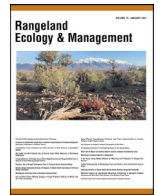




Contents lists available at ScienceDirect

Rangeland Ecology & Management

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

Outcome-Based Approaches for Managing Wildfire Risk: Institutional Interactions and Implementation Within the “Gray Zone”[☆]

K. Wollstein^{1,2,*}, C.B. Wardropper¹, D.R. Becker¹¹ Department of Natural Resources and Society, University of Idaho, Moscow, ID 83844-1139, USA² Department of Animal and Rangeland Sciences, Oregon State University, Corvallis, OR 97331, USA

ARTICLE INFO

Article history:

Received 12 December 2020

Revised 27 March 2021

Accepted 19 April 2021

Key Words:

Adaptive management

Fire risk

Policy

Public lands

Ranching

United States West

ABSTRACT

In the United States, the Bureau of Land Management (BLM) manages rangeland resources under dynamic conditions such as drought, annual grass invasion, and larger and more frequent wildfires. But federal policies governing rangelands are not structured to respond to annual variability or unexpected events. To integrate flexibility into public rangeland administration and potentially leverage fuels management treatments at the landscape scale, the BLM and livestock grazing permittees are exploring outcome-based rangeland management approaches to achieve desired ecological, social and economic conditions. This paper examines administrative policies and barriers to using outcome-based approaches to manage fire risk in Idaho through 70 semistructured interviews with permittees, BLM staff, and other agency and nongovernmental stakeholders in three Idaho BLM field areas. We analyzed how rules and norms in policy implementation contributed to perceptions of barriers within and among different field areas. Factors affecting perceptions of outcome-based rangeland management implementation included BLM staff tenure, permittee-agency relationships, beliefs about the efficacy of grazing to manage fire risk, and leadership and staff experience in navigating National Environmental Policy Act requirements or potential lawsuits. Differences in the informal institutions among field areas led to different interpretations of latitude found within formal institutions (“gray zones”) for implementation. This study highlights the importance of local context and the interactions between administrative policies and agency culture for implementing adaptive approaches to managing wildfire risk on public rangelands.

© 2021 The Society for Range Management. Published by Elsevier Inc. All rights reserved.

Introduction

Climate change, changing land uses, and invasion of exotic annual grasses contribute to larger, hotter, and more frequent fires on US western rangelands (Abatzoglou and Kolden 2011; Balch et al. 2013; Coates et al. 2016). But due to the extensiveness and mixed-ownership of these lands, disparate fuel-management treatments such as prescribed burning or herbicide spraying are singularly inadequate for influencing fire behavior at the landscape scale (Davies et al. 2015a). With livestock grazing authorized on 155 million acres of Bureau of Land Management (BLM) lands in the West, strategic application of grazing is a relatively widespread

but currently underused tool for reducing fuel loads and leveraging existing fire risk management activities (Diamond et al. 2009; Strand et al. 2014; Davies et al. 2015b).

In federal land management, a combination of policies, local culture and norms, and beliefs of managers and users can create barriers to widespread use of fuels management tools such as grazing (e.g., Moseley and Charnley 2014; Schultz et al. 2019). Land managers and resource users alike make decisions in situations structured by biophysical conditions and institutions (i.e., rules and norms governing the management of those resources) (Schlager and Cox 2018). Institutions guide, constrain, and direct people's interactions and actions. Formal institutions are codified in policies and regulations that are legally enforceable. For example, livestock grazing on public rangelands is statutorily required to be administered through grazing permits, which include terms and conditions such as when and how intensively ranchers (permittees, hereafter) may graze livestock. In contrast, informal institutions are products of cultural norms and social interactions that take the form of shared expectations among participants (Christiansen and Neuhold 2012). Implicitly understood by resource managers and users, informal institutions are usually not written down or enforced

[☆] This research was supported by a Joint Fire Science Program Graduate Innovation (GRIN) Award (18-1-01-18), US Dept of Agriculture National Institute of Food and Agriculture McIntire Stennis projects (1019024, 1015330), a University of Idaho (UI) College of Natural Resources Curt Berklund Graduate Research Scholar Award, and a UI Office of Research and Economic Development Research Infrastructure and Scholarly Excellence (RISE) Graduate Research Fellowship.

* Correspondence and current address: Katherine Wollstein, Eastern Oregon Agricultural Research Center, 67826-A Hwy 205, Burns, OR 97720, USA.

E-mail address: katherine.wollstein@oregonstate.edu (K. Wollstein).

inside traditional legal channels (Schlager and Cox 2018). Informal institutions interact with formal institutions by complementing, filling gaps, and operating within “gray zones” (i.e., areas within formal rules that include avenues for interpretation) (Landsbergen and Orosz 1996; Christiansen and Neuhold 2012). For example, the notion of “range readiness” refers to plant phenology and other environmental conditions and governs livestock turnout dates for grazing on BLM allotments. Range readiness is a condition referenced in planning documents like BLM Resource Management Plans. But how range readiness is actually practiced is a function of managers’ experiences and discretion, not a strict date of use. For this reason, decisions guided by laws and regulations may lead to different implementation from place to place, even when executed by individuals from the same agency (Hruska et al. 2017).

Using three case studies of BLM field areas in Idaho, we examine how formal and informal institutions interact and affect the use of outcome-based approaches to manage fire risk on rangelands. Outcome-based rangeland management (OBM) is a recent BLM initiative to adaptively respond to annual variability on rangelands permitted for livestock grazing. For the purposes of this research, we situate OBM within recent trends in adaptive management approaches on public lands. Although much has been written about adaptive management, this study brings an institutional lens to bear on adaptive approaches to rangeland management to understand arenas for implementation within the sideboards of federal policies. The specific objectives of this study were to 1) understand permittees’ and local-level BLM administrators’ perceptions of barriers to OBM implementation and 2) elucidate how differences in informal institutions among field areas contribute to perceptions of barriers to OBM implementation.

Literature review

Although the BLM and other state and federal land management agencies undertake prescribed burning, mastication, spraying herbicides, and other activities to manage rangeland fire risk, some have critiqued such activities as inadequately coordinated or synergistic to influence fire behavior at the landscape-scale (Diamond et al. 2012; Davies et al. 2015a). There is abundant research examining fuel characteristics, fire ignition, and fire frequency in rangeland ecosystems (e.g., Diamond et al. 2009, 2012; Davies et al. 2015a, 2015b, 2017). However, the policies and social factors involved in broad-scale application of such strategies for managing fire risk remain a relatively neglected area of research in rangeland management. Recent research has considered policy barriers for prescribed fire application on BLM and US Forest Service lands (Schultz et al. 2019), but this work does not address opportunities to leverage fuels management efforts in systems where livestock grazing is the predominant land use. As follows, we consider the limits of adaptive approaches to rangeland management within the US federal policy context.

Public rangeland management in the United States takes place within a nested institutional context, wherein federal policies attempt to balance accountable resource management with the realities of environmental variability (Reiners 2012). But mechanisms for learning and adaptation are needed for managing dynamic rangeland systems (Boyd and Svejcar 2009). Adaptive management, an approach used by many natural resource agencies, is an iterative process of structured decision making in which management options are implemented, outcomes assessed, and management strategies are adjusted as learning occurs (Allen and Gunderson 2011). This process can be facilitated through clear objectives and processes that allow flexibility to revisit and learn from past management decisions. Walters (1986) provided an early description of adaptive environmental management as ongoing management activities that serve as experiments, can reduce uncertainties, and

facilitate learning. More recently, the notion of adaptive comanagement or collaborative adaptive management has expanded on this approach, emphasizing participatory multistakeholder processes and structured, deliberative learning that must occur to achieve desired social and environmental outcomes (e.g., Wilmer et al. 2018; Fernández-Giménez et al. 2019). For the purposes of this research, we conceptualize outcome-based rangeland management—a relatively new effort—as an adaptive management approach that emphasizes stakeholder participation and iterative decision making but is distinct from collaborative adaptive management in its lack of formal processes for implementation, learning, and evaluation.

Some scholars posit that rangeland systems are particularly well suited for adaptive management because both uncertainty and controllability are high. System dynamics can be modeled (e.g., state-and-transition models); there are discrete, spatially delineated management units (i.e., pastures and allotments); uncertainties related to management impacts are analyzed when administrators authorize resource uses; and management objectives are often specified (e.g., in BLM Resource Management Plans; Allen and Gunderson 2011; Allen et al. 2011; Allen et al. 2017). However, existing policies and associated administrative structures often require management activities to produce relatively certain outcomes, even in systems where environmental variability is high (Schultz 2008). In the social-ecological systems literature, adaptive management design and implementation are hindered when laws and policies 1) fail to account for the dynamic nature of social-ecological systems; 2) rely on the ability to predict all the environmental and social outcomes of an activity; or 3) default to linear, rather than iterative, decision-making processes (Frohlich et al. 2018). Policies and formal institutions can constrain flexibility and institutional support for adaptive approaches (Benson and Stone 2013). For instance, the National Environmental Policy Act (NEPA) requires review of environmental impacts via environmental assessments or the more extensive environmental impact statements, analysis of proposed actions, and mitigation plans before undertaking federal projects (e.g., erecting a new fence or constructing fuel breaks on federal land). However, NEPA processes require relative certainty of outcomes (identified in the analysis of proposed actions), and judicial review of agency actions or the outcomes of the activity can make implementation difficult because agency staff are often preoccupied with avoiding legal disputes (Schultz 2008; Craig and Ruhl 2014; Fischman and Ruhl 2016). These aspects of NEPA may encourage management approaches that prioritize avoidance of potential lawsuits rather than experimentation and learning (Bjorkland 2013).

Although policy is pivotal in the development and performance of institutions, learning processes that accompany adaptive natural resource management are contextual and “... exist in relation to the place in which they occur, the experiences from which they arise, and the cultures with which they are associated” (Keen and Mahanty 2006, p. 498). That is, informal institutions are the lens through which policies and other formal institutions are interpreted and implemented (Christiansen and Neuhold 2012). For example, political, legal, and cultural factors have been found to be central in BLM and US Forest Service agency personnel’s perceptions of barriers to implementing ecosystem-management (a tenet of which is adaptive management); cultural barriers are related to willingness of agency personnel to innovate and experiment and attitudes and beliefs about resource use (Koontz and Bodine 2008). Informal institutions, created and reinforced by these aspects of culture, operate by complementing or filling gaps in formal institutions (Christiansen and Neuhold 2012).

Given that combinations of formal and informal institutions can create perceptions of barriers to agency implementation of some policies, we must next ask: What institutional arrangements

enhance flexibility and allow adaptive, experimental approaches to be implemented? Landsbergen and Orosz (1996) define “gray zones” as spaces in which laws are silent or ambiguous and agency interpretations and expectations can establish acceptable practices within the sideboards of legislative rules. For example, the Federal Land Policy and Management Act (FLPMA) is a legislative rule and requires the BLM to develop Resource Management Plans (RMPs) to describe how the agency will manage resources within a field area to meet the agency’s objectives. But FLPMA provides only general guidelines for developing RMPs. In practice, RMPs are administrative tools whose contents reflect what field managers and resource specialists view as important for the field area. As administrative tools, RMPs are formal institutions but are also products of informal institutions (i.e., agency experience, culture, local politics, and the values of the public involved in creating the plan). It is these interactions of formal and informal institutions that “give shape” to the gray zone (Landsbergen and Orosz 1996). In order to understand why an adaptive approach is embraced—or not—by a BLM field office, we must consider the interactions of formal and informal institutions and where subsequent gray zones are perceived for agency implementation of OBM.

Methods

Study context

Livestock grazing on BLM rangelands is administered by staff in field offices and authorized through grazing permits, which include legal terms and conditions such as class, timing, and duration of livestock grazing. Because terms and conditions are reviewed every 10 yr, they typically do not allow for much interim flexibility for responding to unexpected conditions such as drought, above-average forage production, or wildfires. Desired changes require analyses of proposed actions per NEPA, which is often time consuming and expensive (Bjorkland 2013). As a result, adaptive responses to dynamic conditions are difficult for agency managers to authorize or implement within the 10-yr lease period.

The BLM has recently been exploring approaches to better respond to variability on public rangelands. In 2018, the agency began piloting outcome-based grazing authorizations (OBGAs) with 11 ranches in six western states. In addition, the BLM issued an instruction memorandum (IM) providing guidance on outcome-based grazing and “flexibility in grazing management” to be optionally implemented outside of the formal pilots by BLM districts (IM 2018-109). For our purposes, we consider the OBGA pilots and other outcome-based approaches described by the IM under the collective term “outcome-based management” (OBM). The goals of OBM are to 1) decrease response time to real-time resource conditions and 2) achieve desired ecological, social, and economic conditions for both the BLM and permittees (BLM 2017). OBM may use options such as livestock turnout dates in response to current rangeland condition such as plant phenology and forage availability, rather than solely the calendar date stipulated on a permit. In Idaho, for example, outcome-based approaches may be useful for addressing annual grass invasion (e.g., cheatgrass [*Bromus tectorum* L.] and medusahead [*Taeniatherum caput-medusae* (L.) Nevski]), which exacerbates fire risk and condenses natural fire return intervals in formerly sagebrush-dominated communities (Balch et al. 2013; Coates et al. 2016). A BLM manager and a permittee may identify the mutually agreed-upon goal of reducing fire risk, increasing native perennial abundance, or improving wildlife habitat. An outcome-based approach may authorize the permittee to graze invasive annual grasses in early spring before perennial emergence to reduce competition between annuals and more fire-resistant native species.

Table 1

Wildland fires larger than 100 000 acres 1997–2019 in Bureau of Land Management (BLM) districts with rangelands in Idaho (NIFC 2020).

| BLM district | Fires larger than 100 000 acres |
|--------------|---|
| Boise | Pony Complex (2013), Soda (2015) |
| Idaho Falls | Mule Butte (1999), Eastern Idaho Complex (2000), Crystal (2006), Sheep (2019) |
| Twin Falls | Clover (2005), Murphy Complex (2007), Rowland (2007), Elk Mountain (2007), Long Butte (2010), Kinyon Road (2012), Flattop 2 (2012), Beaver Creek (2013) |

Study areas

In Idaho, the BLM administers nearly 1 900 livestock grazing permits covering 12 million acres of public rangelands (BLM 2020b). Although the OBGA pilots and guidance on OBM emerged from the national BLM office, we selected our cases from Idaho because early conversations in developing this research indicated that much of the momentum and ideas were driven by BLM leadership within Idaho. Idaho’s rangelands are also a hotspot for fire risk, particularly in the Boise, Idaho Falls, and Twin Falls BLM Districts from which cases were selected (Table 1). In recent decades, fires have become larger and more frequent in these areas due to climate change, changing land uses and increased ignition sources, and proliferation of exotic annual grasses (Abatzoglou and Kolden 2011; Balch et al. 2013). Each year in Idaho, the BLM responds to an average of 330 human and naturally caused fires that burn about 270 000 acres of public and private lands. The agency undertakes mechanical thinning; prescribed burning; and chemical treatments to manage fuels, seedings, and postfire rehabilitation; and creation of fuel breaks to enhance fire-suppression efforts (BLM 2020a). But in some annual grass-dominated areas, fire return intervals may be as short as 3–5 yr, allowing invasive annuals to outcompete slower-growing native perennial grasses and shrubs after a fire (Coates et al. 2016).

In 2018, we conducted exploratory interviews with 22 key informants in six BLM field offices in Idaho to inventory existing understandings of OBM and identify challenges unique to each locale. Initial key informants included permittees, state and federal resource management agencies, and nongovernmental organizations who were identified by University of Idaho Extension faculty and staff in the Idaho State BLM Office; subsequent participants were recruited via snowball sampling (Lewis-Beck et al. 2004). Findings from these interviews were synthesized into memorandums by the lead author and used to develop case study profiles. These syntheses informed our subsequent holistic multiple-case design, in which three cases were selected from 10 BLM field areas, with one case from each of the three BLM districts with rangelands in Idaho (Fig. 1).

BLM field offices administer grazing permits within the field area and represent the local level of implementation, wherein BLM staff work directly with permittees and other agencies and organizations associated with resource management on BLM lands. Field offices receive guidance from district offices, which are all overseen by the state BLM office. Due to the sensitive nature of findings and relatively small sample sizes of BLM staff within field offices, we have anonymized the cases and refer to them as field areas A, B, and C. In our study, comparative case studies allow for contrasting institutional conditions in each field area; cases were selected for yielding theoretical contrast (Yin 2014). Field area A is considered to contain relatively healthy rangelands and has experienced considerably fewer catastrophic fires in the past 20 yr compared with field areas B and C. In addition, one of the field areas includes a formal OBGA pilot. Other factors such as prevalence of litigation related to rangeland management decisions in the field areas, social and political context, and staff turnover also provided theoretical

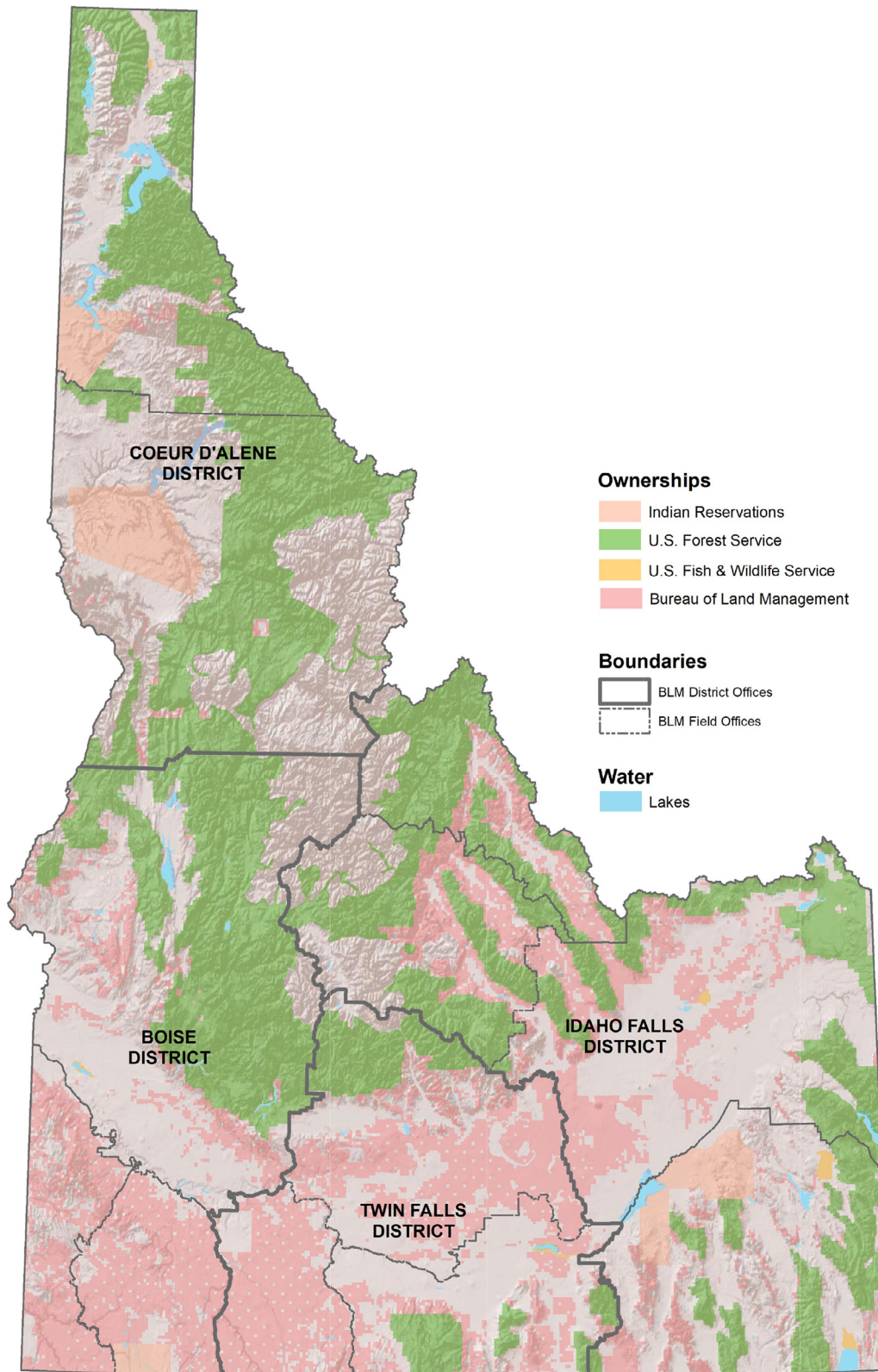


Fig. 1. Bureau of Land Management (BLM) districts and associated field areas in Idaho. Three field areas were selected as case studies, one in each BLM district with rangelands (Boise, Twin Falls, and Idaho Falls Districts). Credit: Chelsea Pennick, University of Idaho.

Table 2

Summary of categories of participants interviewed for each case. Cases were anonymized due to the sensitive nature of findings and relatively small sample sizes of Bureau of Land Management (BLM) staff within field offices.

| Interviewee category | No. of interviews |
|----------------------|-------------------|
| Field Area A | |
| BLM staff | 7 |
| Permittees | 10 |
| Other agency, NGO | 7 |
| Field Area A total | 24 |
| Field Area B | |
| BLM staff | 12 |
| Permittees | 10 |
| Other agency, NGO | 1 |
| Field Area B Total | 23 |
| Field Area C | |
| BLM staff | 9 |
| Permittees | 13 |
| Other agency, NGO | 1 |
| Field Area C Total | 23 |
| Total | 70 |

NGO indicates nongovernmental organization.

contrast among the selected cases. Although case studies are not statistically generalizable, in-depth understanding gained can clarify the relation of a particular set of results to broader theory and determine if alternative explanations may be more relevant (Yin 2014).

Data collection

Given that the BLM's interest in outcome-based approaches is relatively new and because there have been no prior studies on implementing OBM, our study design was exploratory and used multiple types of data. We used a combination of document analysis, in-depth interviews, and qualitative induction to address research objectives and triangulate findings (Maxwell 1996). Due to the politically sensitive nature of the subject matter (e.g., asking BLM staff to describe sometimes difficult interactions with rangeland users, ongoing lawsuits regarding grazing permits), we determined that other data collection methods such as focus groups or surveys would not yield the depth, detail, and nuance necessary to explore how and why some BLM staff perceive barriers to implementing OBM.

Data collection activities took place in summer and fall of 2019 and consisted of 70 in-depth, semistructured interviews with BLM staff in field offices, as well as with permittees and other relevant agencies (e.g., Idaho Department of Fish and Game) and nongovernmental actors (NGO) within the respective field areas (Table 2). BLM participants were purposively sampled for their involvement in grazing permit administration; most staff were rangeland management specialists, fuels managers, or other resource specialists. Permittee, agency, and NGO interviewees were accessed through personal references from BLM staff and sampled via snowball in the field areas. Three individuals had participated in the 2018 exploratory interviews and were again interviewed in 2019. We ceased interviewing when theoretical saturation was reached in each case, wherein no new information was learned from subsequent interviews (Lewis-Beck et al. 2004).

An interview guide was developed using memorandums produced after the 2018 exploratory interviews. For this study, interviews were semistructured, lasted between 60 and 120 min, and were audiorecorded with permission of participants. Permission was not granted in five instances, and handwritten notes were taken instead. Interviews were conversational and first sought to identify management activities participants believed would achieve the desired outcome of reduced fire risk on BLM allotments on which they held grazing permits (permittees), managed (BLM

staff), or conducted other activities (interviewees from other agencies and organizations). Follow-up questions were used to understand participants' perspectives on whether they believed the desired activities they cited are allowable under current rules and regulations. When appropriate, the interviewer probed using context-specific questions about rules configurations to discover whether perceived barriers to implementation were derived directly from policy (formal institutions) or rules-in-use, local norms, and culture (informal institutions). Questions for BLM staff focused on day-to-day permit administration such as how to allocate and manage BLM resources (e.g., staff time), provide information within offices and to permittees, monitor actions, and enforce rules. The interviewer also read verbatim to participants from the 2018 BLM Instruction Memorandum entitled "Flexibility in Livestock Grazing Management" to query how individual participants interpret (or experience, in the cases of permittee interviews) formal protocols or see difficulties in implementing outcome-based approaches for managing fire risk.

Documents collected to provide context and supplement interviews included environmental assessments (EAs) and environmental impact statement documentation from the BLM's National NEPA Register (eplanning.blm.gov) 2005 to 2020 for permit renewals, noxious weed and invasive plant management, vegetation treatments, fuel breaks, and resource management plans for each field area. We also examined BLM manuals for range and fire program management and grazing regulations in the Code of Federal Regulations. These documents were used to validate data collected from interviews (Maxwell 1996), particularly regarding the legal and administrative context of the past 15 yr.

Data analysis

We used NVivo qualitative analysis software and an iterative approach to identify and characterize the barriers to implementing outcome-based approaches for managing fire risk perceived by permittees and BLM staff. Our analysis focused on categorizing perceptions of barriers to the implementation of OBM into formal and informal institutions. After identifying relatively important formal and informal components in perceptions of barriers to OBM based on frequency of references by participants, initial findings were discussed among authors and confirmed separately with key informants via telephone. The lead author then conducted focused coding to accumulate evidence that added to or undermined our initial understandings of relevant institutional components in creating perceptions of barriers. Focused coding also separated permittee and BLM staff perceptions to elucidate if there were shared or divergent perceptions of barriers among categories of actors. Finally, we compared findings across cases, seeking to identify differences in how participants in each case perceived barriers to generate new understandings about the roles of informal institutions in OBM for managing fire risk.

Results

Desired fire risk management activities identified by participants were largely focused on those related to management of fuels (both accumulated native perennial grasses and invasive annual grasses) and fire response, such as construction of fuel breaks to enhance firefighters' responses during incidents (Table 3). Through qualitative analysis, factors creating barriers to OBM most frequently referenced by participants were grouped into policies and formal processes, culture and norms, and experience and history within the field area (Table 4). Frequently referenced formal institutions creating barriers to implementing outcome-based approaches were meeting NEPA requirements and BLM Idaho Standards for Rangeland Health. We additionally found

Table 3
Desired fire risk management activities frequently identified by participants.

| Type of fire risk management | Frequently referenced desired activities |
|------------------------------|---|
| Prefire mitigation | Treat invasive annual grasses with herbicides or targeted grazing Manage fuels buildup by adjusting timing, duration, or intensity of grazing following the growing season (e.g., fall or winter grazing) Increase prescribed burning to reduce fuels, improve rangeland resilience |
| Fire preparedness | Construct fuel breaks (mechanically or with livestock) Maintain existing fuel breaks (planting fire resistant species, discing, spraying) |
| Postfire recovery | Winter or early spring grazing following fire to exclude annual grass establishment |

Table 4
Relatively important components in participants' perceptions of barriers to outcome-based rangeland management categorized in terms of formal and informal institutions. Evidence for these components and associated institutions were accumulated through qualitative analysis in NVivo.

| Component | Institution type | Examples |
|-----------------------------------|------------------|--|
| Policies and formalized processes | Formal | Procedures required by NEPA Terms and conditions Grazing regulations Budget Standards for rangeland health Judicial decisions |
| Culture and norms | Informal | Leadership Inclination to experiment Shared vision (individual, interagency interactions) Beliefs about resource management |
| Experience | Informal | Staff tenure Knowledge of allotments, permittees Permittee-agency relationships Assessment of range readiness Prioritizing workloads Litigation history |

NEPA indicates National Environmental Policy Act.

that informal institutions created by participants' beliefs about resource management, leadership, staff experience with allotments and individual permittees, and litigation history and accompanying perceived risk of litigation in the field area were important factors in participants' perceptions of barriers to implementing OBM for fire risk management. Furthermore, perceptions of barriers to OBM were also influenced by the resource condition of the allotment (e.g., progression of annual grass invasion). Next, we summarize how formal and informal institutions interacted in our case studies and highlight instances of BLM field offices interpreting areas of discretion for implementation. We compare examples from each field area of prefire mitigation strategies and adaptations to annual variability through grazing permitting and explore how combinations of informal and formal institutions and resource conditions created barriers or opportunities for implementation (Table 5).

Policies and formalized processes: NEPA procedures, potential litigation

BLM reportedly had limited capacity to undertake additional formal processes that were perceived to accompany outcome-based approaches. To use grazing as a tool to achieve the desired outcome of addressing emergent fire risk factors (e.g., following a particularly productive growing season or annual grass establishment after a fire), most BLM staff in all field areas agreed that terms and conditions such as timing, intensity, or duration of graz-

ing would need to be modified on grazing permits for the associated allotments. Changing permits requires analysis of the proposed actions under NEPA and can be time consuming. As a result, it is difficult for the BLM to authorize grazing to address emergent fire risk factors in a timeframe relevant to seasonal production and fuels management. For example, one permittee described seeking to change how he used an allotment that had been invaded by medusahead since the permit was last reviewed in order to better manage the new resource condition and heightened fire risk:

[The BLM] won't let you try something new. "Well how about if we try this? I think it would be better for the grass if we did this and tried that." ... They say, "No. We have to write a new RMP [Resource Management Plan] first or have to do NEPA or we have to renew your permit. Let's wait," ... And then those things never happen. They'll be 25 years behind—or whatever they are on permit renewal—so it might not happen till your grandkids are running the ranch (Permittee-B-07).

All BLM interviewees described the need to craft NEPA documentation for outcome-based proposals that would not attract attention from litigants or be able to withstand legal scrutiny should aspects of a grazing permit or other activities on BLM land be litigated. Informal institutions such as staff experience and leadership were associated with navigating potential litigation as a barrier to OBM implementation. For example, Field Area C and its associated district office had experienced an active history of lawsuits over public land grazing. BLM interviewees cited this litigation history in leading Field Office C to adapt their approaches to permitting and managing litigation risk:

We're kind of limiting our [legal] exposure to some extent. Areas that are going good—permittees don't need something changed, or we don't need something changed for resource management—we're going to leave it alone. And if we need something changed, it can be fixed with little tweaks like a new stretch of fence, extension of a pipeline, or even a change of season ... we're going to try it and see if it works. Then we don't have to go through a complete permit renewal ... The folks who are watching us and don't support some of this stuff don't get too excited [i.e., bring a lawsuit] if you're just kind of tweaking a few things (BLM-C-08).

Multiple BLM interviewees in Field Office C emphasized that when they could, they preferred to make small changes to permits that, in their experience, would extend staff capacity and avoid potential litigation. However, as a result, many permittees in Field Area C felt BLM staff were "afraid" or unwilling to make more substantive changes to permits, such as authorizing more animal unit months (AUMs; the amount of forage needed to sustain one cow, five sheep, or five goats for 1 mo) where productive crested wheatgrass seedings (*Agropyron cristatum* [L.] Gaertn) posed a fire risk.

Culture and norms: beliefs about grazing to manage fire risk

Beliefs about grazing to effectively manage fuels while also meeting standards of rangeland health were areas of BLM and permittee disagreement and were thus perceived to create barriers to OBM implementation. Annual grass monocultures or non-native crested wheatgrass seedings were dominant in some allotments in Field Areas B and C. In these cases, permittees believed their current forage utilization levels were contributing to seasonal fire risk and agreed that the BLM issuing them more AUMs would allow them to better use grazing to manage fuels in some areas of their allotments. However, many BLM and other agency interviewees were skeptical about the effectiveness of widespread grazing to reduce fire risk, citing that in order to reduce fuels to an extent that fire behavior is influenced, utilization would need to be increased to such a level that they would have concerns about

Table 5

Comparison of resource conditions and relevant formal and informal institutions involved in examples of prefire mitigation strategies and adaptations to annual variability through grazing permitting in each field area.

| | Field Area A | Field Area B | Field Area C |
|--|--|--|--|
| Resource condition considerations | Monitoring data must show allotments meet standards for rangeland health | Due to frequent fires, allotments lost shrub component and transitioned to annual grass monocultures | Some allotments dominated by crested wheatgrass; interviewees agreed authorized AUMs were too low given the productivity of the areas and resultant fuel loading |
| Relevant formal institutions | Grazing regulations; required NEPA analysis when changing terms and conditions; standards for rangeland health | Required NEPA analysis when changing terms and conditions; FLPMA mandating BLM staff manage for multiple uses | Grazing regulations; required NEPA analysis when changing terms and conditions; judicial decisions |
| Relevant informal institutions | Presence of permittee-agency relationships; long-tenured BLM staff familiar permittees' stewardship records; supportive field office leadership inclined to experiment | Absence of permittee-agency relationships; low continuity of BLM staff knowledge of allotment condition; different beliefs about grazing to manage fire risk; strained staff capacity due to prevalence of nongrazing uses in the field area | History of lawsuits in the field area; experienced BLM staff sensitive to actions that may incur a lawsuit |
| Resulting perceptions of barriers or use of gray zones | When renewing grazing permits, BLM staff expanded some permittees' on and off dates in terms and conditions to accommodate annual variation in range readiness | BLM staff were unable to adjust some permits' terms and conditions after resource condition transitioned to new state | BLM staff were reluctant to make "big" changes to permit terms and conditions (e.g., increasing AUMs), but instead made "little tweaks" (e.g., changes to seasons of use or new fencing) |

AUM indicates animal unit months; NEPA, National Environmental Policy Act; FLPMA, Federal Land Policy and Management Act; BLM, Bureau of Land Management.

habitat quality for sensitive species such as greater sage-grouse (*Centrocercus urophasianus*) and meeting Idaho BLM standards of rangeland health.

Differences in permittee and BLM staff beliefs about the efficacies of grazing to manage wildfire risk were particularly notable in Field Area B, where all categories of interviewees agreed that allotments dominated by annual grass monocultures pose significant fire risk. In addition, FLPMA guides how the BLM must administer rangeland uses. BLM interviewees in Field Area B described being pulled in multiple directions by frequent fires and a diversity of demands related to the nonranching public, such as rights-of-way and recreation access. High staff turnover combined with limited staff resources devoted to grazing culminated in low continuity in staff experience with permittees or the resource condition on allotments, "We're kind of in the thick of it right now, trying to figure out what all we are supposed to be accomplishing as a field office. There has not been a large continuity of managers, particularly for about the last decade. I think that's led to some of the disconnect [with permittees]" (BLM-B-21). Permittees in Field Area B referenced this discontinuity in experience in explaining why they believed BLM permit administrators would not work with them to address annual grasses and fire frequency on their allotments. For example, many permittees believed fall or early spring grazing would help them reduce annual grass abundance and, thereby, competition with native perennial grasses. But in many instances, these alternative seasons of use would require a change to their permit's terms and conditions and, "All of us around here have asked for changes [to our permits]. It's a complete waste of time. They just say no ... There's no give whatsoever" (Permittee-B-05). High turnover among field area leadership and rangeland management specialists (RMSs, who administer grazing permits) resulted in low trust and infrequent communication between BLM staff and permittees.

Culture and norms: permittee-agency relationships, discretion after fire

BLM guidance for livestock grazing after fire in the field areas is found in an emergency stabilization and rehabilitation (ESR) document produced after a specific fire event or in field areas' land use plans or RMPs. Nearly all permittees in Field Area B expressed desire to graze in the fall or winter following a fire, believing

that livestock grazing could curtail annual grass invasion on bare ground in burned allotments. But Field Area B's procedures following fire and development of site-specific ESR plans are guided by a district-wide normal fire rehabilitation plan that states:

Burned but not re-vegetated areas will be closed to livestock grazing for a minimum of two growing seasons following the season in which the wildland fire occurred to promote recovery of burned perennial plants and/or facilitate the establishment of seeded species ... Livestock closures for less than two growing seasons may be justified on a case-by-case basis, based on sound resource data and experience.

Despite the language allowing for case-by-case discretion, BLM and other agency interviewees pointed to the procedures governing postfire rehabilitation as limiting opportunities to experiment with livestock grazing after fire. When asked about factors that are important in making the decision to again authorize grazing on an allotment in Field Area B, a BLM interviewee explained:

A lot comes down to the conditions pre-fire and the relationship that the permittee has with the local field office staff ... if you have a high-trust relationship with that permittee, you can say, "Yeah, go ahead and take care of it. We'll come out and check on it, but just keep your cows off this [burned area]," and you can work off an agreement that way. If you have a permittee with a low trust relationship with the Field Manager, the Field Manager is not going to take that risk. They're going to say, "It's just not worth it. We're going to rest the pasture for another year" (BLM-B-12).

Permittees in Field Area B felt exclusion of grazing after fires was relatively rigid. Although there was agreement among all interviewees in Field Area B regarding annual grass proliferation contributing to poor resource condition and frequent fires, beliefs about the usefulness of grazing to curtail annual grass invasion following a fire, as well as an absence of long-term permittee-agency relationships, were all barriers to adaptive approaches after fire to manage future fire risk.

Field Area C also operated under a programmatic ESR plan that details how site-specific ESR plans are to be developed following individual fires. Terms and conditions for allotment closures are issued in grazing decisions after fires. Although interviewees in Field Area C agreed this often amounted to exclusion of grazing

for two growing seasons, instead of specifying a period of time an allotment must be closed, the programmatic ESR plan contains objectives that must be achieved for grazing to resume in natural recovery areas (i.e., not seeded following a fire), such as amount of bare mineral soil and a qualitative visual assessment of plant vigor. Similarly, Field Area A's land use plan guides postfire rehabilitation and does not specify that livestock grazing should be excluded for two growing seasons after fire. Instead, the document contains resource objectives including one that requires 70% of the cover of native perennial bunch grasses before the fire before livestock grazing can resume.

The "case-by-case" condition in Field Area B's programmatic ESR document and the threshold based on resource condition in Field Areas A and C illustrates that even within formal guidance for postfire rehabilitation, BLM staff had discretion to determine the suitability of livestock grazing and how it might be useful for achieving resource objectives. However, this discretion within formal processes was influenced by informal institutions such as beliefs about resource management and relationships with permittees.

Experience: leadership and staff tenure, knowledge of permittee stewardship

In instances where outcome-based approaches were being used to address fire risk, BLM interviewees usually described working within existing permit terms and conditions or an approved EA (i.e., no new NEPA analysis is required) to overcome staff capacity challenges. These activities included, for example, implementing targeted grazing as a biological control measure to manage fuels buildup under an existing EA and dormant season grazing to remove prior seasons' growth in cases where a permit's season of use includes fall or winter.

Although targeted grazing is authorized in the BLM's grazing regulations to reduce fuel loads when resources on the public lands "are at substantial risk of wildfire" (43 C.F.R. § 4190.1[a][1]), there was widespread agreement from all types of interviewees that targeted grazing to manage fire risk was more acceptable to the public if it were authorized as a fuels treatment rather than through the BLM's grazing program. To overcome this barrier to implementing targeted grazing to reduce fuels, Field Office A opted to authorize targeted grazing as a biological treatment through a vegetation EA implemented by BLM's fuels program (rather than the grazing program), in which "experimental" application of cattle, sheep, or goats are considered a method for managing fuels buildup in designated areas such as roadsides and firebreaks. There had been few public land grazing lawsuits in the field area, and interviewees referenced a culture of experimentation and feelings that they had support from the field manager and district office to test new approaches rather than focus on avoiding lawsuits, "We're really in this gray realm with targeted grazing. How do we authorize it? How do we do the NEPA? I've always been one to exploit those gray areas and say, 'Unless I've got a policy telling me explicitly I can't—I'm going to do it.' That's how we're approaching targeted grazing in this office" (BLM A-18). Field Office A was notably characterized by experienced, long-tenured staff (e.g., the most recently hired RMS had been there for 8 yr) and consistent leadership known in Idaho for engaging in collaborative processes with rangeland users.

There was broad agreement among BLM staff, permittee, and other agency interviewees that an outcome-based approach—even if implemented through existing permit terms and conditions—was only appropriate for trusted permittees with proven records of meeting the BLM's Standards for Rangeland Health. This sentiment was aligned with BLM grazing regulations, which explicitly state that allotment management plans shall, "Specify the limits of

flexibility, to be determined and granted on the basis of the operator's demonstrated stewardship" (43 CFR § 4120.2[a][3]). When authorizing permits for permittees with records of good stewardship, RMS staff in Field Office A reported writing "off dates" in the terms and conditions (i.e., when livestock must be moved out of the allotment) 2 wk later than a permittee has historically needed so that they overlap with the turnout date on the permittee's subsequent allotment in their grazing rotation:

We write the season [of use] just as wide as we think it might need to go. So instead of giving [the permittee] a June 15th date when their [U.S. Forest Service] permit starts on the 16th, we're going to write [their BLM permit] until the 20th or the 25th. They won't actually use that time, but should the Forest Service say, "Hey, the range isn't ready [for livestock grazing]," we can help (BLM-A-08).

They explained that this practice retains the existing stocking rates and AUMs and isn't meant to keep livestock on allotments longer. Rather, it was the field office's strategy to accommodate annual variability and conditions indicative of range readiness while also eliminating the need to complete additional NEPA analysis. This practice in Field Area A was related to supportive leadership, knowledge of permittees with proven histories of meeting Standards for Rangeland Health, and shared understanding between permittees and BLM staff regarding range readiness and overall rangeland resilience to disturbances such as fire; this practice was further supported through formal processes, that is, ensuring that all administrative procedures for livestock permitting were completed via the permit renewal process.

Discussion

Through comparative case studies of three BLM Field Areas in Idaho, we investigated barriers to implementing outcome-based approaches to manage fire risk on Idaho's BLM rangelands. We found that informal and formal institutions, in addition to resource condition within field areas, were mutually reinforcing and, together, affected perceptions of barriers to using outcome-based approaches to manage fire risk (Fig. 2). Our findings are consistent with other scholarship that finds biophysical factors, as well as institutional context, shape the barriers to adaptive management (Reiners 2012). In our study, some field offices used gray zones—areas of interpretation within existing policies and regulations—to manage weeds or fuels. These gray zones were created by formal administrative tools including terms and conditions for grazing permits, planning documents such as ESR following fires, and NEPA documents authorizing tools such as targeted grazing. Our study revealed that informal institutions were influential in whether a field office explored gray zones for OBM implementation. These institutions were related to BLM staff tenure and relationships with permittees, experience and depth of staff knowledge of allotment condition and permittees' histories of stewardship, beliefs about the efficacies of grazing to manage fire risk, and leadership and staff expertise in navigating NEPA and potential lawsuits.

Although all field offices remained, as required, within the sideboards of legislative rules including FLPMA and NEPA, we saw differences in use of administrative tools among our case studies. Administrative tools are formal institutions, but they interact with informal institutions and are products of agency interpretation. Administrative tools created within a field area (e.g., RMPs or EAs) are thus understandably diverse and act differently to expand or restrict gray zones and, thereby, opportunities for adaptive approaches to fire risk management. Field Office A used resource objectives to guide resumption of livestock grazing following fire, written into their land use plan. This gave Field Area A's BLM staff and permittees some latitude to respond to environmental variability and freedom from a one-size-fits-all policy approach

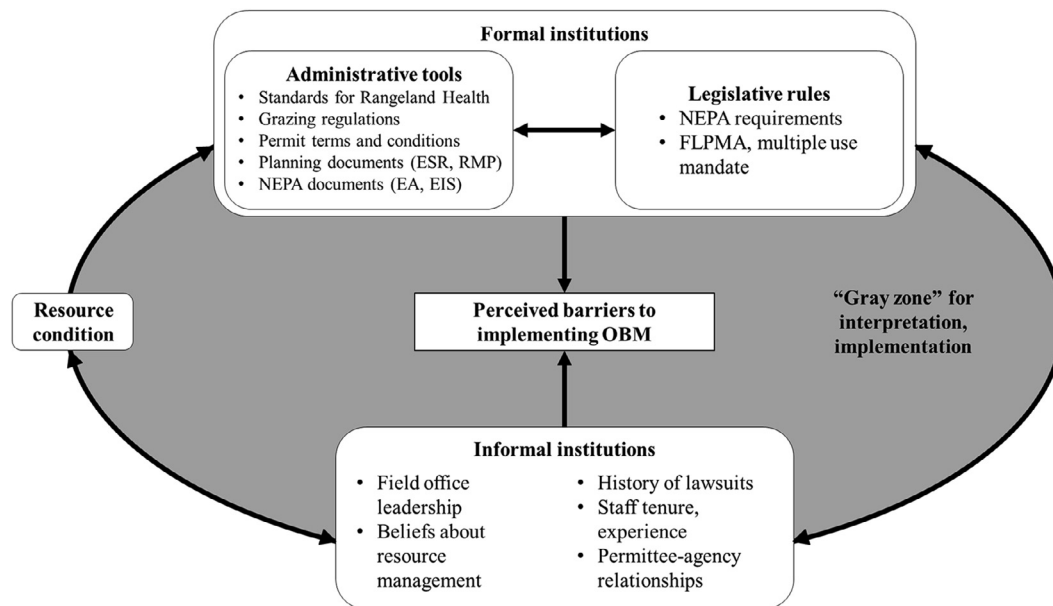


Fig. 2. Conceptual figure of informal and formal institutions and resource conditions. Our study finds they are interactive and mutually reinforcing and create context in which barriers are perceived by study participants. Within these interactions, gray zones of possible adaptation are created. Institutional components interact both within and among the boxes. For example, resource condition informs permit terms and conditions (and vice versa); staff tenure and experience influence permittee-agency relationships.

to authorizing livestock grazing following fire. Field Area B's procedure for livestock grazing following fire was authorized through a programmatic EA specifying ESR procedures. It recommended exclusion of livestock for 2 yr following fire but also offered BLM staff case-by-case discretion. In practice, permittees in Field Area B felt this discretion was rarely used and viewed the relative rigidity in resumption of livestock grazing as a lost opportunity to curtail annual grass invasion and, thereby, fire risk. But Field Office B had high turnover, an absence of long-term permittee-agency relationships, and low capacity as staff tended to other nongrazing interests. These conditions culminated in field office culture that preferred prescriptive, rather than adaptive, approaches to post-fire management despite the provision of "case-by-case" discretion within its administrative tools. Taken together, our findings highlight that even within arenas of discretion for implementing adaptive approaches, agency culture, including the interactions of beliefs about resource use and willingness to experiment, created barriers to adaptive management (Koontz and Bodine 2008; Frohlich et al. 2018).

Scholars agree that adaptive management of dynamic natural systems is in tension with rigid administrative law (Fischman and Ruhl 2016). Indeed, perceived barriers to implementing OBM in Field Areas B and C stemmed from BLM staff feelings that adaptive approaches could not be reconciled with current policies. But our study also shows that this tension may be eased by informal institutions present within field areas and allow agency managers to "see" gray zones. Two of these informal institutions were permittee-agency relationships and beliefs about resource management. When these relationships are absent or beliefs misalign, collaborative adaptive management highlights the roles of participatory processes and stakeholder engagement in building trust among actors, increasing transparency in decision making, and integrating multiple knowledge systems (e.g., Fernández-Giménez et al. 2019; Wilmer et al. 2018). Unlike OBM in Idaho, these formal venues for adaptive management implementation are useful for assembling knowledge from diverse experiences to address multiple actors' goals. Monitoring is also essential to adaptive management; joint monitoring between agency staff and permittees can begin to address differences in beliefs about

resource management (Fernández-Giménez et al. 2005). Furthermore, technical learning between agencies and permittees about the outcomes of management activities can promote ongoing relationships (Williams and Brown 2018).

Agency support and flexibility are necessary for adaptive management (e.g., Benson and Stone 2013); it was here we saw an outsized role for leadership within field areas in implementing outcome-based approaches, especially when those approaches run counter to traditional agency culture (Koontz and Bodine 2008; Archie et al. 2012). Despite perceived risk of OBM incurring lawsuits, leadership and experience emboldened BLM staff in Field Area A to implement experimental fuels reduction via targeted grazing ("Unless I've got a policy telling me explicitly I can't, I'm going to do it"). Field Office A's approach is aligned with Landbergen and Orosz's (1996) concept of "risk taking for a purpose," wherein public managers' use of the gray zone is most effective when it is part of a broader strategic effort (see also Abrams et al. 2018). This broader strategic effort may serve to further refine the boundaries of the gray zone through institutional learning, in which managers reflect on and modify adaptive management components (i.e., decision elements, objectives, and alternatives; Williams and Brown 2018).

Checks on agencies by the courts can also create accountability and consistency in agency discretion. However, perceived risk of litigation can also act as a force to stifle adaptive approaches (Schultz 2008; Bjorkland 2013; Craig and Ruhl 2014). In our study, a history of frequent litigation over public lands grazing in the field areas or Idaho more generally (e.g., Lewin et al. 2019) led some BLM staff, particularly in Field Area C, to prioritize lawsuit avoidance over OBM implementation because of uncertainty in legal outcomes. Activities that are viewed as too politically or logistically difficult are known to constrain adaptive management; managers faced with such conditions often instead opt for "small-scale management experiments," which can improve management "around the edges" (Allen and Gunderson 2011; 1382). Within the context of our study, we see Field Office C carrying out this approach by experimenting within the gray zone where the legal risk is perceived to be relatively low (e.g., changes in season of use but not large increases in AUMs). To manage legal risk in adaptive manage-

ment approaches, agencies that define clear processes to achieve the desired outcomes, monitoring thresholds, and actions triggered by thresholds are prepared to withstand scrutiny under substantive and procedural law (Allen et al. 2011; Fischman and Ruhl 2016).

Lawsuits or further legislative action can be useful for clarifying policy and making the gray zone explicit (Landsbergen and Orosz 1996; Allen et al. 2011). However, clarifying or formalizing actions within the gray zone can potentially shrink areas of implementation discretion. This tension is fundamental in rangeland governance: In a complex and dynamic system, it is difficult to develop formal institutions that effectively protect resources but also include legal avenues for experimentation and adaptation to uncertainty (Reiners 2012). Although some interviewees in our study were reluctant to implement outcome-based approaches given its inherent uncertainties, further clarifying OBM through lawsuits, legislative actions, or implementation guidelines (i.e., institutionalization; Moseley and Charnley 2014) may restrict the very purpose of OBM, that is, to escape a one-size-fits all approach to grazing administration and adaptively respond to place-specific challenges.

Implications

OBM is a recent experimental initiative meant to advance adaptive management approaches to respond to annual variability on BLM rangelands. We find that informal institutions such as field area leadership, agency culture, permittee-agency relationships, and history of litigation interact with formal institutions such as NEPA procedures and grazing regulations and create perceptions of barriers or opportunities for implementation. Our study highlights the role of informal institutions in implementing OBM; differences in the informal institutions among field areas lead to different interpretations of latitude found within formal institutions (gray zones) and, thus, different perceptions of the feasibility of OBM implementation. The findings here suggest promising avenues for adaptive management in public lands contexts—a setting characterized by formalization and bureaucracy—but show less promise if local agency offices lack leadership inclined to experiment, experienced staff, relationships with resource users, or shared beliefs regarding resource management challenges.

This research also has implications for public land management beyond grazing and fire risk management. First, in a complex governance system, it is important to continue to assess types of barriers to implementation and how they can be addressed; our findings indicate that barriers were not solely derived from inflexible federal policy but rather came from both interpretations of latitude found within administrative tools and informal institutions at play within field areas. Second, although substantive policies can set parameters for policy implementers, our study indicates that in the absence of formal policy (i.e., legislative rules) on OBM implementation, informal institutions, such as permittee-agency relationships, shared understandings of desired outcomes and how to achieve them, and leadership committed to experimentation within the gray zone, have a role in either reinforcing or overcoming implementation barriers.

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.

Acknowledgments

We gratefully acknowledge BLM staff, grazing permittees, and other agency and NGO interviewees in the Idaho Falls, Twin Falls, and Boise BLM Districts for their participation in this study.

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.rama.2021.04.007.

References

- Abatzoglou, J.T., Kolden, C.A., 2011. Climate change in western US deserts: potential for increased wildfire and invasive annual grasses. *Rangeland Ecology & Management* 64, 471–478.
- Abrams, J., Wollstein, K., Davis, E.J., 2018. State lines, fire lines, and lines of authority: rangeland fire management and bottom-up cooperative federalism. *Land Use Policy* 75, 252–259.
- Allen, C.R., Gunderson, L.H., 2011. Pathology and failure in the design and implementation of adaptive management. *Journal of Environmental Management* 92, 1379–1384.
- Allen, C.R., Fontaine, J.J., Pope, K.L., Garmestani, A.S., 2011. Adaptive management for a turbulent future. *Journal of Environmental Management* 92, 1339–1345.
- Allen, C.R., Angeler, D.G., Fontaine, J.J., Garmestani, A.S., Hart, N.M., Pope, K.L., Twidwell, D., 2017. Adaptive management of rangeland systems. In: Briske, D.D. (Ed.), *Rangeland systems: processes, management and challenges*. Springer Nature, Cham, Switzerland, pp. 373–394.
- Archie, K.M., Dilling, L., Milford, J.B., Pampel, F.C., 2012. Climate change and western public lands: a survey of U.S. federal land managers on the status of adaptation efforts. *Ecology and Society* 17, 20.
- Balch, J.K., Bradley, B.A., D'Antonio, C.M., Gomez-Dans, J., 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980–2009). *Global Changes in Biology* 19, 173–183.
- Benson, M.H., Stone, A.B., 2013. Practitioner perceptions of adaptive management implementation in the United States. *Ecology and Society* 18, 32.
- Bjorkland, R., 2013. Monitoring: the missing piece: a critique of NEPA monitoring. *Environmental Impact Assessment Review* 43, 129–134.
- Boyd, C.S., Svejcar, T.J., 2009. Managing complex problems in rangeland ecosystems. *Rangeland Ecology & Management* 62, 491–499.
- Bureau of Land Management (BLM), 2020a. Idaho Fire Information. Available at: <https://www.blm.gov/programs/public-safety-and-fire/fire-and-aviation/regional-info/idaho>. Accessed 13 July 2020.
- Bureau of Land Management (BLM), 2020b. Public land statistics 2019. Available at: <https://www.blm.gov/about/data/public-land-statistics>. Accessed 13 July 2020.
- Bureau of Land Management (BLM), 2017. BLM offers livestock operators increased flexibility through outcome-based grazing authorizations (press release). Department of the Interior Available at: <https://www.blm.gov/press-release/blm-offers-livestock-operators-increased-flexibility%C2%A0through-outcome-based-grazing>.
- Christiansen, T., Neuhold, C., 2012. *International handbook on informal governance*. Edward Elgar, Northampton, MA, USA 574 pages.
- Coates, P.S., Ricca, M.A., Prochazka, B.G., Brooks, M.L., Doherty, K.E., Kroger, T., Blomberg, E.J., Hagen, C.A., Casazza, M.L., 2016. Wildfire, climate, and invasive grass interactions negatively impact an indicator species by reshaping sagebrush ecosystems. *PNAS* 113, 12745–12750.
- Craig, R.K., Ruhl, J.B., 2014. Designing administrative law for adaptive management. *Vanderbilt Law Review* 67, 1–88.
- Davies, K.W., Boyd, C.S., Bates, J.D., Hulet, A., 2015a. Dormant season grazing may decrease wildfire probability by increasing fuel moisture and reducing fuel amount and continuity. *International Journal of Wildland Fire* 24, 849–856.
- Davies, K.W., Boyd, C.S., Bates, J.D., Hulet, A., 2015b. Winter grazing can reduce wildfire size, intensity and behavior in a shrub-grassland. *International Journal of Wildland Fire* 25, 191–199.
- Davies, K.W., Gearhart, A., Boyd, C.S., Bates, J.D., 2017. Fall and spring grazing influence fire ignitability and initial spread in shrub steppe communities. *International Journal of Wildland Fire* 26, 485–490.
- Diamond, J.M., Call, C.A., Devoe, N., 2009. Effects of targeted cattle grazing on fire behavior of cheatgrass-dominated rangeland in the northern Great Basin, USA. *International Journal of Wildland Fire* 18, 944–950.
- Diamond, J.M., Call, C.A., Devoe, N., 2012. Effects of targeted grazing and prescribed burning on community and seed dynamics of a downy brome (*Bromus tectorum*)-dominated landscape. *Invasive Plant Sci. Management* 5, 259–269.
- Fernández-Giménez, M.E., McClaran, S.J., Ruyle, G., 2005. Arizona permittee and land management agency employee attitudes toward rangeland monitoring by permittees. *Rangeland Ecology & Management* 58, 344–351.
- Fernández-Giménez, M.E., Augustine, D.J., Porensky, L.M., Wilmer, H., Derner, J.D., Briske, D.D., Stewart, M.O., 2019. Complexity fosters learning in collaborative adaptive management. *Ecology and Society* 24, 29.
- Fischman, R.L., Ruhl, J.B., 2016. Judging adaptive management practices of U.S. agencies. *Conservation Biology* 30, 268–275.
- Frohlich, M.F., Jacobson, C., Fidelman, P., Smith, T.F., 2018. The relationship between adaptive management of social-ecological systems and law: a systematic review. *Ecology and Society* 23, 23.
- Hruska, T., Huntsinger, L., Brunson, M., Li, W., Marshall, N., Oviedo, J.L., Whitcomb, H., 2017. Rangelands as social-ecological systems. In: Briske, D.D. (Ed.), *Rangeland systems: processes, management and challenges*. Springer Nature, Cham, Switzerland, pp. 263–302.
- Keen, M., Mahanty, S., 2006. Learning in sustainable natural resource management: challenges and opportunities in the Pacific. *Society and Natural Resources* 19, 497–513.

- Koontz, T.M., Bodine, J., 2008. Implementing ecosystem management in public agencies: lessons from the U.S. Bureau of Land Management and the Forest Service. *Conservation Biology* 22, 60–69.
- Landsbergen, D., Orosz, J.F., 1996. Why public managers should not be afraid to enter the "gray zone.". *Administration & Society* 28, 238–265.
- Lewin, P.A., Wulforst, J.D., Rimbey, N.R., Jensen, K.S., 2019. Implications of declining grazing permits on public land: An integrated social and economic impact analysis. *Western Economic Forum* 17, 86–97.
- Lewis-Beck, M.S., Bryman, A., Liao, T.F., 2004. *The SAGE encyclopedia of social science research methods*. SAGE Publications, Thousand Oaks, CA, USA 1528.
- Maxwell, J.A., 1996. *Qualitative research design: an interactive approach*. SAGE Publications, Thousand Oaks, CA, USA 153.
- Moseley, C., Charnley, S., 2014. Understanding micro-processes of institutionalization: stewardship contracting and national forest management. *Policy Science* 47, 69–98.
- National Interagency Fire Center (NIFC). 2020. *Wildfires larger than 100,000 acres (1997-2019)*. Available at: https://www.nifc.gov/fireInfo/fireInfo_statistics.html. Accessed 13 July, 2020.
- Reiners, D., 2012. Institutional effects on decision making on public lands: an inter-agency examination of wildfire management. *Public Administration Review* 77, 177–186.
- Schlager, E., Cox, M., 2018. The IAD framework and the SES framework: an introduction and assessment of the Ostrom Workshop frameworks. In: Weible, C.M., Sabatier, P.A. (Eds.), *Theories of the policy process*. Westview Press, Boulder, CO, USA, pp. 215–252.
- Schultz, C., 2008. Responding to scientific uncertainty in U.S. forest policy. *Environmental Science Policy* 11, 253–271.
- Schultz, C.A., McCaffrey, S.M., Huber-Stearns, H.R., 2019. Policy barriers and opportunities for prescribed fire application in the western United States. *International Journal of Wildland Fire* 28, 874–884.
- Strand, E.K., Launchbaugh, K.L., Limb, R., Torell, L.A., 2014. Livestock grazing effects on fuel loads for wildland fire in sagebrush dominated ecosystems. *Journal of Rangeland Applications* 1, 35–57.
- Walters, C., 1986. *Adaptive management of renewable resources*. McMillan Publishing Company, New York, NY, USA 374.
- Williams, B.K., Brown, E.D., 2018. Double-loop learning in adaptive management: the need, the challenge, and the opportunity. *Environmental Management* 62, 995–1006.
- Wilmer, H., Derner, J.D., Fernández-Giménez, M., Briske, D.D., Augustine, D.J., Porensky, L.M. the CARM Stakeholder Group, 2018. Collaborative adaptive rangeland management fosters management-science partnerships. *Rangeland Ecology & Management* 71, 646–657.
- Yin, R.K., 2014. *Case study research: design and methods*. SAGE Publications, Thousand Oaks, CA, USA 282.