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Integrating Rangeland Fire Planning and Management: The Scales, Actors, and Processes ☆

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ABSTRACT

Research continually adds to our understanding of the ecological factors and biophysical processes driving frequent, large-scale fires on Great Basin rangelands in the western United States. Yet, even with advances in forecasting rangeland fire probabilities and likely ecological outcomes of fire, it remains difficult for individuals, communities, or organizations to coordinate their actions across jurisdictions and at an ecologically relevant scale to address collective wildfire risk. In this forum, we discuss current institutional arrangements that perpetuate scale mismatches in this system (i.e., institutional objectives, authorities, and capacities that limit coordinated actions to mitigate collective wildfire risk). We make a case for fireshed-scale coordination via rangeland Fireshed Councils, a proposed rangeland and fire planning and management unit that has both biophysical and social relevance to individuals and organizations engaged in fire risk mitigation. A rangeland Fireshed Council offers a venue for diverse group members to mix and match their respective rules and tools to navigate institutional barriers and capacity challenges in new ways. Operating in a collective arrangement at this scale aims to ensure that an individual's or entity's activities transcend traditional modes of planning (i.e., parcel-scale), complement concurrent management activities, and translate to fire-resilient landscapes and human communities. Rangeland Fireshed Councils will require resources and support from high governance levels for sustainability and legitimacy, as well as relative autonomy to determine how best to support local needs.

Introduction

Large-scale wildfires in the northern Great Basin of the western United States (i.e., > 400 ha; Smith et al. this issue) are increasing in frequency, underlining the need for new, strategic approaches to rangeland and fire planning and management. Research continually adds to our understandings of the ecological factors and biophysical processes driving these trends (e.g., Holmgren et al. 2006; Abatzoglou and Kolden 2013; Balch et al. 2013; Coates et al. 2016; Pilliod et al. 2017; Bradley et al. 2018), as well as social conditions and policy configurations that may enable effective responses (e.g., Stasiewicz and Paveglio 2017; Abrams et al. 2018; Wollstein et al. 2021). Yet even with advances in forecasting rangeland fire probabilities and likely ecological consequences of fire (e.g., Chambers et al. 2014; Smith et al. this issue), it remains difficult for managers to identify, prioritize, and then engage in coordinated activities that will mitigate fire risk at a meaningful scale and, importantly, promote fire resilience (Collins et al. 2010; Busby et al. 2012; Ager et al. 2015; Smith et al. 2016; McWethy et al. 2019; Charnley et al. 2020; Wollstein et al. 2022a).

Recent advances in fuels-based wildfire probability modeling using remotely sensed data show promise for informing wildfire risk mitigation and wildfire preparedness within the Great Basin (e.g., Bradley et al. 2018; Jones et al. 2021; Smith et al. this issue). Data and tools that can inform the probable ecological outcomes of rangeland fire also exist or are in development (e.g., Miller et al. 2013; Chambers et al. 2014; Miller et al. 2015; Barker et al. 2019; Creutzburg et al. 2022). Fuels treatment efficacy via grazing and other tools to influence wildfire probability and fire behavior have also been extensively investigated (e.g., Diamond et al. 2009; Pyke et al. 2014; Davies et al. 2015; Davies et al. 2017; Ellsworth et al. 2022; Clark et al. this issue; Thomas and Davies this issue). Taken

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together, there is abundant science-based information available to support managers' decisions to reduce wildfire risk and improve ecological outcomes of fire. Using this science to then implement appropriate activities on the ground in a relevant timeframe and at meaningful scales is an entirely different challenge (Li et al. 2020; Wardropper et al. 2021).

In this forum we examine these difficulties in planning and implementing management activities in response to emergent information regarding wildfire risk conditions. We contend that rangeland and fire planning and management currently operate at spatial, temporal, and jurisdictional scales that limit effective engagement in collective actions to address the occurrence of frequent, large-scale wildfires (Cash et al. 2006; Cumming et al. 2006). We posit that challenges stem from governance institutions that cannot accommodate uncertainty inherent in rangeland systems, differences in objectives between rangeland and fire management institutions despite the interrelated nature of the issues, and planning and implementation processes that do not necessarily occur at an appropriate and with relevant actors (i.e., individuals, communities, or organizations). Drawing on principles of Community-Based Natural Resource Management and social-ecological fire resilience, we propose social and biophysical variables to advance an applied concept for integrating rangeland and fire planning and management at a scale that is relevant for managing large-scale wildfires on Great Basin rangelands. We conclude by offering a Fireshed Council model for rangelands that may transcend traditional modes of planning and management and allow different actors to coordinate their actions in an effective collective arrangement.

Challenges with mobilizing preemptive fine fuel management

There is great potential for using recently developed wildfire probability forecasting information to support strategic management decisions aimed at preemptively reducing wildfire risk. Annual herbaceous biomass production models can inform where to strategically deploy targeted livestock grazing to reduce fine fuels (see Maestas et al. this issue). However, wildfire risk in the Great Basin is highly dynamic across space and time (Smith et al. this issue); it is challenging in this setting for multiple individuals or organizations (e.g., rangeland and fire managers, livestock grazing permittees) to mobilize a timely response to emergent information (Wollstein et al. 2021).

Addressing frequent, large-scale wildfires is also a collective action problem in which the actions (or inaction) of multiple actors contribute to the occurrence and outcomes of wildfire in mixed-ownership landscapes that often include a diversity of values, management objectives, and interests (Smith et al. 2016; Paveglio et al. 2019; Charnley et al. 2020). Landowners within a fire-prone area are interdependent because the likelihood of an individual management parcel burning in a wildfire is both a function of the site condition, as well as conditions of neighboring parcels under different ownership or management (Busby et al. 2012; Ager et al. 2019; Hamilton et al. 2019; Charnley et al. 2020). That is, if one land manager neglects to mitigate fire risk on their own jurisdiction, multiple individuals at a larger spatial scale have a greater potential to experience adverse effects of fire. For example, untreated invasive annual grasses increase the likelihood that an ignition will propagate a fire and that subsequent fires will be more frequent (Balch et al. 2013). This can further annual grass dominance and expansion onto neighboring parcels—elevating collective risk (Epanchin-Niell et al. 2009). In this, herbaceous fine fuel management at smaller spatial scales is linked to wildfire risk and ecological resilience at larger spatial and temporal scales.

Later, we describe scale mismatches created by current governance arrangements for rangeland and fire management; gaps and overlaps in institutional authorities, capacities, and objectives ("rules and tools"); and limitations of the scales at which actors and institutions operate. Scale mismatches manifest when governance institutions (i.e., rules and norms) or management actions do not "map coherently on the biogeophysical scale of the resource, either in space or time" (Cash et al. 2006, p. 8). Scale mismatches are especially persistent where there are multiple jurisdictions with different rules, culture, and norms, across which actions must be coordinated to mitigate collective wildfire risk.

In examining scale mismatches and limitations in mixing and matching actors' rules and tools, we articulate a need for integrated work at an appropriate scale for coordinating and sustaining collective actions to create or maintain fire resilience. By fire resilience, we mean human communities that adapt to new fire realities and reduce their future vulnerability (Schoennagel et al. 2017). Ecological resilience is embedded in this concept; fire resilience in the sagebrush ecosystem is fostered through management decisions that enhance plant communities' resistance to annual grass invasion and resilience to disturbances such as fire (e.g., Johnson et al. 2022).

Scale mismatch: ecological uncertainty over space and time

Rangelands are characterized by varying wildfire risk probabilities over space and time. The northern Great Basin, in particular, presents highly dynamic interannual fire risk conditions primarily driven by weather patterns and herbaceous fine fuel accumulation (Pilliod et al. 2017; Smith et al. this issue). The ecological outcomes of wildfire also vary over space and time with prefire biotic conditions and along environmental gradients that influence resistance to annual grass invasion and resilience to fire (Chambers et al. 2014). Maestas et al. (this issue) call for using fuels-based rangeland fire probability forecasts to target "… the right fuels management strategies in the right places" (p. 3). But the inherent variability in fire risk and recovery potential in this system complicates planning and implementing such an approach because the same practices to achieve desired outcomes cannot be applied in the same way in every location and in every year (Boyd and Svejcar 2009).

Furthermore, a spatial scale in the context of rangeland management may be a single pasture, a grazing allotment composed of multiple pastures, a ranch operation using a combination of private land and allotments for livestock forage needs, or a landscape supporting multiple ranching operations. It is notable that as spatial scale increases, so does the complexity of social-ecological interactions (Cash and Moser 2000; Cumming et al. 2006; Termeer et al. 2010), and spatial scales intersect with temporal ones including livestock rotations, growing seasons, or periods of elevated fire risk. Processes occurring at large spatial scales are also likely to overlap with jurisdictional scales and their associated institutions, such as timing of grazing on state and federal allotments stipulated by the terms and conditions of a livestock grazing permit (Robinson et al. 2017; Fig. 1).

Grazing allotments and pastures are used at different times—within and among years—and each potentially contain different levels of wildfire risk at different places and different times depending on management history and other biophysical conditions (Fuhlendorf et al. 2017; Mitchell et al. 2017; Barker et al. 2019). There is a scale mismatch when the ecological system requires adaptive, nimble responses to new information about wildfire risk, while administrative processes or a livestock operation cannot easily be adjusted to accommodate emergent needs (Allen et al. 2017). For instance, if the application of grazing to address fine fuel accumulation exceeds the number of animal unit months (AUMs; the amount of forage needed to sustain one cow, five sheep, or five

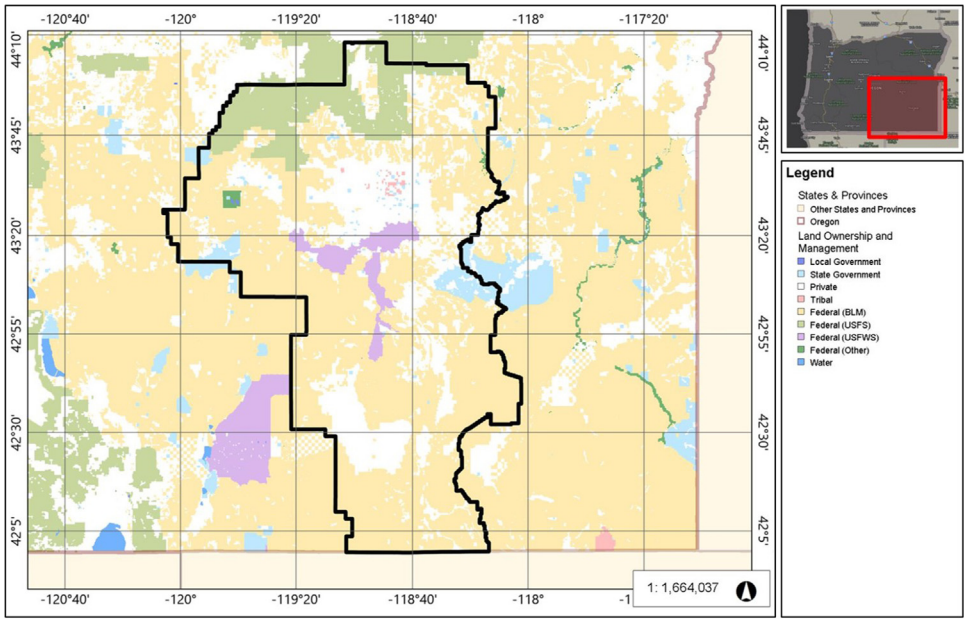

Figure 1. The Burns Interagency Fire Zone, a single administrative unit, covers nearly 1.7 million ha and includes intermixed private, state, and tribal lands, as well as the US Forest Service Emigrant Creek Ranger District, Burns District Bureau of Land Management, and the US Fish and Wildlife Service Malheur National Wildlife Refuge. In each jurisdiction, there are different actors with different roles, responsibilities, rules, culture, and norms. Given this, it can be difficult for actors to coordinate management among parcels and other ownerships to synergistically influence fire behavior and outcomes at larger spatial scales.

goats for 1 mo) authorized on a federal livestock grazing permit, then seasonal livestock grazing to respond to elevated fire risk is essentially an unusable tool until the permit's terms and conditions are revised to reflect the new need (Wollstein et al. 2021). Similarly, the Bureau of Land Management's (BLM) grazing regulations provide for "biological thinning" for the purpose of fuels reduction and mitigating the risk of wildfire (43 CFR 4190.1[a][1]). But use of this administrative tool requires infrastructure and a livestock operation able to efficiently deploy grazing animals and at different places in different years (Davies et al. 2022).

Scale mismatch: different "rules and tools"

A single administrative unit within the Great Basin often contains several jurisdictions. For example, the Burns Interagency Fire Zone (BIFZ) covers nearly 1.7 million ha in southeastern Oregon. Within the BIFZ boundary, there is intermixed private, state, and tribal lands, as well as the US Forest Service Emigrant Creek Ranger District, Burns BLM District, and US Fish and Wildlife Service Malheur National Wildlife Refuge (see Fig. 1). In each jurisdiction, there are different actors with different roles, responsibilities, rules, power, culture, and norms (Robinson et al. 2017; Cyphers and Schultz 2019; Aslan et al. 2021; Davis et al. 2021; Paveglio 2021; Wollstein et al. 2021; Miller et al. 2022), which complicate the execution of collective actions across boundaries (e.g., Epanchin-Niell et al. 2010; York and Schoon 2011; Paveglio et al. 2019; Charnley et al. 2020). Davis et al. (2021) term this "parallel play," in which individuals, communities, or organizations would ideally coordinate their actions to mitigate collective wildfire risk yet are constrained by power imbalance and rules pertaining to how they can combine and apply their respective resources, authorities, and processes.

Resources, authorities, and processes are partly reflections of actors' different management objectives or roles, which may vary within a jurisdiction or even within an organization (Davis et al. 2021). The BLM's Rangeland Management Program (the "Range Program," hereafter) is tasked with managing public rangelands for multiple uses and values, while the BLM Fire Program is focused on wildland fire and fuels management operations to protect the public, natural landscapes, and other values (BLM 2021). As a result, the programs have different budgets, planning processes, disciplinary staffing, timelines, and tasks they undertake to support their respective objectives—making it difficult to coordinate management even within the same project area (Smith et al. 2016; Cyphers and Schultz 2019).

Differing institutional rules and tools can also create mismatches in the spatial and temporal scales at which tasks are undertaken by each entity. For example, the Range Program largely completes planning and management at the allotment scale. While this may be best for fulfilling the Range Program's objective to provide for livestock grazing while ensuring rangelands are sustainably used, this approach may neglect to account for how the effects of allotment-scale activities aggregate at other spatial, temporal, and jurisdictional scales. In this, the Range Program's prevailing scale for rangeland administration may limit the BLM's ability to coordinate management among parcels and other ownerships to synergistically influence fire behavior and outcomes at larger spatial scales (Wollstein et al. 2022a; see Fig. 1).

Furthermore, different aspects of an agency's or program's objectives receive different resources or are subject to different authorities and processes. BLM's fire response, in particular, occurs within a highly formalized system coordinated at the national level (i.e., the National Interagency Fire Center) to provide for firefighter safety, allocate resources, and protect human lives and values (Steelman 2016). In contrast, fuels treatments or postfire rehabilitation is typically planned and implemented by local BLM staff, agency partners, and nongovernmental actors. Thus, even within an agency, those responsible for fire response do not necessarily plan or coordinate with managers associated with fire risk mitigation (Fischer et al. 2016). Steelman (2016) refers to this as the "siloization of suppression activities," in which fire response is funded, planned, and executed separately from fire risk mitigation. As a consequence, those responsible for fire response and mitigation may each lack complete information about the larger spatial and temporal context or effects of their respective activities (Aslan et al. 2021; Davis et al. 2021).

Private landowners also have their own set of management objectives, constraints, and expectations (e.g., Abrams et al. 2017; Wollstein and Davis 2017). Rangeland Fire Protection Associations (RFPAs) offer an expanded role for private landowners in rangeland fire response. RFPA members are authorized to provide initial attack on wildfires on BLM and state lands in remote areas of southeastern Oregon and southwestern Idaho (Abrams et al. 2017; Davis et al. 2020). RFPA members are primarily ranchers, who are uniquely invested in wildfire suppression, across private landholdings and public lands to protect leased forage (Abrams et al. 2017; Stasiewicz and Paveglio 2017) and promote the long-term viability of their operations (Wollstein and Davis 2017). Although fire response activities can yield beneficial ecological effects (e.g., protection of low-resilience rangelands from conversion to invasive annual grassland; Creutzburg et al. 2022), strategic prefire and postfire management can have comparatively outsized effects on rangeland fire outcomes (e.g., prefire grazing treatments can reduce burn severity and, thereby, decrease the risk of postfire annual grass invasion; Davies et al. 2010).

Yet RFPA members have limited authority and willingness to engage in wildfire risk mitigation activities off the fireline and beyond the boundaries of enrolled private lands (Abrams et al. 2018). If ranchers are concerned about an accumulation of fine fuels on their BLM grazing allotments, they lack authority to apply treatments because their use of the allotment is overseen by the BLM Range Program, which has limited flexibility to authorize fuels treatments through a grazing permit (see Wollstein et al. 2021). On private lands, RFPA members may enact wildfire risk reduction such as treating annual grasses with targeted grazing or herbicides and cutting western juniper *(Juniperus occidentalis)*. But this work may strain their financial capacity and if adjacent ownerships do not also engage in wildfire risk reduction, the effectiveness will be limited.

In summary, different actors are subject to different rules and have available to them different tools to achieve their respective objectives. This is best encapsulated by how grazing to manage fine fuels may be implemented by different actors: private landowners may apply grazing wherever they judge is appropriate on their private landholdings but do not have authority to do so on any allotments associated with their ranch outside of the terms and conditions of their permit (e.g., they cannot apply grazing outside of dates specified on the permit). BLM's Range Program administers grazing on BLM lands through a system of grazing permit authorizations to ensure that rangeland resources are managed for multiple uses and values. The stipulations of grazing authorizations may or may not align with ecologically relevant timeframes and conditions indicative of elevated fire risk. Although livestock grazing is a tool available to BLM's Fire Program to manage fine fuels and meet program objectives, authorizing its application may require case-by-case or programmatic approval under the National Environmental Policy Act (NEPA).

Scale mismatch: institutions and norms

Lastly, different actors involved in rangeland and fire management may each have their own norms, culture, and unwritten rules that guide their actions (Schlager and Cox 2018). Although the BLM Range Program administers grazing, a widespread tool for managing herbaceous fine fuels, if norms are such that the Fire and Range Programs do not communicate or readily work together through one another's respective planning processes, it is possible that those responsible for rangeland management will not coordinate their activities with those responsible for fire and fuels management, and vice versa. Even if the Fire Program has secured authorization to use livestock as a biological control to address fine fuels and reduce the impact of wildfire, if BLM fuels managers are not accustomed to working with grazing permittees, it is unlikely that they will seek them out to aid in implementing fuels management treatments (Varela et al. 2014; Wollstein et al. 2021).

Furthermore, Wollstein et al. (2021) found that some BLM field offices in Idaho perceived NEPA requirements to be a barrier to adaptively addressing wildfire risk due to the potential for attracting attention from a litigious public opposed to grazing. As a result, Fire Program personnel may instead focus on implementing brush management or herbicide treatments to control invasive annual grasses, given that there are perceptions of fewer implementation barriers associated with such practices. Due to the extensive nature of rangelands, these other practices are costly, difficult to deploy at large spatial scales, and may not achieve desired outcomes (Taylor et al. 2013; Strand et al. 2014; Ellsworth et al. 2022).

In short, it is difficult for actors associated with rangeland and fire management to coordinate or combine their rules and tools. First, different individuals and organizations have different objectives guiding both the types of activities they undertake and the scales at which they plan and operate. Second, they each have different authorities and abilities to act that may or may not overlap on a landscape. Lastly, culture and norms may facilitate or prevent actors from working together. This culminates in difficulties getting effective combinations of actors, resources, and authorities to engage in collective actions at relevant scales to promote fire resilience.

Navigating scale mismatches: what are the scales, actors, and processes?

Addressing dynamic, persistent problems requires sustained collective actions at meaningful scales and the ability to adaptively implement those actions in response to new information. Because wildfire risk mitigation (or not mitigating) influences the occurrence of fire and future ecological conditions at much larger spatial and temporal scales than individual management actions, rangeland and fire planning and management must occur at scales beyond those of individual parcels. To enable coordination of the different authorities, capacities, and actors' roles surrounding this issue (i.e., overcome "parallel play"), rangeland and fire planning and management must be integrated and aligned to promote fire resilience.

Integration of planning and management will require developing adaptive institutions and coordinating activities among multiple jurisdictions and actors at a relevant scale (Steelman 2016; McWethy et al. 2019; Davis et al. 2021). To this end, we offer considerations for defining the scales at which this work should occur using social and biophysical boundaries. We extend a firesheds concept to one adapted for rangelands settings, where communities and fire management units are spatially extensive and fire occurrence and outcomes are intertwined with local economies, jurisdictional scale, and site-specific resilience and resistance. Lastly, we propose a new framework for coordination, Fireshed Councils, and describe how they may function and build on existing rangeland and fire management institutions in Oregon.

Defining a "right" scale

Although there is no perfect scale for matching governance institutions to an ecological system (Cash et al. 2006; Folke et al. 2007), the geographic extent of an integrated unit must make sense from both a rangeland and fire management perspective. Due to persistent scale mismatches, current institutions must be adjusted so that planning and management are responsive to emergent information and the multiple authorities' and actors' capacities and resources are coordinated at a scale that is relevant

for creating fire resilience (Cyphers and Schultz 2019; McWethy et al. 2019).

Regarding the matter of geographic extent, a "firesheds" concept has been advanced by the US Department of Agriculture Forest Service and in the wildfire governance literature for forestlands and Wildland-Urban Interface communities (e.g., North et al. 2012; Ager et al. 2015; Kline et al. 2015; Ager et al. 2019). A fireshed is a grouping of areas with similar fire regimes, fire history, and wildfire risk. These are refined through simulations of where fires are likely to ignite, their extent under given time periods, and potential effects on valued resources (Collins et al. 2010; Thompson et al. 2013; Scott and Thompson 2015). A fireshed is conceptually useful in terms of delineating the biophysical scale at which fuels treatments may modify landscape-scale fire behavior (e.g., size, severity, and what burns). In rangeland settings, additional biophysical delineations that may define a planning unit include anthropogenic or natural landscape features that act as substantive barriers to fire spread (e.g., major roads and water bodies; Wollstein et al. 2022b).

Although firesheds offer a useful concept to inform the geographic extent of a rangeland and fire planning and management unit, it presupposes that actors within an area defined by fire simulation modeling have the knowledge, willingness, or capacity for ongoing coordination of actions to mitigate fireshed-wide risk. Other models from fire-prone areas around the world have acknowledged the need to merge social and biophysical dimensions of wildfire risk in society's response to wildfire (e.g., Smith et al. 2016; Schoennagel et al. 2017; McWethy et al. 2019; Bacciu et al. 2022); frameworks that integrate landscape and biophysical features related to wildfire risk with human values and social networks have included "firescapes" (Smith et al. 2016) and "Fire Smart Territories" (Tedim et al., 2016). Yet models such as these do not necessarily capitalize on wildfire response capacities and motivations to mitigate risk characteristic of natural resource-dependent communities. On Great Basin rangelands, communities often possess experiential knowledge or social memory of wildfire (Stasiewicz and Paveglio 2017; Davis et al. 2020) and are motivated by a shared economic interest in preventing wildfires (Toledo et al. 2012; Abrams et al. 2017).

The local social context, in addition to biophysical conditions that affect rangeland wildfire occurrence and outcomes, provides the logic for a scale at which it makes sense for actors to work together in the sagebrush ecosystem. Boundary designations of a rangeland and fire planning and management unit must have both biophysical and social relevance to those engaging in fire risk mitigation. For example, RFPAs have emerged at a scale that is large enough to effectively respond to wildfires yet localized enough to engender the reciprocity and cooperation required to enable coordinated fire response (Abrams et al. 2017; Davis et al. 2020). Boundaries are initially proposed by landowners with an interest in preventing large-scale wildfires within a geographic area; informed by local knowledge of the land, resources, and fire behavior; existing social networks (i.e., "neighbors helping neighbors"; Abrams et al. 2017); and adjusted for physical barriers on the landscape (M. Vetter, personal communication, October 2021). However, current RFPA authority is centered solely on fire response and coordinated almost exclusively with the BLM Fire Program's suppression functions.

Thus, rangeland firesheds are necessary planning and management units in which an individual or entity's activities transcend the scale of a single allotment or parcel and complement concurrent management activities to meaningfully influence fire outcomes and improve ecosystem resilience to future fires. This necessitates reorganizing current institutional arrangements within a unit that reflects existing social dynamics and motivations (Paveglio et al. 2019). Below, we propose an institutional framework to support this need.

Integrating planning and management through rangeland Fireshed Councils

We propose the formation of rangeland Fireshed Councils, a governance arrangement similar to Watershed Councils. Watershed Councils, formally recognized units in the US West since the early 1990s, are community-based nonprofit organizations consisting of governmental and nongovernmental stakeholders who collaborate to address water and other natural resources issues at the scale of a watershed (Griffin 1999). Watershed Councils have been documented to be effective for integrating local knowledge into decision processes, creating rules for resource use to better reflect local needs, and nurturing experimentation (Curtis and De Lacy 1995; Curtis et al. 2002; Flitcroft et al. 2009).

A rangeland Fireshed Council would be oriented toward coordinating among different jurisdictions and actors within the fireshed and long-term planning focused on adaptation to fire. Much like the existing Watershed Council model, a rangeland Fireshed Council must operate at a governance level that enables actors to mix and match their rules and tools in new ways to navigate administrative, cultural, and capacity challenges. Tasks are ideally allocated to the lowest governance where individuals and organizations possess the capacity to act (Marshall 2008; Marshall and Stafford Smith 2010). There are other community-based models for fire resilience such as the Northern Colorado Fireshed Collaborative and the Greater Santa Fe Fireshed Coalition; an important role of a rangeland Fireshed Council would be to situate or coordinate local-level decisions and rangeland management activities on individual allotments or private parcels within a relevant spatial and temporal scale for managing fire both within and among rangeland firesheds (Cash et al. 2006; Marshall 2008; Wyborn and Bixler 2013).

Fire resilience hinges on human communities adapting to new fire realities; capacity to adapt depends on their abilities to learn and collectively act (Schoennagel et al. 2017). Accordingly, a rangeland Fireshed Council would comprise members with existing motivations to mitigate risk and share a vision for fire resilience. Because RFPAs are distinct networks largely composed of participants with similar management goals and attitudes toward wildfire (Abrams et al. 2017), RFPAs' knowledge integration from nonfire response organizations (e.g., using rangeland management principles to influence fire occurrence and outcomes) may be limited (Fischer and Jasny 2017). Rangeland Fireshed Councils, in contrast, shift rangeland and fire planning and management from typically disparate processes with limited opportunities for learning and complex problem solving to an integrated unit for collaborative decision making that supports fire resilience (Fig. 2).

Membership must include private landowners within the fireshed in addition to governmental actors with decision-making authority on public lands and other rangeland stakeholders with knowledge, resources, or capacity to contribute to rangeland, fuels, and fire management within the fireshed. Sustained interactions for group learning and trust building within the rangeland Fireshed Council may allow these members to communicate a need or discuss mixing and matching rules and tools in complementary and novel ways within the fireshed (Prager 2010).

Building fire resilience requires processes that are flexible and able to be adapted over time to cope with new fire realities (Schoennagel et al. 2017). This necessitates formal or informal adaptive management approaches that may include setting objectives, using or developing decision-support tools to inform both short- and long-term strategies, and monitoring and evaluation within an environment of continuous learning (Allen et al. 2017). This may involve the rangeland Fireshed Council selecting from a suite of rangeland and fuels management tools that will best foster fire-adapted shifts in the sagebrush ecosystem (i.e., promote resistant and resilient plant communities; Johnson et al. 2022)

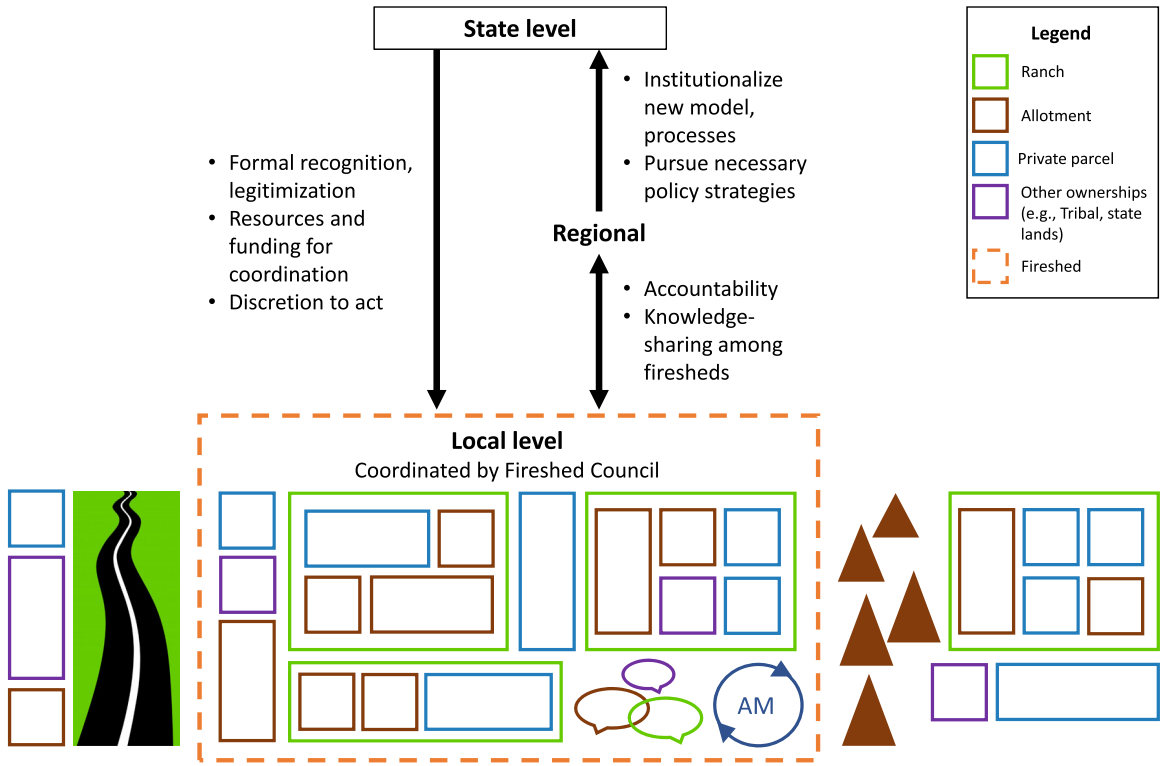

Figure 2. Proposed Fireshed Council model, incorporating a combination of private, federal (allotment), and other landownerships. Fireshed boundaries are defined by a combination of biophysical and social factors. Ongoing learning, negotiation, communication for adaptive management occurs within a fireshed, while necessary policy support is pursued by higher levels where the Fireshed Council model may eventually be institutionalized. The state level provides resources and funding for coordination; formal recognition enhances perceptions of Fireshed Council legitimacy at local levels.

and in human communities (i.e., reduce community vulnerability; Smith et al. 2016; Schoennagel et al. 2017; McWethy et al. 2019; Bacciu et al. 2022). For example, the rangeland Fireshed Council may agree that protecting intact areas of the sagebrush ecosystem with low resistance to annual grass invasion and resilience to fire is a priority within the fireshed, as not doing so may lead to more large-scale fires and negatively affect overall ecosystem resilience (Creutzburg et al. 2022). Therefore, the BLM Fire Program's activities may include implementing strategic fuel breaks to improve wildfire response to protect those areas, and the BLM Range Program may work with grazing permittees to apply grazing to maintain those fuel breaks or target areas with high accumulations of fine fuels (see Wollstein et al. 2022a). Rangeland Fireshed Councils serve to coordinate the deployment of rangeland management tools, such as grazing, to support fuels management and enhanced fire response should a wildfire occur within the fireshed unit.

In the longer term, rangeland Fireshed Councils may create an environment for long-term solutions, adaptation in the face of change and uncertainty, and a culture of learning among rangeland and fire managers. It is important to acknowledge that learning and communication alone cannot overcome some institutional barriers to adaptive management approaches (Wollstein et al. 2021). Some internal negotiation or new institutions will be required for organizations such as the BLM to overcome "siloization" and better capitalize on opportunities for grazing administration and fuels management to be complementary (Smith et al. 2016; see, e.g., Varela et al. 2018). For example, the nimble deployment of grazing to support a rangeland Fireshed Council's objective of creating or maintaining fire resilience will require an administrative environment that can accommodate adaptation despite uncertainty (Allen et al. 2017). The BLM may consider integrating decision-support products and thresholds into NEPA analyses; if fire probability maps (e.g., the Rangeland Analysis Platform's fuels-based maps; Smith et al. this issue) routinely indicate areas within the fireshed with higher mean fire probability, a change to the terms and conditions of a livestock grazing permit may be warranted to ensure that grazing is applied during the most ecologically relevant period and at an intensity so as to influence fire probability and fire behavior. Additionally, NEPA requires an analysis of the cumulative effects of a proposed action, such as grazing, on rangeland resources. Information shared through a rangeland Fireshed Council may better situate how such a decision affects the fireshed as a whole and how its effects may aggregate over time.

Lastly, for rangeland Fireshed Councils to be fully institutionalized, the new unit must receive recognition and support from higher levels to be perceived as legitimate and sustained in the long term (Lane and McDonald 2005; Robinson et al. 2017; Vermunt et al. 2020; see Fig. 2). Other Oregon governance arrangements offer insights into configurations for higher-level support for rangeland Fireshed Councils. For example, the Sage Grouse Conservation (SageCon) Partnership's coordination efforts in Oregon precluded listing of the greater sage-grouse *(Centrocercus urophasianus)* under the Endangered Species Act in 2015. SageCon coordinated policy and management across the sagebrush ecosystem in Oregon by providing a forum for lower levels (Soil and Water Conservation Districts) to develop local programs that would incentivize voluntary conservation by private landowners and also align with higher-level US Fish and Wildlife Service requirements for a nonlisting decision (Wollstein and Davis 2020). Importantly, high levels supported the arrangement through legislation and state and federal funding, while middle levels (i.e., counties and Natural Resource Conservation Districts) acted as intermediaries bridging levels and filling governance gaps. In a rangeland Fireshed Council model, intermediaries within counties or regions would be important for enhancing local perceptions of legitimacy of the arrangement and ensuring it is sufficiently resourced by linking

with state-level initiatives and other rangeland Fireshed Councils (i.e., horizontal and vertical linkages, respectively; Cash et al. 2006; Prager et al. 2010).

There are limitations to our proposed Fireshed Council model. First, the existence of a rangeland Fireshed Council does not in and of itself empower local actors. Ongoing high-level recognition and support will be essential (Lane and McDonald 2005; Hibbard and Lurie 2008; Chaffin et al. 2015). In contexts in which landowners, resource users, or local governments have limited power, true shared decision making may require formal power-sharing arrangements (Abrams et al. 2018; Miller et al. 2022). Second, although rangeland Fireshed Councils would ostensibly offer local control or co-management, validation of this new institutional arrangement would depend on the Fireshed Council's ability to foster productive discourse, navigate administrative challenges, and provide long-term coordination (Habron 2003). Securing participation will also be challenging, especially if potential group members do not feel the plans are salient or inclusive (e.g., Kusters et al. 2018; Vermunt et al. 2020). Lastly, rangeland Fireshed Councils are not a panacea for this complex problem; some problems require other or complementary approaches at other governance levels (Cohen and Davidson 2011).

Conclusion

Although strategic application of grazing to reduce fine fuels and influence fire probability and behavior is supported by research (e.g., Diamond et al. 2009; Davies et al. 2015b; Thomas and Davies this issue) and management decisions will potentially be better informed by preseason fire probability maps advanced by Smith et al. (this issue), complex and overlapping authorities, resources, and capacities can create barriers to broadscale implementation of grazing for fuel reduction purposes. Currently, scale mismatches including different authorities, resources, and capacities ("rules and tools") associated with rangeland and fire institutions limit collective actions to address rangeland wildfire risk. An era of frequent, large-scale rangeland wildfires demands coordination of relevant actors and processes at biophysically and socially relevant scales, as well as the ability to mix and match rules and tools for addressing fine fuel accumulation across multiple scales. Thus, new institutions are necessary so that capacity and resources can be directed at coordinating the multiple authorities and roles of actors to advance a shared vision.

We proposed an institutional framework, rangeland Fireshed Councils, in which different members' authorities, resources, and capacities may be synergistic and coordinated to be applied in novel ways to promote fire resilience. Rangeland Fireshed Councils must have the support from higher levels of governance, articulating objectives and providing resources and coordination, while lower levels have the discretion to implement in ways that reflect local conditions and needs. In concert with this, enabling policies are necessary for using adaptive management bolstered by tools such as fire probability maps. Coordination and communication between the Range and Fire Programs of the BLM, as well as private landowners and other relevant stakeholders, will ease logistical barriers such as deploying livestock in an ecologically relevant timeframe.

The rangeland Fireshed Councils model is an effort to advance integrated rangeland and fire management planning and implementation at biophysically and socially relevant scales. Yet challenges associated with this model include securing long-term commitment to active participation from relevant stakeholders, overcoming institutional inertia associated with entrenched funding and planning procedures and modes, and securing new or redistributing existing capacity and resources to support coordination of activities for a novel planning unit. Despite these challenges, we submit that new rangeland and fire planning and management institutions will support the actors, capacities, and processes that will promote fire resilience in a complex social-ecological system.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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