Oklahoma, and Kansas is a valuable natural resource used by a wide variety of landowners. Producers, wildlife enthusiasts, recreational landowners, and rural residents all share this resource and may have different opinions about land use.

To better understand and address current issues in the Southern Great Plains, we'd like to ask you about your opinions and experiences as a landowner or producer in this area. Specifically, we want to know:

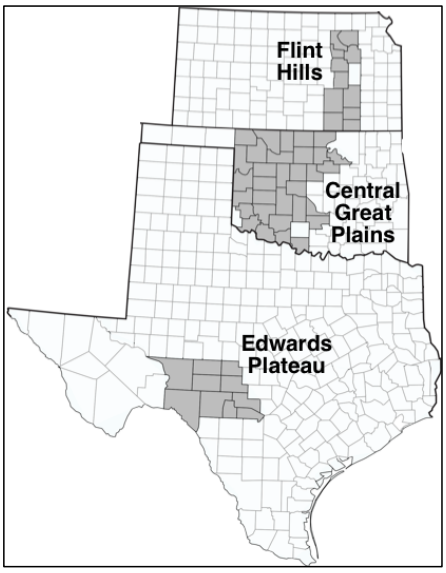
- Your unique perspective about the land you own,
- Your perceptions of vegetation changes on the landscape, and
- Your use of land management practices.

Your PLACE in the «ecoregion» of «statename»

We will use the term **PLACE** throughout the survey. Your **PLACE** is all of the rural land you own outside of any city limits.

If you own multiple rural properties in the «ecoregion», please consider them all together in terms of one overall **PLACE**.

Your response will be a great help!



The three regions in the Southern Great Plains covered by our study.

BEGIN SURVEY →

SECTION A: FIRST, WE INVITE YOU TO TELL US A BIT ABOUT YOU AND YOUR PLACE

1. Who makes most of the day-to-day decisions about your land?

- ❑ Just me, or Me & my spouse
- ❑ My children, parents, or other relatives
- ❑ My land manager
- ❑ My business partner(s) including associations, clubs & corporations
- ❑ The person who leases my land from me
- ❑ Me and my children, parents, or other relatives
- ❑ Me and my land manager
- ❑ Me and my business partner(s)
- ❑ Me and the person who leases my land from me
- ❑ Other: _____

2. In a typical week, about how many hours do you spend managing, operating, or working on your place?

_____ hours

3. How do you primarily use your land?
(*Check only one*)

- ❑ For a livestock operation
- ❑ For a farming operation
- ❑ For a commercial hunting enterprise (game ranch, private hunting leases)
- ❑ For a commercial ecotourism/agrotourism enterprise
- ❑ For wildlife management/conservation (non-commercial)
- ❑ For outdoor recreation purposes
- ❑ For the rural lifestyle
- ❑ For a financial investment in land/real estate
- ❑ I am not particularly involved with my land
- ❑ As a mixed operation (*please specify)*_____
- ❑ Other (*please specify)*_____

4. How many years have you personally owned your place? _____ years

5. Did you inherit or acquire any of your land from your family? ❑ Yes ❑ No

6. Do you live on your place full-time?

- ❑ Yes
- ❑ No → **How many miles, one way, is your closest parcel of property from your primary residence?**

  _____ miles

SECTION B: WHAT YOUR LAND MEANS TO YOU

We want to learn more about your place, your experiences there, and the way you think about your land. For each of the following questions, please indicate:

a. **how well certain ideas describes your beliefs about your place, and**
b. **the degree to which you count on or rely on your land to provide certain outcomes.**

EXAMPLE:

My place:	a. Does this describe your place? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	b. Do you rely on your place for this? Not at all	Slightly rely	Moderately rely	Mostly rely	Completely rely
is a forest	☐	☐	☐	☒	☐	☒	☐	☐	☐	☐

7. Please tell us the extent to which the items below describe the <u>general characteristics</u> of your place as well as the degree to which you rely on your place to provide these characteristics.

My place…	Does this describe your place? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	Do you rely on your place for this? Not at all	Slightly rely	Moderately rely	Mostly rely	Completely rely
is a grassland	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is habitat for wildlife	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
produces food for people	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
reflects nature as it used to be in this area before Europeans arrived	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
has beautiful natural scenery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is for hunting and/or fishing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is for outdoor recreation other than hunting or fishing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is for grazing/browsing livestock	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is for growing crops	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is for making a profit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is a source of income	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
is a business	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

8. **Please tell us the extent to which the items below describe your beliefs about how you <u>personally connect</u> to your place as well as the degree to which you count on your place to provide these connections.**

My place…	Does this describe your beliefs? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	More than anywhere else, does your place provide this? Not at all	Slightly	Moderately	Mostly	Completely
reflects important aspects of who I am.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
has been a significant influence in shaping who I've become.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is a source of personal pride	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is where I live life how I want.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

9. **Please tell us the extent to which the items below describe your beliefs about your <u>personal experiences</u> on your place as well as the degree to which you rely on your place to provide these experiences.**

My place…	Does this describe your beliefs? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	More than any other place, do you rely on your place to provide this? Not at all	Slightly rely	Moderately rely	Mostly rely	Completely rely
is where I reduce the level of stress in my life	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I find peace and quiet.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I feel very little pressure to get things done.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is a source of inspiration	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I feel connected to all living things and the earth.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I gain or find perspective on my life	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I escape from my day-to-day routine	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I enjoy the process of working on the land as much as the results	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

10. Tell us the extent to which the items below describe your beliefs about your <u>personal experiences</u> on your place as well as the degree to which you count on your place to provide these experiences.

My place…	Does this describe your beliefs? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	More than anywhere else, does your place provide this? Not at all	Slightly	Moderately	Mostly	Completely
is where I generally feel the happiest	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I really miss when I am away for too long	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I can really be myself	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is where I am free to decide things for myself	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I have few obligations to anyone else	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I feel more like a caretaker of the land than an owner	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I am responsible for conserving native prairie and its species	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I balance my needs with the needs of plants and wildlife	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

11. Please tell us the extent to which the items below describe your beliefs about <u>social interactions</u> on your place as well as the degree to which you rely on your place to provide these interactions.

My place…	Does this describe your beliefs? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	More than any other place, do you rely on your place to provide this? Not at all	Slightly rely	Moderately rely	Mostly rely	Completely rely
helps me connect with my professional network	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is for enjoying time with friends and/or family	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is part of a community of friendly neighbors	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

12. Tell us the extent to which the items below describe your beliefs about your <u>personal and family history</u> on your place as well as the degree to which you count on your place to connect to this history.

My place…	Does this describe your beliefs? Not at all	Slightly describes	Moderately describes	Mostly describes	Completely describes	More than anywhere else, does your place provide this? Not at all	Slightly	Moderately	Mostly	Completely
is where I feel most at home	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
represents generations of my family's history in the area	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is a source of family pride	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
represents my way of life	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is where I do the kind of work I love.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is where ordinary tasks feel more like leisure than work.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
keeps my family connected to each other.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
represents my family's traditions and culture	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
represents my personal legacy ...	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
symbolizes a way of life I want to pass on to future generations.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
is somewhere I uphold my family's legacy.....	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

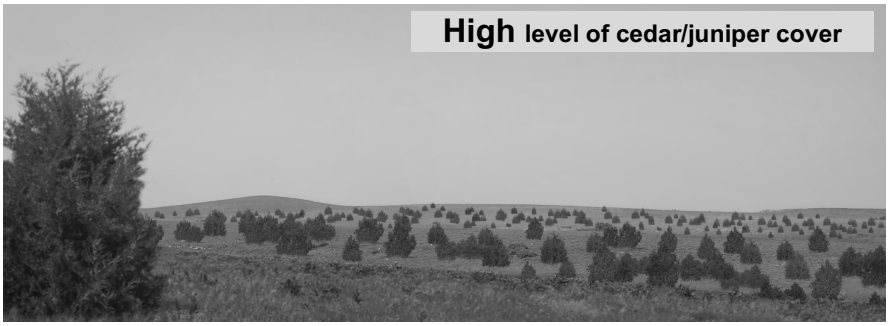
SECTION C: YOUR LANDSCAPE PREFERENCES

Woody shrubs and trees are found in grasslands and rangelands throughout the Southern Great Plains. In the rest of the survey, we'll ask you questions about CEDAR/JUNIPER, which refers to the following species:

- **Cedar or Eastern Red Cedar** *(Juniperus virginiana*)
- **Blueberry Juniper, Ashe Juniper, or Mountain Cedar** *(Juniperus ashei)*
- **Redberry Juniper** *(Juniperus pinchotti*)

We want to know your opinions about these species even if these trees do not grow on your place.

In this section, we'll ask you questions using the following photos that show cedar/juniper on a grassland landscape. Although the landscape in these photos may not look exactly like your place, this section will help us understand your preferences for cedar/juniper.



For the following questions, please consider each photo as a view of your place.

If each of these photos were of your land, how would you feel about the number of cedar/juniper?

13. For each of the three photos, tell us your opinions of cedar/juniper.

The number of cedar/juniper is:

		Extremely	Moderately	Slightly	Neither	Slightly	Moderately	Extremely	
LOW level of cedar/juniper	Acceptable	❑	❑	❑	❑	❑	❑	❑	Unacceptable
	Threatening	❑	❑	❑	❑	❑	❑	❑	Encouraging
	Undesirable	❑	❑	❑	❑	❑	❑	❑	Desirable
MEDIUM level of cedar/juniper	Acceptable	❑	❑	❑	❑	❑	❑	❑	Unacceptable
	Threatening	❑	❑	❑	❑	❑	❑	❑	Encouraging
	Undesirable	❑	❑	❑	❑	❑	❑	❑	Desirable
HIGH level of cedar/juniper	Acceptable	❑	❑	❑	❑	❑	❑	❑	Unacceptable
	Threatening	❑	❑	❑	❑	❑	❑	❑	Encouraging
	Undesirable	❑	❑	❑	❑	❑	❑	❑	Desirable

14. Based on your preferences for your own land, would you say the number of cedar/juniper in each photo is:

	Much too low	Too low	About right	Too high	Much too high
LOW level of cedar/juniper	❑	❑	❑	❑	❑
MEDIUM level of cedar/juniper	❑	❑	❑	❑	❑
HIGH level of cedar/juniper	❑	❑	❑	❑	❑

15. To what degree does each of the three photographs represent the general amount of cedar/juniper on your place?

	Not at all	A little	A moderate amount	A lot	Almost completely
LOW level of cedar/juniper	❑	❑	❑	❑	❑
MEDIUM level of cedar/juniper	❑	❑	❑	❑	❑
HIGH level of cedar/juniper	❑	❑	❑	❑	❑

SECTION D: DECIDING WHAT TO DO ON YOUR PLACE

16. Landowners and producers often balance many considerations when determining how best to achieve what they want on their land. Please indicate how well each statement describes your philosophy for making decisions about your place.

When I make a decision about what to do with my land, I do things that…	Does not describe my beliefs	Slightly describes my beliefs	Moderately describes my beliefs	Mostly describes my beliefs	Completely describes my beliefs
are easy to implement	❑	❑	❑	❑	❑
others expect me to do	❑	❑	❑	❑	❑
are best for me	❑	❑	❑	❑	❑
are best for the health of the land	❑	❑	❑	❑	❑
improve conditions for future generations	❑	❑	❑	❑	❑
make me better off than I currently am	❑	❑	❑	❑	❑
give me great personal satisfaction	❑	❑	❑	❑	❑
maintain or enhance my reputation	❑	❑	❑	❑	❑

When I make a decision about what to do with my land, I do things that…	Does not describe my beliefs	Slightly describes my beliefs	Moderately describes my beliefs	Mostly describes my beliefs	Completely describes my beliefs
give me a good return on my investment	❑	❑	❑	❑	❑
I think are morally the right thing to do	❑	❑	❑	❑	❑
have a predictable outcome	❑	❑	❑	❑	❑
provide relatively fast results	❑	❑	❑	❑	❑
have potential to increase my income	❑	❑	❑	❑	❑
do not disturb the balance of nature	❑	❑	❑	❑	❑

SECTION E: YOUR OPINIONS ABOUT CEDAR AND JUNIPER

Landowners and producers in the Southern Great Plains use their land for a variety of purposes. Some folks may like cedar/juniper while others do not. We'd like your opinions about these trees even if they do not grow on your land.

17. Please indicate the extent to which you agree or disagree with the following statements.

Cedar/juniper…	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
enhance habitat for wildlife	❑	❑	❑	❑	❑	❑	❑
reduce the amount of water flowing in springs and creeks	❑	❑	❑	❑	❑	❑	❑
increase my sense of privacy	❑	❑	❑	❑	❑	❑	❑
are pleasant to look at	❑	❑	❑	❑	❑	❑	❑
cause allergies	❑	❑	❑	❑	❑	❑	❑
are a source of products that I can use or sell	❑	❑	❑	❑	❑	❑	❑
increase the types of wildlife species on my land	❑	❑	❑	❑	❑	❑	❑
reduce the amount or quality of forage available for livestock	❑	❑	❑	❑	❑	❑	❑
are an important source of shade	❑	❑	❑	❑	❑	❑	❑
reduce the number and types of other plant species	❑	❑	❑	❑	❑	❑	❑
increase soil quality	❑	❑	❑	❑	❑	❑	❑
increase soil erosion	❑	❑	❑	❑	❑	❑	❑
improve the aesthetics of the landscape	❑	❑	❑	❑	❑	❑	❑
provide useful windbreaks	❑	❑	❑	❑	❑	❑	❑
increase risk of wildfires	❑	❑	❑	❑	❑	❑	❑

18. In general, which option below best describes your goal for cedar/juniper on your place?

- ❑ My goal is to <u>increase</u> the level of cedar/juniper on my place
- ❑ My goal is to <u>maintain</u> the current level of cedar/juniper on my place
- ❑ My goal is to <u>decrease</u> the level of cedar/juniper on my place
- ❑ I have <u>no goal</u> for the level of cedar/juniper on my place

19. Please indicate the degree to which you agree or disagree with each statement.

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
On my place, cedar/juniper is my personal responsibility to control	❑	❑	❑	❑	❑	❑	❑
Regardless of what other people do, my personal values oblige me to control cedar/juniper on my place	❑	❑	❑	❑	❑	❑	❑

20. On my place, controlling cedar/juniper is _____.

- ❑ Not possible
- ❑ Slightly possible
- ❑ Moderately possible
- ❑ Very possible
- ❑ Extremely possible

21. Most people I know with cedar/juniper _____ control these species on their place.

- ❑ Never
- ❑ Rarely
- ❑ Sometimes
- ❑ Usually
- ❑ Always

22. How satisfied or dissatisfied are you with the current level of cedar/juniper on your place?

- ❑ Extremely dissatisfied
- ❑ Dissatisfied
- ❑ Neither dissatisfied nor satisfied
- ❑ Satisfied
- ❑ Extremely satisfied

SECTION F: YOUR OPINIONS ABOUT PRESCRIBED FIRE

Applying prescribed fire to grasslands and rangelands is one way that people control cedar/juniper throughout the Southern Great Plains.

PRESCRIBED FIRE, or a PRESCRIBED BURN, is an intentional fire that is ignited under specific conditions to burn a designated portion of land to achieve desired objectives. Prescribed fire does NOT include burning stationary piles of debris (e.g., slash piles).

Even if you have never conducted a prescribed burn, we want to know your opinion on using fire to control cedar/juniper.

23. Conducting a prescribed burn on my grasslands/rangelands would be:

	Extremely	Moderately	Slightly	Neither	Slightly	Moderately	Extremely	
Expensive	❑	❑	❑	❑	❑	❑	❑	Inexpensive
Undesirable	❑	❑	❑	❑	❑	❑	❑	Desirable
Difficult	❑	❑	❑	❑	❑	❑	❑	Easy
Effective	❑	❑	❑	❑	❑	❑	❑	Ineffective
Foolish	❑	❑	❑	❑	❑	❑	❑	Wise
Complex	❑	❑	❑	❑	❑	❑	❑	Simple
Controllable	❑	❑	❑	❑	❑	❑	❑	Hard to control
Possible	❑	❑	❑	❑	❑	❑	❑	Impossible
Safe	❑	❑	❑	❑	❑	❑	❑	Risky
Valuable	❑	❑	❑	❑	❑	❑	❑	Worthless
Unpredictable	❑	❑	❑	❑	❑	❑	❑	Predictable
Infeasible	❑	❑	❑	❑	❑	❑	❑	Feasible
Inappropriate	❑	❑	❑	❑	❑	❑	❑	Appropriate
Harmless	❑	❑	❑	❑	❑	❑	❑	Dangerous

Landowners and producers may or may not use prescribed fire for a number of reasons. We would like to learn more about your thoughts on prescribed burning.

	Not true at all	Slightly true	Moderately true	Very true	Completely true
24. If I wanted to, I could conduct a prescribed burn on my grasslands/ rangelands to control cedar/juniper.....	❑	❑	❑	❑	❑

25. I have _____ over conducting a prescribed burn on my grasslands/rangelands.

- ❑ No control
- ❑ A little control
- ❑ Moderate control
- ❑ A lot of control
- ❑ Complete control

We are also interested in how you think other people might feel about using prescribed fire to control cedar/juniper.

26. Most people who are important to me _____ use prescribed fire to control cedar/juniper on my grasslands/rangelands.

- ❑ think I definitely should
- ❑ think I probably should
- ❑ do not care whether I
- ❑ think I probably should not
- ❑ think I definitely should not

27. Most people who are important to me _____ use prescribed fire to control cedar/juniper on their grasslands/rangelands.

- ❑ Always
- ❑ Often
- ❑ Sometimes
- ❑ Rarely
- ❑ Never

28. Most people I know with cedar/juniper _____ use prescribed fire to control these species on their grasslands/rangelands.

- ❑ Always
- ❑ Often
- ❑ Sometimes
- ❑ Rarely
- ❑ Never

SECTION G: USE OF PRESCRIBED FIRE

29. Tell us about your use of fire to intentionally burn portions of your grasslands/ rangelands. This does not include burning debris piles.

On my place…	Yes	No
I used prescribed fire prior to 2013	❑	❑
I used prescribed fire between 2013 and 2017	❑	❑
I currently use prescribed fire	❑	❑
I intend to use prescribed fire in the next 5 years	❑	❑

30. Throughout your ownership of your place, please indicate the overall extent to which you have used prescribed fire on your grasslands/rangelands.

❑ 0% of my grasslands: I have never used prescribed fire.
❑ 1% to 25% of my grasslands/rangelands
❑ 26% to 50% of my grasslands/rangelands
❑ 51% to 75% of my grasslands/rangelands
❑ 76% to 100% of my grasslands/rangelands

31. On average, how many years do you wait to re-burn the same portion of your grasslands/rangelands?

Every _____ year(s) I typically re-burn the same portion of your grasslands/rangelands.

❑ Check this box if you have never re-burned the same portion of your grasslands/rangelands.

SECTION H: ADDITIONAL LAND MANAGEMENT PRACTICES

32. Please indicate whether you have ever used and intend to use each management practice to control cedar/juniper.

For each practice, ***check all that apply***	Never used	Yes, more than 5 years ago	Yes, in last 5 years	Yes, currently	I intend to in next 5 years
	----------Check ALL boxes that apply----------				
Mechanical equipment (tractor, skid-steer, bobcat, etc.)	❑	❑	❑	❑	❑
Handheld tools (chainsaws, handsaws, clippers, etc.)	❑	❑	❑	❑	❑
Goats as a biological control	❑	❑	❑	❑	❑
Chemical herbicides	❑	❑	❑	❑	❑

SECTION I: A LITTLE MORE ABOUT YOU AND YOUR LAND

People think about themselves in many different ways. In this section, we ask you to reflect on the role of ranching or farming in relation to how you see yourself.

33. Please think about meeting someone for the first time. You want to introduce yourself so that they'll really know you. From the choices below, which best fits what you would do?

- ❑ I would introduce myself as a rancher or farmer
- ❑ I might mention that I ranch/farm, but it wouldn't be the first thing I'd say
- ❑ I would not mention ranching or farming at all

34. We would like to know how ranching/farming may currently fit into your life. Please indicate to what extent you agree or disagree with each statement.

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
A lot of my life is organized around ranching/farming	❑	❑	❑	❑	❑	❑	❑
Ranching/farming is an important part of who I am.....	❑	❑	❑	❑	❑	❑	❑

35. About how many acres of rural land do you own?

_____ acres owned

36. About how many acres of rural land do lease (rent) from others?

_____acres leased (rented)

37. About how many acres of your rural land do you lease out (rent out) to others?

_____acres leased out (rented out)

38. Of the acres you own, about how many acres of your place are:

Grassland/Rangeland:	_____acres
Planted pasture:	_____acres
Cropland:	_____acres
Woodland or Forest:	_____acres

SECTION J: DEMOGRAPHICS

Your willingness to share some limited background information will help us appreciate the challenges of owning and managing rural land. It will also help us accurately report the demographic characteristics and economic aspects of rural land ownership to inform public policy and decision makers in Kansas, Oklahoma, and Texas.

Your responses will be kept <u>confidential</u> and we will <u>never</u> release your name or personal information to any individual, business, or government agency.

39. Are you a member of a Prescribed Burn Association? ❑ Yes ❑ No

40. In the past 2 years, how often have you or your family/friends hunted on your place?

- ❑ Never
- ❑ Rarely
- ❑ Sometimes
- ❑ Often
- ❑ Very often

41. Have you ever received cost-share or direct payments from a state or federal agency to remove woody plants through mechanical, manual, biological, or chemical methods?
❑ Yes ❑ No

42. Have you ever received cost-share or direct payments from a state or federal agency to control woody plants through conducting a prescribed burn?
❑ Yes ❑ No

43. What is your primary occupation? *(If RETIRED, what <u>was</u> your primary occupation?)*

_____

a. **Considering this occupation, please indicate the extent that you agree or disagree with this statement.**

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
This is the only job I can imagine doing	❑	❑	❑	❑	❑	❑	❑

b. **Considering this occupation, are you currently:**
- ❑ Working full-time
- ❑ Working part-time
- ❑ Not currently working
- ❑ Retired

c. **Is this occupation part of, or related to, the farming/ranching industry?**
- ❑ Yes
- ❑ No

SECTION J: DEMOGRAPHICS

Your willingness to share some limited background information will help us appreciate the challenges of owning and managing rural land. It will also help us accurately report the demographic characteristics and economic aspects of rural land ownership to inform public policy and decision makers in Kansas, Oklahoma, and Texas.

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❑ Yes ❑ No

42. Have you ever received cost-share or direct payments from a state or federal agency to control woody plants through conducting a prescribed burn?
❑ Yes ❑ No

43. What is your primary occupation? *(If RETIRED, what was your primary occupation?)*

_____

a. **Considering this occupation, please indicate the extent that you agree or disagree with this statement.**

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
This is the only job I can imagine doing	❑	❑	❑	❑	❑	❑	❑

b. **Considering this occupation, are you currently:**
- ❑ Working full-time
- ❑ Working part-time
- ❑ Not currently working
- ❑ Retired

c. **Is this occupation part of, or related to, the farming/ranching industry?**
- ❑ Yes
- ❑ No

44. Do you currently have a second job?

- ❑ No
- ❑ Yes → What is it? _____

45. In what year were you born? _____ year

46. Are you: ❑ Male ❑ Female

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

- ❑ Some high school or less
- ❑ High school diploma or equivalent
- ❑ Some college
- ❑ Trade school, formal apprenticeship, or 2-year degree
- ❑ Completed a 4-year college degree
- ❑ Some graduate or professional school
- ❑ Completed graduate or professional school

48. Are you of Spanish/Hispanic origin?

- ❑ No, not Spanish/Hispanic
- ❑ Yes, Mexican, Mexican American, or Chicano
- ❑ Yes, other Spanish/Hispanic group (*Please specify group)*:_____

49. What is your race? Please indicate the one or more races that may apply.

- ❑ White
- ❑ Black, African American
- ❑ American Indian or Alaska Native
- ❑ Asian, including Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese
- ❑ Native Hawaiian, Guamanian or Chamorro, Samoan and other Pacific Islander
- ❑ Some other race (*Please specify*): _____

50. In a typical year, approximately what percent of your annual household income comes from activities related to your land?

_____ % (Agricultural production, hunting leases, tourism, etc.)

_____ % (Oil, gas, mineral, or wind power developments)

51. Please select the category that best describes your average annual household income.

- ❑ Less than $50,000
- ❑ $50,001– $75,000
- ❑ $75,001– $100,000
- ❑ $100,001– $500,000
- ❑ More than $500,000

Is there anything else you would like to share with us?

We sincerely appreciate your time and thoughtful contributions to this study. Please return your completed questionnaire in the postage-paid envelope as soon as possible.

Thank You!

Appendix C. Survey Implementation Schedule and Contact Documents

Survey Phase	Day	Date mailed	Quantity mailed (% of original sample)
1. Introductory letter	Day 1	Wednesday 2/28/18	2,993 (100%)
2. Survey packet & cover letter	Day 7	Wednesday 3/07/18	2,993 (100%)
3. Reminder/thank you postcard	Day 14	Wednesday 3/14/18	2,993 (100%)
4. Replacement survey packet	Day 43	Thursday 4/12/18	2,059 (68.8%)
5. Final reminder letter	Day 63	Wednesday 5/2/18	1,887 (63%)

*9 additional replacement survey packets (phase 4) were mailed at the request of respondents.

Survey Phase 1. Introductory Letter

TEXAS A&M UNIVERSITY
College of Agricultural and Life Sciences

College of Agricultural Sciences and Natural Resources

VirginiaTech
College of Natural Resources and Environment

Kiandra Rajala
310 W. Campus Drive
Blacksburg, VA 24061
(406) 207-5734; krajala@vt.edu

Jane Doe
123 Landowner Road
Ruraltown, Texas 78111

ID: EP01

Dear Jane,

On behalf of my colleagues, I am writing to ask for your help with an important research study about private land management and changing land uses within the Southern Great Plains. I am a graduate student at Virginia Tech and am partnering with colleagues at Texas A&M and Oklahoma State University to better understand how private landowners, like yourself, think about their land and perceive changes to it. We hope our findings will inform regional decisions in ways that help to promote rural communities and the health of farms, ranches, and other working lands.

Out of more than 9,000 landowners in the Edwards Plateau of Texas, you are one of only 1,000 people in your region we are asking to help us. Your feedback is important for us to truly understand the experiences and concerns of landowners and producers in the Edwards Plateau. We obtained your name from public records in Val Verde County. Regardless of how you use your land—for agriculture, ranching, recreation, or other reasons—you have a unique perspective that is very important to us.

In the next week or so, we will send you a request to contribute to this research by completing a questionnaire about your experiences as a landowner. I am writing to you in advance because many people like to know ahead of time that they will be asked to fill out a questionnaire.

This research can only be successful through the generous participation of people like you. We hope that you enjoy the opportunity to voice your thoughts and opinions about private land ownership in the Southern Great Plains. We hope that you will consider completing the questionnaire and look forward to hearing from you.

Sincerely,

Kiandra Rajala
Graduate Research Assistant
Virginia Tech

Urs Kreuter
Professor
Texas A&M University

Sam Fuhlendorf
Professor
Oklahoma State University

Mike Sorice
Associate Professor
Virginia Tech

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TEXAS A&M UNIVERSITY
OKLAHOMA STATE UNIVERSITY

Survey Phase 2. Survey Packet Cover Letter

TEXAS A&M UNIVERSITY
College of Agricultural and Life Sciences

College of Agricultural Sciences and Natural Resources

VirginiaTech
College of Natural Resources and Environment

Kiandra Rajala
310 W. Campus Drive
Blacksburg, VA 24061
(406) 207-5734; krajala@vt.edu

Jane Doe
123 Landowner Road
Ruraltown, Texas 78111

ID: EP01

Dear Jane,

About a week ago, we sent you a letter introducing a study about understanding your perceptions of how your land in Val Verde County, Texas may be changing. We are now asking for your help. You are part of a select group of landowners invited to participate in this study. Whether you use your land for crop or livestock production, wildlife habitat, or to enjoy outdoor recreation opportunities and the rural lifestyle, we really want to hear your unique perspective!

To participate in this study, please complete the included questionnaire. The questionnaire should take about 30 minutes to complete, but feel free to answer questions at your own pace.

The questionnaire has a unique identification number in place of any personal identifying information to protect your confidentiality. This number will help us know that we received your questionnaire. Your participation is voluntary. You are free to skip any questions that you prefer not to answer, and you may withdraw from the study at any time. If you prefer not to participate, please feel free to return a blank questionnaire in the enclosed envelope and we will remove your name from our mailing list.

This project is a collaborative effort between Virginia Tech, Texas A&M, and Oklahoma State University. If you have any questions or would like further information about this research, please feel free to contact Kiandra at (406) 207-5734 or krajala@vt.edu. If you have any questions about the protection of research participants regarding this study, please contact the Virginia Tech Institutional Review Board for the Protection of Human Subjects at (540) 231-3732 or irb@vt.edu.

By sharing your experiences and opinions as a landowner, you will greatly help us understand the range of current land uses and conditions within the Edwards Plateau and greater Southern Great Plains. Please return the completed questionnaire in the postage-paid return envelope enclosed in this packet. We value your time and very much appreciate your input into this project.

Thanks for your help!

Kiandra Rajala
Graduate Research Assistant
Virginia Tech

Urs Kreuter
Professor
Texas A&M University

Sam Fuhlendorf
Professor
Oklahoma State University

Mike Sorice
Associate Professor
Virginia Tech

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TEXAS A&M UNIVERSITY
OKLAHOMA STATE UNIVERSITY

Survey Phase 3. Reminder/Thank You Post Card

CHANGING LANDSCAPES PARTNERSHIP
c/o *U. Kreuter & K. Rajala*
Department of Ecosystem Science & Management
2120 TAMU
College Station, Texas 77843-2120

Return Service Requested

Jane Doe
123 Landowner Road
Ruraltown, Texas 78111

Recently, we sent you a questionnaire asking for your thoughts on your land. **If you have already completed and returned the questionnaire, please accept our sincere thanks. If not, please consider participating by completing and returning the questionnaire as soon as possible.**

Whether you own land for production, wildlife, recreation, or any other purpose, we want to hear from you! Because you are one of only a small percentage of landowners selected in your area, it is important that your opinion is represented in our study.

If you did not receive the questionnaire, or need a replacement, please contact Kiandra at (406) 207-5734 or by email at krajala@vt.edu, and we will get another one in the mail to you today.

Many thanks for your help!

Kiandra Rajala
Graduate Research Assistant
Virginia Tech

Urs Kreuter
Professor
Texas A&M University

Sam Fuhlendorf
Professor
Oklahoma State University

Mike Sorice
Associate Professor
Virginia Tech

Survey Phase 4. Replacement Survey Packet

TEXAS A&M UNIVERSITY
College of Agricultural and Life Sciences

College of Agricultural Sciences and Natural Resources

VirginiaTech
College of Natural Resources and Environment

Kiandra Rajala
310 W. Campus Drive
Blacksburg, VA 24061
(406) 207-5734; krajala@vt.edu

Jane Doe
123 Landowner Road
Ruraltown, Texas 78111

ID: EP01

Dear Jane,

In recent weeks, we sent you a questionnaire asking for your opinions on your land in the Edwards Plateau of Texas and your perceptions of how your land may be changing. To the best of our knowledge, we have not yet received your response.

We are writing again because your unique perspective is very important to us. One of the best ways to understand issues related to landscape change in the Southern Great Plains is to ask people who own land in this area to share their thoughts, opinions, and experiences. The comments from other landowners who have already responded include a wide range of land uses and opinions. Your input can help insure that our results will accurately represent the range of issues important to landowners and producers across the Southern Great Plains.

Please complete the enclosed questionnaire and return it in the postage-paid reply envelope at your soonest convenience. The questionnaire should take about 30 minutes to complete. Your responses are voluntary and will be kept confidential. There is a unique identification number on your survey to protect your confidentiality and for mailing purposes. When your questionnaire is returned, we will remove your name from our mailing list to ensure that you do not receive any further reminders. If you prefer not to participate, please indicate that to us by returning a blank questionnaire.

This project is a collaborative effort by Virginia Tech, Texas A&M, and Oklahoma State University. We are happy to answer any questions you may have. To get in touch, please contact Kiandra at (406) 207-5734 or by email at krajala@vt.edu. If you have any questions about the protection of research participants regarding this study, please contact the Virginia Tech Institutional Review Board for the Protection of Human Subjects at (540) 231-3732 or irb@vt.edu.

We hope that you will complete the questionnaire and enjoy the opportunity to express your opinions on some of the important issues facing landowners in the Southern Great Plains. We very much appreciate your help!

Sincere thanks,

Kiandra Rajala
Graduate Research Assistant
Virginia Tech

Urs Kreuter
Professor
Texas A&M University

Sam Fuhlendorf
Professor
Oklahoma State University

Mike Sorice
Associate Professor
Virginia Tech

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Survey Phase 5. Final Reminder Letter

TEXAS A&M UNIVERSITY
College of Agricultural and Life Sciences

College of Agricultural Sciences and Natural Resources

VirginiaTech
College of Natural Resources and Environment

Kiandra Rajala
310 W. Campus Drive
Blacksburg, VA 24061
(406) 207-5734; krajala@vt.edu

Jane Doe
123 Landowner Road
Ruraltown, Texas 78111

ID: EP01

Dear Jane,

In the past few weeks, we contacted you as part of a small group of landowners and producers in the Edwards Plateau of Texas to ask for your thoughts and opinions on land ownership and landscape changes in your area. We'll begin summarizing our results soon, and hope to receive your questionnaire so that we can include your perspective in this project.

You can help us by answering the questionnaire we mailed to you and returning it in the postage-paid envelope we provided. Through the input of all of our invited participants, we aim to accurately represent the range of people who own land in the Southern Great Plains. We hope that this study will provide insight on the issues important to landowners and producers and contribute to efforts promoting the health of farms, ranches, and other rural lands throughout the Southern Great Plains.

This is the last contact you will receive from us, as we are bringing this phase of the project to a close. If you would like a replacement survey or have any questions about this research, please feel free to contact Kiandra by phone at (406) 207-5734 or email at krajala@vt.edu.

We value your time and would greatly appreciate your help!

Best regards,

Kiandra Rajala
Graduate Research Assistant
Virginia Tech

Urs Kreuter
Professor
Texas A&M University

Sam Fuhlendorf
Professor
Oklahoma State University

Mike Sorice
Associate Professor
Virginia Tech

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OKLAHOMA STATE UNIVERSITY

Frequently Asked Questions
Here are some questions landowner and producers have asked us over the course of this survey.

Why did you ask me to participate? We asked you to participate in this research because you own land in the Southern Great Plains (Texas, Oklahoma, and Kansas). We got your name and mailing address from the Bandera County public records. As a landowner or producer in the Edwards Plateau, your opinions and unique perspective are very important to us. Your feedback will help us understand the landscape changes and current issues facing private landowners in the Southern Great Plains.

Why is this study being conducted? This study is part of a larger collaborative research project investigating how changes in land use and land management may influence grassland ecosystems in the Southern Great Plains. Hearing from the full range of landowners and producers is crucial to understand how people use grasslands and rangelands, make management decisions, and perceive changes on their land. The results of this research can help inform regional policy and efforts to promote rural communities and healthy landscapes.

How soon do I need to complete the survey? We would appreciate if you can complete and return the questionnaire in the next few days, as it will take some time to compile all of our findings. If you prefer not to participate, simply mail us back the blank questionnaire.

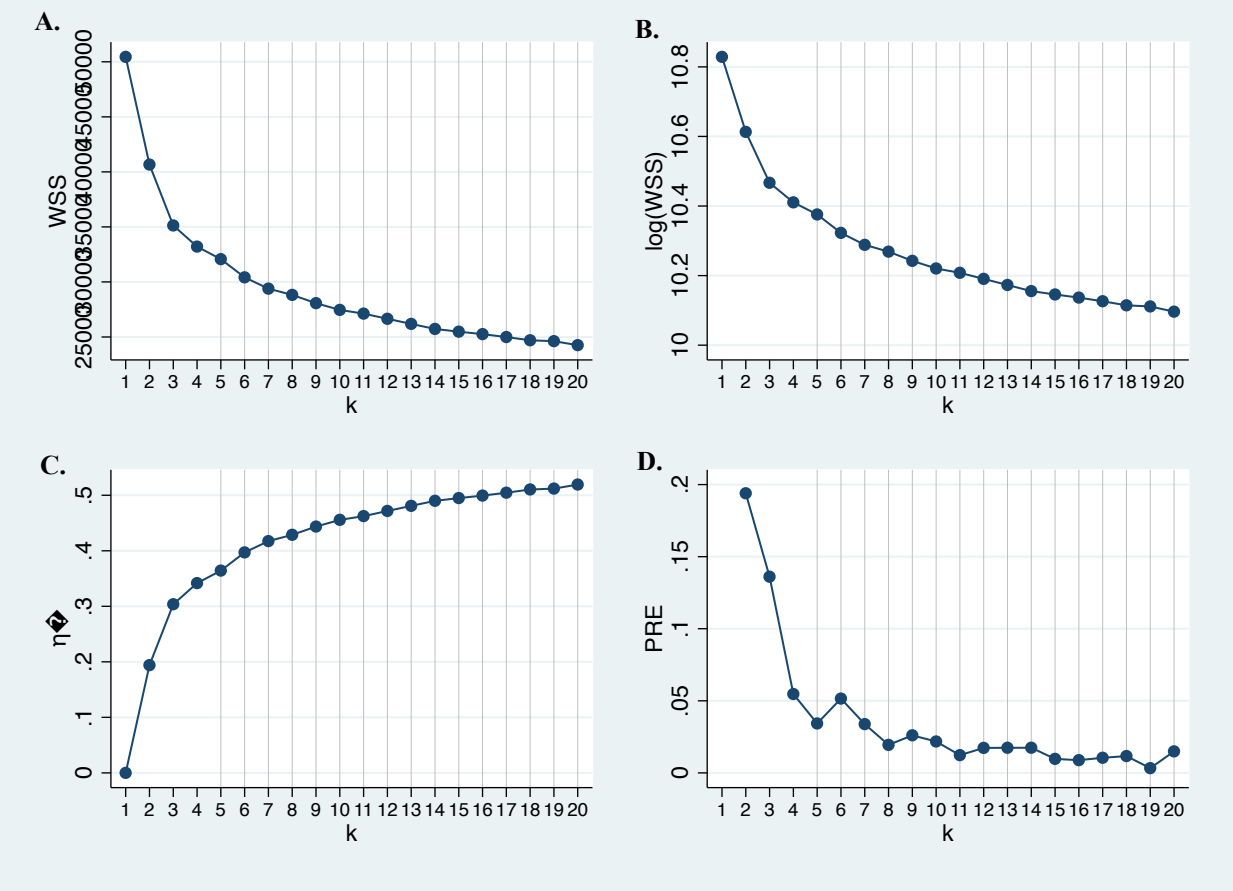
What will happen to my responses? Once all surveys have been returned, the research team from Virginia Tech will analyze the data. Final results will be combined together to describe regional trends. We plan to share our findings with colleagues at Texas A&M University and Oklahoma State University, publish our findings, and present our results around the region to help inform interested parties about the current trends and issues facing landowners in the Southern Great Plains.

How will my confidentiality be protected? You will see that your survey has a unique ID number. This is used, in place of your name or any identifying information, to keep track of who has returned their survey and should not receive further reminders in the mail. Once the survey phase of this project is complete, your name and contact information will be deleted. We take your confidentiality very seriously. As research universities, we all adhere to strict rules and regulations that protect your identity at all times.

Why is Virginia Tech involved with this study? Michael Sorice at Virginia Tech has spent the last decade working with private landowners and has expertise in survey research design and analysis. He received his Ph.D. from Texas A&M in 2008 and has continued to partner with Texas A&M and Oklahoma State to study issues relating to private lands management in the Southern Great Plains. Under his guidance, Virginia Tech graduate student Kiandra Rajala is also engaged in this phase of the research project.

Will Virginia Tech sell my name to others who may contact me? Absolutely not.

Appendix D. Elbow Method Results for 2-20 K-means Cluster Solutions with Fixed Seed



A. Scree plot of within sum of squares (WSS) for each number of *k* groups.
B. Scree plot of the logarithm of the within sum of squares (log(WSS)) for each number of *k* groups.
C. Eta-squared (η^2) for each number of *k* groups.
D. Proportional reduction of error (PRE) for each number of *k* groups.

Appendix E. Assessment of 6-Cluster Solution on External Variables

Appendix E. Results of chi-square test and ANOVA results for the 6-cluster solution of landowners' relationship to the land using landowner socio-demographics and characteristics. Cramer's V and eta-squared provide strength of association for each variable.

	Cluster 1 13% (n = 77)	**Cluster 2** 17% (n = 101)	**Cluster 3** 16% (n = 95)	**Cluster 4** 21% (n = 126)	**Cluster 5** 19% (n = 115)	**Cluster 6** 14% (n = 81)
Socio-demographics						
Average age (years) F = 0.86, p = 0.511, n = 466 Eta-squared = 0.01	65.6	62.7	63.6	63.4	65.6	64.9
Percentage female** $X^2_{(5)}$ = 20.50, p = 0.001, n = 472 Cramer's V = 0.21	20%	7%	33%	19%	27%	31%
Percentage with 4-year college degree of higher education $X^2_{(5)}$ = 6.96, p = 0.224, n = 473 Cramer's V = 0.12	55%	72%	60%	60%	59%	70%
Primary occupation:						
Percentage "Farmer"* $X^2_{(5)}$ = 12.82, p = 0.025, n = 483 Cramer's V = 0.16	8.33%	0%	2.47%	0.96%	2.17%	1.67%
Percentage "Rancher"*** $X^2_{(5)}$ = 51.48, p<0.001, n = 483 Cramer's V = 0.33	5%	0%	9.88%	0%	21.74%	1.67%
Percentage "Farmer/rancher"*** $X^2_{(5)}$ = 42.78, p<0.001, n = 483 Cramer's V = 0.33	13.33%	0%	2.47%	0%	16.30%	1.67%
Percentage part of or connected to the ranching/farming industry*** $X^2_{(5)}$ = 103.13, p<0.001, n = 475 Cramer's V = 0.30	46%	6%	37%	11%	65%	22%
Annual household income** Less than $50,000 $50,001- 75,000 $75,001-100,000 $100,001- $500,000 More than $500,000 $X^2_{(20)}$ = 44.32, p = 0.001, n = 437	 15% 15% 23% 45% 2%	 9% 13% 10% 61% 8%	 11% 27% 13% 40% 1%	 16% 27% 13% 40% 4%	 14% 26% 33% 26% 1%	 13% 27% 21% 31% 8%

Cramer's V = 0.16

	Cluster 1 13% (n = 77)	**Cluster 2** 17% (n = 101)	**Cluster 3** 16% (n = 95)	**Cluster 4** 21% (n = 126)	**Cluster 5** 19% (n = 115)	**Cluster 6** 14% (n = 81)
Average percentage of annual income derived from land*** F = 34.19, p<0.001, n = 356 Eta-squared = 0.33	35.8%	3.9%	31.7%	3.2%	57.5%	20.9%
Landowner and land characteristics						
Percentage from each region*** Flint Hills (KS) Central Great Plains (OK) Edwards Plateau (TX) $X^2_{(10)}$ = 131.54, p<0.001, n = 483 Cramer's V = 0.37	 42% 57% 2%	 28% 7% 65%	 36% 38% 26%	 27% 7% 66%	 42% 29% 28%	 42% 38% 20%
Percentage that inherited or acquired land from family*** $X^2_{(5)}$ = 156.13, p<0.001, n = 482 Cramer's V = 0.57	81%	5%	54%	19%	75%	58%
Average years of land ownership*** F = 16.67, p<0.001, n = 483 Eta-squared = 0.15	24.4	14.5	21.0	17.2	31.0	21.1
Average proportion of adult life they have owned their land*** F = 13.68, p<0.001, n = 466 Eta-squared = 0.13	50%	32%	47%	39%	68%	43%
Average acres owned*** F = 6.17, p<0.001, n = 474 Eta-squared = 0.06	828	323	825	499	1884	825
Average proportion of land owned that is leased out** F = 4.02, p = 0.001, n = 470 Eta-squared = 0.04	39%	20%	37%	21%	34%	60%
Percentage who live full-time on land*** $X^2_{(5)}$ = 72.6, p<0.001, n = 483 Cramer's V = 0.39	53%	20%	51%	38%	73%	18%

	Cluster 1 13% (n = 77)	**Cluster 2** 17% (n = 101)	**Cluster 3** 16% (n = 95)	**Cluster 4** 21% (n = 126)	**Cluster 5** 19% (n = 115)	**Cluster 6** 14% (n = 81)
Average one-way distance in miles of full-time residence from land, assigning those who live on land full-time "0" (miles)**	181	216	96	157	39	210
F = 4.06, p = 0.001, n = 481						
Eta-squared = 0.05						
Average one-way distance of non-resident landowners' primary residence from land (miles)	396	270	195	255	144	258
F = 1.33, p = 0.252, n = 273						
Eta-squared = 0.04						
Average frequency of personal or friends/family hunting participation on land[b] ***	3.1	3.6	3.4	3.7	3.6	2.8
F = 5.04, p<0.001, n = 478						
Eta-squared = 0.05						
Average prominence of the farmer/rancher identity[a] ***	3.6	2.2	3.3	2.9	4.3	2.4
F = 36.51, p<0.001, n = 479						
Eta-squared = 0.28						
Average involvement on land (hours/week)***	25.3	8.0	19.6	12.8	35.6	7.0
F = 26.87, p<0.001, n = 427						
Eta-squared = 0.24						
Primary land use***						
Livestock operation	13%	10%	53%	6%	56%	30%
Farming operation	32%	0%	0%	2%	4%	5%
Livestock and farming	22%	1%	1%	1%	11%	5%
Rural/natural amenities	5%	55%	7%	50%	2%	13%
Other use or combinations of uses	28%	34%	38%	42%	26%	47%
$X^2_{(5)}$ = 303.81, p<0.001, n = 595						
Cramer's V = 0.40						

Variables that differed significantly among clusters are shown in bold; *p<0.05, **p<0.01, ***p<0.001.

[a]Farmer/rancher identity prominence was measured on a scale of *1 = none* to *5 = very strong*.

[b]Frequency of hunting was measured on a scale of *1 = never* to *5 = very often*.

Appendix F. Intraclass Correlation for Multilevel Models Predicting Threshold

Appendix F. The intraclass correlation (ICC) and standard error of the intraclass correlation (SE(ICC) for only level 2 and level 3 variables predicting threshold of acceptability.

Level	ICC	SE (ICC)	95% Confidence interval
2. Individual	0.15	0.03	0.09 – 0.26
3. Region (using county)	0.26	0.05	0.18 – 0.37

Appendix G. Exploratory Factor Analysis Results for Place Meanings Constructs

Appendix G. Exploratory factor analysis (EFA) results and Cronbach's alpha (α) for survey items used to measure multi-item place meanings constructs. Responses were on a scale from 1 = *Not at all* to *5 = Completely*.

	Belief in Place Meaning				Dependence on Place Meaning			
Place meaning constructs and survey indicators *My place…*	**M**	**SD**	**α**	**Factor loading**	**M**	**SD**	**α**	**Factor loading**
Autonomy			0.79				0.83	
is where I am free to decide things for myself	3.82	1.29			3.66	1.38		
is somewhere I have few obligations to anyone else	3.41	1.34			3.32	1.37		
Economics			0.92				0.93	
is for making a profit	2.77	1.55		0.91	2.57	1.51		0.91
is a source of income	2.89	1.56		0.93	2.68	1.52		0.93
is a business	2.61	1.60		0.82	2.47	1.56		0.85
Family identity			0.84				0.86	
keeps my family connected to each other	3.18	1.39		0.74	3.17	1.41		0.79
represents my family's traditions and culture	3.39	1.42		0.79	3.31	1.43		0.82
is a source of family pride	3.86	1.25		0.78	3.75	1.31		0.78
Individual identity								
Factor 1			0.84				0.87	
has been a significant influence in shaping who I've become	3.15	1.34		0.74	3.35	1.27		0.72
reflects important aspects of who I am	3.54	1.17		0.70	3.09	1.35		0.74
is a source of personal pride	3.55	1.47		0.59	3.86	1.17		0.56
Factor 2			0.81				0.82	
is where I live life how I want	4.04	1.06		0.70	3.52	1.47		0.68
is somewhere I can really be myself	3.85	1.30		0.70	3.71	1.37		0.69
Restorative								
Factor 1			0.83				0.87	
is where I reduce the level of stress in my life	3.49	1.33		0.71	3.30	1.35		0.75
is somewhere I find peace and quiet	3.88	1.26		0.68	3.61	1.33		0.69
is somewhere I feel little pressure to get things done	2.84	1.32		0.54	2.75	1.34		0.55
Factor 2			0.86				0.89	
is somewhere I gain or find perspective on my life	3.37	1.32		0.69	3.24	1.35		0.68
is a source of inspiration	3.52	1.30		0.69	3.30	1.32		0.70
Stewardship/conservation			0.83				0.86	
is somewhere I feel connected to all living things and the earth	3.76	1.29		0.67	3.52	1.36		0.38
is somewhere I am responsible for conserving native prairie and its species	3.58	1.34		0.80	3.52	1.38		0.71
is somewhere I balance my needs with the needs of plants and wildlife	3.43	1.32		0.85	3.40	1.36		0.69
is somewhere I feel more like a caretaker of the land than an owner	3.44	1.38		0.64	3.40	1.42		0.40
Attachment			0.92				0.91	
is where I feel most at home	3.63	1.40		0.84	3.57	1.44		0.80
is somewhere I really miss when I am away for too long	3.73	1.33		0.88	3.61	1.36		0.91
is where I generally feel the happiest	3.57	1.26		0.90	3.48	1.31		0.90
Purpose/legacy			0.86				0.88	
represents my personal legacy	3.59	1.36		0.83	3.55	1.39		0.85
symbolizes a way of life I want to pass on to future generations	3.80	1.31		0.83	3.69	1.35		0.81
is somewhere I uphold my family's legacy	3.40	1.52		0.83	3.35	1.53		0.80
Psychological Flow			0.88				0.89	
is where ordinary tasks feel more like leisure than work	3.38	1.32		0.82	3.33	1.36		0.84
is somewhere I enjoy the process of working on the land as much as the results	3.65	1.39		0.81	3.50	1.41		0.81
is where I do the kind of work I love	3.48	1.44		0.85	3.43	1.45		0.87

EFA and Cronbach's alpha was used to reduce items based on all eligible survey respondents prior to restricting sample to primary decision makers (n = 991). Due to item non-response, the number of respondents for each indicator ranged from 887 to 948.

Appendix H. Exploratory Factor Analysis Results for Perceived Threat Index

Appendix H. Exploratory factor analysis (EFA) results and Cronbach's alpha (α) for survey items used to create perceived threat index for low, medium, and high levels of cedar.

Perceived threat survey items	M	SD	α	Factor loading	Uniqueness
Low cedar photo			0.83		
Extremely acceptable (1) to extremely unacceptable (7)	3.45	2.19		0.67	0.55
Extremely encouraging (1) to extremely threatening (7)	4.32	1.94		0.80	0.36
Extremely desirable to (1) to extremely undesirable (7)	4.59	2.16		0.82	0.32
Medium cedar photo			0.85		
Extremely acceptable (1) to extremely unacceptable (7)	5.11	2.01		0.75	0.45
Extremely encouraging (1) to extremely threatening (7)	5.47	1.62		0.81	0.34
Extremely desirable to (1) to extremely undesirable (7)	5.63	1.69		0.85	0.27
High cedar photo			0.84		
Extremely acceptable (1) to extremely unacceptable (7)	6.30	1.48		0.71	0.49
Extremely encouraging (1) to extremely threatening (7)	6.29	1.40		0.82	0.33
Extremely desirable to (1) to extremely undesirable (7)	6.43	1.35		0.85	0.26

EFA and Cronbach's alpha was used to reduce items based on all eligible survey respondents prior to restricting sample to primary decision makers (n = 991). Due to item non-response, the number of respondents for each indicator ranged from 887 to 948.