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Impacts of multi-method learning on prescribed fire perceptions in Texas

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Abstract

Background Woody plant encroachment is a significant issue affecting the diversity and continuity of vulnerable grassland savanna ecosystems throughout the southern Great Plains. Prescribed fire, particularly when paired with other techniques such as patch-burn grazing, offers a cost-effective solution toward controlling the spread and preserving these ecosystems. Despite its effectiveness, prescribed fire perceptions are often misunderstood among many stakeholder groups, further emphasizing the need for more effective outreach and education programs among today's extension agents, range managers, prescribed fire advocates, and future landowners. This study assessed the effects of multi-method teaching strategies on enhancing knowledge and attitudes about prescribed fire among adult and youth participants in Texas using pre- and post-evaluation surveys.

Results Key findings revealed that teaching methods which incorporated hands-on learning and interactive web-based learning were the most effective at improving prescribed fire knowledge and perceptions among participants. Further, the age group which experienced the most positive significant impact throughout the study was the 9th–12th age group. Lastly, this study revealed that a majority of participants in this study harbored no fear or apprehension toward prescribed fire before the intervention, but still improved overall perceptions following the study.

Conclusion Our findings indicate that the methods and curriculum utilized in this study could serve as a valuable framework for extension agents and prescribed fire advocates to enhance public knowledge and perceptions about prescribed fire. Further research, particularly with participants who have varying levels of familiarity and experience with prescribed fire, may provide deeper insight to tailor communication to bridge the perceptual divide and expand outreach and educational efforts. This approach could help improve future extension programs to address diverse audiences effectively, which can in turn strengthen support for prescribed fire as a management tool.

Keywords Multi-method learning, Perceptions, Prescribed fire, Ranch tours, Rangeland, Texas, Web-based learning, Woody plant encroachment

Resumen

Antecedentes El incremento en la densidad de arbustos es un tópico significativo que afecta la diversidad de los ecosistemas de pastizales-sabanas en las grandes planicies de los EEUU. Las quemas prescritas, cuando se asocian a otras técnicas como el quemado y pastoreo en parches, ofrecen una solución costo-efectiva para controlar la invasión de arbustos y preservar estos ecosistemas. A pesar de su efectividad, las percepciones de las quemas prescritas son frecuentemente no comprendidas por muchos grupos de administradores de tierras, lo que enfatiza

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la necesidad de ampliar su conocimiento más efectivamente y con programas de educación para los agentes de extensión, los gestores de tierras, los que abogan por las quemas prescritas, y futuros dueños de tierras. Este estudio determinó los efectos de estrategias de enseñanza con métodos múltiples para aumentar el conocimiento y las actitudes sobre las quemas prescritas, entre participantes adultos y jóvenes en Texas usando relevamientos previos y posteriores a los programas de enseñanza.

Resultados Los resultados claves revelaron que los métodos de enseñanza que incorporaron aprendizaje in-situ, e interacciones de aprendizaje basadas en la WEB, fueron los más efectivos para mejorar el conocimiento sobre las quemas prescritas y las percepciones entre los participantes. Además, los grupos etarios que experimentaron los impactos más positivos a través de todo el estudio fueron quienes pertenecían a los grupos de edad que correspondieron a estudiantes de 9no. al 12mo. grado escolar. Finalmente, este estudio reveló que la mayoría de los participantes no albergaron miedos ni ningún tipo de aprehensión hacia las quemas prescritas antes de las intervenciones, mientras que mejoraron su percepción en general luego del estudio.

Conclusiones Nuestros resultados indican que los métodos y la currícula utilizados en este estudio pueden servir como un marco de referencia valioso para agentes de extensión y para los defensores de las quemas prescritas, y aumentar el conocimiento público y sus percepciones sobre estas quemas. En futuras investigaciones, particularmente los participantes que tienen diferentes grados de familiaridad y experiencia con las quemas prescritas, pueden proveer de conocimientos más profundos para adaptar y expandir los alcances y los esfuerzos educacionales. Esta aproximación al tema puede ayudar a mejorar los futuros programas de extensión, y re-direccionarlos hacia diversas audiencias de manera efectiva, lo que a su vez puede robustecer el apoyo a las quemas prescritas como herramienta de manejo.

Background

The rapid expansion of woody plants (both undesirable shrubs and trees) is a pervasive threat to the integrity and sustainability of grassland savanna ecosystems throughout the Great Plains (Roques et al. 2001; Briggs et al. 2005; Londe et al. 2022). In the southern Great Plains, woody plant encroachment (WPE) is reported to occur at rates 5 to 7 times higher than any other region in the USA (Engle et al. (Engle 2008); Barger et al. 2011). In Texas, WPE has been historically facilitated by factors such as overgrazing, suppression of periodic wildfires, and land fragmentation emanating from row crop agriculture (Box 1967; Diamond and True 2008; Londe et al. 2022). According to Wilcox et al. (2018), fire has been consistently recognized as a key element for maintaining the balance between woodland and grassland-dominated ecosystems. This is attributed to prescribed fire's ability to suppress woody plant growth effectively and its cost efficiency at preventing seedling emergence and maturation of woody trees, especially when compared to chemical or mechanical methods (Hoffmann 1999); Su et al. 2015; Scholtz et al. 2018). Additional results on patch-burn grazing have focused on increased plant diversity and forage quality while reducing WPE (Taylor 2008; Wilcox et al. 2018).

Research on barriers limiting the adoption and acceptance of prescribed fire as an effective economic and ecological tool has generated an extensive body of literature (Harr et al. 2014; Twidwell et al. 2015; Weir et al. 2019).

A study by Kreuter et al. (2008) found Texas landowner's perspectives regarding the ecological effects on prescribed fire to be generally positive. However, perceptions regarding fire's overall effects on woody plant mortality were found to be less optimistic and more diverse (Kreuter et al. 2008). Stroman et al. (2020) found no statistical difference between Texas landowners' preference for woody cover and the use of prescribed fire. This is likely because some landowners harbor reservations regarding the use of prescribed fire as a safe and efficient tool for managing rangelands (Morton et al. 2010; Stroman et al. 2020). Additional concerns about property damage, lack of training, proper equipment, ability to manage fires effectively, and public campaigns like Smokey Bear have only reinforced the public belief that fire is a risk to society and the environment (Abrahamson 1984; Harr et al. 2014; Twidwell et al. 2015). Additional literature elucidates the multifaceted perceptions of prescribed fire among diverse publics, revealing a complex interplay of trust, risk assessment, and ecological literacy as pivotal determinants. McCaffrey (2006) and McCaffrey et al. (2013) posit that apprehension toward prescribed fire frequently stems from its conflation with uncontrolled wildfires, a cognitive bias amplified by salient memories of catastrophic events rather than the managed parameters of prescribed burns. Furthermore, Vaske et al. (2007) corroborated that rural stakeholders, often possessing direct land stewardship experience, exhibit greater receptivity to prescribed fire as a pragmatic management

strategy, whereas urban constituencies, distanced from fire-adapted landscapes, tend to perceive it as an unwarranted hazard. All of which collectively underscores and emphasizes the necessity of tailored communication to bridge perceptual divides.

Efforts such as The Prairie Project (TPP) (www.thepairieproject.org) have been initiated to overcome barriers limiting adoption, understanding, and acceptance of prescribed fire. A primary objective of TPP is to create outreach and educational initiatives that enhance rangeland literacy for natural resource professionals, land managers, and the public, both present and future. Many studies support that methods such as prescribed fire are more likely to be accepted and adopted if citizens can openly engage in discussion about merits, risks, and future outcomes (Shindler 2003; Toman et al. 2006; McCaffrey 2006). While research has established the effectiveness of public education toward understanding the need for prescribed fire, there is a lack of literature that investigates the effectiveness of multiple teaching methods and content matter within different age groups, particularly youth, future landowners, and range managers, to propel prescribed fire understanding and knowledge forward.

To bridge the current knowledge gap, our study seeks to investigate the knowledge and attitudes of K-12 students and adults regarding prescribed fire, both before and after an educational intervention. We are particularly interested in understanding how various teaching methods can influence their knowledge and attitudes toward this topic. The teaching approaches utilized in our study include hands-on learning, ranch tours, traditional face-to-face lectures, collaborative group-based learning, and web-based activities. A quasi-experimental, sometimes called pre-post intervention, design was used to answer two research questions: (1) What is the change in knowledge associated with each method of outreach and education? (2) What is the change in attitude associated with each method of education? (Harris et al. 2006). By employing a quasi-experimental design, we aim to establish a direct cause-and-effect relationship between the treatment groups and the survey scores of participants (Harris et al. 2006).

Based on peer-reviewed articles used for background and literature review of this study, we hypothesize the following:

1. Participants exposed to interactive and experiential learning methods (e.g., hands-on activities, ranch tours) will demonstrate a greater increase in knowledge about prescribed fire compared to those receiving traditional lecture-based or hands-off web-based education.
2. Participants engaged in collaborative and immersive learning experiences (ranch tours led by ranch owners) will show a more positive shift in attitudes toward prescribed fire as a woody plant management strategy compared to those receiving solely informational or passive learning interventions such as lecture-based or hands-off web-based education.

Methods

Study sites

The Prairie Project collaborated with four demonstration ranches across Texas: Hoover K. Bar Ranch, Rocking Chair Ranch, Head of the River Ranch, and Duff Ranch (Fig. 1). These ranches, which are situated in Schleicher, Crockett, and Tom Green Counties, represent a geographically diverse area in the Rolling Plains and Edwards Plateau Ecoregions dominated by mixed-grass prairie and savannas. Average annual rainfall ranges from 58.4 to 88.9 cm in the Edwards Plateau (Texas A&M Forest Service (Texas 2024)). Soils in this region are described as shallow profiles, consisting of yellowish clay to clay loam Surface layers, with depths reaching only about 25.4 cm. Primary vegetation types include live oak (*Quercus virginiana* Mill), Texas oak (*Quercus buckleyi* Nixon & Dorr), Ashe juniper (*Juniperus ashei* J. Buchholz), honey mesquite (*Prosopis glandulosa* Torr.), and a mix of tall, medium, and short warm-season grasses (Texas A&M Forest Service (Texas 2024)) with a few cool-season grasses, namely Texas wintergrass (*Nassella leucotricha*).

In comparison, the Rolling Plains receive an average annual rainfall of 55.9–76.2 cm. Soils vary from neutral to alkaline (Texas A&M Forest Service (Texas 2024)). The Yield Gap analysis reveals a significant transition of grassland savanna ecosystems into juniper woodlands since 1990 (Rangeland production lost to tree encroachment 2024). This shift is particularly evident in Crockett County, where approximately 63,725.04 ha have undergone conversion.

Similarly, Substantial amounts of land in Tom Green County and Schleicher County have experienced this ecological change, totaling 35,448 ha and 35,101 ha, respectively (Rangeland production lost to tree encroachment 2024). To counteract this issue, ranchers at these sites used patch-burn grazing and prescribed fire to manage their pastures. For this study, participants visited one of these 4 ranches to engage with ranch owners, learning firsthand about prescribed fire and patch-burn grazing, and observed the results of these practices in pastures dominated by woody plant encroachment.

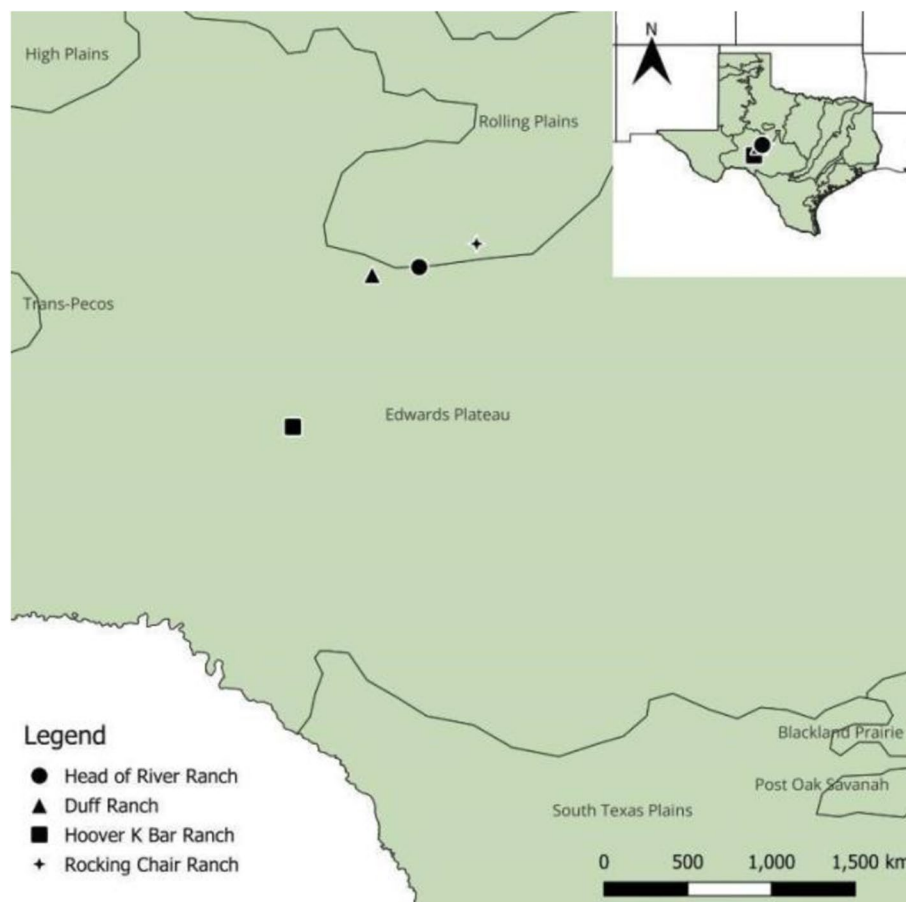


Fig. 1 Approximate locations of the four demonstration ranches utilized in the ranch tour treatment curriculum

Curriculum

The three types of (~4 h each) curricula that were developed in this project included an online RAP Curriculum Workshop, a Ranch Tour Workshop, and a Traditional Lecture Workshop. Each of the curricula developed utilized one of the following: Rangeland Analysis Platform (RAP; www.rangelands.app), ranch tours with ground-truthing vegetation monitoring, and traditional classroom lecture with an interactive activity. The RAP is a web-based tool that provides comprehensive data and insights on rangeland health, productivity, and vegetation trends across the USA. It leverages remote sensing data from satellites, such as Landsat and MODIS, to monitor and analyze vegetation cover, biomass production, and land changes over time, offering valuable information for land managers, ranchers, and conservationists. Participants used the RAP online tool used to evaluate the impacts of management practices such as prescribed fire and patch-burn grazing on various cover types: bare ground, tree, perennial forb and grass, and shrub (Sullivan et al. 2024). Participants used data on pastures managed with prescribed fire to those with no fire, prescribed

fire and patch-burn grazing compared to those grazed with cattle alone, and differences between grassland ecological sites and juniper-woodland sites (Sullivan et al. 2024).

Participants also engaged in ranch tours led by ranch owners implementing prescribed fire and patch-burn grazing including hands-on monitoring on demonstration ranches near San Angelo, TX, utilizing the same ground-truthing techniques mentioned in Sullivan et al. (2024). Two primary methods were used: the line-point intercept and closest individual methods. For the line-point intercept, participants recorded cover types such as litter, forbs, grass, tree, rock, shrub, and bare ground at each corresponding meter mark (1,2,3...50). For the closest individual method, participants measured tree density at specific points along an established transect.

Additionally, a traditional lecture curriculum was developed with integrated activities such as a social media assignment, an interactive rangeland walk, and an in-person lecture with accompanying PowerPoint® slides. This curriculum aimed to establish an understanding of WPE, rangelands, and sustainable land management

practices as it pertains to prescribed fire and patch-burn grazing on Texas rangelands (Sullivan et al. 2024).

Online RAP Curriculum Workshop treatment

Between 2022 and 2023, 12 workshops focused exclusively online using the RAP were held at various locations throughout the state, recruiting 177 participants in total (Fig. 2). These workshops were commonly held in a computer lab on campus or in Texas A&M AgriLife Extension Centers where participants brought computers. This treatment began with an introductory tutorial to familiarize attendees with the RAP curriculum. Participants were then encouraged to finish the curriculum with the instructor assisting if need be. The workshops concluded with a group discussion facilitated by the instructor, thereby allowing participants to share their findings and explore the practical implications of patch-burn grazing and prescribed fire in Rangeland management. Workshop durations spanned anywhere 1 to 6 h, influenced by factors such as the number of attendees and the pace at which participants completed the curriculum (Fig. 2).

Ranch tour workshop treatment

Between 2022 and 2023, five ranch tours were conducted, involving 45 participants (Fig. 1). Each tour started with an overview of the management strategies employed and a conversation with the ranch owner/operator about their implementation of strategies on the demonstration ranch. To provide participants with practical experience, they were divided into groups to carry out ground-truthing exercises. The tours included visits to three pastures managed uniquely with prescribed fire, patch-burn grazing, and no fire. In each pasture, participants implemented vegetation transects to determine average cover by functional group (grass, forb, shrub, and tree). Following the ground-truthing activities, participants engaged in interactive discussions with the rancher, exploring practical applications of patch-burn grazing and prescribed fire as rangeland management strategies. Finally, participants compared the data they collected on-site to the remotely sensed data available on RAP to deepen their understanding of grassland savanna responses to prescribed fire negligible (Fig. 3).

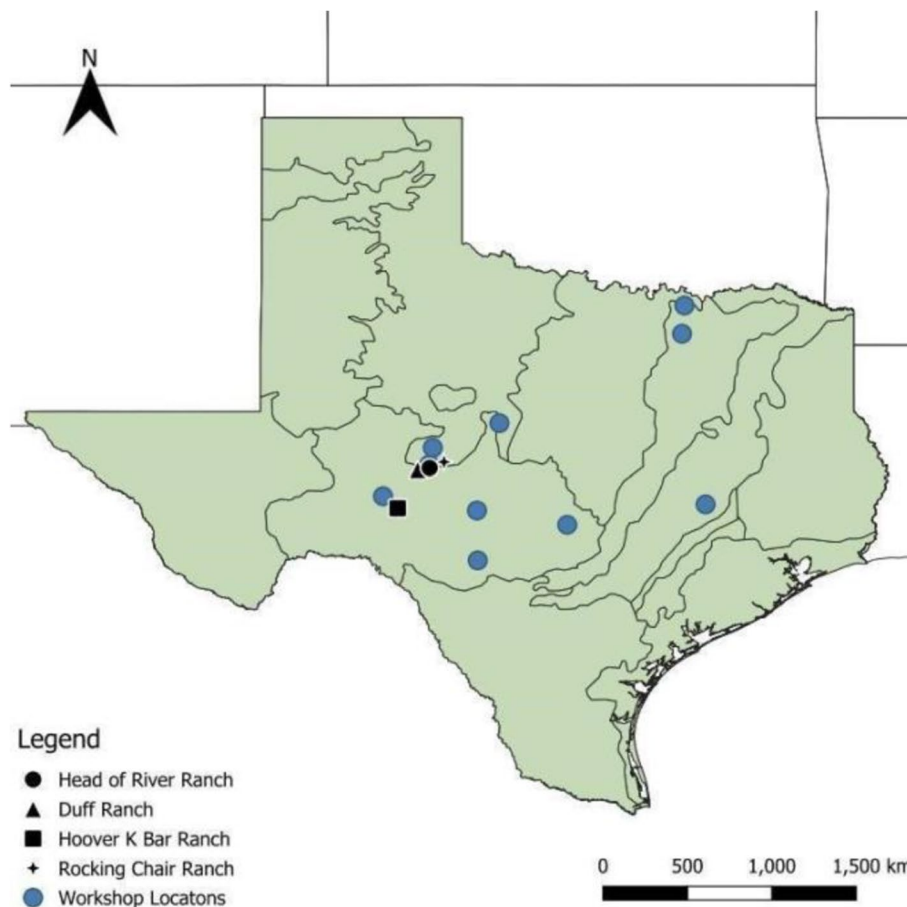


Fig. 2 Approximate locations of all 22 workshops held between 2022-2023 in Texas consisting of the online RAP, ranch tour, and traditional curricula

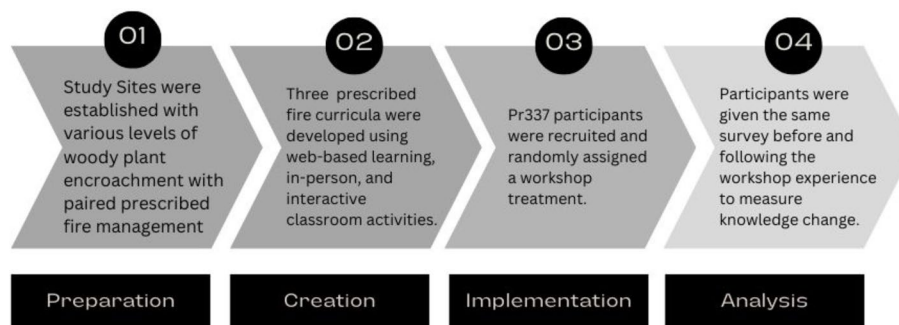


Fig. 3 Process chart outlining the start-to-finish stages of the project milestones delivered throughout the study

Traditional lecture workshop treatment

From 2022 to 2023, a total of four workshops were coordinated for the traditional curriculum treatment group, recruiting 115 participants. The workshops adhered to traditional PowerPoint® lecture on WPE and included a hands-on ground-truthing exercise in a nearby rangeland area rather than at a demonstration ranch. After completing the ground-truthing activity, attendees participated in group conversations pertaining to potential benefits of employing patch-burn grazing and prescribed fire as rangeland management strategies.

Participants

This 2-year study included 337 participants Such as Texas A&M AgriLife County Extension Agents, high school agriculture science teachers, undergraduate students, Texas Master Naturalists, and members of organizations Such as Ranch Brigades, Texas Section Society for Range Management Youth Range Workshop, and 4H/FFA clubs and chapters. Study participants were actively recruited by the authors through engagement with local and state natural resource organizations, educators, and Extension professionals.

Survey instrument

A 17-question survey was created in Qualtrics to assess the impacts of various educational methods on participant knowledge and attitudes. Participants took this survey prior to the start of each workshop and at the end of each workshop, resulting in pre/post knowledge gains and understanding. The survey aimed to measure: (1) knowledge change correlated with web-based activities, ranch tours, group-based learning, hands-on experiences, in-person lectures, and ranch tours, and (2) attitude change linked to these same approaches. To address the research objectives, four Likert-scale questions were chosen from the survey (Table 1). Additional questions were excluded from this study as they were not directly related to assessing participants' knowledge and perceptions of prescribed fire. Participants

Table 1 Survey questions (Q1–4) using a Likert-scale were utilized throughout the pre- and post-evaluations to determine changes in knowledge and attitude of prescribed fires and patch-burn grazing from 337 participants across Texas

1. Rangeland fires are devastating

2. I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland
3. Lack of fire can result in the increase of shrubs/trees on rangelands
4. Should recently prescribed burned areas be grazed?

completed the survey anonymously both immediately before and after the extension activity to evaluate educational effectiveness. Approval for this survey was obtained by Texas A&M University's Institutional Review Board (IRB2023-0158).

Statistical analysis

Data analysis was conducted using version 29 of the Statistical Package for Social Sciences (SPSS). Welch's *t*-test was employed to evaluate the statistical significance of participants' pretest and posttest scores after workshop participation. Cohen's *d* formula was applied to determine effect sizes when significant results were identified. To maintain consistency and validity, standardized scores were used for all survey questions, including reversal scoring for negatively worded Likert-scale questions. The formula (Posttest score – Pretest score)/Pretest score was used to measure changes in knowledge and attitudes. Responses with missing data for specific questions were excluded from the final mean pretest and posttest analysis for those questions.

Results

We fail to reject hypothesis 1, which posits that interactive and experiential learning methods (e.g., ranch tours) yield greater knowledge increases about prescribed fire compared to traditional lecture-based or web-based

education, because the ranch tour group demonstrated a significant 30.26% improvement in rejecting the notion that “rangeland fires are devastating” ($P=0.007$) and an 18.07% reduction in worry about observing prescribed fire ($P=0.05$). These results Substantially outpaced the modest 5–6% attitude improvements from the online RAP curriculum and traditional lectures ($P<0.001$ and $P=0.002$), Supporting the hypothesis that hands-on methods are more effective. Similarly, we fail to reject hypothesis 2, which states that collaborative and immersive learning (e.g., ranch tours led by ranch owners) produces more positive attitude shifts toward prescribed fire as a woody plant management strategy, as evidenced by the ranch tour’s strong outcomes and the RAP curriculum’s 46% higher positive attitude toward grazing burned areas ($P<0.001$), particularly among 9th–12th graders with a 40% improvement ($P=0.008$).

Ranch tours outperform lectures and web-based methods in boosting prescribed fire knowledge

When determining responses by age, similarly, participants were surveyed using Likert-scale questions to assess how different treatment groups influenced their knowledge and attitudes regarding prescribed fire. Participants consisted of diverse age groups, including K-8th graders, 9th–12th graders, college students, and adults. When asked, “rangeland fires are devastating,” the 9th–12th age group in ranch tour treatment experienced the most significant attitude change at 40% ($t(39.27)=2.80, P=0.008$) (Table 2). It is worth noting that the 9th–12th and college students in the online RAP curriculum treatment also exhibited significant improvements ($P=0.001$ and $P=0.005$), but with only negligible changes.

When asked, “I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland,” the 9th–12th age group in the online RAP curriculum showed significant attitude changes of 18% ($t(194.98)=-4.17, P=0.0001$). Surprisingly, both the 9th–12th and adult age groups (40 years+) in the online RAP curriculum treatment significantly enhanced their attitudes of prescribed fire ignitions ($P=0.018$ and $P=0.009$) (Table 3).

No statistically significant increase in values were recorded for “lack of fire can result in the increase of shrubs/trees on rangelands.” However, similar to online RAP curriculum results, “should recently prescribed burned areas be grazed?”, the 9th–12th age group in the online RAP curriculum treatment displayed the most significant attitude changes at 95% ($t(164.84)=-7.29, P\leq 0.001$) (Table 4).

Ranch tours drive stronger positive attitude shifts toward prescribed fire as a management strategy

The survey implemented in this study consisted of a series of Likert-scale questions aimed at evaluating participants’ attitudes toward prescribed fire. In Table 5, the most substantial attitude change outcomes are displayed for three distinct treatment groups: RAP curriculum, ranch tour, and traditional lecture. The ranch tour treatment group exhibited the most significant improvement in attitudes, with a 30.26% increase when asked whether “rangeland fires are devastating” ($t(53.87)=2.82, P=0.007$). It is also worth mentioning that the online RAP curriculum and traditional lecture treatments demonstrated significant changes ($P<0.001$ and $P=0.002$, respectively), but with only modest 5–6% attitude improvements.

Table 2 Overall attitude change by age group for online Rangeland Analysis Platform (RAP), ranch tour, and traditional lecture curricula treatment groups for Q1

1. Rangeland fires are devastating. ^a								
Age group	PRE	SD	POST	SD	% attitude change	t	P	d
RAP curriculum treatment group								
9th–12th ¹	3.27	1.23	3.96	1.06	21.10%	3.26	0.001	0.60
College students ²	3.87	0.94	4.33	0.94	11.89%	2.83	0.005	0.49
Adult ³	4.34	0.87	4.57	0.68	5.30%	1.28	0.21	0.28
Ranch tour treatment group								
K-8th ⁴	3.86	0.90	4.29	0.95	11.14%	0.87	0.40	0.46
9th–12th ⁵	2.76	1.18	3.86	1.35	39.86%	2.80	0.008	0.86
Traditional classroom lecture								
9th–12th ⁶	4.25	1.04	4.67	0.81	9.88%	-3.2	0.002	0.45
College students ⁷	4.81	0.60	4.80	0.42	-0.21%	0.08	0.94	0.04

^a Likert scale is 1 = strongly agree to 5 = strongly disagree

¹ Pretest = 62; posttest = 55, ² pretest = 68; posttest = 67, ³ pretest = 47; posttest = 30, ⁴ pretest = 7; posttest = 7, ⁵ pretest = 21; posttest = 21, ⁶ pretest = 104; posttest = 97, ⁷ pretest = 11; post = 10

Bold values indicate age groups with highest % attitude change

Table 3 Overall attitude change by age group for online Rangeland Analysis Platform (RAP) and traditional lecture treatments for Q2

Q2: I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland.^a

Age group	PRE	SD	POST	SD	% attitude change	t	P	d
Online RAP curriculum treatment								
9th–12th ¹	3.83	1.23	4.35	1.14	13.58%	−2.41	0.018	0.44
College students ²	4.29	0.81	4.39	0.89	2.33%	−0.64	0.52	0.11
Adult ³	4.45	0.97	4.87	0.35	9.44%	−2.70	0.009	0.53
Traditional classroom lecture								
9th–12th ⁴	3.53	1.21	4.18	0.98	18.41%	−4.17	<0.001	0.58
College students ⁵	4.09	0.54	4.30	0.95	5.13%	−0.61	0.55	0.28

^a Likert scale is 1 = strongly agree to 5 = strongly disagree

¹ Pretest = 62; posttest = 55, ²pretest = 68; posttest = 67, ³pretest = 47; posttest = 30, ⁴pretest = 104; posttest = 97, ⁵pretest = 11; posttest = 10

Bold values indicate age groups with highest % attitude change

Table 4 Overall attitude change by age group for online Rangeland Analysis Platform (RAP), ranch tour, and traditional lecture curricula treatment groups for Q4

Q4: Should recently prescribed burned areas be grazed?^a

Age group	PRE	SD	POST	SD	% attitude change	t	P	d
RAP curriculum treatment group								
9th–12th ¹	2.26	1.41	3.26	1.89	44.25%	3.20	0.002	0.60
College students ²	2.18	1.55	3.09	1.95	41.74%	3.00	0.003	0.52
Adult ³	3.26	1.89	4.00	1.72	22.70%	1.78	0.08	0.41
Traditional classroom lecture								
9th–12th ⁴	1.75	1.25	3.41	1.89	94.86%	7.29	<0.001	1.04
College students ⁵	2.45	1.57	3.20	1.99	30.61%	0.95	0.36	0.42

^a Likert scale is 1 = strongly agree to 5 = strongly disagree

¹ Pretest = 62; posttest = 55, ²pretest = 68; posttest = 67, ³pretest = 47; posttest = 30, ⁴pretest = 104; posttest = 97, ⁵pretest = 11; posttest = 10

Bold values indicate age groups with highest % attitude change

Table 5 Overall attitude change for online Rangeland Analysis Platform (RAP) curriculum (RC), ranch tour (RT), and traditional lecture (TL) treatment groups for Q1–Q4

	PRE	SD	POST	SD	% attitude change	t	P	d
Q1: Rangeland fires are devastating. ^a								
RC ¹	3.78	1.12	4.25	1.04	12.43%	4.04	<0.001	0.44
RT ²	3.04	1.20	3.96	1.26	30.26%	2.82	0.007	0.75
TL ³	4.3	1.02	4.68	0.78	8.84%	3.12	0.002	0.42
Q2: I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland. ^a								
RC ¹	4.17	1.04	4.47	0.93	7.19%	2.77	0.006	0.30
RT ²	3.21	1.13	3.79	0.99	18.07%	2.01	0.05	0.54
TL ³	3.58	1.18	4.19	0.97	17.04%	4.18	<0.001	0.15
Q4: Should recently prescribed burned areas be grazed? ^b								
RC ¹	2.49	1.66	3.33	1.90	33.73%	4.22	<0.001	0.47
RT ²	1.86	1.27	1.86	1.58	0.00%	0.00	1.00	0.00
TL ³	1.82	1.29	3.39	1.89	86.26%	7.19	<0.001	0.98

^a Likert scale is 1 = strongly agree to 5 = strongly disagree

^b Likert scale is 1 = no, 3 = I don't know, 5 = yes

¹ RAP curriculum: pretest = 115; posttest = 115, ²ranch tour: pretest = 45; posttest = 45, ³TL: pretest = 177; posttest = 177

Bold values indicate workshops with highest % attitude change

When asked “*I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland*”, the ranch tour group displayed a significant attitude change of 18.07% ($t(53.10) = -2.01, P = 0.05$). However, the online RAP and traditional lecture treatments did not enhance participant attitudes with no difference pre- and post-learning in regard to observing active prescribed fire ignitions on rangeland.

No statistically significant values were recorded for “*lack of fire can result in the increase of shrubs/trees on rangelands*” for all treatments. Interestingly, the online RAP curriculum treatment ($t(185.72) = -7.19, P \leq 0.001$) yielded 46% higher positive attitude changes when asked “*should recently prescribed burned areas be grazed?*” compared to the ranch tour and traditional lecture treatments.

Discussion

The periodic application of prescribed fire serves as a valuable management strategy for controlling PE maintaining the sustainability of grassland savanna ecosystems (Kreuter et al. 2008). Despite the advantages associated with the periodic use of prescribed fire, this management tool has not yet been widely adopted due to perceived risks and public campaigns like Smokey Bear (Kreuter et al. 2008). To facilitate widespread acceptance and adoption, outreach and education efforts are needed to change perceptions. In this study involving 337 participants, significant improvements in participants’ attitude scores were observed post workshop curricula. Furthermore, these findings highlighted three significant points for consideration when teaching prescribed fire and patch-burn grazing concepts in fire-dependent ecosystems: (1) hands-on experience is highly effective, (2) web-based activities show promise for diverse age groups and understanding of synergistic application of fire and grazing, (3) most participants were unafraid and not worried about prescribed fire.

Hands-on experience is highly effective

Identifying the knowledge and attitude change corresponded with each treatment group is critical to understanding the most effective teaching methods for improving prescribed fire perceptions. In our study, we observed that the ranch tour treatment displayed the most significant attitude change for survey questions, “*rangeland fires are devastating*” and “*I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland*.” This is unsurprising as the primary teaching methods consisted of hands-on approaches such as collaborative group learning, field excursions, and real-life problem solving (Akpan and Beard 2016). This type of learning is designed to foster the development of social and communication skills while facilitating the exchange and collaboration of ideas among students.

These findings are corroborated by Scasta et al. (2015) who studied the impact of experiential learning on college students enrolled in a prescribed fire course. That study revealed that experiential learning techniques such as conducting a prescribed fire, writing a burn plan, and hands-on spot and equipment training were ranked most effective and beneficial by students. A study by Parkinson et al. (2003) also found hands-on learning to be an effective method for reaching participants about wildland fire. We recommend educators and prescribed fire advocates consider incorporating hands-on approaches for educating the public on the merits of prescribed fire.

Web-based activities show promise for diverse age groups

Our results revealed the 9th–12th age group within the online RAP curriculum and ranch tour treatments experienced the most significant attitude change for survey questions, “*rangeland fires are devastating*,” “*I would be worried if I saw people conducting a controlled/prescribed fire in a rangeland*,” and “*lack of fire can result in the increase of shrubs/trees on rangelands*.” This significant change in attitude is unsurprising as youth have less knowledge and fewer life experiences than their adult counterparts (Bransford et al. 1999). Additionally, it is worth noting that the college and adult age groups within the online RAP curriculum treatment experienced noteworthy changes in their prescribed fire perceptions.

This result is exciting as it suggests that web-based training can also be an effective means for teaching multiple age groups on prescribed fire. Research on web-based training as a teaching method supports this claim. For example, Pennisi (2005) conducted a study involving Master Gardeners and county extension agents to explore their perceptions after using a web-based tool. The results demonstrated high levels of effectiveness and user satisfaction. Additionally, interactive computer-based training was shown to be as effective as traditional instruction methods. This is further supported by McCann (2007) who reported interactive online learning achieved results comparable to those produced by conventional learning techniques. Based on the results of the online RAP curriculum treatment, it becomes evident that web-based learning can prove to be an effective and time-efficient means of educating diverse age groups on prescribed fire. We encourage extension professionals and educators to consider incorporating web-based training into future prescribed fire programs.

Most participants were unafraid of prescribed fire

Lastly, this study aimed to investigate whether participants were fearful of prescribed fire. After analyzing responses for survey question, “*I would be worried if I*

saw people conducting a controlled/prescribed fire in a rangeland," analysis revealed most participants did not express apprehension about the practice. This outcome may be attributed to several factors. Many of the adults who participated in this study likely had prior knowledge or experience with prescribed fire, which may have drawn them to the workshops due to their relevance to their own work or research (Remenick and Goralnik 2019). Additionally, some college students were concurrently enrolled in rangeland-related courses, contributing to their familiarity and comfort with prescribed fire concepts. Notably, post-survey results indicated a decline in participant concerns, reinforcing that education and exposure play pivotal roles in overcoming perceived barriers to adopting prescribed fire as a land management tool (Toman et al. 2006). Additional research involving participants with diverse levels of familiarity and experience with prescribed fire could offer valuable insights for refining and broadening outreach and educational initiatives.

Conclusion

Our study proves the importance of outreach and education in reshaping public perceptions and increasing acceptance of prescribed fire as a Rangeland management tool. Among the 337 participants, significant knowledge and attitude changes post-curricula were observed, emphasizing the potential value of incorporating hands-on learning and web-based activities into prescribed fire education programs. Conversely, this study found that participants' overall perceptions of prescribed fire were mostly positive, likely because of prior experience or knowledge. However, their perceptions still improved following the workshop. This finding highlights the critical role of targeted education and experiential activities in reducing perceived risks and building more confidence in prescribed fire practices. The insights gained by participants in this study may influence the adoption and promotion of prescribed fire. On a broader scale, this knowledge gained by participants can help equip youth, future landowners, range managers, and informed voters with the knowledge to support grasslands and safeguard them from WPE.

Notes

1. Woody plant encroachment is defined the rapid proliferation of woody plant species in an area where tree populations were previously nonexistent or low in density.
2. The Prairie Project is a non-profit organization dedicated to creating outreach and educational initiatives that enhance rangeland literacy for natural resource

professionals, land managers, and the general public, both present and future.

3. The Rangeland Analysis Platform is an online tool which generates data on plant biomass and cover categories such as grass, bare ground, litter, rock, shrub, tree, and grass.

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Authors' contributions

MT conceptualized the study and designed the methodology. ES collected the data and performed the statistical analysis. ES drafted the initial manuscript. MT and ES revised the manuscript critically for intellectual content. All authors read and approved the final manuscript.

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Data availability

Datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Approval for this survey was obtained by Texas A&M University's Institutional Review Board (IRB2023-0158).

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

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