Western Economics Forum
A Journal of the Western Agricultural Economics Association

Public Perceptions and Tradeoffs in Using Prescribed Fire to Reduce Wildfire Risk

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Abstract
Forest and rangeland managers in Western North America have called for expanding the use of prescribed fire as an ecologically appropriate tool to reduce flammable fuels and risk of catastrophic wildfire. Achieving this goal has been difficult, in large part because of anticipated public opposition. Survey research on perceptions of prescribed fire among residents of wildfire-prone areas reveals that large majorities believe it is acceptable to use in carefully chosen settings. However, there is less support for burning everywhere. Managers believe burning would be beneficial, driven largely by levels of confidence, that government agency managers can use it safely and effectively. In the evaluation of whether to employ prescribed fire or mechanical removal for diminishing fuel hazards on public lands, decision-makers must carefully consider various tradeoffs. These include assessing the risks and costs to property owners stemming from both wildfire and prescribed fire, as well as the pertinent costs associated with fuel-reduction options. Furthermore, decision-makers must consider the potential smoke impacts, particularly on vulnerable individuals, and the associated costs and benefits for wildlife and ecosystems. Additionally, they should factor in the public's awareness of these tradeoffs. Traditional cost-benefit analyses may not be sufficient for such an evaluation. Instead, risk assessment frameworks used in natural disaster planning may prove valuable in conjunction with a public outreach strategy that includes general information on prescribed fire risks and benefits, regular communication about agency activities, and project-specific information aimed at helping people reduce negative impacts.

Introduction
Wildfire is a vital ecological process in western forests and rangelands, yet increasingly it poses a great societal challenge. In recent decades, fires have intensified in severity and the amount of area burned annually (Parks and Abatzoglou, 2020). These changes result from a combination of factors including climate change (Zhuang et al. 2021), non-native annual grass invasion (Bradley et al., 2018), and a buildup of flammable native vegetation due to longstanding forest and wildfire policies (Busenberg, 2004) including complete abandonment of Indigenous burning practices (Lake et al., 2017). Excluding fire from ecosystems that evolved with occasional wildfires has caused a reduction in ecosystem services and major changes in future fire behavior (Ryan, Knapp, and Varner, 2013). To improve ecosystem service provision and sustain these ecosystems, forest and rangeland managers seek to greatly increase the use of forest and rangeland fuels-reduction treatments. These treatments would reverse the buildup of flammable vegetation and allow wildfire to resume its ecological role

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(Stephens et al., 2012; Shinneman et al. 2023). Where feasible and ecologically appropriate, there is particular interest in increasing the use of *prescribed fire* – the controlled application of fire to vegetation under specified weather conditions – as the fuels-reduction tool most likely to achieve ecological benefits (Ryan, Knapp, and Varner, 2013).

This task would be challenging enough given the extent of the vegetation buildup across Western North America and the costs of implementation at regional scales. However, its difficulty is compounded by trends in human population growth. Nationally, between 1990 and 2010, the number of residents doubled in what is called the wildland-urban interface (WUI), where homes are built close to natural areas such as forests and rangelands (Radeloff et al., 2018). The fastest WUI growth occurred in places such as the U.S. Southwest and California where wildfire risk is greatest (Zhuang et al., 2021). Rates of migration to WUI zones may decline immediately after large and heavily publicized wildfires (Winkler and Rouleau, 2021), but an experience of wildfire influences few residents to move to safer locales (Sharygin, 2021). It is crucial to reduce fuel loads and protect lives and livelihoods in WUI areas in ways that are effective, safe, and accepted by residents who live closest to natural settings.

To reduce the risks to human populations and adverse ecological impacts, various fuels-reduction approaches can be applied. These can be classified into four general categories:

- *Mechanical treatments*, common in forests and woodlands, involve using machinery such as chainsaws, mowers, or masticators (basically a giant wood-chipper). Often the goal is not to remove flammable vegetation but rather to reduce it to smaller pieces that will burn faster and with shorter flames, thereby altering fire behavior to reduce the risk of the most catastrophic wildfires. Where commercially viable, whole trees may be harvested for use as wood products; at other times brush and woody debris may be pushed into piles to be burned when the risk of wildfire is thought to be low.
- *Biological treatments* for rangelands include planting fire-resistant vegetation to strategically slow wildfire spread; applying soil pathogens to reduce flammable non-native grasses; or using goats, sheep, or cattle to reduce vegetation height and biomass.
- *Chemical treatments*, also limited mainly to rangelands, can be used to kill undesirable plants and encourage the growth of native grasses that may be less likely to fuel wildfires.
- *Prescribed fire* can be useful in many grassland and forest settings where native species are adapted to wildfire as an ecological process, so long as fuel loads or vegetation structure does not pose a significant risk of catastrophic wildfire or an escape to non-target areas.

While prescribed fire may be the most appropriate tool ecologically in many regions, including the prairies of the Great Plains as well as many (but not all) Rocky Mountain and Pacific coast forest types, these benefits may be offset by social considerations in a region that includes many of the fastest-growing states and provinces, especially in the WUI. There can be public opposition to increasing use of fire as a management tool despite its natural role in ecosystems. This paper examines research results about public perceptions of wildfire, tradeoffs between its positive and negative aspects and proposes a framework for evaluating tradeoffs.

Public Perceptions of Prescribed Fire

Along with technical considerations such as weather conditions, unusually high fuel loads, or project area access, impediments to prescribed burning include staffing and budget limitations, real or perceived liability, and public opinion, with different factors weighing more heavily depending on whether treatments are planned for public or private lands (Brunson and Shindler, 2004; Kobziar et al. 2015). This article focuses on perceptions about the use of fuels treatments on public lands because those are the dominant forest and rangeland ownership in the Western United States. Additionally, local public opinion is likely to hold more sway for activities on public lands which are subject to the National Environmental Policy Act (NEPA).

Most studies of public perceptions about fuels reduction in the Western U.S. have asked respondents to rate the acceptability of various methods as a management tool. No national or west-wide survey exists, but instead researchers have focused on responses from fire-prone locations. A 2001 survey of residents in four western locales adjacent to national forests (Yavapai County, Arizona; Boulder and Larimer Counties, Colorado; Deschutes and Jefferson Counties, Oregon; Salt Lake and Tooele Counties, Utah) found that when asked to rate their support for treatments as a legitimate tool that managers can use wherever they deem appropriate, support tended to be higher for mechanical treatments (43%-61% depending on the community) than for prescribed fire (37%-56%) (Brunson and Shindler, 2004). However, when asked whether each practice might *ever* be appropriate, there was no statistically significant difference between practices, with conditional approval rates varying from 79% to 91%. Six years later, Toman et al. (2014) re-surveyed individuals who had responded to the first survey and found higher levels of support for prescribed fire in two study areas (Arizona, and Oregon), but less support in Colorado and no change in Utah. A similar survey in 2006 conducted in three urban and three rural areas in Idaho, Nevada, Oregon, and Utah found similar rates of acceptance for prescribed fire as a tool for use in BLM[2]-managed rangeland settings, with 84% of urban respondents and 81% of rural respondents finding it acceptable in some circumstances (Shindler et al. 2011).

The above studies included respondents living outside the wildland-urban interface that might be less vulnerable to wildfire except under extreme circumstances. Toman et al. (2011) conducted a more geographically focused survey in five forested WUI neighborhoods: three in Central Oregon and two in Southwestern Utah. Overall, mechanical thinning received the highest levels of support (67%-91% of respondents), but there was also > 60% support for prescribed fire in four of the five neighborhoods. That survey also distinguished between prescribed fire around neighborhoods versus in remote forest areas. The proportion of respondents saying prescribed fire would be acceptable around neighborhoods was slightly less than in remote forest locations (62% versus 66% overall), but the proportion who believed prescribed fire was definitely *not* acceptable near neighborhoods was twice as large (27% versus 14%).

In 2010, Gordon et al. (2014) re-surveyed respondents to the 2006 study of fuels treatments in rangelands, finding that support for prescribed fire and three different mechanical treatments held steady across years, but many respondents gave different answers to the same question than they had four years earlier. For prescribed fire, 64% of respondents gave the same acceptability rating in both years, but 21% changed their response from "acceptable" to "not acceptable" and 22% changed their response from "not acceptable" to "acceptable." A change in acceptance could result from added experience with fuels treatments, increased knowledge about the tradeoffs associated with treatment choices, or factors not directly related to the practice itself. Gordon et al. (2014) found that the best predictor of a response change from 2006 to 2010 was not a change in perceived risk or knowledge about rangeland conditions, but in respondents' trust that land management agencies can implement

[2] BLM stands for Bureau of Land Management.

the treatment safely and effectively. Toman et al. (2014) reported a similar finding in a longitudinal analysis of acceptability judgments in seven locations of the interior West and upper Midwest. Judgments about fuels reduction were relatively stable over time, and acceptance was strongly influenced by respondents' confidence in natural resource managers and in their beliefs that treatments would lead to positive outcomes for people and the forest.

Lack of trust or confidence can arise from unfamiliarity with a practice, negative experience with an agency, miscommunication among agency and residents, or a more general perception that government does not share citizen's goals or values. Gordon et al. (2014) concluded that the latter explanation was most likely in their study. What happens if a fuels treatment goes wrong? In September 2003, a prescribed burn on the Uinta National Forest east of Provo, Utah, escaped from Forest Service control, burning over 7,800 acres and sending smoke into the Salt Lake City metropolitan area for a week. Brunson and Evans (2005) re-surveyed respondents to the 2001 Salt Lake and Tooele County survey mentioned above. Brunson and Evans also surveyed a new sample in the metropolitan area and exurban Wasatch County, where the fire burned. Among respondents who were re-surveyed, significantly fewer respondents said prescribed fire should be used wherever managers see fit. However, the proportion of respondents who believe prescribed fire could *sometimes* be useful did not change. When asked if the fire had influenced their feelings about prescribed fire, 75% of Wasatch County residents and 66% of metropolitan residents responded affirmatively. Of those, nearly half said they felt more negative about prescribed fire, while about one-fourth said they wished to learn more about it. However, 85% of Wasatch respondents and 62% of metropolitan respondents said they felt more skeptical about agencies' ability to use prescribed fire as a management tool.

Tradeoffs in Prescribed Fire Use

The benefits to society from wildland fuel reduction may seem obvious given the enormous economic and social costs of wildfire. Wildfires, and the smoke they produce, threaten lives, property, and livelihoods. Fatalities have been caused by the fires themselves (Haynes et al., 2020) and by landslides resulting from heavy rain on slopes laid bare of vegetation by wildfire (Tiwari et al., 2020). The smoke generated by wildfires also can be fatal, mainly by increasing mortality among persons already compromised by chronic or acute conditions (Schwarz et al., 2022). Kochi et al. (2020) estimated 133 excess deaths due to heart or respiratory illness during a single Southern California wildfire event, with a social cost of about $1 billion. Smoke also can cost millions to rural economies through reduction in nature-based tourism revenues (Kim and Jakus, 2019), contamination of drinking water supplies (Proctor et al., 2020), or damage to agricultural crops such as wine grapes (Summerson et al. 2021).

Socially vulnerable populations, including Native American, Hispanic, and Black communities, may be especially burdened by wildfire impacts because these populations often are less able to modify their risk or to recover after wildfire (Palaiologou et al., 2019). Using Census Bureau data and U.S. Forest Service fire hazard models, Davies et al. (2018) estimated that nearly 30 million Americans live in areas with significant potential for extreme wildfires, including 12 million classified as socially vulnerable. Analysis of fire transmission patterns in three western states (California, New Mexico, Washington) found that communities occupied mainly by vulnerable groups tend to be disproportionately exposed per area burned because they are more densely populated (Palaiologou et al., 2019).

Additional costs that might be mitigated through fuels treatments (Holland et al. 2022) are those attributable to property loss or the cost of fighting wildfires. The Federal National Interagency Coordinating Center estimated that fighting the ten worst California fires in 2021 cost about $2.25 billion (NICC 2022). That year in California alone, wildfires burned 3,363 structures; a single wildfire in Colorado in December 2021 burned more than 1,000 homes in just a few hours (NICC 2022). Other costs can include loss of public infrastructure, increased need for medical care, crop losses, and drinking water contamination.

A more difficult issue is to determine whether and when prescribed fire is the best tool to reduce wildland fuel loads. One criticism of prescribed fire is that it reduces plant materials to ashes which might otherwise be used for forest products, harvestable biomass, or carbon credits. However, the cost of implementing mechanical fuels treatments usually exceeds revenue generated by those outputs (Hunter and Taylor, 2022).

Cost comparisons for fuels treatments are not as straightforward as it might seem. Available cost data often are not always calculated the same way across management units, and planning costs can vary greatly depending on management experience, risks involved, local labor costs, and social-political contexts (Calkin and Gebert, 2006; Loomis et al., 2019a). One must consider not only the economic costs of the treatment itself, but the economic benefits that society gains from implementing treatments. These include reduced firefighting costs if a treated area is the site of a subsequent wildfire, property damage due to wildfire, and ecosystem service improvements. Again, cost-benefit analyses that incorporate these factors do not present a clear conclusion. One analysis found that mechanical treatment was linked to lower fire suppression costs in California's national forests while prescribed fire was not. However, no difference was found for national forests in the Rocky Mountains, Great Basin, or Southwest (Loomis et al. 2019b). Conversely, property damage was reduced in areas where prescribed burning was used, but not where mechanical treatments were applied.

Smoke impacts are also a consideration when using prescribed fire near homes and businesses. WUI residents are most likely to experience negative impacts of smoke from either wildfires or prescribed fire. Although, when multiple fires are burning around a state or region, the impacts can be felt far from the fires themselves. A comparative study in the Northern Rocky Mountains and South-Central U.S. found that residents of Texas and Louisiana, where there is a longer history of prescribed fire as a management tool, were slightly more tolerant of prescribed fire smoke (Blades et al., 2014). Navarro et al. (2018) compared levels of small particulate matter ($PM_{2.5}$), a known health hazard, produced by wildfires versus prescribed fires. $PM_{2.5}$ levels from prescribed fire smoke were considerably lower than those for wildfire smoke. A survey of 106 medically-vulnerable persons in a rural, high fire risk county in California found that 58% had suffered health impacts from wildfire smoke while 26% reported health impacts from prescribed fire smoke (Hoshiko et al. 2023). However, Williamson et al. (2016) caution that tradeoffs between smoke sources likely depend on weather and fuel loads at the fire site as well as the number of people exposed, duration of exposure, and vulnerability of the people exposed.

One characteristic of prescribed fire that may mitigate impacts is that land management agencies can provide advance warning of a prescribed burn, allowing medically vulnerable or sensitive individuals a chance to temporarily relocate. Respondents to the Blades et al. (2014) survey believed advance warning about potential smoke impacts was important, and they preferred a personal form of communication to a public service announcement.

A final tradeoff consideration in the minds of the public is the impact of fire, whether prescribed or naturally ignited, on the ecosystems that people value. There is less research on this topic, but a 1999 survey in Florida (Jacobson, Monroe, and Marynowski, 2000) found that most respondents knew fire is a naturally occurring process that is beneficial to Florida's native forests. However, they were more likely to believe that prescribed fire can prevent larger wildfires and improve land for human uses, such as forestry and grazing, than to believe that it can improve wildlife habitat. Conversely, they ranked harm to wildlife as the greatest risk of using prescribed fire. Their study also analyzed the content of news media coverage of fire issues, finding that those information sources also focused primarily on benefits to humans and their property rather than to natural ecosystems.

Weighing Tradeoffs and Influencing Public Perceptions

A strong ecological basis exists for increasing use of prescribed fire in many forest and rangeland ecosystems. Yet doing so on U.S. public lands requires careful consideration of tradeoffs including potential public opposition. Research shows clear support for prescribed burning in some situations, but much of that support is conditional. A sizeable minority is likely to oppose its use near homes and structures, and opposition will be greater if local communities are already skeptical about the agency applying the treatment. Managers considering a prescribed fire treatment must weigh the costs of project failure against the ecological and hazard-reduction benefits of project success. Failures include a burn that does not achieve its ecological or management objectives, one that escapes control and causes undesired impacts, or one that must be halted in the project-planning stage due to public opposition. However, a traditional benefit-cost analysis may not be the best approach, due to the difficulty of estimating some costs and benefits, uncertainty about the likelihood of future fire events, and the reality that each situation brings together a unique set of physical and social factors that can affect success or failure. Instead, a risk assessment framework may be more useful.

Natural hazards professionals have identified risk assessment approaches that may be especially useful for this problem. Prescribed fire may not technically be a "natural" hazard, but it is designed to simulate one. Risk calculations consider the likelihood of a potential future adverse event and the costs of such an event, acknowledging there is uncertainty associated with any such calculation (Eiser et al. 2012). Evaluations take rational choice into account but also consider other decision factors (e.g., the tendency to value something lost more highly than an equivalent thing that is gained) as well as social contexts and trust (Eiser et al. 2012). There are many such frameworks, but a useful one for this purpose is the INFORM Model developed by the European Commission (Marin-Ferrer, Vernaccini, and Pljansek, 2017). Risks associated with natural hazards such as wildfire, hurricanes, floods, etc., are evaluated considering hazard and exposure (the physical possibility that a hazard will affect people or infrastructure), vulnerability (the possibility that an exposed population will experience damaging effects), and coping capacity (effort by responsible government entities plus existing institutions and infrastructure to reduce risk). Figure 1 presents a conceptual model of factors to be considered in such an evaluation using the INFORM approach.

The best way for land and fire managers to influence the risk calculation, and thereby increase their ability to implement a prescribed fire treatment while reducing risk to the public, is through communications with local affected communities (infrastructure item #1 under coping capacity in Fig. 1). Such communication can follow three tracks: messaging about prescribed fire itself, ongoing communication about agency activities and processes, and event-specific outreach (Toman and

Shindler, 2006). In the first track, public education messages about fuels treatment should emphasize the full spectrum of prescribed-fire benefits, including how it can protect or enhance ecosystem services as well as human lives, livelihoods, and structures. At the same time, messages should emphasize how human and natural systems are buffered against negative outcomes, whether through agency actions or the natural resilience of wildlife and ecosystems (e.g., how wildlife in fire-adapted ecosystems survive a fire). For the second track, agencies must be transparent about fuels-reduction plans and options, sharing information regularly and not solely through legally-mandated steps in a NEPA process. Building trust takes time and must be a primary goal of a public outreach strategy. Agencies should use multiple outlets and media types to reach the widest possible affected audience. The third track is closely related to the second: ensuring that potentially affected persons know when and where a treatment will be applied, what the impacts might be, and how people can mitigate those impacts. Extra care should be exercised to inform vulnerable populations that might be most negatively affected and least able to take steps to reduce negative outcomes. The best practice is to attempt individualized outreach, e.g., through door-to-door distribution of information. Taking such steps cannot eliminate the chance of negative outcomes for the public, the agency, or the site to be treated, but they can help sustain an agency's ability to keep prescribed fire in its fuels-reduction toolkit.

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Fig. 1. Risk assessment framework for planning and implementing prescribed fire in forests and rangelands. Considerations shown will apply to all situations, and those listed may not be comprehensive. Adapted from (Marin-Ferrer, Vernaccini, and Pljansek, 2017).