LANDOWNER PERCEPTIONS OF WOODY PLANT ENCROACHMENT AND PRESCRIBED FIRE LIABILITY

A Thesis

by

ALEXANDRA ANNE ABNEY

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Chair of Committee,	Urs P. Kreuter
Committee Members,	Robert Knight
	Roel Lopez
Head of Department,	Kathleen Kavanagh

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ABSTRACT

Prescribed fire is an affordable and effective tool in managing woody plant encroachment, but landowners' liability perceptions contribute to their inconsistent application of fire. Personal liability concerns can be exacerbated or allayed by social and legal factors. This research focuses on the extent landowner perceptions regarding prescribed fire liability influence their willingness to participate in prescribed burns for woody plant management. Questionnaires mailed to 1918 landowners in 16 counties of Oklahoma and Texas evaluated several factors that might affect their willingness to burn. These include: attitudes concerning woody plants and fire; use of land management practices; knowledge about prescribed fire; Prescribed Burn Associations (PBAs) membership; and landowner characteristics. Membership in a PBA was positively correlated with landowner willingness to burn their own or a neighbor's property while a perception of general personal liability was negatively related with willingness to burn. Percentage of income earned from rural property, place of residence, state of residence, education level, perceived relative affordability of prescribed fire as a woody plant management tool, and burn bans were all factors that significantly influenced landowner willingness to burn depending on situational context, i.e. on their property v. another person's property. The results of this study contribute to our understanding of landowner decision-making with respect to social and legal concerns over prescribed fire and suggest a need for increased connection of landowners with local prescribed burn associations, communication between policy makers and landowners, and reduction of barriers to landowners who wish to apply prescribed fire.

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NOMENCLATURE

PBA	Prescribed Burn Association
SD	Standard Deviation
AIC	Akaike Information Criterion

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Introduction

Woody plants such as mesquite (*Prosopis l.*), Chinese tallow (*Triadica sebiferium*), redberry juniper (*Juniperus pinchotii*), ashe juniper (*Juniperus ashei*), oak (*Quercus* sp.) have increased in range and density in the Southern Great Plains. Historically, most of the Great Plains was predominantly grassland from the Texas panhandle northward with trees growing only along floodplains and some steeper terrain of the northern Great Plains (Trimble 1980). Though these woody plants can provide unique ecosystem services and economically beneficial functions, these plants are equipped with mechanisms to overtake prairies under disturbance conditions (Denslow 1980, Archer 1995). Research and economic comparisons of prairies experiencing woody plant encroachment have found that there are significant barriers to grassland management if action is taken too late, or if no action is taken to reduce woody plants in open grasslands (Fuhlendorf et al. 1996). The primary reason for this encroachment is that the Great Plains have historically been burnt by periodic natural and anthropogenic fire, leaving little opportunity for brush expansion (Pyne 1982). Seventy years of fire exclusion in addition to resource exploitation have generally increased aboveground fuel loads, especially in the form of woody plants, to volumes that foster larger, more severe and less controllable fires (Brown 1985; Arno and Brown 1991; Mutch et al. 1993; Kolb et al. 1998; Keane et al. 2002; Pinol et al. 2005).

Prescribed fire can be used to reduce accumulated aboveground fuel, consisting of both woody plants and moribund grass biomass. Fuel removal also reduces the risk of wildfire, improves forage growth and quality, and can also improve wildlife habitat (Ratajczak et al. 2014). Prescribed fire is one of the more effective tools for integrated management practices to reduce woody plant groundcover (Twidwell et al. 2015) and, unlike mechanical and chemical woody plant treatments, can provide positive returns on investments (Van Liew et al. 2012). However, when applying fire, landowners must weigh benefits and risks to determine if the potential of fire escape and smoke hazard is greater than reduced forage production, increased woody plant biomass, and elevated wildfire risk (Toledo et al. 2012). Decisions about the use of prescribed fire on privately-owned rangelands in the Southern Great Plains are influenced in part by landowner perceptions about the expansion of woody plants and prescribed fire liability (Kreuter et al. 2008; Toledo et al. 2012). Researchers who have studied the ecological, economic, social, and legal aspects of using prescribed fire have drawn conclusions about the importance and efficacy of this land management tool (Twidwell et al. 2012, 2016; Van Liew et al. 2012, Toledo et al. 2013; Wonkka et al. 2015). In particular, liability concerns have been identified as a major deterrent for landowners to use prescribed fire as a management tool (Kreuter et al. 2008). What has been less well explored, but is vital to the widespread adoption of this land management tool, is the relationship between landowner perceptions about prescribed fire liability and their application of prescribed fire.

To address this knowledge gap, my research will examine landowner perceptions about this relationship within two states in the Southern Great Plains, Texas and Oklahoma. These two states have dissimilar fire histories due to ecological, economic, social, and legal differences, but both states have experienced wildfires and have active prescribed burn associations (PBAs). I will specifically focus on the relationship between landowners' use of prescribed fire and their self-described liability-related concerns. My research will also address uncertainty about landowners' perceptions of liability regarding the use of prescribed fire in the two states.

Literature Review

Previous research has addressed many factors influencing land management decision-making. In relation to the use of fire, Toledo et al. (2012) presented the decision whether to burn or not as an economic evaluation of benefits and costs of applying fire. The exclusion of fire from ecosystems that historically experienced periodic fire can create an ecological risk of thicketization, which can lead to a reduction in forage supply and, therefore, a decline in economic profitability of ranching operations (Archer et al. 2000). The altered landscape influences biogeochemical cycles linked with climate change and nitrogen fixation rates. Air, soil, and water cycles are altered by changing rates of exchange that once primarily facilitated C4 grasses (Jackson et al. 2002). These effects of woody plant expansion may however be delayed while landowners are able to continue obtaining income from hunting and recreational use on their land, even when

livestock production potential declines. Therefore, landowner economic evaluations of using prescribed fire as a land management tool face temporally disconnected costs (Van Liew 2012). Specifically, while the cost of applying fire, including the potential liability for damages from escaped fire, are immediate, the economic costs of not burning and resulting thicketization may be substantially delayed.

Factors that influence landowner decisions about conducting prescribed fires are not necessarily limited to liability. In a survey conducted by Toledo et al. (2012), respondents cited two other categories of drivers influencing the use of prescribed fire; lack of knowledge or experience in fire safety, and lack of labor and equipment to conduct prescribed fire. The first relates to the fact that fire is easy to ignite, but appropriate knowledge and skills are needed to ensure that the goal of the burn is achieved. The second relates to the need for adequately trained labor and equipment to ensure the fire is applied in a way that does not cause harm to people involved with the fire or to neighboring landowners.

Insurance can reduce risk of personal liability and is normally available with the requirement that a certified burn manager presides over the burn (Fawcett 2015). Thus, general land insurance and fire-specific insurance can remove the "cost" of potential liability from a prescribed burn. Total net benefit is gained with insurance protection from potential damages, rendering the activity more profitable *if* the landowner weighs the scenario numerically (Yoder et al. 2004).

Numerous studies have observed that landowners frequently decide not to use prescribed fire despite the substantial ecological and economic benefits of using fire

(Ham et al. 2001, Yoder et al. 2004, Yoder et al. 2008, Sun and Tolver 2012, Toledo et al. 2012, Wonkka et al. 2015). Other factors also affect the decision to apply certain land management decisions, including fire. Social science research has led to the recognition that peer pressure and peer-to-peer mentorship can be influential in land management decision-making (Kreuter et al. 2008, Toledo et al. 2013). Social interactions may positively reinforce recommended land management practices whereas negative "press" can discourage their adoption (Jacobson et al. 2001). For example, Toledo et al. (2012) studied factors that influence landowners' decisions regarding prescribed fire and identified landowner perceptions of fire liability as a major factor influencing the use of this management tool. Often, laws and policies influence the economic bottom-line of land management and clarify dangerous, unacceptable, or inadvisable practices that influence landowners' decisions regarding prescribed fire. For example, the Texas Air Control Board provides regulations for prescribed burns relating to air quality caused by smoke and particulates (White et al. 1994). It is important to understand the basis of the risk perceptions because they may not accurately reflect actual dangers associated with the use of prescribed fire. A better understanding of landowner perceptions about woody plant encroachment and prescribed fire with respect to liability should lead to educational efforts and policies that enhance the use of prescribed fire as an effective land management tool.

Concerns over liability regarding the use of prescribed fire were addressed by Kreuter et al. (2008) and by Wonkka et al. (2015). The first of these two manuscripts, Kreuter et al. (2008) identified PBAs as a mechanism for reducing prescribed fire

liability. This is achieved through fire safety training, equipment, labor and, in some cases, insurance coverage that PBAs provide to their members for burning. The 2008 paper connected the perceived reduction of personal liability with the increase in landowner willingness to conduct a prescribed burn.

The second paper, Wonkka et al. (2015), explored the effect of the legal statutes for fire-related liability on the use of prescribed fire by landowners. There are three primary liability standards: strict liability, simple negligence, and gross negligence. Strict liability means that a landowner is responsible for all damages emanating from a fire initiated by the burner. Under simple negligence statutes a burner must take "reasonable care" in applying fire and a plaintiff must provide evidence of negligence (both Texas and Oklahoma are simple negligence states). Gross negligence means that if a burner follows codified regulations, plaintiff must show "reckless disregard" of duty. Required items to meet gross negligence requirements include (1) a written burn plan, (2) the presence of a Certified Prescribed Burn Manager; (3) adequate personnel and fire breaks; and (4) burn permits. In their study, Wonkka et al. (2015) compared incidence of burning between bordering counties that were governed by simple and gross negligence statutes. They found that the legal framework for liability in each county significantly influenced the perception of risk using prescribed fire and, therefore, the use of this land management tool. Specifically, landowners in gross negligence states burned significantly more land than those in simple negligence states. Moreover, the number of landowners burning in counties that require a permit did not differ from counties that require additional statutorily mandated regulatory measures (Wonkka et al. 2015).

Additionally, there was no significant difference in burning incidence in counties that allow burn ban exemptions for certified prescribed burn managers compared to counties that do not have this requirement (Wonkka et al. 2015). Therefore, a person's perception of liability regarding the use of fire appears to be related not only to estimation of the potential economic costs versus the benefits of engaging in certain behavior, but more importantly their perception of liability, which can be based on real or imagined risk.

In states with gross negligence, where burners' liability for using fire is substantially reduced, landowners perceive there is a lower risk of using fire. By contrast, where there is legal precedence to hold prescribed burners accountable for actions beyond their control, landowners may be discouraged from using prescribed fire. This was exemplified in the case of Koos v. Roth, which involved litigation over an escaped fire (Yoder et al. 2004). In this case, the local fire chief testified that even when reasonable precautions were taken when using prescribed fire, unforeseen conditions caused 12.5% of such fires to escape and therefore make this an "ultra-hazardous activity." Oregon, where this case was argued, has simple negligence standards; therefore, the case was based as an issue of negligence. Once the testimony rendered the activity "ultra-hazardous", the burden of damages was imposed upon the person who applied the fire, regardless of reasonable practices taken. With this case, designation of prescribed fire as "ultra-hazardous" effectively removed all protection from damages associated with prescribed fire, thereby substantially increasing the risk of liability and reducing the incentive for using this land management tool.

Danger of escaped fire has led policymakers to adopt precautionary stances. Safe practices enforceable by law or encouraged by policies can reduce unnecessary risk-taking by discouraging landowners from impromptu management burns. These same laws and policies can become obstructive, however, when landowners are uncertain about ways in which liability laws influence them, or about how they can affect laws and policies that influence their perceptions of liability.

Legal frameworks influence not only public perception, but also represent the risk filters managers use before choosing an action for land management. A risk filter influences the estimated cost of action or inaction (Haimes et al. 2002). Legal liability that is adjusted by an alternate legal framework can influence the monetary cost of action or inaction, and is a very real example of how negligence laws affect landowners' potential choices in management.

When social networks and legal frameworks influence public perception of prescribed burn liability risk, subjective norms are likewise altered. Positive public perception and supportive social networks can result in subjective norms that promote prescribed fire while the opposite outcome often occurs with negative public perception and negatively responding social networks (Jacobson et al. 2001). Social networks pool community skills and resources, strengthening members. These skills and resources help reduce risk, preventing negative subjective norms concerning prescribed fire. The less risk there is, the less likely that prescribed fire liability will be an issue that influences land management decisions.

Research Question and Hypotheses

The purpose of this research is to identify factors that influence ***landowners' perceptions regarding prescribed fire liability*** (legal dimension) and ***their willingness to burn their own land or participate in the application of prescribed fire on other peoples' land*** (social dimension). The primary question that the study therefore addresses is, "To what extent do landowner perceptions regarding prescribed fire liability influence their willingness to participate in prescribed burns for woody plant management on their own land and on other peoples' property?" In order to answer that question, I tested *three hypotheses*.

H1 (Legal): ***The likelihood that a landowner will apply prescribed fire to their own land or participate in the application of prescribed fire on other people's land is negatively correlated with his/her perception about the legal liability for applying fire.*** That is, landowners who perceive fire to be a legally risky management tool will be less likely to engage in prescribed fire than landowners who perceive this tool to be less risky. For example, in states where prescribed fire statues impose lower liability standards for burners, landowners tend to burn more frequently than in states were legal liability is greater (Wonkka et al. 2016).

H2 (Social): ***Landowner perception of legal liability for applying prescribed fire is positively mediated by their social connectedness provided by membership in prescribed burning associations (PBAs).*** In other words, landowners who are PBA

members are likely to perceive prescribed fire to be less risky and are more likely to burn than non-members. PBAs engage landowners in fire safety training, they provide resources landowners often feel they lack, and they may also provide prescribed fire liability insurance for members (Taylor 2005). Additionally, because there are more PBAs in Oklahoma then Texas, it is anticipated that, in general, landowners in Oklahoma will express greater willingness to burn (Weir et al. 2016).

H3 (Management): ***Landowners who perceive fire to be an effective, affordable, and easy to use tool for woody plant management will be more willing to burn than those who do not have this positive perspective of prescribed fire*****.** This is based on the observation that positive perceptions about the effectiveness (especially in the short-term), affordability, and ease of use of a land management practice contribute to the widespread adoption of that practice (Davis 1989, Adrian 2005, Kreuter et al. 2001).

CHAPTER II

METHODOLOGY

Study Area

This study was conducted using a mail survey of landowners in the Southern Great Plains regions of Texas and Oklahoma. "The Southern Great Plains encompasses three eco-regions in the South-Central U.S., including the Central Great Plains, the High Plains, and the Southwestern Tablelands. Combined, these eco-regions total nearly 72.8 million hectares managed mostly in private landownership" (Assal et al. 2015). This eco-region was selected as the focus area of the study because of the preponderance of private landholdings and extent of woody plant expansion, which makes it possible to address the primary research question across a large spatial scale.

The research was conducted in sixteen counties in Texas and Oklahoma (Figure 1). In Texas, the counties are located in the Edwards Plateau region and include: San Saba, Llano, Mason, Gillespie, Kimble, Menard, Sutton, and Schleicher. In Oklahoma, the counties are located in the Rolling Red Plains and include: Beckham, Comanche, Dewey, Ellis, Roger Mills, Tillman, Pawnee, and Payne.

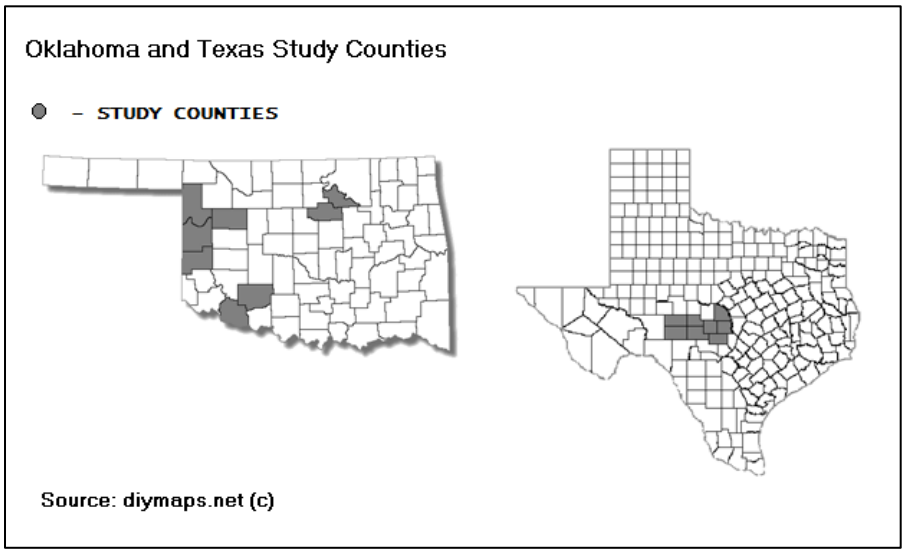

Figure 1. Study area in Texas and Oklahoma with the 16-county study area shaded.

Mail Survey Sampling Methods

This research was conducted using a five-phase mail survey technique (Dillman et al. 2009). The mailings included: 1) an initial pre-survey letter describing the purpose of the study; 2) the survey questionnaire with cover letter and postage paid return envelope; 3) a reminder/thank-you postcard. Survey participants who did not respond after the first three mailings were sent; 4) a replacement questionnaire; and, finally, 5) a second reminder/thank you card postcard. Each postcard was posted two weeks after the survey questionnaire to allow adequate response time. The survey was conducted in October and November of 2015 and responses were accepted for approximately 5 months. Previous studies (Kreuter et al. 2005, Sorice et al. 2013, Stroman et al. 2014) using this type of mail survey protocol generally report response rates between 30-50%.

The questionnaire consisted of 12 pages with 153 questions, plus an additional 24 questions for self-identified PBA members. The questionnaire also included space at the end for respondents to provide additional comments about prescribed fire and woody plants. Topics of inquiry in the questionnaire included: Attitudes concerning woody plants and fire; use of various land management practices, including prescribed fire; knowledge about prescribed fire, information about prescribed burn associations; and landowner characteristics. The survey questionnaire was developed with input from numerous stakeholders including personnel from Texas A&M University, Texas A&M Agrilife Extension, Oklahoma State University Extension, the University of Nebraska, and Virginia Tech, private landowners and prescribed burn association members. Once completed, the questionnaire was sent to these same stakeholders for detailed review and feedback. Based on this feedback, the questionnaire was revised and finalized.

Categorical response options were used extensively to obtain quantitative responses from survey participants. Most of the categorical response questions used a seven-point Likert-type response scale (strongly disagree = 1, disagree = 2, somewhat disagree. = 3, neutral = 4, somewhat agree = 5, agree = 6, and strongly agree = 7). Survey participants were instructed to mark questions they could not answer with either a D/K = don't know, or N/A = not applicable. Binary Yes/No response options and short open-ended responses also were used for some questions. For example, survey participants were asked to provide the name of a prescribed burn association (PBA) or choose multiple land management practices from a list.

Data Analysis

Survey data were entered into Microsoft Excel and analyzed using STATA 12.0. (STATA 2011). Statistical analyses included: descriptive statistics for demographic data and principal components analysis (PCA) to group related variables into functional indices. Logistic regression models were used to test the three hypotheses.

Principal Components Analysis

To compare perceptions of landowners who are willing to conduct prescribed burns and those who were not, I first needed to determine if the some of the questions to which the survey participants responded were correlated. Positive response correlations facilitate amalgamation of some variables into fewer latent indices. The goal of condensing variables was to reduce the number of variables in the regression models. PCA with varimax rotation was conducted on two sets of variables to test for collinearity. The first PCA focused on motivations for landownership and the second on prescribed fire liability concerns. The resulting latent variables were used as explanatory variables in the regression models developed to explain landowner willingness to burn.

After the initial PCA was conducted, orthogonal varimax rotation was used to create indices without inter-correlated components. Variables not unique in initial PCA analysis were used as standalone variables and not included in the final analysis of independent variables. Cronbach's alpha (α) values were obtained to test the internal reliability of the summative rating scales of the aggregated variables. A Cronbach's alpha (α) of 0.70 or more is generally considered adequate for internal reliability of the

latent indices (Cortina 1993). However, Schmitt (1996) argued that measures with lower levels of alpha may still be quite useful, and that it may be less critical to base the validity of items interrelatedness upon some "sacred level" level of alpha. Accordingly, in this study it was decided to relax the internal validity standard to $\alpha > 0.60$. The resulting latent variables (Table 1) were then included in the logistic regression models for hypothesis testing.

Table 1. Rotated factor loading results of PCA analysis of independent variables concerning liability and prescribed fire with Cronbach's α measuring internal scale reliability.

Independent Variables	*Rotated Factor Loadings*		
	Reduced concern α= 0.8965	Influence α=0.7938	Liability α=07498
Burn plans reduce escape	**0.9011**	0.1198	0.0007
New tech reduce injury	**0.9107**	0.0866	0.0548
Affordable liability insurance access	**0.8672**	0.1453	0.0901
State laws affecting liability	**0.7896**	0.1319	0.1197
Influence on state legislation	0.1421	**0.8474**	-0.0475
Influence on affordable insurance	0.1107	**0.8525**	0.0822
Influence over county officials	0.1748	**0.7911**	-0.0022
Concern over personal liability on own land	0.1013	-0.1012	**0.8439**
Concern over personal liability on other's land	0.0377	0.0402	**0.8570**
Concern that burns reduce access to insurance	0.0795	0.1472	**0.7246**
Insurance protection*	0.3191	0.5565	-0.0889
State liability standards*	0.4518	0.4615	-0.0431
Influence of burn bans*	0.3425	0.0457	0.2256

*- variable did not load on any particular factor

Three latent indices, Reduced concern (α= 0.8965), Influence (α=0.7938), and Liability (α=07498), were created from ten variables including (Table 1). Three additional variables, Insurance protection, State liability standards, and Influence of burn

bans, did not load onto the other variables and retained as single item independent variables.

Additionally, five latent indices were created from 17 response items relating to landownership motivations (Table 2) and were used as independent variables in the regression models. They include: Recreation/amenity (α=0.8574), Ranching/profit (α=0.8526), Heritage (α=0.9206), Hunting (α=0.6289) and Farming (α=0.6693). Based on Akaike Information Criterion (AIC), which was used to determine model selection, two additional variables relating to landowner motivation (produce goats as livestock, and ownership for profitable land sale) were not included in the final regression models.

Table 2: Principal components analysis of landowner motivation response variables, with Cronbach's α measuring internal scale reliability.

Landowner Motivations	*Rotated Factor Loadings*				
	Recreation / Amenity α=0.8574	Ranch/ Profit α=0.8526	Heritage α=0.9206	Hunting α=0.6289	Farming α=0.6693
Enjoy the outdoors	**0.8132**	0.1247	0.1615	0.0798	-0.0706
Place to relax	**0.8883**	0.0195	0.0572	0.0747	0.0117
Recreational fishing	**0.8020**	-0.0949	0.0590	0.2146	0.0697
Recreational hunting	**0.8386**	0.0450	-0.0060	0.2309	0.0412
Operate farm/ranch	0.0702	**0.8709**	0.1704	0.0710	0.0980
Maintain family ranch/farm tradition	0.0004	**0.6943**	0.5299	0.0843	0.1167
Produce grazing livestock (cattle/sheep)	0.0185	**0.8561**	0.1962	0.0040	0.0942
Earn a profit	-0.0270	**0.6702**	0.1280	0.0774	0.3765
Keep land in family	0.0669	0.2411	**0.9176**	0.0169	0.0608
Leave land for family	0.1050	0.1664	**0.9184**	0.0655	0.0738
Operate hunting enterprise	0.0177	0.2631	0.0877	**0.8071**	-0.0769
Manage large wildlife (deer)	0.2923	-0.0128	-0.0010	**0.8657**	-0.0793
Manage other wildlife	0.2770	-0.0773	0.0799	**0.7387**	0.1939
Produce hay/forage	0.0599	0.3569	0.1370	-0.2315	**0.6425**
Cultivate crops	-0.0216	0.1995	0.1282	-0.0159	**0.7628**
Obtain income from minerals	-0.0988	0.0775	0.1841	0.1023	**0.6747**
Have financial investment	0.2230	0.1096	-0.1402	0.0359	**0.6175**

Regression Model Development

Logistic regression models were developed to address the three stated hypotheses. In these models, the binary responses to landowner willingness to burn on their own land or on another person's land are the dependent variable (Table 3). In addition to the PCA indices (latent variables), Table 3 also provides a list of independent variables used in the regression models. Correlation coefficients for independent variables that are statistically significant ($p<0.05$) are considered to be potential predictors of landowner willingness to burn their own land or another person's land.

Table 3. Dependent and Independent variables used in regression models.

Dependent Variables	**Variable Descriptions**
Conduct prescribed burn on own land	Binary response to question, "Have you ever conducted a prescribed fire on your land"? (1=yes, 0=no)
Conduct prescribed burn on other people's land	Binary response to question, "Have you ever participated in a prescribed fire on someone else's land"? (1=yes, 0=no)
Independent Variables	
	Hypothesis 1 – Liability issues
General/personal liability	Latent variable for liability issues with prescribed fire (<3=negative … >3=positive)
Concern reduction (risk)	Latent variable for prescribed fire risk reduction (<3=negative … >3=positive)
Influence	Latent variable for influences on landowner use of prescribed fire (<3=negative…>3=positive)
Burn bans	Ordinal response for, "I have been prevented from using prescribed fire due to burn bans imposed by county commissioners." (1= strongly disagree … 7 = strongly agree)
Prescribed fire insurance	Ordinal response for, "Prescribed fire insurance effectively protects burners from liability in case of escape fires." (1= strongly disagree … 7 = strongly agree)
State legislated liability standards	Ordinal response for, "State-legislated lower liability standards for prescribed burning protects burners from liability in case of escaped fires." (1= strongly disagree … 7 = strongly agree)
	Hypothesis 2 – Social connectedness
PBA membership	Membership in Prescribed Burn Association. Binary single item variable.
State	State of residence; (0=Oklahoma, 1=Texas)
	Hypothesis 3 – Fire as a management tool
Fire affordability	Ordinal response for, "Prescribed fire is less costly than other methods for controlling woody plant encroachment." (1= strongly disagree … 7 = strongly agree)
Fire ease	Ordinal response for, "Prescribed fire is easier to implement than other methods for controlling woody plant encroachment" (1= strongly disagree … 7 = strongly agree)
Fire efficacy	Ordinal response for, "Prescribed fire is more effective than other methods for controlling woody plant encroachment" (1= strongly disagree … 7 = strongly agree)

Table 3 Continued

Independent Variables	Variable Descriptions
	Landowner characteristics
Gender	1=male 0=female
Age (years)	Landowner's age in 2015 (continuous single item variable)
Education	Landowner's level of education: High school (reference category), some post-secondary/bachelor's degree, graduate/professional degree.
Years of ownership	Number of years since land ownership (continuous single item variable)
Property size	Ordinal response for property size: 100-500 acres (reference category), 501-2500 acres (medium acreage) and > 2500 acres (larger acreage).
Residency	Categorical response for used for place of residence: full time resident, occasional resident, and absentee resident (reference category)
Income from rural property	Ordinal response for, "In 2014, approximately what percent of your total annual income was generated from activities on your rural property?" – 0% (reference category), 1-25%, 26-50%, 51-75%, 76-100%.
Hunting	Latent variable for hunting as primary ownership motivator (<3=unimportant … >3=important)
Farming	Latent variable for farming as primary ownership motivator (<3=unimportant … >3=important)
Ranching/profit	Latent variable for ranching/ profit as primary ownership motivator (<3=unimportant…>3=important)
Recreation/amenity	Latent variable for recreation as primary ownership motivator (<3=unimportant … >3=important)
Heritage	Latent variable for leaving land to family as primary ownership motivator (<3=unimportant … >3=important) (<3=unimportant…>3=important)

CHAPTER III

RESULTS

Response Rate

Of the initial sample of survey recipients (n=1918), 65 questionnaires were returned with incorrect addresses resulting in an effective survey sample of 1853. We received 771 responses, which included 680 completed survey questionnaires and 91 respondents indicating they did not wish to participate in the study. Therefore, the overall raw response rate was 42.0% and the useable response rate was 37.0%. PBA members replied at a greater than average rate compared with all general landowners in each state and overall (Table 4).

Table 4. Landowner participant response rate

Response Rates by group	Questionnaires sent	Completed received	% of usable response
Texas general landowners	800	272	40.0%
Texas PBA members	126	112	16.5%
Oklahoma general landowners	800	192	28.2%
Oklahoma PBA members	192	104	15.3%
Total	**1918**	**680**	**100.0%**

Respondent Characteristics & Demographic Information

Respondent demographics are reported in Table 5. More than half (56.5%) of respondents were Texas residents. Table 5 also shows that 32.0% of respondents indicated they were members of a PBA. The large majority of respondents (81.0%) were male, and the mean respondent age was 66 years. Half of the respondents reported their highest level of education as some college attendance/ bachelor's degree. The mean

years of property ownership of respondents was 26.4 years, and about a third of respondents (33.0%) reported their property had been in their family for over 100 years. About half (54.0%) reported they live on their property full-time, and the greatest proportion of respondents (40.0%) reported they generated between 26- 50 % of their 2015 income from their property.

Table 5. Survey respondent demographics

Demographic Variable		***Statistic***
Age (years)		Med=67, M=65.9; SD=10.9, Range 30-93
Years property ownership		Med=25, M=26.4, SD=16.9, Range 0-100
Years of family ownership		Med=75, M=71.4, SD=44.1, Range 0-400
Gender	Male	81.0%
PBA Member	Yes	32.0%
State of Residence	Texas	56.5%
	Oklahoma	43.5%
Education	High school	15.0%
	Some post-secondary/Bachelor's degree	50.0%
	Graduate/professional degree	35.0%
Property size	100-500 acres	29.4%
	501-1000 acres	19.8%
	1001-2500 acres	25.0%
	2500 acres +	25.8%
Live on property	Full-time resident	54.0%
	Weekend/occasional resident	19.0%
	Do not reside on property	27.0%
% Income from property	0-25%	15.6%
	26-50%	39.9%
	51-75%	15.9%
	76%+	14.9%

Regression Results

The results of the regression models are presented in Table 6. These models were developed to identify variables that predict a landowner's willingness to participate in prescribed burns for woody plant management on their land or upon the land of others. Statistical significance for explanatory variable was determined by $p<0.05$. The results of the study are presented with respect to each of the three hypotheses.

Hypothesis 1 stated the likelihood that a landowner will apply prescribed fire to their own land or participate in the application of prescribed fire on other people's land is negatively correlated with his/her perception about the legal liability for applying fire. The study results at least partially corroborated this negative correlation. Survey respondents who perceived a higher level of fire-related legal liability were (25.7%) less likely to apply prescribed burns to their own land and (38.0%) less likely to assist with the application of prescribed burns on someone else's land than respondents who perceived legal liability for doing so to be lower. Additionally, a burn ban, which elevates the level of liability for igniting a prescribed fire during hot dry periods, was another significant barrier (22.4%) to respondents being willing to burn their own property, but was not significant with respect to willingness to assist with burns on other people's properties. This is possibly due to perceptions that others would not ignite fire on their land when burn bans are in place. Other liability factors related to the application of prescribed fire, including prescribed fire insurance and state legislated liability standards, were statistically not significant for explaining differences in willingness to apply prescribed fire.

Table 6. Logistic regression models of factors influencing willingness to apply prescribed fire on own and other's land. Bolded results indicate significance at p<0.05.

	Burn on own land Pseudo R^2= 0.2491; p<0.001		*Burn on other's land Pseudo R^2= 0.3163; p<0.001*	
Independent Variables	%Δ odds	p-value	%Δ odds	p-value
Hypothesis 1: Legal liability				
General/personal liability (risk)	**-25.7**	**0.025**	**-38.0**	**0.000**
Burn ban influence (barrier to burning)	**22.4**	**0.001**	7.1	0.263
Reduced concern	19.4	0.228	19.2	0.228
Influence	10.2	0.461	-6.7	0.613
Prescribed fire insurance	3.0	0.691	9.8	0.223
State-legislated liability standards	10.6	0.140	-1.8	0.798
Hypothesis 2: Social connectedness				
Prescribed Burn Association member	**280.6**	**0.000**	**577.5**	**0.000**
Oklahoma Residency	**60.1**	**0.003**	-7.1	0.813
Hypothesis 3: Fire as a management tool				
Prescribed fire is less expensive	**30.7**	**0.004**	9.7	0.309
Prescribed fire is easier	0.6	0.936	-3.3	0.651
Prescribed fire is effective	7.9	0.373	-13.1	0.227
Landowner characteristics				
Gender (male)	-27.3	0.375	62.8	0.056
Age	-2.1	0.071	-2.2	0.073
Some undergraduate/Bachelor's degree[a]	41.9	0.325	-26.4	0.384
Some graduate/Graduate degree[a]	28.6	0.506	**-52.9**	**0.050**
Years of property ownership	1.6	0.067	0.8	0.375
Medium acreage	-5.4	0.873	-28.9	0.332
Large acreage	40.0	0.292	-4.3	0.895
Full time resident [b]	**128.7**	**0.005**	-22.8	0.393
Occasional resident[b]	93.9	0.069	**-65.1**	**0.005**
1 % to 25 % income[c]	30.5	0.500	**136.1**	**0.043**
26 % to 50 % income[c]	49.1	0.420	**293.1**	**0.009**
51 % to 75 % income[c]	15.4	0.791	**365.4**	**0.008**
76 % to full income[c]	67.0	0.360	**218.1**	**0.052**
Hunting	5.4	0.710	**58.8**	**0.002**
Farming	-11.0	0.412	**-22.7**	**0.074**
Ranch/profit	-9.3	0.508	-7.6	0.608
Recreation/amenities	4.3	0.734	7.6	0.556
Heritage	-15.9	0.179	-13.1	0.297

[a] High school is reference category
[b] Non-resident on property is reference category
[c] 0% annual income from rural property is reference category

Hypothesis 2 stated that landowner perceptions of legal liability for applying prescribed fire are positively mediated by social connection provided by membership in PBAs; members of PBAs were expected to be more willing than less connected landowners to participate in prescribed burns. The regression models show that respondents who belonged to PBAs were, in fact, 280.6% more willing to burn on their own property and 577.5% more likely to be willing to assist in burns on another person's property than respondents who were not PBA members. Additionally, respondents who reside in Oklahoma, which has more PBAs and where there appears to be a greater fire culture, were 60.1% more likely than Texas respondents to apply prescribed burns on their land.

Hypothesis 3 landowner perceptions regarding the relative efficacy, affordability and ease of use of fire compared to other woody plant management options would be positively associated with willingness to apply prescribed fire. The regression models corroborated this hypothesis in only one instance; respondents who reported they believed prescribed fire to be an affordable woody plant management tool were 30.7% more willing than those who felt otherwise to apply prescribed fire, but only on their own property and not on someone else's property. By contrast, perceptions about efficacy and ease of use of fire were not associated with landowner willingness to use this management tool either on their own or on another's property.

Numerous demographic control factors were also significantly correlated with respondent willingness to apply prescribed fire. In particular, respondents with some level of graduate education were 52.9 % less likely to assist with a prescribed burn on

another person's land.. Compared to non-resident (absentee) landowners, full-time resident respondents were 128.7 % more likely to burn on their own property, while part-time resident respondents were 65.1 % less likely to assist with prescribed burns on another person's property. Some property ownership motivations were also diametrically opposed with respect to assisting with the application on another person's land; farming as a primary ownership motivation was negatively associated (22.7%) with willingness to assist with the application of prescribed fire, whereas hunting was positively associated (58.8%) in this regard perhaps because of the importance of managing wildlife habitat across individual property boundaries. Finally, respondents who obtained any proportion of income from their property were 136.0%-365.0% more willing to assist other property owners with prescribed burns but were not statistically not more willing to apply fire on their own land.

CHAPTER IV

DISCUSSION

Expounding on previous research, I hypothesized that a variety of landowner perceptions regarding prescribed fire liability would influence landowner willingness to apply prescribed burns. This research addressed two dependent variables, using *three hypotheses* in order to understand how landowner perceptions influence their behavioral intention with respect to the use of prescribed fire. The first dependent factor, "Willingness to apply a prescribed burn on (my) own property", generated a sense of liability tied to personal returns and risks. The second dependent factor, "Willingness to apply a prescribed burn on another person's property," still has social and legal implications but the legal consequences for a landowner who participates in a prescribed burn on another person's property is generally lower. These two factors were used as dependent variables to determine what independent variables explain willingness to apply fire under different liability scenarios. Such knowledge can help inform polices aimed at reducing a landowner's perception of risk in order to encourage wider application of prescribed fire on private land. Summarized significant factors are included for reference in Table 7 and in Figure 2.

Table 7. Summarized significant factors influencing landowner willingness to burn in two scenarios, on personal property or on another's property using percent change in odds.

	On own land	On another person's land
Increased willingness	Prescribed Burn Association membership (280.6%) Full time residency (128.7%) Oklahoma residency (60.1%) Affordability of fire as a management tool (30.7%)	Prescribed Burn Association membership (577.5%) Income 51-75% (365.4%) Income 26-50% (293.1%) Income 76-100% (218.1%) Income 1-25% (136.1%) Hunting as land ownership motivation (58.8%)
Decreased willingness	General/personal liability (-25.7%) Influence of burn bans (-22.4%)	Occasional residency (-65.1%) Graduate/some graduate education (-52.9%) General/personal liability (-38.0%) Farming land ownership motivation (-22.7%)

Hypothesis 1 addressed willingness to apply prescribed fire as a function of perceived differences in legal liability for escaped fire from a burn on one's own land versus participation in a burn on another person's land. In general, the results corroborate this notion that willingness to burn was inversely related to perception of risk when applying prescribed fire. Unexpectedly, however, this negative correlation was stronger for willingness to apply fire on another person's land than for willingness to apply fire on one's own, suggesting that landowners with a certain level of risk tolerance will more likely apply prescribed fire on their own land than another person's land. This may be explained by the observation that diffuse public benefits provided by a successful fire are not enough to convince all landowners to participate in what they perceive as a risky behavior for which they will be liable (Yoder et al. 2004). The benefits of burning one's own land would be greater than the benefits of participating in a burn on another person's land; therefore, the risks of applying fire are offset to a

greater degree by benefits of applying fire on one's' own land than on another person's land. Additionally, the respondents may have also been unsure of their legal liability of participating in burns on other people's property or with the adequacy of liability insurance the hosting landowner has to protect other participants.

In addition, burn bans reduced landowner willingness to apply prescribed fire on his or her own land, but did not significantly influence willingness to burn on another person's property. This result can be explained by the observation that some landowners do burn their land during burn bans to obtain a high intensity restoration burn, but would be unwilling to take such a risk on another person's land.

Other factors that could be expected to mediate perceptions that applying fire is risky were surprisingly, not statistically significant explanatory variables for willingness to apply prescribed fire. For example, access to fire insurance and social influence, which could reduce the risk of applying fire, were not associated with willingness to burn. This is surprising because many landowners have claimed that access to liability insurance for applied fire would increase their willingness to apply prescribed fire; however, this has not been the case in Oklahoma (John Weir, Oklahoma State University, personal communications, January 12, 2017).

Hypothesis 2 addressed the effect of social network membership, specifically PBA membership, as a mediator of legal liability concerns for applying prescribed fire. As hypothesized, compared to non-member respondents, respondents who were members of PBAs were almost three times more willing to apply fire on their land and nearly six times more willing to apply prescribed fire on another person's property. The

likely reason for this is that PBAs engage their members in fire safety training and provide resources that landowners often feel they lack in order to apply fire safely. Some PBAs also release their members from perceived personal liability through the provision of liability insurance for members who participate in prescribed burns (Toledo et al. 2014, Kreuter et al. 2008, Taylor 2005). Social networks, such as PBAs and Wildlife Management Associations, have also been shown to build trust among members, which in turn facilitates the application of management practices in which they are interested, such as prescribed fire (Siegrist et al. 2000; Toledo et al. 2014, Wagner et al. 2007). Finally, membership in a PBA does imply, at the least, an interest in prescribed burns.

Survey respondents from Oklahoma were also significantly more willing to apply prescribed fire than Texas respondents. This is consistent with the reported stronger fire culture in Oklahoma, possibly due to the greater number and more rapid developments of PBAs in Oklahoma than in Texas (John Weir, Oklahoma State University, personal communications, January 12, 2017, Wonkka et al. 2015).

Hypothesis 3 pertained to willingness to apply prescribed fire as a function of perceived greater affordability, ease of use, and efficacy of fire as a management tool compared to mechanical and chemical woody plant management treatments. The results indicated that only affordability was a statistically significant explanatory variable for respondents' willingness to burn their own land. Prescribed fire has been shown to be economically much more feasible than either mechanical or chemical woody plant treatments (Van Liew et al. 2012). From a rational standpoint it is, therefore, not surprising that a positive perception of affordability was positively associated with

respondents' willingness to burn their own land. Surprisingly, neither the ease of use nor biological effectives of prescribed fire for managing woody plants were statistically significant explanatory variables. This unexpected result might be explained by the perceived difficulty in creating burn plans, gathering resources, and employing skilled help (Toledo et al. 2012). We predicted that landowners who understood the intrinsic benefits of prescribed fire might weigh the risks and rewards to reflect a more positive attitude to the use of fire as a management tool (Yoder et al. 2004). While affordability as an incentive to apply fire did seem to motivate some respondents to burn on their own property, "personal/general liability" still appear to outweigh this advantage of prescribed fire. One implication is that future outreach materials aimed at promoting the use of prescribed fire should highlight the economic advantages of burning over other woody plant management treatments in an attempt to offset concerns over prescribed fire-related legal liability.

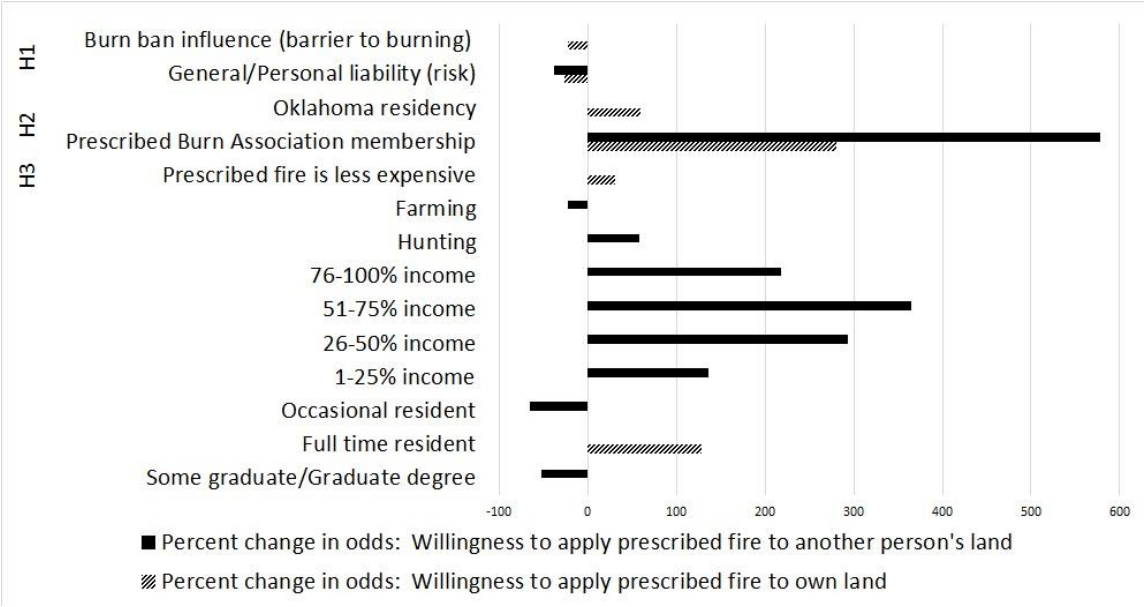

Figure 2. Summarized significant factors influencing landowner willingness to burn in two scenarios, on personal property or on another's property using percent change in odds.

Demographic factors were, in some instances, also found to be significant explanatory variable for willingness to apply fire. Focus on these factors when developing material for landowners to enhance the use of this land management tool may also be important. This includes landowner residency on the property, landowners who derive at least some household income from their property, and whose primary land ownership motivation is wildlife-related activities. Additionally, a focus on expanding membership in PBAs or other landowner associations could increase trust and reciprocity among neighboring landowners, both of which could help offset liability concerns over the use of prescribed fire.

These findings are consistent with previous findings. Distance of residence from a property, full-time versus part-time residency, may remove the potential for teamwork

towards a desired management goal, while still leaving the risks of an escaped fire (Bradner et al. 2004), while increased social interactions in a geographically close relationship facilitate planning and expedite notification within established social networks. In the case of a prescribed burn, full-time residency may encourage neighbors to voice displeasure or aid in a burn application should they so desire. The potential for aid, or the warning of community hostility to a prescribed burn attempt, influences a landowner's decision when considering woody plant management tools (Toledo et al. 2014). Additionally, applying a prescribed fire to another person's property as a social investment sustains a generally positive cooperation (Sutherland et al. 2011). There are low risks to assistance with potentially high returns to both parties, such as, increased trust, knowledge, and skills gained by those participating in addition to land management benefits (Toledo et al. 2013). Landowners who own their property to hunt were more willing to assist another in a prescribed burn, and therefore potentially help offset legal liability concerns due to greater communication over wildlife-related operations and have greater likelihood of belonging to wildlife social/educational groups and possibly also PBA membership (Gass et al. 2006).

Limitations and future research: Survey participants were also asked to respond to questions about their perceptions of woody plant coverage and encroachment on their property; however, their responses are not reported in this thesis. While this study focuses on perceived liability associated with the use of prescribed fire, further research is needed to determine the point at which concern over woody plant encroachment outweighs the perceived risk of applying prescribed fire. Additionally, this research was

conducted in Texas and Oklahoma, both of which apply simple negligence liability standards to situations involving escaped fires. Future research should compare perceptions about prescribed fire liability in regions with simple negligence and gross negligence standards; the latter has been found to have a significantly greater incidence of prescribed fire (Wonkka et al. 2015).

CHAPTER V

CONCLUSIONS

Using previous research and critically examining these findings, I identified several factors that influenced landowners' perceptions regarding prescribed fire liability and their willingness to burn their own land or participate in the application of prescribed fire on other peoples' land. Membership in a PBA was highly significant in increasing willingness to conduct a burn, regardless of property ownership, one's own or another person's. Perception of personal liability was inversely related with willingness to burn. Additionally, burn bans and the perception that prescribed fire is an affordable woody plant management tool were found to inhibit and enhance, respectively, respondent willingness to apply prescribed fire. Other significant explanatory variables included state of residence, on property residence, education level and income earned from rural property. Previous research has determined the ecological and economic benefits of burning. Landowners who are aware of the benefits of prescribed fire report hesitance to burn based on a perception of potential liability. Key insights from this study provide several important management implications including the need for: (1) connecting landowners with existing prescribed fire association members, (2) increasing communication between policy makers, such as county commissioners who initiate burn bans, and landowners for more effective burn guidelines, (3) reduction of barriers and availability of insurance that protects landowners, property loss, and those who assist in application of burn plans.

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