Rangeland Ecology & Management 86 (2022) 73–79

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: www.elsevier.com/locate/rama

Exploring Opinions for Using Prescribed Fire to Control Eastern Redcedar *(Juniperus virginiana)* Encroachment in the Southern Great Plains, United States ☆

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ARTICLE INFO

Article history:
Received 20 October 2021
Revised 15 July 2022
Accepted 12 October 2022

Key Words:
best management practices
encroachment
Great Plains
SWOT-AHP

ABSTRACT

Eastern redcedar *(Juniperus virginiana)* is rapidly encroaching on grasslands in the southern Great Plains. This has several adverse effects on the landscape including increased wildfire risk, decreased water runoff, and reduced forage available for cattle production. Several best management practices have been identified to reduce the spread of eastern redcedar, including the use of prescribed fire. However, numerous barriers exist against the use of prescribed fire such as societal acceptance or liability concerns. The purpose of this study was to determine how stakeholders from government agencies, nongovernmental organizations, and landowners perceive the use of prescribed fire to control eastern redcedar encroachment. The strengths, weaknesses, opportunities, and threats–analytical hierarchical process method was used for data analysis. The study showed that governmental and landowner stakeholders viewed that the negatives associated with prescribed fire outweigh the potential benefits. Nongovernmental organization stakeholders had differing opinions, and they were largely supportive of using prescribed fire. The results suggest that there is a need for tailored outreach to alleviate the concerns associated with risks and liabilities, as escaped prescribed fires are highly uncommon.

Introduction

Eastern redcedar *(Juniperus virginiana)* is a conifer native to the Cross-Timbers ecoregion of the southern Great Plains. This tree has encroached into prairies of this region due to passive land management and fire suppression (Kaur et al. 2019). In particular, fire suppression became the dominant paradigm after European American settlement of the area and is attributable to various factors including logging, railroad industries, cotton plantations, higher industrial demand for timber products, and protection of built structures (Fowler and Konopik 2007; McGranahan and Wonkka 2020). Native Americans are often attributed to using fire for various purposes including ecosystem management, promotion of valued species, and agriculture (Wyckoff 1984; Joshi et al. 2019). Following the displacement and disruption of indigenous land practices, fire diminished from the landscape (Wilcox et al. 2018).

Eastern redcedar is an extremely fire-intolerant species, and as fire became less commonly applied on the landscape, more land became habitable for this species (Bidwell et al. 2002). This encroachment has led to several environmental problems including greater wildfire risk, reduced water yield, unfavorable wildlife habitat, changes in nutrient cycling and carbon sequestration, and reduced forage (Norris et al. 2001; Van Els et al. 2010; Kaur et al. 2019). In particular, eastern redcedar negatively impacts Northern bobwhite quail habitat *(Colinus virginianus),* which is one of the most important game animals in the southern Great Plains (Kaur et al. 2019).

Societal views regarding eastern redcedar have evolved over time. In the early 19th century, eastern redcedar was considered an important windbreak tree species, as well as a useful component for railway fences, pencils, paneling, chests, and furniture. Additionally, eastern redcedar was known for its aesthetic appeal (Meneguzzo and Liknes 2015). Unfortunately, with its rapid expansion into grassland prairies, eastern redcedar altered grassland ecology in the Great Plains of the United States, causing fragmentation and displacement of native grasses and forbs. Forest inventory and analysis (FIA) data suggest that there were > 200 000

☆ The research was conducted as a part of Niblack Research Scholars Program at the Oklahoma State University. The Faculty sponser (Joshi) received partial support from US Dept of Agriculture–National Institute of Food and Agriculture Sustainable Agricultural Systems project (SRS 06-505941) and Mc-Stennis project (OKL03229) to conduct the study.

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https://doi.org/10.1016/j.rama.2022.10.002
1550-7424/

acres of eastern redcedar growth in the central United States between 2007 and 2012 (Meneguzzo and Liknes 2015). These results also showed that Nebraska witnessed an almost twofold increase in eastern redcedar encroachment in the past decade. In Oklahoma alone the economic losses of leaving eastern redcedar untreated are estimated to be over $477 million (Drake and Todd 2002). In Kansas, FIA data in 2010 suggested that eastern redcedar volume has increased by a factor of 15 over a 45-yr period (Galgamuwa et al. 2020). According to recent FIA data (FIA 2022), most eastern redcedar encroachment (> 90%) in the southern Great Plains states like Oklahoma, Nebraska, and Kansas is in privately owned areas. Likewise, the majority of redcedars are located in transition zones between productive timberland and nonforested lands (FIA 2022).

Aggressive encroachment has negatively impacted forage production, which has reduced livestock stocking capacity. Accordingly, cultural views have changed and it is now considered as a primary challenge for sustainable range management in the central United States (Morton et al. 2010). Even so, a 2001 survey of state nurseries found that eastern redcedar seedlings were part of agency-sponsored tree planting programs in 22 states (Ganguli et al. 2008).

Commonly adopted practices to control eastern redcedar include prescribed fire, mechanical brush control, and herbicide use (Ortmann et al. 1998). Mechanical brush control involves selectively harvesting redcedar trees and is the most effective practice to remove larger specimens. Likewise, killing eastern redcedar trees through chemical application is another commonly adopted best management practice. Despite their effectiveness, both of these methods are expensive and bring significant financial burden to rangeland owners (Smith 2011). Therefore, prescribed fire is one of the most appropriate methods for controlling eastern redcedar as it is a management alternative that may be more economical and effective at a landscape scale (Bidwell et al. 2002).

In the southern Great Plains, several efforts have been made to explore landowner perceptions about the use of prescribed fire to control eastern redcedar encroachment. For example, Harr et al. (2014) conducted concept mapping and qualitative interviews to explore landowners' views on risks associated with eastern redcedar management in Iowa and Missouri. The authors found that while landowners generally acknowledged the positive role of prescribed fire in grassland management, they perceived it as a risky tool and were found to be less confident in adoption. Similarly, Morton et al. (2010) explored landowners' perceptions concerning the adoption of best practices for eastern redcedar management in tallgrass prairies. While most (84%) landowners were found to take some action to control eastern redcedar, mechanical and chemical methods were more preferred than prescribed fire. Elmore et al. (2010) found that a solid majority of landowners and agricultural producers in Oklahoma were supportive of controlling eastern redcedar through prescribed burning. In addition, several other social science–focused studies (Twidwell et al. 2013; Symstad and Leis 2017; Kreuter et al. 2019; Stroman, Kreuter et al. 2020) have highlighted landowner perceptions concerning the role of prescribed fire for woody encroachment control in the southern Great Plains.

It is worth noting that although natural resource management agencies have pledged to use prescribed fire as a land management tool, many have not made significant advancements in its application and have become increasingly risk averse in public land management (Maguire and Albright 2005). Although woody vegetation is commonly sought as a windbreak and eastern redcedar can be beneficial for erosion control (Ganguli et al. 2008), the promotion of woody plant expansion in the southern Great Plains contradicts the broader conservation goal of grass-dominated prairie ecosystems.

Current wildfire dynamics highlight the need for reducing hazardous wildfire risks, and research has shown that eastern redcedar is very flammable under dry conditions with low live fuel moisture (Weir and Scasta 2014; Dudek 2020). Previous research provides useful information on how landowners perceive the use of prescribed fire in controlling eastern redcedar; however, literature is limited to determine how other natural resource stakeholders align on the use of prescribed fire as a management tool to control eastern redcedar encroachment. This reveals a significant knowledge gap in one important area of social science inquiry that has implications for effective communication and broader social acceptance of prescribed fire in the southern Great Plains. Therefore, it is necessary to understand the perceived benefits and challenges associated with the use of prescribed fire among key natural resource management stakeholders in the region. Further, such assessment will help determine whether other stakeholders align with the management goals of landowners involving rangeland productivity and woody encroachment control.

While previous research (Twidwell et al. 2013; Symstad and Leis 2017; Kreuter et al. 2019; Stroman et al. 2020) is useful to understand landowner perceptions of prescribed fire, our study is unique in its aims to gauge the degree of similarity or difference between landowners and other stakeholders regarding their views of prescribed fire as a management tool to control eastern redcedar in the southern Great Plains. Accordingly, this study aims to understand stakeholders' opinions regarding prescribed fire and the benefits and challenges associated with its use on encroached landscapes.

Methods

In the southern Great Plains of the United States, prescribed burn associations have played an important role in promoting shared knowledge, resources, tools, and techniques concerning prescribed burns among their members, which involve landowners, public land managers, extension professionals, and government employees (Weir et al. 2016). Therefore, we have posited this stakeholder perception analysis following the underpinnings of collective action theory. According to this theory, successful collective action is possible through the shared governance of the commons (Ostrom 1990). However, the actions must build on common interests, mutual respect, and reciprocity among stakeholders (Ostrom 1990; Kahan 2003).

Collective action principles have been adopted to understand the complex natural resource problems involving invasive species (Epanchin-Niell et al. 2010), water resources, rangeland, and forest management (Knox and Meinzen-Dick 2001). Like other natural resource management issues, eastern redcedar management in the southern Great Plains requires collective actions from resource managers, landowners, and other stakeholders (Weir et al. 2016; Kaur et al. 2019; Weir et al. 2019). Therefore, we evaluated stakeholder perception using the Strength, Weakness, Opportunity, and Threat (SWOT)–Analytical Hierarchy Process (AHP) platform, which is commonly used in the natural resource discipline to gauge similarities or differences of opinions among multiple stakeholders (Joshi et al. 2018). SWOT-AHP combines two distinct tools. The SWOT technique is a commonly used strategic planning tool in which strategies and the alignments likely to impact business are divided into internal and external factors (Namugenyi et al. 2019). The internal factors, which can be positive or negative factors of business establishment, are represented by strengths and weaknesses, respectively (Namugenyi et al. 2019). The external factors, which are listed as opportunities and threats, represent the attributes that indirectly favor or hinder the business environment (Namugenyi et al. 2019).

While SWOT factors provide useful information that can help with the success of a plan, program, or strategy (Kurttila et al. 2000), these factors cannot be quantified to discern their relative

Table 1
Four Strength, Weakness, Opportunity, and Threat factors chosen to compare stakeholders' perceptions of prescribed fire that can help prevent future eastern redcedar encroachment in the southern Great Plains.

Strengths	Weaknesses
S1: Cost-effective	W1: Ineffective for large trees
S2: Pollen reduction	W2: Weather dependent
S3: Easily accessible to landowners	W3: Specialized training required
S4: Help reduce fuel load	W4: Smoke management
Opportunities	Threats
O1: Provide wildlife habitat	T1: Liability issues/uncontrolled fire
O2: Improve cattle/pastureland production	T2: Cultural stigma against fire
O3: Pest control (ticks and horn flies)	T3: Inconsistent policies among agencies
O4: Enhance public acceptance of fire	T4: Inability to burn in urban interface

importance (Joshi et al. 2018; Namugenyi et al. 2019). This brings significant limitations in critical issue identification, resource prioritization, and program reevaluation (Joshi et al. 2018). The inadequacy in SWOT analysis can be overcome by the addition of AHP, which is the multicriteria decision-making tool that can rank these attributes on the basis of a structured scale (Kurttila et al. 2000). The process involves a pairwise comparison between attributes by a select number of experts knowledgeable on the matter or issue (Saaty 1980). Therefore, in SWOT-AHP, the SWOT factors are evaluated against each other using a Likert scale, which provides qualitative comparisons between the different SWOT factors (Joshi et al. 2018).

The data collection process was initiated with the SWOT attribute design, followed by survey design and then data collection in two stages. For attribute design, a focus group meeting was convened among knowledgeable professionals to identify major strengths, weaknesses, opportunities, and threats associated with prescribed fire, which has been recommended to control eastern redcedar in the southern Great Plains. These individuals represented university researchers and other professionals who were affiliated with natural resources management organizations within the region. The process began with a discussion of the brainstormed list of potential strengths, weaknesses, opportunities, and threats. After deliberate discussion within the group and further review of literature, we reduced the list to four factors for each SWOT category. The first survey was designed to solicit ranking on all the factors identified in the focus meeting. The survey participants for this research included prescribed burn professionals primarily knowledgeable on eastern redcedar encroachment. The Institutional Review Board at Oklahoma State University reviewed and approved the survey before administration. A description of the identified SWOT factors is given in Table 1.

The data analysis from the first survey reveals top ranked attributes in each category. Those top-ranked attributes are then used in the second survey to rank attributes across the categories (strength to weakness, opportunity, and threats). The top factor of each SWOT category found in the first survey can theoretically differ between stakeholders; therefore, multiple versions of the second survey were designed to solicit ranking across the categorical factors (Joshi et al. 2018). Following this protocol, the second survey took the top SWOT factors identified in the first survey and then asked responders to compare those in a similarly designed pairwise comparison table. These surveys were originally designed in *Microsoft Word* and replicated in the Qualtrics platform for online distribution. The surveys were administered to landowners, governmental professionals, and nongovernmental organization (NGO) professionals (Table 2).

For the first survey, 47 responses from government employees, 34 responses from landowners, and 16 responses from NGO employees provided SWOT ratings. For the second survey, 38 responses were from government employees, 42 responses were from landowners, and 18 responses were from NGO employees. While most respondents chose only one stakeholder group, 15 respondents in each round represented multiple stakeholder groups, so their responses were counted for each group. The number of responses used for our data analyses were comparatively higher than many SWOT-AHP–designed natural resource stakeholder analysis studies (Shrestha et al. 2004; Dwivedi and Alavalapati 2009; Starr et al. 2019).

Responders completed a pairwise comparisons table as shown in Table 2. This table uses a Likert scale established by Saaty (1977), which includes odd numbers from 1 to 9. The even numbers were designed to serve as transitional values between the successive judgments (Saaty 1977). A selection of 1 meant the factors were equally important, and a selection of 9 meant that the chosen factor has absolute importance over the alternative factor.

Although stakeholders represented prescribed burn professionals and were expected to be familiar with the issue, participants were still provided with some background information on the role of prescribed fire as a land management tool to control eastern redcedar in the southern Great Plains. The data collected from these surveys were then analyzed using the procedures recommended in literature (Saaty 1977; Kurttila et al. 2000). In the first step, a geometric mean of aggregate responses was found for each comparison to account for variance among survey responses. Next, the data were placed into a pairwise comparison matrix as shown in Equation 1 (Saaty 1977) and its reciprocal was then mirrored as depicted. The super matrix for this can be explained in the following equation:

$$B = \begin{bmatrix} 1 & t_1/t_2 & \cdots & t_1/t_n \\ t_2/t_1 & 1 & \cdots & t_2/t_n \\ \vdots & \vdots & 1 & \vdots \\ t_n/t_1 & t_n/t_2 & \cdots & 1 \end{bmatrix} \quad (1)$$

In Equation 1, t represents relative weight for each pairwise comparison. After this step, each column was normalized to 1 and the maximum eigenvalue, λ_{max}, was calculated following the process suggested in the AHP literature (Saaty 1977). Lastly, the maximum eigenvalue was multiplied by the factor weight to produce a consistency ratio (CR) for each set of comparisons (Saaty 1977; Catron et al. 2013). The CR determination is the most important indicator in AHP analysis as it allows insight into the validity of the model and whether the responders generally agree with their rankings of the SWOT attributes (Starr et al. 2019).

Equations 2 and 3 show how the CR was calculated.

$$CI = (\lambda_{max} - n)/(n - 1) \quad (2)$$

$$CR = \left(\frac{CI}{RI(n)}\right) * 100 \quad (3)$$

Table 2
Illustration showing how pairwise comparisons were done between attributes. The direction of arrow shows respondent preference.

Factors	9	7	5	3	1	3	5	7	9	Factors
Cost-effective										Pollen reduction
Cost-effective										Easily accessible to landowners
Cost-effective										Help reduce fuel load
Pollen reduction										Easily accessible to landowners
Pollen reduction										Help reduce fuel load
Easily accessible to landowners										Help reduce fuel load

1 = Equally important; 3 = Moderately more important; 5 = More important; 7 = Very important; 9 = Extremely important.

Table 3
The Strength, Weakness, Opportunity, and Threat (SWOT) factor and global priorities of prescribed fire for eastern redcedar for each stakeholder group,

SWOT attribute	Factor priority			Global priority		
	Government	Landowner	NGO	Government	Landowner	NGO
Strengths				***0.25***	***0.21***	***0.31***
S1: Cost-effective	0.31	0.34	*0.34	0.08	0.07	0.11
S2: Pollen reduction	0.10	0.09	0.09	0.02	0.02	0.03
S3: Easily accessible to landowners	0.25	0.20	0.25	0.06	0.04	0.08
S4: Help reduce fuel load	*0.35	*0.37	0.32	0.09	0.08	0.10
Weaknesses				***0.21***	***0.22***	***0.17***
W1: Ineffective for large trees	0.14	0.17	0.19	0.04	0.04	0.06
W2: Weather dependent	*0.35	*0.33	0.29	0.09	0.07	0.09
W3: Specialized training required	0.30	0.32	*0.37	0.08	0.07	0.12
W4: Smoke management	0.21	0.17	0.14	0.05	0.04	0.04
Opportunities				***0.21***	***0.23***	***0.38***
O1: Provide wildlife habitat	0.29	0.26	0.33	0.07	0.06	0.10
O2: Improve cattle/pastureland production	*0.32	*0.38	*0.39	0.08	0.08	0.12
O3: Pest control (ticks and horn flies)	0.12	0.15	0.09	0.03	0.03	0.03
O4: Enhance public acceptance of fire	0.26	0.21	0.18	0.07	0.04	0.06
Threats				***0.33***	***0.34***	***0.14***
T1: Liability issues/uncontrolled fire	*0.33	*0.38	0.27	0.08	0.08	0.08
T2: Cultural stigma against fire	0.25	0.20	*0.33	0.06	0.04	0.10
T3: Inconsistent policies among agencies	0.22	0.17	0.19	0.05	0.04	0.06
T4: Inability to burn in urban interface	0.20	0.24	0.21	0.05	0.05	0.07

N GO indicates nongovernmental organization; *, highest-ranked attribute during factor priority calculation; italicized and bold values, multipliers used to estimate overall priority scores.

Equation 2 shows how the consistency index is related with the maximum eigenvalue (λ_{max}) and the size of the matrix (n), which was 4 in our case. As shown in Equation 3, the final step is the CR calculation, which requires a random index. The random index does not change for given matrix order, and the value is 0.9 for a 4×4 matrix (Saaty 1980). A CR value of $< 10\%$ indicates consistency among opinions of stakeholders and of the model (Starr et al. 2019).

Results

Every SWOT attribute had consistency ratios of $< 10\%$, which indicates consistency among the opinions of the stakeholders and validity of the results. Most (95%) respondents were familiar with eastern redcedar as a management challenge in the southern Great Plains. Among our respondents, most (88%) were male and white (91%) with the average age of 54 years. The results provided an important perspective on stakeholder priorities regarding SWOT attributes related to prescribed burning. Using AHP analysis, priority scores (p) were calculated for each of the 16 factors from the first survey (factor priority) and 4 categories from the second survey (global priority). Table 3 displays the primary results of the research and is organized by category of SWOT attribute and differentiates between the stakeholder groups. Figure 1 provides a further visual aid for examination of the similarities and differences between the stakeholder groups.

Regarding the individual factor priorities, the greatest strengths identified by all stakeholder groups were cost-effectiveness (S1) and hazardous wildfire fuel reduction (S4). For NGO stakeholders, S1 was the highest prioritized strength ($P = 0.34$) while landowners and government stakeholders highlighted its ability to help reduce fuel loads ($P = 0.37$ and 0.35, respectively). The greatest weaknesses emphasized were weather dependency (W2) and the requirement of specialized training (W3). Government and landowner stakeholders prioritized weather dependency ($P = 0.35$ and 0.33, respectively) while NGOs selected specialized training (0.37).

Factor priorities for the opportunities category were similar across all three stakeholder groups with production improvement to cattle and pastureland (O_2) given the highest priority. Government stakeholders provided a relatively similar priority score to cattle and pastureland production and wildlife habitat ($P = 0.32$ and 0.29, respectively), while landowners and NGO members provided greater relative emphasis for the former ($P = 0.38$ and 0.39, respectively). Government and landowner stakeholders found liability issues (T1) to be the greatest threat ($P = 0.33$ and 0.38, respectively). For NGOs, cultural stigma against fire (T2) was the greatest threat ($P = 0.33$).

Turning to the global priorities gathered during the second survey, both government and landowner stakeholders indicated that threats are the most significant of the SWOT categories ($P = 0.33$ and 0.34, respectively). Otherwise, both groups prioritized strengths, weaknesses, and opportunities similarly. NGO stakeholders gave opportunities the highest ranking ($P = 0.38$), followed somewhat closely by strengths ($P = 0.31$). The lowest scored category for NGOs was threats ($P = 0.14$).

Discussion

Overall, our results suggest that two primary stakeholders of prescribed fire, private landowners and state or federal agency pro-

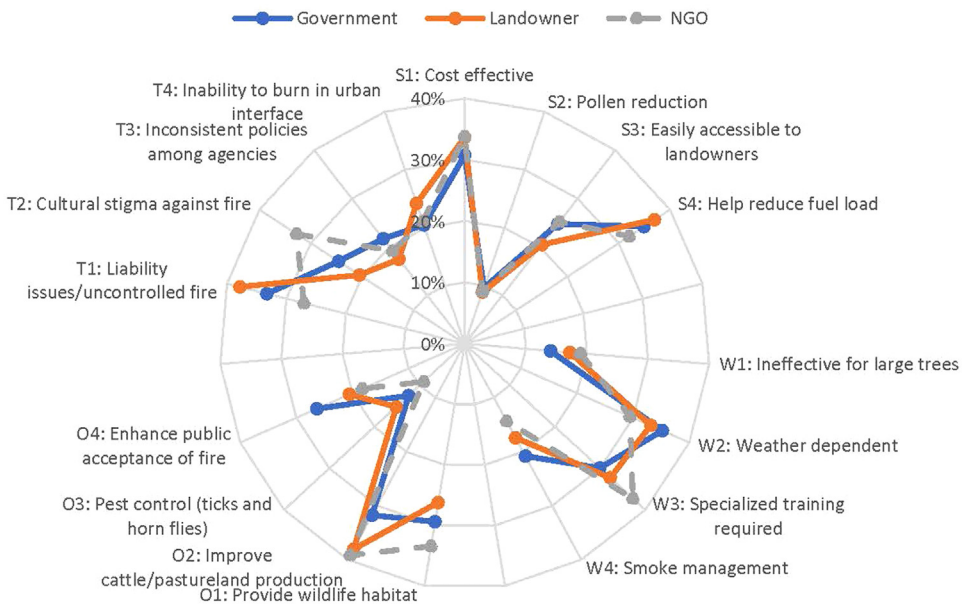

Figure 1. The diagram describes how different stakeholder groups placed importance on Strength, Weakness, Opportunity, and Threat attributes regarding eastern redcedar spread.

fessionals, have several concerns that have collectively outweighed the positive aspects of prescribed fire. These concerns included negative cultural stigma, liability concerns, weather dependency, and a need for specialized training, among others. These concerns created challenges for prescribed burn adoption in the southern Great Plains as several government agencies were mandated to provide technical assistance on prescribed fire to private landowners or other needy constituents (Wilbur et al. 2021). Nonetheless, perceived risks associated with liabilities from fire escape have been consistently identified as obstacles for prescribed fire success in the Great Plains (Elmore et al., 2010; Joshi et al. 2019), and our results also corroborated those findings. Interestingly, there was not universal consensus and the stakeholders representing NGOs perceived these concerns less severely. While NGOs partner with government agencies to establish a culture of shared responsibility and comanagement to alleviate prescribed fire constraints (Marks-Block and Tripp 2021), their involvement may serve in a more supportive role in the other two groups who possessed more legal liability. Previous research also suggests varied risk perceptions among prescribed burn professionals (Parajuli et al. 2019). In particular, landowners and elderly respondents using a burn plan in 14 states in the midwestern, western, and southern regions of the United States were more likely to acquire prescribed burn insurance than others (Parajuli et al. 2019). The contrasting degree of involvement in prescribed fire practice may explain these differences. Likewise, wind speed and moisture conditions play significant roles in ensuring prescribed burn success (Joshi et al. 2019; Yurkonis et al. 2019). Therefore, results suggesting weather dependency as a weakness of prescribed fire make intuitive sense.

Our results also highlighted some positive perspectives, which may help promote broader social acceptance of prescribed fire as a management tool to control eastern redcedar in the southern Great Plains. The use of prescribed fire is among the most cost-effective best management practices and is substantially cheaper than other alternatives such as mechanical brush control and herbicide use (Bidwell et al. 2002; Maggard and Barlow 2018). Our stakeholders broadly acknowledged this fact. In the southern Great Plains, range management for livestock production is a primary objective and research suggests net present value for livestock production is highest when prescribed fire is used in the early stages of eastern redcedar invasion (Coffey 2013). Stakeholder recognition of this was evident in our results as the role of prescribed fire as an opportunity to improve rangeland and forage production was also rated highly.

While prescribed fire use in the southern Great Plains is the focus of the present research, its importance for reducing wildfire risk in other landscapes is well noted across the United States (Kolden 2019). However, it should be noted that prescribed fire adoption and implementation must be anchored by an adherence and acknowledgement of local context. For example, smoke tolerance is notably higher in the southern United States than in other regions (Engebretson et al. 2016). More recently, extremely large fires resulting from escaped prescribed burns in New Mexico during the 2022 burn season resulted in the US Forest Services pausing all prescribed burn activities pending agency review (USFS 2022). In future research, it would be interesting to analyze SWOT attributes, which might vary regionally.

The SWOT-AHP methodology used in this research benefits from fast and cost-effective deployment. We feel that additional research in this vein might be instrumental in creating greater depth and understanding within and across other regions and localities. This is particularly prescient as fire management efforts at various levels across the country continue to strive for greater success in mitigation of wildfire and restoration of fire-dependent ecosystems. This approach would likely be helpful in allowing researchers and managers to respond quickly to changing policies and increasing natural disturbances such as extreme wildfires.

Some limitations of this study are noteworthy. Although most stakeholders were knowledgeable about prescribed fire and its role in controlling eastern redcedar encroachment, some found the Likert scale comparisons difficult to understand or use. Likewise, these stakeholders were not 100% mutually exclusive as a few respondents revealed representing more than one stakeholder group. Though these discussions could be best achieved through in-person meetings, such planning was not possible due to the ongoing COVID-19 pandemic. In the future, in person data collection may help minimize these challenges.

Implication

Our study results have important management implications. For example, despite higher perceived risks associated with escaped prescribed fire (Harr et al. 2014; Joshi et al. 2019; Weir et al. 2019), the actual number of incidents remains very low (approximately 1.5% from 1995 to 2012) (Weir et al. 2015) and the dread factor is mostly attributed to the cultural stigma (Twidwell et al. 2015). Frequent wildfires in the wildland-urban interface and the associated media coverage often enhance fears (Twidwell et al. 2015) that can negatively influence stakeholder perception. Therefore, more tailored outreach on burn plans, smoke management, burn insurance, and other risk minimizing factors may help alleviate this situation. In particular, landowners and government stakeholders may gain a sense of reassurance through burn insurance acquisition and other best practices.

In the southern Great Plains, as well as in much of the southern United States, there is a higher level of cultural familiarity with prescribed fire and its effects. This familiarity appears to positively influence acceptance of this practice (Winter et al. 2006). Additionally, private, government, and NGO actors showed similar responses to the SWOT attributes except for those differences noted in our results. Such relative alignment may positively influence management policies and actions needed to reduce potential wildfire risk. Our results further align this research topic within the realm of social exchange theory and its relationship to collective action and social capital (Ostrom 1990; Cropanzano and Mitchell 2005).

Although prescribed fire requires specialized training, opportunities can be made less intimidating, particularly with peer learning events that are available through many cooperatives, such as prescribed burn associations (PBAs). Fortunately, the citizenry empowered through the PBAs continues to grow in the southern Great Plains (Twidwell et al. 2013) and their success will likely bring stakeholders together to learn from each other. PBAs are often affiliated with the extension offices of state universities, as well as various NGOs including the Nature Conservancy and Wild Turkey Federation. In the southern Great Plains, the Natural Resources Conservation Service, Coalition of Prescribed Fire Councils, and Southern Fire Exchange also represent valuable repositories of expertise. The expansion of educational and youth-outreach efforts in fire safety and land stewardship should be considered a key stepping stone to strengthen the institutional and operational knowledge base of future generations of land stewards.

For researchers and practitioners alike, it will be important to remain vigilant for opportunities to look for, recognize, and include those who may be underrepresented in programs that strive to address ecological issues in the southern Great Plains. Efforts to mitigate such inequities are desirable as has been observed with Black farmers affected by eastern redcedar encroachment in Oklahoma (Fagundes et al. 2020). Additionally, care must be taken to consider how structures associated with those norms and practices espoused in PBAs may also create barriers for the implementation of cultural or traditional burn practices (Adlam et al. 2021). Collaboration and understanding of shared values and differences are needed to define successful future stewardship practices.

Conclusion

This study uses the SWOT-AHP platform to understand how natural resource management stakeholders perceive prescribed fire as a BMP to control eastern redcedar encroachment. Our results suggested that stakeholders representing NGOs favor the positive factors associated with prescribed fire. However, landowners and government stakeholders are particularly concerned about potential fire threats. The primary challenges to promote prescribed fire include cultural stigma, liability, weather dependency, and the need for specialized manpower, which may collectively outweigh the positive aspects of prescribed fire in a given location. Interestingly, stakeholders representing NGOs have somewhat contrasting opinions toward prescribed fire as a land management tool. These findings also suggest broad agreement among stakeholders that prescribed fire is a cost-effective practice that can help reduce fuel loads and improve pastureland. Since landowners and government agencies are two primary stakeholders in the promotion of prescribed fire, their consternations suggest the need for tailored outreach including opportunities to get hands-on experience and increase ease of access to resources and information. We suggest supporting locally attuned fire learning and knowledge exchanges through PBAs and other fire learning networks, as well as university and state extension offices.

Declaration of Competing Interest

Authors do not have any conflict of interest in study design, analysis, and publication.

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