

Article

Perceptions of Prescribed Fire Among Ranchers near Northern US National Grasslands

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Abstract: Many barriers prevent ranchers from supporting prescribed fire on grazing leases or their own land. Barriers include negative perceptions of fire resources limitations, and fear of liability. We surveyed ranching landowners around four National Grasslands in North and South Dakota—public grazinglands managed by the USDA Forest Service—to assess landowner attitudes towards prescribed fire and provide insight into the barriers to using prescribed burning on the National Grasslands. Respondents reported being motivated by an interest in stewardship and want managers to prioritize sound science in decision-making on the National Grasslands. But respondents generally had negative perceptions of fire and reported little awareness of potential benefits. With respect to prescribed fire, specifically, respondents reported their greatest degree of trust in prescribed fire activity and/or information of Pheasants Forever and county Extension, and their lowest trust in the USDA Forest Service. Despite their proximity to public grazingland, where the risk and resource barriers for prescribed burning would be borne by the USDA Forest Service, respondents disagreed that prescribed fire use on the Grasslands should be increased and stated a lack of readiness to conduct prescribed burns on their own ranches. As the primary barriers to prescribed fire use in these communities appear to be negative perceptions, educational materials from trusted sources and opportunities to engage with burning might help explain where and when prescribed fire use would be appropriate on the landscape and aid understanding between entities that would like to use prescribed fire and those who are concerned about prescribed fire use.



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1. Introduction

Although fire has long been an ecological process in rangeland ecosystems, its use in modern land management can be controversial, especially in the northern Great Plains. The northern Great Plains historically experienced a frequent, low-intensity fire regime [1], but currently operates on an infrequent, variable regime [2–4]. Prior to Euro-American settlement, Indigenous peoples used fire to remove old vegetation, promote grass growth to attract huntable herbivores, manage game, and for other cultural purposes [5–7]. Fire promotes landscape heterogeneity, controls invasive plants and woody plant species, and

increases rangeland forage quality [8,9]. Despite these benefits, wildfire suppression and minimal prescribed fire use leaves the contemporary northern Great Plains largely unburned [4]. Less than 0.3% of permanent pasture acres were burned in North and South Dakota in 2020 [10,11]. Reintroducing fire through prescribed burning has proven difficult, as social perceptions often weigh heavily against prescribed fire use in the Great Plains [12]. Across the Great Plains, landownership primarily consists of private or state and local governments, with small areas of federal lands [13]. For example, only 4.7% of North and South Dakota are federally owned and managed [13]. Therefore, understanding the prescribed fire perspectives of private landowners can be important to understanding the barriers to its use in the northern Great Plains.

Social barriers include societal norms and attitudes; liability; and education, knowledge and training, whereas physical barriers include labor, equipment, cost, and government restrictions [12,14]. Social norms tend to highlight the attitude many community members display [15], as they often have “feelings or moral obligation to perform or refrain from specific action” [16]. Social science can help public and private land managers identify and evaluate management plans based on social and ecological tradeoffs [17] and make decisions that are better for humans and the environment alike. Human perceptions of landscapes are often shaped by our cognitive mind and mental models or heuristics [18,19], indicating the importance of concrete data being made available to us as our minds determine the value of different aspects of the land.

Considering social and ecological components together could assist managers in designing socially acceptable management plans that also meet ecological objectives [18]. But in the northern Great Plains, social norms on what is considered poor or good management might play a central role in the decision-making process of ranching communities [20,21]. Social concerns often weigh on government and private agencies as well, determining how often they use or support fire for management of federal, state, and private lands [22–25]. Ranching communities in the southern Great Plains—having more widely recognized that a lack of disturbance caused a decline in biodiversity and livestock forage production—formed prescribed burn associations to bring fire back into the landscape [26]. In contrast, the formation of prescribed burn associations has been slow to take hold in the northern Great Plains, with only three currently documented in eastern North and South Dakota and none in Montana or Wyoming [27].

The transtheoretical model of behavior changes outlines and conceptualizes intentional behavioral change. The five stages of change include precontemplation, contemplation, preparation, action, and maintenance. The beginning stages include no intention of behavioral change, or a lack of awareness that a problem exists and an awareness of a problem but no commitment to an action for change [28]. Navigating this process requires both knowledge and social support for the individual to comprehend the need for change and be committed to implementing it.

An important driver of decision-making for landowners and ranchers is being a good steward. Humans develop a sense of stewardship for landscapes as a basic component of their natural and cultural heritage; landscapes help form local cultures and provide ecosystem services for individual and societal wellbeing [29]. In North America, working landscape partnerships foster effective stewardship and conservation of land through active management [30]. Landscape stewardship comprises all “efforts to create, nurture and enable responsibility in landowners and resource users to manage and protect land and its natural and cultural heritage” [31]. ‘Stewardship’ is not only a management approach but perhaps even more, an ethic that emphasizes responsibility, collaboration, participation, and communication in the planning and management of land resources [32]. Stewards

often manage environmental features, especially those important for wildlife, to conserve them for future generations [33].

Social perceptions of fire can foster negative attitudes towards the role of fire in stewardship. Community members may be concerned that fire poses risk to nearby property, human safety, forage resources, soil stability, and wildlife. One study reported that ranchers and other community members in North Dakota agreed that there was potential for negative effects when a prescribed fire was on their neighbor's property [28]. However, a review of 23,050 prescribed burns in the US showed that less than 1% of fires result in an escape—a low likelihood relative to the large concern ascribed to fear of escapes [34]. Risk to human safety is also often an outsized concern given the rates of injury from conducting prescribed fire. Prescribed burns have fewer accidents than crop and animal production; between 1963 and 2013, only six deaths and one minor injury were reported from prescribed burns in the 23,050 prescribed burns studied [35]. However, potential practitioners do not just worry about the safety of those conducting the burn, but also community members in the area that may have to deal with harmful smoke, particularly vulnerable populations, leading to another barrier [36]. Additionally, ranching communities are often deterred from burning by a perception that fire destroys livestock forage [23] and increases runoff and soil erosion until vegetation regrows [37].

Liability is a particularly potent barrier to prescribed fire use. Numerous studies have found that liability is the largest barrier identified by landowners, including risk of an escaped fire; harm to neighbors and the community; and personal safety [22,23,28,36,38]. Weir et al. [34] infer that people often fear the perception of liability and suggest that “inaccurate perception of the danger and severity of liability is a greater barrier to prescribed fire than that of the actual danger and liability”. In other words, the actual risks of fire are different from the perceived risks. Liability standards applied to personal injury and property damage related to prescribed burning vary among states [39].

Perceptions can also turn into personal beliefs about fire. Clark et al. [12] found that only 5% of studies noted that over 50% of their respondents found prescribed fire beneficial. Others felt that burning should only be used in limited circumstances, only be used by professionals, and those that conduct prescribed burning should have adequate training.

A novel way to assess potential “what if?” scenarios regarding the removal of known barriers to prescribed fire is to focus on ranchers who operate near public grazinglands. Several barriers to prescribed fire use relate to risk or costs incurred by an individual or corporate entity conducting prescribed burns themselves and/or on their own land, but many of these barriers do not pertain to public land management agencies. For example, federal land management agencies in the United States maintain fire management resources including equipment, ~18,700 trained personnel, and budgets [40]. By transferring the cost and risk of conducting a prescribed burn away from the private landowner to the agency managing public lands, ranchers should theoretically be more likely to consider the potential benefits of prescribed fire.

The National Grasslands of the USDA Forest Service (USFS) present the best opportunity to study ranchers with access to public grazingland in the Great Plains, given that public grazingland is largely restricted to the western US [41]. Overall, 42% of land area in the 11 western states is federally owned by the US Government and managed by either the USFS and or the Department of Interior's Bureau of Land Management (BLM), 85% of which is grazed by domestic livestock; these livestock account for half of the commercial beef herd in these states [42]. In the Great Plains, public grazingland is a small percentage of the landscape [13] and the largest areas of public grazingland are the nearly 1.7 million ha of National Grassland, federally owned and managed by the USFS [43].

Regardless of the federal agency or state managing the lease of public grazingland, permittees are generally required to maintain access to “base ranch” land—grazingland which is mostly under the permittees’ own private ownership and/or management—creating a unique community of ranchers with interest in the sustained quality of both public and private rangeland, and potentially differing perceptions of best management practices for each. Such a landscape mosaic evokes the Reserves-As-Catalyst model [44] for employing otherwise discrete blocks of agency-managed, conservation-oriented land (e.g., the National Grasslands) as demonstration sites for innovative practices (e.g., prescribed fire, alternative grazing rotations) that might become acceptable across the broader landscape after early adopters first experience the benefits of the practice in the context of an agricultural business (e.g., ranchers who run cattle on public grazingland under USFS prescribed fire management).

Our study focuses on landowners in the Northern Great Plains located near the four national grassland units that comprise the Dakota Prairie Grasslands in North Dakota and north-central South Dakota [39]. These Grasslands encompass over a half-million ha and include 546 grazing allotments [45]. We sought to determine how prescribed fire is perceived in these unique communities with a mixture of public- and privately owned grazingland, and whether these ranchers held different perceptions of prescribed burning conducted by the USFS on federally owned land as opposed to their own home ranches. Understanding such differences in attitudes could identify barriers among graziers for prescribed fire use on public grazingland, and then potentially identify opportunities for understanding when and where graziers would see a benefit to manage with prescribed fire on private grazingland. For example, North Dakota courts apply strict liability to cases of escaped prescribed fire, meaning that the burner is responsible for damages resulting from escapes regardless of their actions and whether they were negligent [46]. While many states have developed prescribed fire legislation to reduce burner liability and promote prescribed burning in recent decades, statutory revision or creation is a long process requiring leadership within the state and buy-in from groups with large bases of support. Given that statutory relief from liability is not an immediate option in North Dakota, could cases where liability rests wholly on the USFS reduce this barrier such that ranchers are amenable to trying prescribed fire on their allotments? And could subsequent familiarity with grazing burned rangeland overcome other barriers and create interest in attempting to burn on the home ranch?

2. Materials and Methods

This study was designed to assess the perceptions of private landowners in the Northern Great Plains who are likely to graze livestock on public grazingland towards prescribed fire as an aspect of rangeland management. We followed the two-phase Exploration and Confirmation approach employed to study rangeland landowner perceptions of energy development elsewhere in western North Dakota [47] and in South Africa [48].

2.1. Survey Design

Our Exploratory Phase consisted of unstructured interviews with rangeland management stakeholders to familiarize ourselves with prominent issues and preferred nomenclature. We initially reached out to Grazing Associations, who distributed our contact information to their members, who subsequently contacted the researchers on their own volition. From those initial contacts, we conducted snowball sampling [49]—we requested additional contacts from their peer group who might not have received information from a Grazing Association. We also included agency and non-governmental organizations

(NGOs) by contacting individuals on organizational websites, also pursuing additional individuals through snowball sampling.

Conducted via telephone or Internet video calls, audio from the interviews was recorded using Microsoft Windows voice recorder, transcribed to text, and coded to identify emergent themes with the RQDA qualitative data management package [50] for the R statistical environment [51]. Using the emergent themes to focus on key dimensions of known human dimensions of prescribed fire management in the Great Plains in general [12,14], we developed a survey questionnaire specific to the Northern Great Plains for distribution to agricultural landowners in counties including or adjacent to USFS National Grasslands in North and South Dakota. The survey was administered using the basic Dillman protocol [52], consisting of mailing introductory postcards, the survey instrument, a reminder postcard for unreturned surveys, and a final abbreviated survey designed to assess potential nonresponse bias.

2.1.1. Study Area and Participants

The survey was distributed to landowners in 18 counties—13 in North Dakota and 5 in South Dakota—that either include or are adjacent to management units of the USFS Dakota Prairies National Grasslands. Focal counties, by nearest Grassland, included: *Little Missouri National Grassland*—Billings, Golden Valley, McKenzie, Slope, and Hettinger Counties, North Dakota; *Grand River National Grassland*—Adams County, North Dakota; Butte, Corson, Harding, Perkins, and Ziebach Counties, South Dakota; *Cedar River National Grassland*—Grant, Morton, and Sioux Counties, North Dakota; and *Sheyenne National Grassland*—Cass, Ransom, Richland, and Sargent Counties, North Dakota. Photographs of each Grassland are included in Appendix A.

Participants were primarily identified—and addresses obtained—through a Freedom of Information Act request to the USDA Farm Service Administration (FSA) based on records of pasture and rangeland ownership within each county. Additional case-by-case information was obtained from county FSA offices. In 2021, approximately 75 survey participants were randomly drawn from the mailing lists of each of the 18 counties, for a total of 1350 participants. The response rate was 18% following 247 surveys returned as undeliverable. This response rate is similar to a 2016 survey on prescribed fire in North Dakota (21% response rate) [28] and other regional prescribed fire surveys in the country (13 to 37% response rates) [53,54]. The survey was conducted by North Dakota State University and surveyors identified themselves as university researchers interested in learning about prescribed fire perspectives near the National Grasslands.

2.1.2. The Survey Instrument

Response options for questions in the survey instrument consisted primarily of five-point Likert scales in which respondents were asked to indicate the degree to which they agreed or disagreed with a series of statements: strongly disagree, disagree, neutral, agree, and strongly agree. The instrument also included several questions designed to better understand the demographic and geographic distribution of the respondents.

Questions were organized around the following themes:

Agency relationships—The survey asked participants to assess their use of, and trust in, resources provided by a number of institutions known to interact with landowners and managers in North Dakota. *Federal agencies* included the United States Department of Agriculture (USDA), Agricultural Research Service (ARS), USDA Forest Service (USFS), and Natural Resource Conservation Service (NRCS), as well as the United States Department of Interior Bureau of Land Management (BLM) and Fish and Wildlife Service (USFWS). One *state agency* involved was the North Dakota State Game and Fish Department (ND

G&F). Non-governmental organizations included the Audubon Society, Pheasants Forever, and The Nature Conservancy (TNC). In addition to the USFS, the USFWS and BLM manage smaller parcels of federally owned land with permitted grazing in North and South Dakota [13]. These agencies may have different relationships with adjacent private landowners than the larger USFS. The NRCS provides financial and technical assistance to private landowners to manage their own land. Research on land management practices also comes through county Extension offices associated with land-grant universities, such as North Dakota State University, and ARS, which has two rangeland research units near the Dakota Prairie Grasslands (Miles City, MT, USA; Mandan, ND, USA). State game and fish agencies are responsible for managing wildlife and facilitating access for hunting on state and private lands. Multiple non-government organizations (NGOs), such as TNC, Audubon Society, and Pheasants Forever, have an interest in land conservation that can involve owning and managing land, providing grants supporting wildlife habitat initiatives, and generally partnering with public and private landowners to ensure landscape continuity of natural habitats. Respondents were asked about each source in general terms of natural resource management, and with respect to prescribed fire, specifically.

Management decision-making—Participants were asked to identify which environmental concerns were important to them, and what drives their decision-making with respect to rangeland management. Potential environmental concerns included plant diversity, control of encroaching or invading woody plants, grassland/prairie restoration, wildlife habitat protection, invasive plant species control, and wildfire risk reduction. Considerations for management decisions included being a good steward, teachings of previous generations in their family/community, professional advice, scientific research and/or university publications, and management decisions/attitudes of neighbors.

Attitudes towards public grazinglands—As the target community for the survey was landowners likely to hold or apply for permits to graze livestock on the Grasslands as part of their livestock operation [55], we asked respondents about their attitudes regarding management of public grazinglands, and their own additional uses of these federal lands managed specifically for multiple use, including recreation. Respondents were asked to identify the degree to which they felt public grazingland managers perform well in management, whether managers should use the best available science, whether managers should manage to meet user expectations, whether there is an appropriate amount of prescribed fire on public grazingland, and whether there should be more prescribed fire in public grazingland management. Participants were also asked to describe whether they or their families also use National Grasslands for walking/hiking, hunting, bird watching, horseback riding, mountain biking, or camping.

Attitudes towards prescribed fire—Participants were asked to focus on their perceptions of prescribed fire, firstly in terms of how they perceive prescribed fire to be understood by their communities, and secondly in terms of how they personally perceive prescribed fire. With respect to community perceptions, participants were asked to identify the degree to which members of their community felt fire poses a risk to nearby property and human safety, produces harmful smoke, results in lost forage or soil erosion, or has negative impacts to wildlife. With respect to their personal perceptions, they were asked to identify the degree to which they agreed that burning is a poor management practice that should not be used or whether it can only be used in a limited set of circumstances; whether it should only be used by professionals or whether it is a good option for anyone with training, and whether people should be able to use fire as frequently as they want; whether their management plan includes prescribed fire use; and whether they are prepared to use prescribed fire if they choose to.

2.2. Survey Analysis

All survey questions other than demographic inquiries were based on five-point Likert scales. Data were analyzed using the agreement index employed in prior surveys of rangeland landowners [47,48,56]. The agreement index combines (a) the magnitude of the mean response by calculating an effect size on the difference between the distribution of the responses and a null, uniform distribution across response categories [57] and (b) whether the positive (agreement) or negative (disagreement) trend is significantly different than zero (ambivalence) by multiplying the above-derived effect size by the mean response [58] in 1000 simulations that allow for the estimation of 95% confidence intervals using R script available in McGranahan et al. [47]. Given that preliminary analysis indicated no discernable patterns in responses among demographic and geographic categories, responses are combined here to maximize statistical power.

3. Results and Discussion

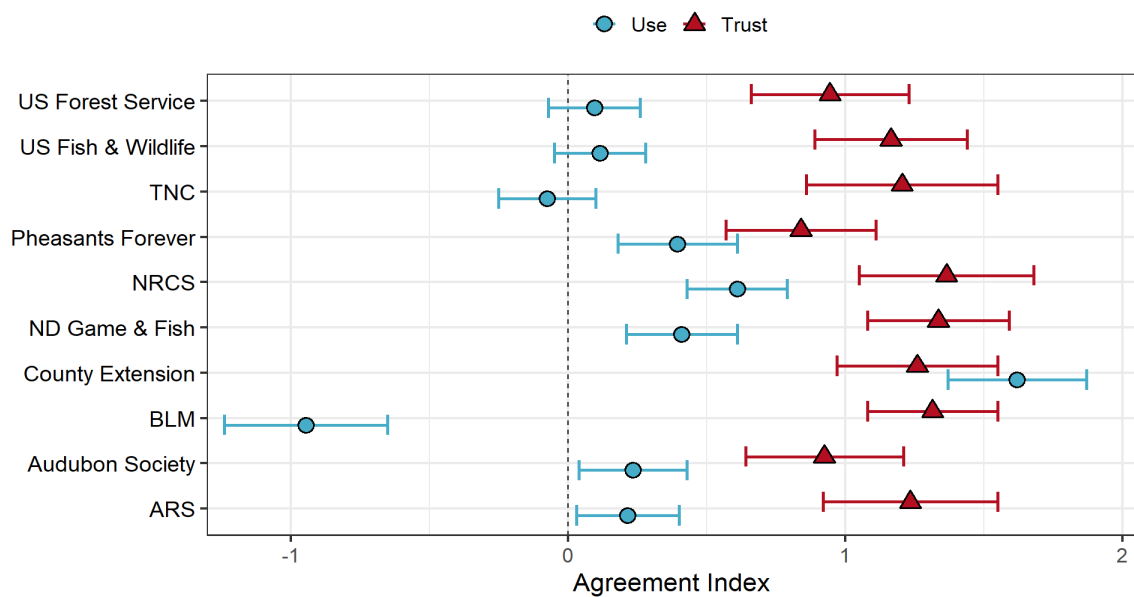
3.1. Agency Relationships

We found that although respondents generally have a high degree of trust in information from the queried sources, county Extension offices stood out as most-used by respondents (Figure 1A). High reliance on Extension is consistent with other studies, including studies asking for overall consensus of trust and information, like cattle, forage production, wildlife, and more [59,60]. We found the Bureau of Land Management (BLM) was used the least, likely because there are only small amounts of BLM land in the study area. As the most trusted resource, Extension offices could be the ones to connect ranchers/landowners and scientists together to allow information to be shared [61].

We asked respondents which organizations and agencies they associate and trust with prescribed fire, because trust in an agency performing prescribed fire shapes public acceptance [59,62]. Overall, respondents indicated a high degree of trust in Pheasants Forever with prescribed fire activity and information. These results support previous work suggesting that environmental groups and organizations are often trusted more than government agencies [59,60], the exception being county Extension. Studies in the southern Great Plains found that prescribed burn associations use NRCS or Pheasants Forever as knowledge sources on prescribed fire liability significantly more than they use state or federal wildlife agencies [34], demonstrating how non-governmental organizations may be more trusted sources for planning prescribed fire than state or federal agencies.

Respondents associated the USFS the most with prescribed fire but rated them least trusted regarding prescribed fire (Figure 1B), which is consistent with previous work indicating that the public holds greater trust in environmental groups than government entities [62]. Escaped prescribed fires can also erode trust in communities where they occur and often lead to the cancelation of other local burns. Perceptions of the USFS and prescribed fire near these National Grasslands may still be affected by the 2013 escaped prescribed fire (Pautre Fire) which occurred on the Grand River National Grassland [63]. Public trust in the USFS can quickly erode, as demonstrated by the decline in the trust of the USFS regarding fuel reduction strategies, including prescribed fire and mechanical thinning, in forest communities in the northwestern US over a four-year period [59]. Trust issues can extend from one agent to the entire organization, allowing one bad interaction to preclude trust in the future [64]. Trust has been found to be a strong predictor of approval and acceptance of government agencies to make proper decisions about management methods, including prescribed burning [65].

A. "In general, I personally use/trust resources from this organization"



B. "I associate/trust this organization with Rx fire activity or information"

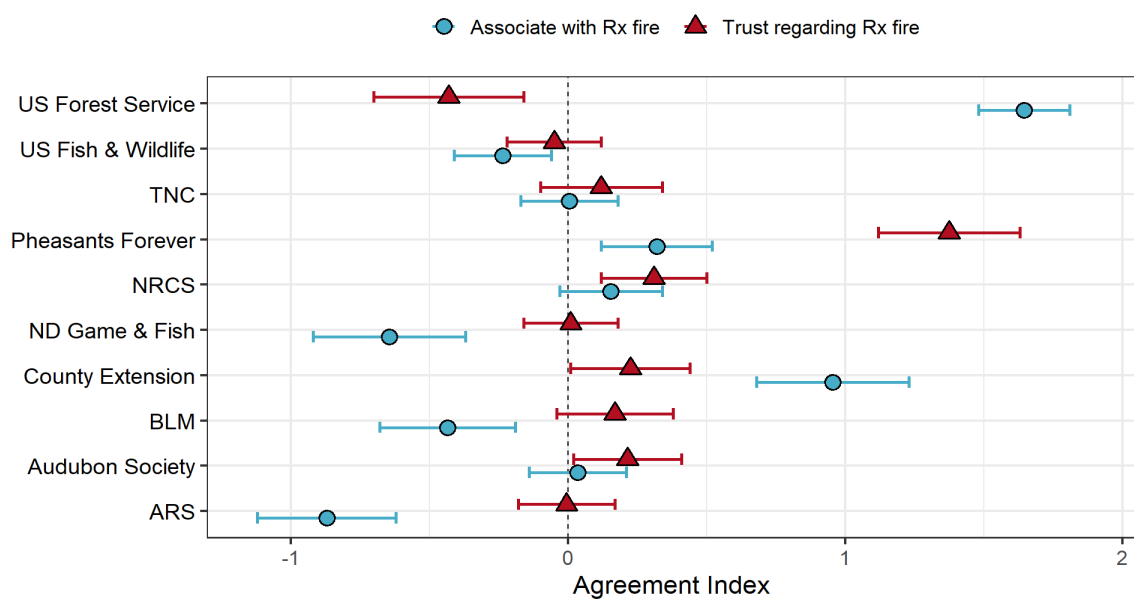


Figure 1. Degree to which survey participants agreed with statements about several governmental agencies and non-governmental organizations and (A) respondents' personal use and trust of resources in general, and (B) respondents' association and trust regarding prescribed fire, specifically. Agreement index quantifies median effect size of response and 95% confidence intervals based on five-point Likert scales. Organization abbreviations on vertical axis include TNC = The Nature Conservancy, NRCS = the US department of Agriculture Natural Resource Conservation Service; BLM = the US Department Interior Bureau of Land Management; ARS = the US Department of Agriculture Agricultural Research Service; US = United States, indicating US Government agencies; ND = North Dakota state agency.

3.2. Perceptions of Management and Decision-Making

Respondents generally expressed a positive view of management practices on National Grasslands, believing that the best science should take precedence over user needs or preferences (Figure 2). At the same time, there was general disagreement that prescribed fire use should be increased. Therefore, the trust between the USFS and its users would

need to be addressed when prescribed fire is considered in future management plans. Even if respondents believe that the best science should prevail, they disagree that the management plan should include fire. Without the trust, cooperation, and coordination among landowners, prescribed fires may be difficult to implement due to fragmented landscape ownership that includes both private and public land [66]. Vaske et al. [67] found that perceived similarity often initiates public trust; when someone believes that they share similar values as a management agency, they tend to trust that agency more.

"I personally believe the following about public grazingland management"

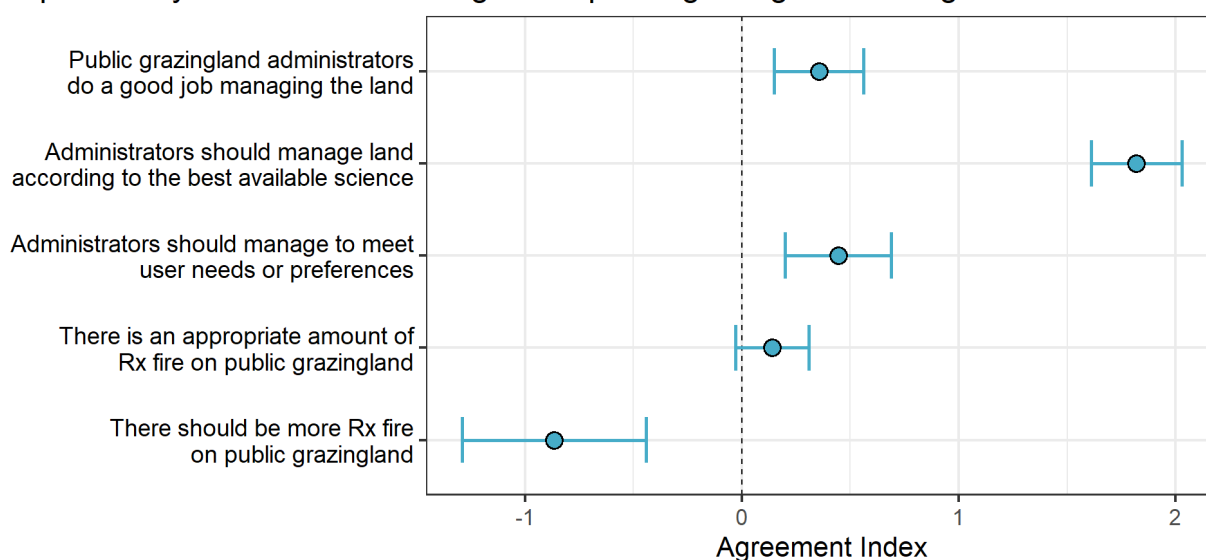


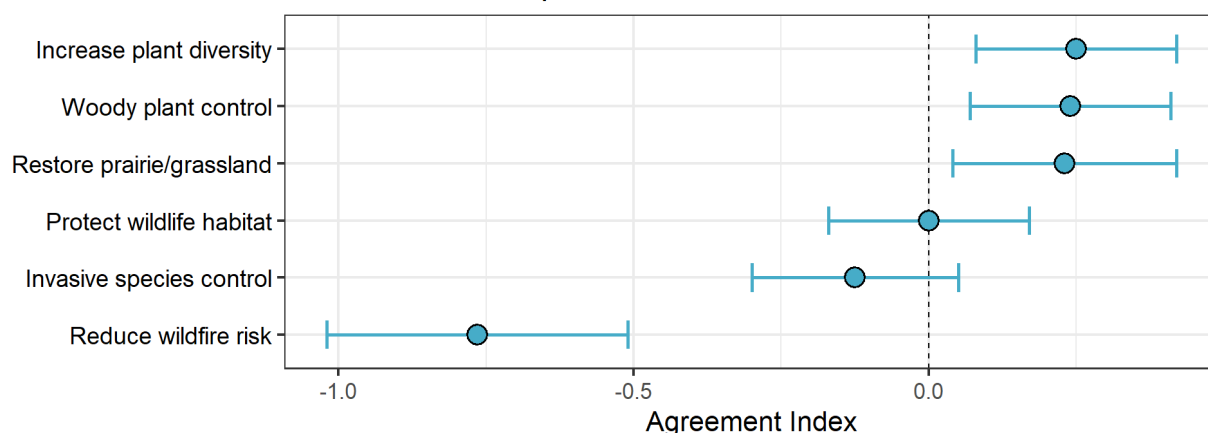
Figure 2. Degree to which survey participants agreed with statements regarding their perceptions about how public grazingland is managed by agencies like the US Forest Service, who administers grazing permits on the National Grasslands. Agreement index quantifies median effect size of response and 95% confidence intervals based on five-point Likert scales.

To understand perceived co-benefits and other potential motivations for introducing or increasing prescribed fire use, we asked respondents to identify environmental concerns of personal importance to them. In response, landowners reported that they value open rangelands, increasing plant diversity, controlling woody plants, and restoring prairie/grassland, but they do not seem to care about reducing wildfire risk (Figure 3A). Other studies have shown that ranchers value open rangeland, noting that open space and wildlife habitat were as important factors as food and fiber production in protecting agricultural land [68]. Landowners worry about prescribed fire on their land due to the possibility of limited forage production in years to follow because of drought [69]. With above-average rainfall, post-fire productivity in the Northern Great Plains can increase by 56% [70]. Increased post-fire productivity in the arid grasslands of the Northern Great Plains may not occur after every fire as it depends on post-fire precipitation, grazing history, and the dominant grass species [71]. Yet, livestock performed better on pastures with patch-burn grazing as compared to continuously grazed, unburned pastures during drought in the Northern Great Plains [72–74], demonstrating the benefits of the combination of grazing and prescribed fire in years of drought.

However, these results suggest respondents are not familiar with existing research reporting the value of prescribed fire for rangeland forage and cattle production. Elsewhere in the Great Plains, when portions of pastures have recently been burned, cattle can spend as much as 75% of their grazing time in the most-recently burned patches [75]. Recently burned areas also have fewer ticks and horn and face flies [76,77]. In North Dakota, recently

burned patches offer higher forage nutritional value and greater mineral content [78]; as a result, grazing systems that incorporate prescribed fire enhance cattle performance compared to unburned continuous or rotational systems [74].

A. "This environmental concern is important to me"



B. "This consideration affects my management decisionmaking"

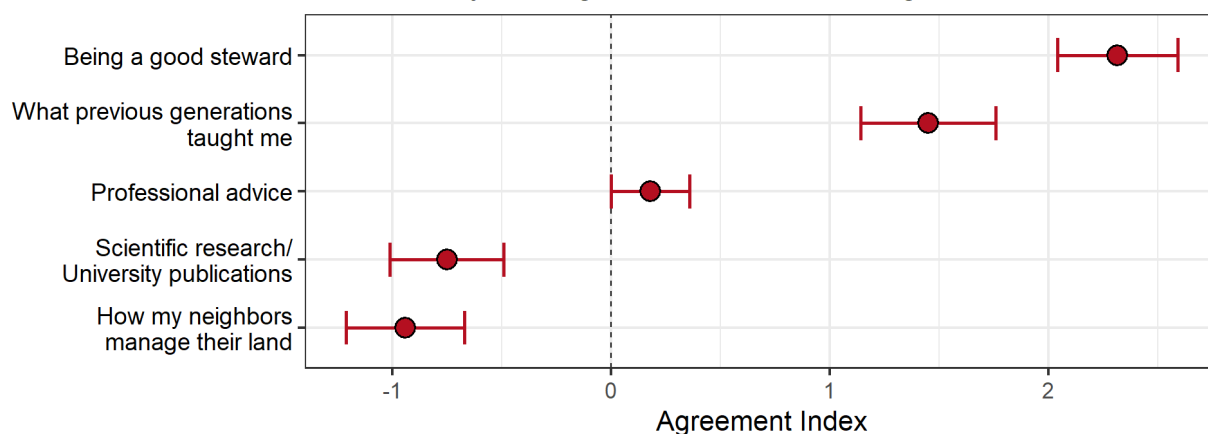


Figure 3. Degree to which survey participants agreed with statements regarding motivation for management decision-making. (A) Respondents' personal concern about potential environmental co-benefits to prescribed fire. (B) Respondents' regard for potential influences on management. Agreement index quantifies median effect size of response and 95% confidence intervals based on five-point Likert scales.

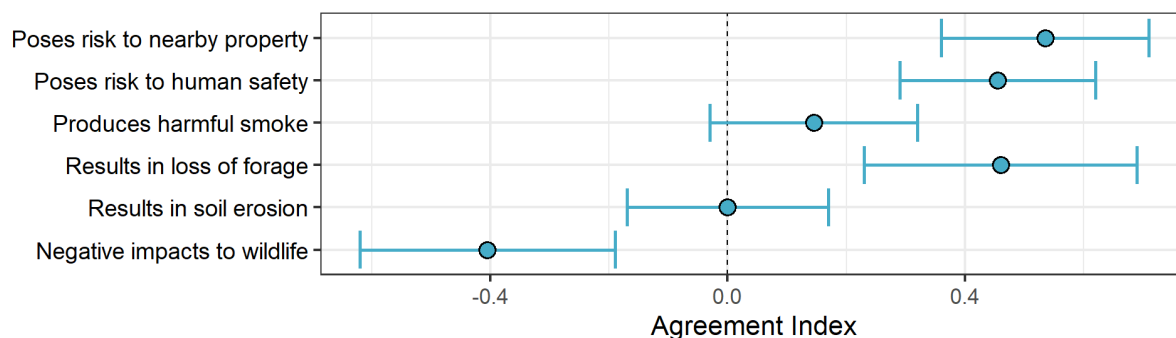
The strongest drivers of management decision-making were the desire to be responsible land stewards and the lessons passed down by generation, with these influences often intertwining (Figure 3B). Scientific research and the practices adopted by neighboring landowners provided the least motivation, showing that ranchers do not associate stewardship and historical management with science or their neighbor's actions. Valuing stewardship is noted in many studies throughout the Great Plains as a motivator, where respondents value "conserving natural resources" over economic gain [60]. Valuing stewardship includes a sense of responsibility for environmental concerns [79]. The concept of stewardship is often passed down from generation to generation [33], so the notion of being a good steward and following what previous generations have taught are coupled.

3.3. Attitudes About Prescribed Fire

Overall, respondents to our survey felt that fire is risky to people, property, and forage (Figure 4A). At the same time, respondents felt that fire was beneficial for wildlife and had neutral attitudes towards smoke. McCaffrey [62] also found a lower barrier imposed

by smoke limiting people's attitude towards fire, as they felt smoke would be inevitable, whether from wildfire or prescribed fires alike. Our findings are consistent with other studies in which respondents reported fire to be risky towards property, people, and forage, where landowners indicated that there were negative effects of fire when on a neighboring property. The concern of fire being harmful to neighbors creates a barrier, as landowners have a feeling of moral obligation to their neighbors [79]. In the eastern Great Plains (Iowa and Missouri), landowners indicated that fire did not directly benefit ranching operations as much as wildlife, and oftentimes destroyed food for their cattle [23].

A. "Members of my community generally believe the following about Rx fire"



B. "I personally believe the following"

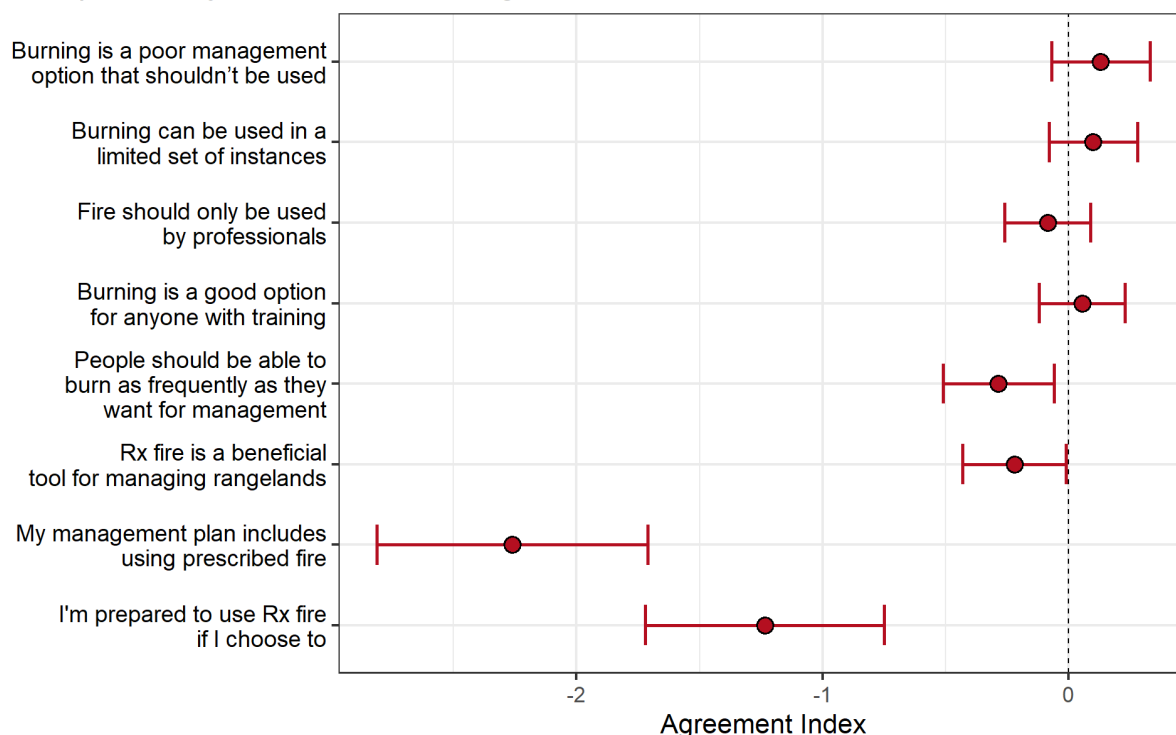


Figure 4. Degree to which survey participants agreed with statements regarding their beliefs about prescribed fire. (A) Respondents' perceptions about how members of their community regard prescribed fire. (B) Respondents' personal attitudes regarding when, and for whom, prescribed fire use is appropriate. Agreement index quantifies median effect size of response and 95% confidence intervals based on five-point Likert scales.

We found strong evidence that respondents are neither prepared nor willing to burn on their own land (Figure 4B). In a review of research from across the Great Plains, Clark et al. [12] found that most respondents did not see fire as a beneficial tool, which is

consistent with our findings that respondents tended to disagree that fire is beneficial in the northern Great Plains, specifically.

Respondents reported both a lack of willingness and preparedness or willingness to use prescribed fire, which is indicative of the precontemplation/contemplation stage of the transtheoretical model of behavior changes [28]. These early levels of behavior change are characterized by having little to no intention of changing, being either unaware of a problem, or being aware of a problem but having not yet committed to action, respectively. Our results suggest that respondents recognized little value of fire to rangeland resources, suggesting that respondents are in the precontemplation phase of behavioral change to prescribe fire practice. Behavioral change may occur when respondents observe that prescribed fire is beneficial to them and when that is conveyed by a trusted source [80–82], such as, in this case, Pheasants Forever and county Extension outlets.

3.4. Addressing Barriers

Although much attention is given to the barriers landowners face in accepting or adopting new practices, social science research often describes remedies that can help overcome such barriers. Clark et al. [12] matches *barrier builders* with *barrier busters* to help articulate how specific approaches can reduce perceived barriers to prescribed fire use. In this model, *barrier builders* are conditions or perceptions that limit or restrict prescribed fire use. *Barrier busters* are tools, information, or initiatives that provide resources, support, and opportunities to remove barriers and encourage or facilitate prescribed burning [12]. Barrier busters can generally achieve this by fostering positive social attitudes towards fire or directly supporting burning through access to expertise and equipment or lowering risk [12].

These results provide little evidence that the opportunities for public–private partnerships offered by the mosaic of federal grazingland and ranchers around National Grasslands have immediate potential to overcome negative perceptions of prescribed fire in the northern Great Plains. Firstly, ranchers near National Grasslands do not generally believe that additional prescribed fire should be used on public grazinglands (Figure 2), even though several known barriers—e.g., liability concerns and resource limitations—would not impede the ranchers themselves. Secondly, ranchers near National Grasslands in North and South Dakota showed no greater likelihood of conducting prescribed burns on their own land than elsewhere in the Great Plains (where public–private partnerships are less likely) as respondents strongly disagreed that they were either prepared to use prescribed fire or currently include prescribed burning in management plans for their home ranches (Figure 4). Although the mosaic of public and privately owned grazingland around National Grasslands seems ideal for existing frameworks to spin innovative management from public land onto private via early adopters who are keen to explore novel practices (e.g., Reserves-As-Catalyst [44]), these data suggest a negative perception of prescribed fire and a distrust of the USFS that precludes a willingness to advance beyond the precontemplation stage of behavioral change towards prescribed fire [28].

4. Conclusions

This survey of ranching landowners around Dakota Prairie Grasslands indicates little interest in increasing prescribed burning on either public grazinglands managed by the US Forest Service, or on their own private ranches. Nor do these data indicate a high likelihood of success in trying to use the Grasslands as demonstration sites for the benefits of prescribed fire to overcome barriers created by negative perceptions of fire unless trusted sources conduct or participate in prescribed fire demonstrations on private or public land. Although respondents were motivated by an interest in being good stewards and felt

managers of public grazinglands ought to prioritize sound science in making management decisions, respondents associated prescribed fire more with risk to property and forage resources than with its potential benefits. Overall, these results suggest that ranchers associated with the Dakota Prairie Grasslands remain in the early, precontemplation stage of behavioral change in which they do not see sufficient reason to consider the benefits of prescribed fire against perceived risks of prescribed fire—as such, we suggest that the primary barriers to prescribed fire use in these communities are negative perceptions, ahead of tangible barriers like resource limitations and policy. Changes in behavior to prescribed fire might only be supported upon the benefits of prescribed fire being recognized by the ranching community and presented by trusted sources (e.g., Pheasants Forever, county Extension). As our study focused on landowners near the National Grasslands in North and South Dakota, future research should assess the potential for public–private partnerships to increase prescribed fire management of rangelands in other parts of the northern Great Plains and with other federal partners.

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Appendix A

Photographs illustrating each of the USDA National Forest Service National Grasslands included in this study.



Figure A1. Grand River National Grassland: Adams County, North Dakota; Butte, Corson, Harding, Perkins, and Ziebach Counties, South Dakota. Credit: Jonathan Spiess, with permission.

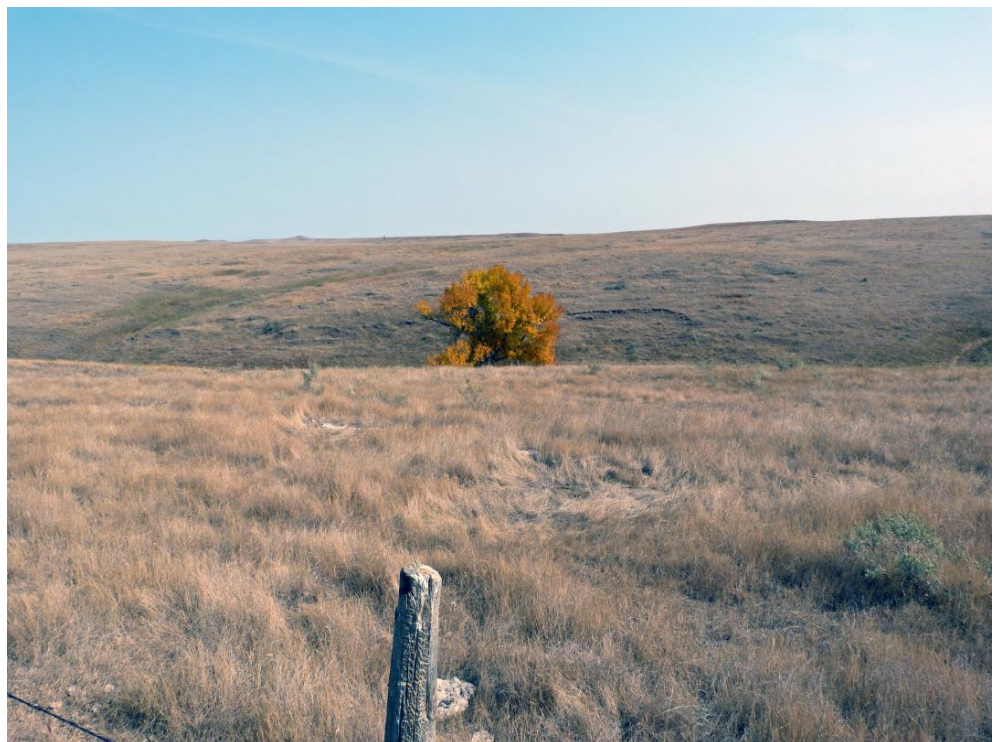


Figure A2. Cedar River National Grassland: Grant, Morton, and Sioux Counties, North Dakota. Credit: Dan Svingen, USDA, CC BY 2.0.



Figure A3. Sheyenne National Grassland: Cass, Ransom, Richland, and Sargent Counties, North Dakota. Credit: flickr user cjbakker, CC BY-NC-SA 2.0.

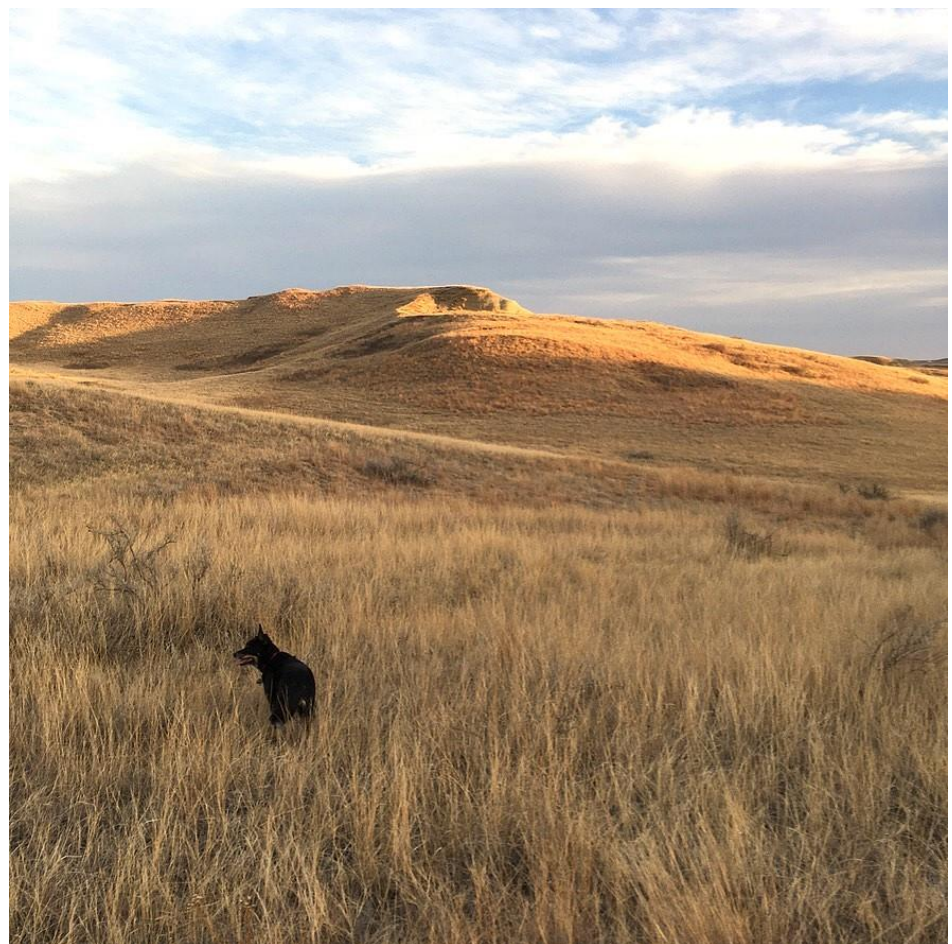


Figure A4. Little Missouri National Grassland: Billings, Golden Valley, McKenzie, Slope, and Hettinger Counties, North Dakota. Credit: CL Wonkka.

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