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Factors influencing wildfire management decisions after the 2009 US federal policy update

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ABSTRACT

Background. The decision making process undertaken during wildfire responses is complex and prone to uncertainty. In the US, decisions federal land managers make are influenced by numerous and often competing factors. **Aims.** To assess and validate the presence of decision factors relevant to the wildfire decision making context that were previously known and to identify those that have emerged since the US federal wildfire policy was updated in 2009. **Methods.** Interviews were conducted across the US while wildfires were actively burning to elucidate time-of-fire decision factors. Data were coded and thematically analysed. **Key results.** Most previously known decision factors as well as numerous emergent factors were identified. **Conclusions.** To contextualise decision factors within the decision making process, we offer a Wildfire Decision Framework that has value for policy makers seeking to improve decision making, managers improving their process and wildfire social science researchers. **Implications.** Managers may gain a better understanding of their decision environment and use our framework as a tool to validate their deliberations. Researchers may use these data to help explain the various pressures and influences modern land and wildfire managers experience. Policy makers and agencies may take institutional steps to align the actions of their staff with desired wildfire outcomes.

Keywords: agency administrators, decision making, framework, managed fire, risk, strategy, suppression, US federal policy, wildland fire, USDA Forest Service.

Introduction

The increase in global wildfire activity in many regions where people live (Bowman *et al.* 2017) has brought into public focus the need for wildfire management and the need to better understand how to improve wildfire management outcomes. Significant scientific attention has been invested in understanding wildfire behaviour and ecology (Shuman *et al.* 2022), but less is known about the various decision making processes of wildfire management (Fillmore *et al.* 2021; Thompson *et al.* 2023). It remains uncertain how and why different management strategies are chosen to manage a wildfire, in large part because the decision making process of key actors must account for an often overwhelming range of elements (Cortner *et al.* 1990; Thompson 2014; Fillmore *et al.* 2021). The elements that complicate informed decisions include a high level of uncertainty related to incomplete information (Borchers 2005), the need to make time-compressed decisions (O'Connor *et al.* 2016), rapidly evolving physical and sociopolitical risks (Parsons *et al.* 2003; Thompson 2014), the presence of internal and external political pressures (Steelman and McCaffrey 2011; Steelman 2016), uncertainty about whether needed firefighting resources will be available (Katuwal *et al.* 2017), and difficulty in communicating both timely and accurate information (Steelman *et al.* 2015).

An important decision within any wildfire incident is to develop the primary management strategy under which the wildfire will be managed. Along with the above described complications, this decision must consider existing federal wildfire policy that has shifted over time. With some exceptions, the United States (US) has largely followed the practice of controlling all wildfires as quickly as possible. This approach softened over time and formally shifted in 1995 to the first national wildland fire policy that included room for strategies that do not seek to immediately suppress every wildfire. See Hyde *et al.* (2017) for a detailed timeline of this and other related US wildland fire management policies. The 2009 update to the 1995 US federal wildland fire policy established that every wildfire ignition will generate a response. Associated actions that follow are to be 'based on ecological, social, and legal consequences of fire' (USDA and USDI 2009). The appropriate wildfire response is determined by 'the circumstances under which a fire occurs and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and values to be protected' (Philpot *et al.* 1995). The 2009 policy update further differentiates wildfire into two specific categories: planned and unplanned. Planned fires are intentionally ignited by managers to achieve an objective related to resource or value protection and are more commonly known as prescribed fires (Kolden 2019; Hiers *et al.* 2020). Unplanned fires are those ignited by natural means or through the accidental or malicious action of humans. The 2009 update requires that the initial response is to suppress and extinguish all unplanned human-caused fires as efficiently and safely as possible (USDA and USDI 2009; Stephens *et al.* 2016). This strategy is generally known as 'full suppression'. Unplanned wildfires may be managed to achieve one or more objectives at the same time and these are adjustable throughout the course of a wildfire to meet changing circumstances (USDA and USDI 2009). Prior to 2009, fire policy allowed wildfires to be managed for either suppression or resource benefit, but not both simultaneously (National Wildfire Coordinating Group (NWCG) 2001).

Naturally ignited wildfires may also be managed to achieve natural resource benefit objectives if allowable within local Land Management Plans (Miller *et al.* 2012). In general, this means implementing a response strategy that does not aim to fully suppress the wildfire as soon as possible. This strategy is reported in the Incident Management Situation Report (NIFC n. d.) as 'managed with a strategy other than full suppression (OTFS)'. Examples of resource benefit objectives include restoring wildfire regimes (North *et al.* 2012), reducing fuel loading (Hunter *et al.* 2011; North *et al.* 2021), improving wildlife habitat (Reid and Fuhlendorf 2011) and improving watershed functioning (Stevens *et al.* 2020).

Although the current US policy allows naturally ignited fires to be managed for resource benefit objectives, it is ambiguous regarding when and where the appropriate use of this strategy should be employed, which allows fire managers wide latitude in its application (Seielstad 2015). Although this wide decision space was intended to create more opportunity for multiple objectives to be utilised on a wildfire, particularly in areas outside designated wilderness areas, there is some evidence the opposite effect has occurred. This suggests that managers are operating in a risk-averse manner regarding the use of wildfire to achieve resource benefits and highlights the need to better understand its associated decision making process (Seielstad 2015; Young *et al.* 2020; Iniguez *et al.* 2022).

Research background

Numerous actors contribute information and influence the decision making process on wildfires burning on US federal lands. These include agency staff, Incident Commanders (ICs), cooperating agencies, publics and politicians. However, only federal Agency Administrators (AAs) possess delegated authority within the Executive Branch to oversee programs derived from Executive Branch and Congressional direction (Lawton 1954). AAs are responsible for overseeing all aspects of wildfire preparation and response. During wildfire events, AAs are responsible for providing the overall intent about the strategy under which a fire is to be managed and ensure consistency with law and policy. They also possess the delegated authority to sign legal decision documents for the fire (Noonan-Wright *et al.* 2011). Understanding the factors these AAs and their fire management staff consider when making decisions, particularly when defining their intent for a discrete wildfire event, is important because tensions may arise if policies are not aligned with the motivations or institutional norms of decision makers. A more complete understanding of decision factors will allow future policies and strategic decision making tools to incorporate the realities of the decision environment and potentially lead to better outcomes. Research into how managers make decisions on wildfires has used a range of methodological approaches and research foci. Studies that have examined the Wildland Fire Decision Support System (WFDSS), a tool developed expressly to guide decisions on federal lands, have shown that rather than being part of the actual decision process, it is most often used to document cognitive decisional processes. However, tools embedded within WFDSS were shown to be useful to validate any *a priori* assumptions or to examine alternative scenarios (Noble and Paveglio 2020; Rapp *et al.* 2020; Fillmore and Paveglio 2023). Other studies have employed 'choice set' surveys that present decision makers with multiple alternatives to choose from to determine their risk preferences. In one 'choice experiment', Calkin *et al.* (2012) found that social and institutional pressures can lead to increased suppression expenses. A follow-up study using the same choice set found that managers' strategy selection was inconsistent with minimising expected losses and that they might over-allocate resources in low-risk scenarios (Wibbenmeyer *et al.* 2013). Studies focused on whether various heuristics and biases influence wildfire management decisions suggest biases such as discounting, status quo and risk aversion may contribute to suboptimal wildfire outcomes (Maguire and Albright 2005; Wilson *et al.* 2011; Thompson 2014). Heuristics such as Recognition Primed Decision Making (RPD) are seen as especially prevalent in the wildfire context owing to the need to make rapid decisions with limited information (Zimmerman 2011). Case studies have also been useful to explore decision making. For example, Steelman and McCaffrey (2011) found that even when there were divergent viewpoints, early communication between agencies and the public provided a common understanding that emerged over time. Econometric studies have repeatedly found that incentives exist to implement risk-averse strategies despite those strategies tending to be financially unoptimised (Hand *et al.* 2015; Katuwal *et al.* 2017).

A recent review (Fillmore *et al.* 2021) of published research that examined decision making factors related to wildfires managed with a strategy intended to achieve resource objectives found 110 individual factors that influence the decision to either suppress a fire or manage it with an OTFS strategy. These factors were categorised as barrier, facilitator, or unaligned to either. They were also assigned to one of six overarching key thematic areas (KTAs): *Fire Environment*, *Fire Outcomes*, *Institutional Influences*, *Operational Considerations*, *Sociopolitical Considerations* and *Perceived Risk*. Together, KTAs and decision factors were organised into a decision framework to help conceptualise the association between related but discrete prominent thematic considerations. The framework provides a useful leverage point for understanding current decision processes. However, all literature available predated the 2009 policy update, which raises the question of the degree to which the current decision environment has or has not changed.

This study seeks to answer the following questions:

1. Among AAs and fire managers, what factors are being considered in the wildfire decision making process, and how do they affect decisions that are being made?
2. Can we verify the presence of pre-2009 wildfire decision making factors identified in Fillmore *et al.* (2021) within the current post-2009 policy context?
3. Can we detect differences associated with the decision to fully suppress a fire or manage it for objectives other than full suppression?

Methods and analysis

To answer the research question, interviews focused on key decision makers responsible for managing a wildfire known to be actively burning. A series of semi-structured interviews with these decision makers and fire managers was conducted throughout the 2021 US fire season. A hybrid inductive–deductive analysis methodology was used to validate the presence or absence of decision factors found in the 2021 paper and identify any new decision factors that have emerged within the post-2009 policy context.

The primary interview sample was the AA on each identified fire who met our selection criteria, although in select cases, individuals who were operationally involved in the fire or who contributed to its planning were interviewed (Fig. 1). Interviewers spoke with AAs and fire managers

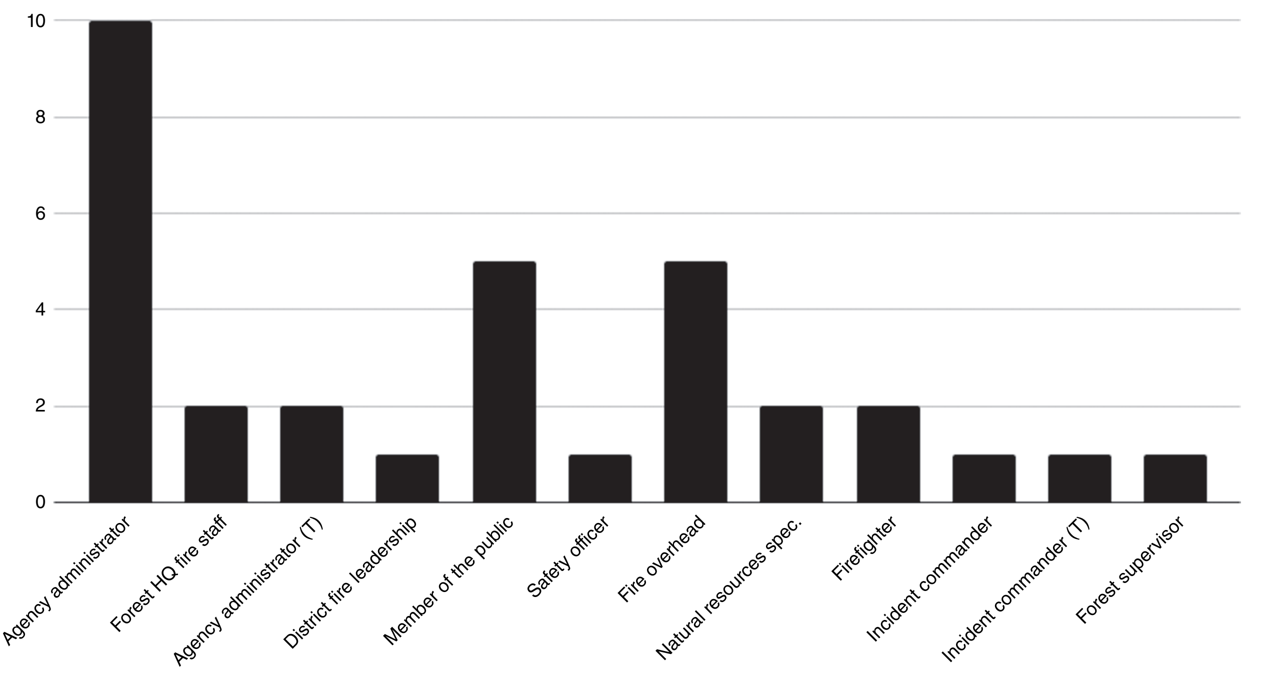

Fig. 1. Distribution of interview participants shown by incident position (HQ, headquarters; T, trainee; spec., specialist).

(defined as anyone associated with wildfire decision making other than the AA, such as a professional fire staff) during fires that were being managed under a variety of strategies and were particularly interested in discussing why one strategy (or set of strategies) was implemented versus other available options. In some cases, interviews were conducted with a small subset of the public affected by our case fires. However, their interview data were only incorporated into the results to the degree that they provided additional social context.

Potential case fires were initially identified based on inclusion criteria that the fire (1) was less than 50% contained or completed, and (2) reflected characteristics indicating that it could have been managed with an OTFS strategy (regardless of whether it was or not). These characteristics were guided by the professional experience of the lead author and by features such as proximity to wilderness, elevation, known culture of fire use and seasonality. Interviews were conducted while the fire was still burning, when participants did not yet know what the outcome of their decisions were, to minimise potential hindsight bias and to increase focus on the factors and biases present within the actual decision making process. Researchers sought to avoid conversations that incorporated aspects of inevitability and foreseeability as these would potentially lead interview data to aspects of decision validation not relevant to the real-time decision considerations we were interested in exploring (Roese and Vohs 2012).

Primary study participants were initially contacted directly through phone calls or enterprise messaging software. Following contact, a short evaluation interview was conducted to verify the inclusion criteria, after which a full interview was arranged, or further contact was terminated. Most interviews were conducted via phone or video teleconference, with 18 interviews conducted on site, which allowed researchers to both contextualise the fire environment and explore lines of questioning based on personal observations of the fire conditions. The sample frame focused on USDA Forest Service (USFS) AAs with delegated oversight of the wildfire to which the interview pertained. The reason for focusing on USFS participants was twofold. The first related to methodological accessibility in that the lead researchers were employed by the USFS, which brought an inherent level of credibility when approaching participants for an interview. This in turn increased trust and allowed conversations to flow with high levels of mutual understanding. Second, the sampling frame was restricted to the USFS to allow cross-case thematic comparisons without having to account for cultural differences influenced by institutional histories. In-person interviewing was initially facilitated by remote contact, but once on site, followed a purposive-snowballing recruitment strategy (Seidman 2013). All interviews were conducted under the provision of anonymity in accordance with human subject research and were overseen by the University of Idaho Institutional Review Board. Interview data included participants from the Rocky Mountain, Southwest, Intermountain, Pacific Southwest and Southern USFS Regions. Field interviews were conducted in the Southwestern and Pacific Southwest Regions. Recruitment and interviews began in April 2021 and continued until theoretical saturation was achieved in September 2021. Theoretical saturation occurs when researchers agree no new major themes or ideas are becoming apparent from subsequent interviews (Bryman 2015).

A semi-structured interview protocol was used to ensure consistent questions were asked of all respondents, while also allowing for follow-up or probing questions to explore the emergence of new ideas (Patton 2002; Bryman 2015). Interviews lasted between 24 and 108 min and averaged 58 min in length. Telephone interviews were recorded using the NoNotes application. Interviews conducted via the video teleconference software Microsoft Teams were securely recorded within the program. In-person interviews were recorded by a Phillips digital recording device. Interviews were transcribed verbatim using the Rev.com transcription service. A total of 44 interviews with 33 people across 15 fire cases were conducted, accounting for approximately 47 h of discussion. On several fires that burned for long periods, the same participant was interviewed multiple times. To avoid over-representing data provided by these participants, all coding associated with a participant and an individual fire case were consolidated into a single file. For example, if a participant expressed concern that a community might be impacted in the first interview, that factor was likely to be repeated in subsequent interviews and inflate its overall presence relative to other codes. Combining interview files prevented the numeric file count from being artificially inflated while retaining the overall reference count in the qualitative analysis software. This reduced 44 total interviews into 36 files.

Data were analysed using the QSR Nvivo Windows (Release 1) qualitative coding software (QSR International 1999). An iterative, hybrid inductive–deductive and multistage coding process guided by principles of thematic analysis, analytic induction and deductive discovery was used (Boyatzis 1998; Ryan and Bernard 2000). Coding took place in three main phases, with each phase representing a separate analysis of the data and discussion about consistency among the researchers to ensure reliability. The first phase of coding was conducted deductively by assigning each distinct segment of respondent dialogue in the interview transcript data to one or more of six topic codes (Richards 2014). Coding was initially guided by a pre-defined codebook adapted from the topic codes described as six KTAs in Fillmore et al. (2021). KTA topic codes are *Fire Environment*, *Fire Outcomes*, *Operational Considerations*, *Sociopolitical Considerations*, *Institutional Influences* and *Perceived Risk*. Each of the initial six topic codes were assigned to three categories: *barriers*, *facilitators* or *unaligned*, for a total of 18 topic codes. Barriers serve to persuade the decision away from managing a wildfire; these were often obstacles that needed to be mitigated. Facilitators make the decision easier for fire managers who wish to manage a fire for OTFS. Unaligned factors exist as a consideration but have no clear effect on the decision on a particular fire and are likely context-dependent in their influence.

The second round of coding used both deductive and inductive reasoning to assign descriptive codes to interview data. This process looked within the data to identify patterns in the perspectives or experiences articulated by respondents (Gibbs 2007; Richards 2014). Descriptive codes equate to factors considered by AAs or fire managers when deciding which fire management strategy to employ for the fire being discussed. Deductive coding was used when a factor was seen that had been seen in the pre-existing codebook. Inductive coding was used when new decision factors were observed and added to the codebook.

Interrater reliability was conducted during the topic coding stages (Boyatzis 1998; McHugh 2012). A subset of transcripts was independently coded and then compared. Observed disagreements within topic coding strategies were discussed among the raters. Refinements to the coding rules continued until the Cohen's Kappa values for each KTA topic code met or exceeded 0.6 (Nichols *et al.* 2010; Gisev *et al.* 2013).

The final stage of 'analytic coding' allowed inconsistent or outlier decision factor codes to be refined into thematic areas with greater represented consistency. It also helped identify consistent relationships among the descriptive codes articulated by respondents, including any similarities or differences among respondents (Saldaña 2016).

Results

We found that many of the pre-2009 decision factors were still being considered by fire managers. Of the original 110 decision factors, 30 barriers, 30 facilitators and 22 unaligned factors were still present. While 68 new decision factors emerged, 28 previous factors were not observed. In total, 150 decision factors were found to be operating in the current wildfire decision making context (Tables 1–6).

Table 1. Fire Environment KTA decision factors.

Fire environment		
Facilitators	**Unaligned**	**Barriers**
Favourable fire behaviour conditions	Expected weather	Fire conditions unfavourable
Fuel conditions favourable	Fuel type and condition	***Fuel conditions not favourable***
Favourable fire weather conditions	***Is it the 'perfect' environment***	***Presence of drought prevents***
Previous fuel reduction work	Drought Index	***New fire environment – climate change***

Factors are listed in descending order of frequency within each facilitator, unaligned and barrier KTA box. Factors shown in bold italic are identified in this analysis but not in Fillmore *et al.* (2021).

Table 2. Fire Outcome KTA decision factors.

Fire outcomes		
Facilitators	**Unaligned**	**Barriers**
Reduction in fuel	***Expected fire effects***	Air quality – public impact
Good outcomes despite drought	Air quality concerns	Uncertainty of outcome
Improvement to forest health and ecology	***Impacts to grazing allotments***	***Previous bad experiences***
Fire will spread unassisted	***Meeting fuels acre targets***	***Worry of killing trees***
Allow natural processes	***Considering watershed effects***	***Result of past practices***
Expected reduction in smoke impact	Expected fire behaviour	***Smoke impacts to wildlife***
Snags are reduced		***Don't manage if it wouldn't grow on its own***

Factors are listed in descending order of frequency within each facilitator, unaligned and barrier KTA box. Factors shown in bold italic are identified in this analysis but not in Fillmore *et al.* (2021).

Table 3. Operational Consideration KTA decision factors.

Operational considerations		
Facilitators	**Unaligned**	**Barriers**
Bringing in a Type 3 Incident Management Team	***Using 'big box' strategy***	Lack of resources
Understanding of local area	Resource availability	Insufficient ignitions
Previous fires make it easier	***Tactics for achieving effects***	Fatigue length of time required
Having enough resources	Planning support	Ownership boundaries
Working in a large land base	***Working with IMTs***	***Too early in the season***
	Expected duration of fire event	
	Experience with fire	
	Proximity to boundary	
	Fatigue of staff	
	Influence of wilderness	
	Coordination is in place	
	Preparedness level	
	Amount of fire allowable	

Factors are listed in descending order of frequency within each facilitator, unaligned and barrier KTA box. Factors shown in bold italic are identified in this analysis but not in Fillmore *et al.* (2021).

This is 40 more than found in the pre-2009 context (Fillmore *et al.* 2021), which suggests that wildfire decision complexity is increasing over time. Unaligned factors increased the most (28 new), which suggests that the decision environment is also increasing in ambiguity. Although identifying missing factors was not within the scope of this research, a basic review found thematic clusters related to financial concerns specific to the pre-2009 policy context, some indication that air quality concerns were shifting away from regulations and towards impacting the public (as seen in our data), and broadening interest in the ecological role of fire instead of specific discipline-based foci.

Overall, the six KTAs operated in the same manner within the contemporary policy context as in Fillmore *et al.* (2021). As before, fire environment factors related to local physical conditions that influenced the decision making process and fire outcome factors were related to the potential positive and negative effects of a fire. These outcomes manifested at different temporal and spatial scales. Operational considerations were driven by the amount and kinds of firefighting resources available to the decision maker. Sociopolitical factors focused on a range of considerations associated with various external stakeholders such as recreational users, adjacent landowners, cooperating agencies and businesses dependent on public lands. Institutional influences are those considerations and pressures that exist internally in the decision maker's agency. Perceived risk was expressed as the level of personal and professional risk decision makers were willing to accept.

Table 4. Sociopolitical KTA decision factors.

Sociopolitical factors		
Facilitators	**Unaligned**	**Barriers**
Collaborative relationships in place	***Media and public interactions***	***The public is afraid of fire***
Public supports	***Relationship building***	Lack of public support
Easier to manage when conversations are had early	Opportunity to educate the public	Political fallout concern
Mitigating impacts to cooperators	***Classifying fire 'types'***	***The public expects to see suppression***
The public advocates for using fire	***Being responsive to public input***	Conflict with cooperators
Communication related to the event	***Pressure from tribal groups***	Economic impact
Public has been educated	***Managing 'optics'***	***Can't talk about benefits in a suppression fire***
Education opportunity for the public	Impact to recreational users	***Negative public health impacts***
	Public support	***Criminal activity makes firefighting unsafe***
	Political support	***Public has not been prepared***
	Impact to cooperators and neighbours	
	Nomenclature may be confusing	

Factors are listed in descending order of frequency within each facilitator, unaligned and barrier KTA box. Factors shown in bold italic are identified in this analysis but not in Fillmore *et al.* (2021).

Table 5. Institutional Influence KTA decision factors.

Institutional influences		
Facilitators	**Unaligned**	**Barriers**
Culture of fire use	***Cultural shifts in the workforce***	***Suppression as baseline***
Planning completed	***AA taskbooks***	Policy as a barrier
Agency supports	***Strategy nomenclature***	***Chief's letter as a barrier***
Technology and data support	Fire cause	Culture not normalised to fire use
Shift to defending to put it out	Agency support	***Impact of hiring practices***
Peer recognition	***Need to coordinate with 'ologists'***	Lack of agency support
More outcome focused planning	***Balancing policy***	Reporting accomplishments
Environmental Analysis has been completed	***Cost related***	Local–regional prohibitions
Policy supports natural role of fire	***IMT related***	Post-fire rehabilitation – no money
	Policy details	

Factors are listed in descending order of frequency within each facilitator, unaligned, and barrier KTA box. Factors shown in bold italic are identified in this analysis but not in Fillmore *et al.* (2021).

Table 6. Perceived Risk KTA decision factors.

Perceived risk		
Facilitators	**Unaligned**	**Barriers**
Would have been unsafe to staff	***Decision making processes***	Threat to private property
Presence of snags leads to indirect	***Desire to see critical thinking***	Bias for suppressing wildfire
Personal ethic supporting OTFS	***Managing risk first***	Generalised risk aversion
Risk sharing	Risk to infrastructure	Threat to natural resources
Willing to take on the risk	***The five 'rights'***	Liability concerns
Resource benefit and safety	Confidence in staff	Threat to infrastructure
Low values at risk allow it	***Risk equation has changed***	***Risk of losing public support***
Would have been unsafe to go direct	Risk to natural resources	Concern about career advancement
Personal satisfaction	Acceptable risk levels	Threat to public safety
	Risk to firefighters on the fire	Stigma of failure
	Risk of escaping boundary	Threat to firefighters
	Agency Administrator satisfaction with the plan	***Can't manage owing to national need***
	Risk to human life	Lack of fire familiarity to be comfortable
		Lack of incentive
		Threat to reputation

Factors are listed in descending order of frequency within each facilitator, unaligned and barrier KTA box. Factors shown in bold italic are identified in this analysis but not in Fillmore *et al.* (2021).

Fire environment

When looking at the KTA of the fire environment, favourable expected fire behaviour, weather forecasts and fuelbed conditions acted as a facilitator when they were expected to contribute to favourable fire conditions (Table 1). Favourable fire behaviour was frequently described as slow to moderate rates of spread and low flame lengths and fireline intensities. Favourable weather conditions were weak winds, high humidity and moderate temperatures. Fires were more likely to be managed for OTFS when the fuel conditions were not too far from their historic range of conditions or had been reduced through prior fuels reduction work. Unaligned factors appeared to operate as background contextual elements, consisting of factors that were considered prior to new wildfire ignitions, and had no inherent indication of how they might ultimately influence the final decision. Here, the presence or magnitude of ongoing drought was considered, as were general weather and fuel condition trends. Several AAs offered their preferred environment under which to manage a fire for OTFS. One AA described the 'perfect fire' as one that:

> …occurs probably in the middle of a wilderness area to where it's got a lot of land around it. It's not going to move. It's not going to threaten a whole lot of value. It's not going to threaten communities. It's not going to threaten a community's infrastructure or water systems or power grid. And it would be one that would start late in September. Later in the year when we've got cooler temperatures at night, where relative humidities are improving and shorter days. Or one that starts maybe a little bit earlier in the season, but it's surrounded by snow pack.

Barriers in the fire environment were mainly made up of newly identified, and often interrelated, factors related to the fuelbed, climate change and drought. Fuel beds were frequently discussed as overly dense or with too much accumulation to manage for OTFS, and climate change was perceived as contributing to drought, thereby creating fuels too dry to be managed with an OTFS strategy. One AA interviewed explained how the fire environment on their district led to using a fire suppression strategy on their fire:

> But I feel like things have changed so much over the last 100 years with the climate, with the state of the drought that we're in currently in this part of the state, that sometimes [people] feel that they can just pick up where they left off without really taking into account all of the change that has occurred, and the suppression actions that have happened over the last 100 years.

Fire outcomes

Except for observable first-order fire effects (e.g. obvious mortality, scorch height), outcomes are somewhat conjectural when discussed while the fire is still burning. The most mentioned outcome factor that facilitated the decision to use OTFS strategies was when managers expected to see reduction in fuel levels on the landscape. Although every fire will inherently reduce fuel, manager comments reflected a Goldilocks principle: enough fuel burned away to have benefits, but not so much that forests would be harmed. The benefits managers hoped to realise included improved forest health and resilience, reduced standing snags and reduced air quality impact from future wildfires.

Managers often described a general desire to allow fire to play its natural role. In several cases, managers described being surprised to see beneficial outcomes despite ongoing drought conditions. In one example, an AA described the effects they observed:

> There's a couple of places where it's sat around and cooked a little hotter than you necessarily would want, but in general, both our fire and aviation staff, as well as the agency administrator folks, we see benefits… it's almost 4000 acres. If you could just put that thing out right now and just walk away from it, that would be a great prescribed fire, and we'd all be happy. Yeah. I think we do see it doing good stuff right now.

The most prevalent unaligned factor was a generalised concern about fire effects uncertainty. Managers also gave general consideration to potential air quality and grazing impacts. Among barriers, air quality impacts were the most frequently discussed. There were five new fire outcome barriers; however, no individual outcome barrier demonstrated a strong signal: although several managers had previous bad experience using OTFS strategies, most barriers focused on the potential to cause environmental harm (tree mortality, degraded air quality, or reduced wildlife habitat).

Operational considerations

Two primary operational factors facilitated the decision to use an OTFS strategy. First, managers expressed a clear preference to keep managed fires at the local Type 3 (or lower) incident complexity level. When the complexity of a fire increased, requiring a Type 1 or 2 Incident Management Team (IMT), managers saw less potential for using OTFS strategies. This corresponds closely to the second facilitating factor, where participants reported greater success managing fires under OTFS strategies when they knew that their fire staff possessed a deep understanding of the local area. The first factor was newly observed; the second had been reported previously. Other facilitators included having sufficient resources, the presence of recent fires proximal to the current fire and extensive USFS land surrounding the fire. Regarding the use of IMTs, one participant remarked that:

> You don't bring in a Type 1 team because you want to manage a fire; you bring them in because you want to put

> it out. And maybe at most, you might be able to get them to do some planned ignitions to reduce fire severity and stuff like that along the way, if they have time.

Several unaligned factors emerged among operational considerations. The most frequently discussed regarded the use of 'big box' strategies. 'Big box' is a colloquial description of a strategy that utilises a large planning area and tends to employ tactical firing operations and other indirect fire control tactics. Participants also considered whether they were likely to have the necessary resources to achieve their management objectives, especially based on their personal expectations of the fire season's continued duration. Many participants also considered the availability of planning support.

The overwhelming operational barrier to managing a wildfire for OTFS concerned firefighting resources (e.g. fire engines, handcrews). This was also the most prevalent barrier found in the pre-2009 policy literature. As before, the concern centred around either having insufficient resources to begin managing the fire or that resources would be reassigned to higher priorities (such as communities at risk from other fires) after they had committed to managing their fire for OTFS. Other significant barriers included fatigue of firefighting staff, close proximity to other land ownership boundaries and seasonality.

Sociopolitical considerations

Respondents reported that the sociopolitical factor that most facilitated the decision to use an OTFS strategy was when cooperative relationships had been pre-established with local stakeholders who would be potentially affected. Examples include adjacent landowners, livestock producers, elected officials and other community leaders. Many AAs discussed the importance of deliberately forging relationships over time, long before a fire started. These relationships were often developed during previous fires or as part of various preparatory actions such as collaborative fuels treatments or fire safe councils. Sometimes relationships existed simply because the interview participant had grown up in the local area. Cattle producers who leased allotments on USFS lands were often reported to be among the strongest advocates for managing fires, as they saw a benefit when dense forests and shrublands were opened up for grass production following a fire. This support sometimes extended to their own adjacent private lands as well, where burning was welcomed as part of management strategies. Any sense the local public supported this strategy also gave managers more confidence to employ it.

Unaligned sociopolitical factors also focused on the status of local relationships; however, in this context there was greater uncertainty with how the public perceived the use of OTFS strategies. The media and its influence also were discussed and considered but did not influence the decision. Many participants viewed the media primarily as a tool for educating the public about alternative wildfire response strategies, especially when the fire was being managed for OTFS. Some participants expressed frustration around how to describe the spectrum of available strategies to the public, particularly when trying to explain the seemingly dichotomous intent of trying to both protect human-focused values and allowing fire to play its ecological role:

> In a managed fire where you're saying, 'You know what, we're going to go ahead and let it do its thing. And we're going to watch it, and we're going to manage effects, and whatever. This is the right thing to do, ecologically.' That's a different conversation with the public. Because now you're making a choice. You're not actively trying to save something, except you're trying to restore [natural resources].

The most frequently expressed sociopolitical barrier also pertained to beliefs about the public's perceptions of acceptable management practices. In half of the cases, participants believed that the public was afraid of wildfire and that managing fires with a strategy OTFS played into their fear. These AAs felt that employing a full suppression strategy helped prevent or alleviate those fears and was often reason enough to justify using a full suppression strategy. Believing that the local public did not support OTFS strategies was a barrier. So too was believing that local political figures were opposed to it. Several AAs felt that it was not palatable to publicly discuss any positive outcomes of fires (e.g. ecologically) if it was being managed with a full suppression strategy.

Institutional influences

The institutional factor most facilitative to the decision to manage a fire with an OTFS strategy was seen when the managing organisation possessed a culture actively supporting the strategy, even to the point of exhibiting pride in being known for it. The scale at which a facilitating culture was most discussed was at the level of a District or Forest; however, we also found evidence for its presence at the USFS Region scale. Whereas some participants believed their Region possessed a managed fire culture (Rocky Mountain and Southwest), others suggested theirs did not (Pacific Southwest and Southeast). A second facilitating factor was pre-planning in anticipation to use OTFS fires; this included planning within the Forest's Land Management Plan (LMP), but also within pre-fire spatial planning tools such as Potential Wildfire Operations Delineations (PODS) (Thompson *et al.* 2016*a*, 2022). Having these types of anticipatory tools showed that the Forest had already gone through deliberations to prepare for the event. The third factor was when the Agency showed clear support for OTFS fires. The scale for this mimics that of culture; agency support was seen at all levels of the organisation, but the most profound for participants was when it came from the Washington Office level such as articulated support (or withholding of support) via the annual Chief's letter of intent for wildland fire.

At the Agency level, the annual letter of intent the Chief of the Forest Service issued for the upcoming fire season had a surprisingly strong effect on local decision making. Throughout the 2021 fire season, three such letters were issued. The first, in April, lent specific support for using managed fire to achieve National Cohesive Strategy goals (Wildland Fire Leadership Council (WFLC) 2014; Christiansen 2021*a*). After a challenging start to the fire season, on 14 July, the Chief issued a second letter urging staff to refocus their efforts towards supporting fire management. This second letter affirmed that managers may 'use fire where allowable' (Christiansen 2021*b*). However, after a continued busy fire season, a newly appointed Chief issued a letter on 2 August restricting the use of fire, directing that 'managing fires for resource benefit is a strategy we will not use' (Moore 2021), citing rationale that safety should be the first priority and that resources wwere limited. We saw an immediate effect in our research, as managers were no longer willing to entertain multiple-objective wildfires, even in Regions where conditions had moderated. Following these letters, managers also felt more restricted in their ability to publicly discuss any potential benefits if they perceived a positive net effect.

Interestingly, the majority of unaligned institutional factors were new, including the three most frequently mentioned factors. The first, described in almost half the interviews, was a sense of cultural changes within the USFS workforce. Many older AAs believed the new generation had much greater interest in incorporating consideration of ecological function into their work, including wildfire management. They also observed greater diversity in the workforce than when they had begun their careers. One person observed the change they saw in these terms:

> But I think that's one of the things that is maybe changing in some ways is that we do have some young people coming into the agency that are from non-traditional backgrounds, and they sometimes can be more engaged in those discussions because they aren't burdened with a whole lot of preconceived notions about what firefighting is or what natural resource management is.

Other participants believed cultural shifts stemmed from changes in policies and practices, especially those that placed an increased emphasis on firefighter safety. Older AAs saw the change to using less aggressive tactics as a matter of risk mitigation, improved land management outcomes and reducing strain on the workforce. Frustration with the nomenclatural ambiguity inherent in the post-2009 wildfire policy update was a commonly mentioned topic. Many managers now found it difficult to describe their intent adequately and consistently to both staff and the public.

Institutional barriers were somewhat evenly distributed across eight factors, including two newly seen in this research. Some managers reported that the ambiguity in being able to adequately describe their strategy served to prevent managers from considering managing the wildfire for OTFS objectives: the simplicity of describing a full suppression strategy made it easier to message to the public and staff. Some indicated they thought that full suppression was the default acceptable strategy and deviating from it required extra planning and communication. One AA described their perspective as:

> If we've made a decision that this is not a good place to manage, and we're going to do 100% suppression, that's considered the baseline acceptable position. If you really think about it, it's when you go beyond that baseline of 100% suppression and have different factors that play off what nuances a decision, that's when people want to have the communication.

Of note amidst this ambiguity is the challenge of trying to distinguish strategies from outside appearances alone, a dynamic noted in discussions during some interviews regarding the decision makers' intent for their fire, and how they chose to characterise their intent to the public, which were not always directly congruent. Two fire cases from one National Forest provide an example; see inset Box 1.

Perceived risk

Within the risk context, both of the facilitating decision factors identified in the pre-2009 literature carried over (*personal satisfaction* and *a professional ethic to manage fires*). Notably, an additional nine facilitating factors emerged in the post-2009 data. The two most frequently discussed were related to safety: whether managers felt it would have been unsafe for firefighters to employ direct suppression strategies, and when the presence of standing snags was considered too risky to use direct suppression tactics. Using OTFS strategies was also facilitated when AAs perceived risk was being shared across multiple levels of the agency. Other conditions that facilitated OTFS included when few values were at risk, or it was feasible to both reduce risk to firefighters while achieving ecological benefits.

Box 1. Short case study of the challenges associated with describing wildfire strategy

The first fire was caused by lightning, and the decision was made to implement an OTFS strategy to achieve resource objectives. A base camp was set up, a Type 3 IMT was ordered and a plan was made to implement tactical firing operations on planned control lines using an indirect containment strategy ('big box'). At its peak, nearly 150 firefighters were assigned to the fire. Approximately 10 days after the fire started, crews had completed firing out the planned area of ~12 000 acres (4856 ha), more than 1000 acres (405 ha) a day of growth on average, and the fire began transitioning down in complexity and the number of resources allocated.

Later in the year, on the same district, lightning ignited another wildfire (which was visited by researchers). The fire was burning within a 9-year-old fire footprint containing numerous snags. The fire exhibited minimal fire behaviour, primarily smouldering in heavy dead and down fuel, and showed little daily growth owing to a lack of available fuel to burn. Because of a nearby community, the decision was made to use a 'full suppression' strategy. However, owing to the extreme snag hazard, firefighters were unable to safely engage directly with the fire and instead prepared indirect control lines along nearby trails and roads. No aircraft were utilised for suppression on the incident. Growth on the fire was monitored remotely while crews prepared control lines and improved community defence features. Over the course of 1 month, the fire slowly grew to 500 acres (202 ha) in size. After another month, the fire was listed as 10% contained with no additional growth in size. Eventually the fire received considerable rainfall and was declared out.

Researchers observed that the official strategy did not necessarily match how others might have perceived the fire to be managed. From outside appearances, the first fire appeared to be managed in the aggressively characteristic manner of full suppression, whereas the second fire was never directly touched by fire resources and was more indicative of a managed fire but was in fact managed for full suppression with a nearby community as the principal value at risk.

Three related unaligned decision factors emerged from our interviews, focused on risk mitigation processes. First, most decision makers interviewed discussed their personal decision making processes, which tended to be flexible and open to input from internal and external sources. Most AAs were able to articulate the pros and cons of a given strategy and overwhelmingly used risk-based considerations. For example, one AA described their desired scenario when fire staff first evaluated a fire:

> Okay, when you get out to a tree strike, this is the process we're going to follow. We're going to assess what we see. Is it one tree? Is it just a spot? Is dropping that tree going to be the best option? Or is leaving it burn and then when it falls apart, then we'll deal with it because it's also a nasty tree that somebody may die trying to cut down.

The second unaligned decision factor reflected managers consistently telling us that the first objective of any fire should be to minimise the risk to firefighters and the public, which aligns to national policy (USDI and USDA 2022). Third, to achieve this objective, managers aspired for firefighters to engage critical thinking while responding to and engaging at the fireline.

As in the previous research, managers reported numerous risk-based barriers; however, few discrete barriers appeared with consistency. The most expressed risk-based barrier was when private land was thought to be at danger, which corresponds to the similar operational concern with boundary adjacency. Several AAs expressed their belief that suppression was the best course of action for wildfires regardless of potential ecological benefit, although all regarded safety as the first priority in any fire response.

Discussion

Wildfire decision makers work in a complex, uncertain and time-compressed environment where they must identify and implement response strategies while considering natural environment, local communities, local economies, user groups, political influences and firefighting staff, as well as their personal interests. Despite the important impacts of different management choices, little research has been conducted to understand how these decisions are made. Our research provides specific insight into the decision process in the post-2009 policy context, specifically the point of decision at which an AA has to decide to follow the well-trodden path of suppressing the fire or accept the attendant risks of an OTFS strategy in exchange for potential ecological, social and operational benefits.

Wildfire decision framework

Given the high degree of flexibility the 2009 guidance provides AAs and managers, the factors presented in the results appear to have universal value for wildfire decision making, regardless of the strategy employed. Given this, we suggest that the '*Managed Fire Decision Framework*' originally presented in Fillmore *et al.* (2021) might simply be called the '*Wildfire Decision Framework*' (WDF) as our findings indicate it has value for all contemporary wildfire decision making scenarios. We present a simplified version of the framework in Fig. 2. The WDF framework demonstrates that each of the six KTAs and the factors nested within them influence the central decision nexus. Decisions are evaluated based on the relative influence assigned by the decision maker based on their risk perception and personal and professional motivations. After the evaluation is complete, a final decision emerges and is represented in a box below the nexus.

Strategic flexibility and manager preferences

The 2009 policy update was intended to give decision makers greater latitude by considering different strategies within

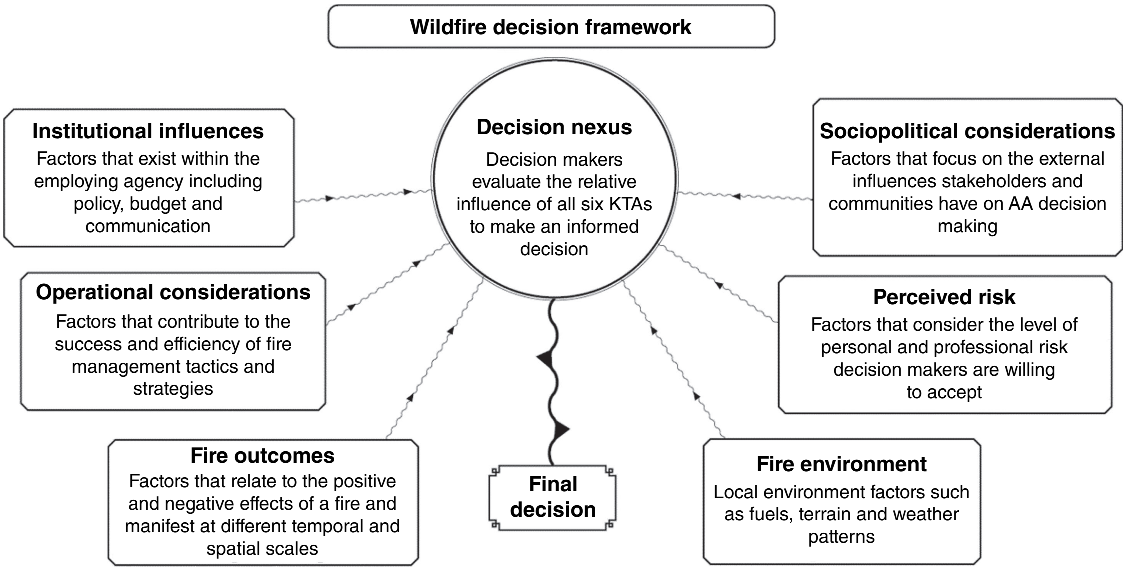

Fig. 2. Simplified representation of Wildfire Decision Framework. Each of the six KTAs shown here contains barrier, unaligned and facilitative decision factors. A total of 150 decision factors are nested within the KTAs.

the same fire rather than a single strategy across the entire fire (USDA and USDI 2009). The update has been successful to that end, as it is now common to see large fires managed to achieve different objectives across portions of the perimeter. Our research corroborates the findings of others suggesting that wildfire objectives now more accurately reflect a spectrum of opportunity that is adjusted throughout the term of the fire depending on the conditions and characteristics of the fire itself (Riley *et al.* 2018; Thompson *et al.* 2019).

We also found evidence that the 2009 policy intention for strategic flexibility appears to have inadvertently complicated the cogency of the message when communicating with internal and external stakeholders. Many AAs and managers we spoke to do not seem to feel the public would understand the wildfire decision making processes. This is evidenced by the disproportionate number of sociopolitical barriers, particularly those regarding public expectations and fear, which decision makers did not want to contribute to through their decision making. Although there were many more facilitating factors discussed, the barriers that exist appear to override them in decision significance. The notion that the public will not understand, is afraid, or is fundamentally opposed to it appears to be a persistent cultural belief perpetuated among the AAs and fire managers themselves, perhaps reinforced by discrete experiences and intermittent withdrawals of the strategy such as was seen in 2021 when the USFS declared that no fires would be 'managed for resource benefit' (Moore 2021).

Importantly, among the 15 fires we examined, no matter what the strategy, an end state with control locations was always defined. No strategy was implemented that included allowing the fire to burn without human intervention. Definitive control and contingency lines were established even on fires that had an OTFS strategy. One of the clearest signals for an OTFS fire was the use of a 'big box' strategy and the use of tactical firing operations designed to surround the planned perimeter with fire. The rate of tactical firing was often determined by the interior spread rate of the fire, whereas other times the 'box' was fired off as rapidly as conditions and resulting fire effects would allow. Managers liked this methodology for several reasons. First, having predefined control lines allowed them to describe an expected end state for the public and staff. Second, it allowed them to target specific areas of the landscape for management, particularly if those areas had been previously cleared through environmental planning documents and were intended to be prescribed burned in the future.

There was a very clear preference for managing fires for OTFS at the Type 3 complexity level when overseen by local fire staff or staff from neighbouring Forests within the Region. All the OTFS-described fires we investigated were managed this way. Given that wildfire is often driven by local factors, such as terrain-driven winds, unusual weather patterns, or fuels-driven burning conditions, managers placed more value on fire management staff with local experience, believing them more capable of managing the fire in a way that produced acceptable (ecological and social) outcomes. There was great reluctance to step the complexity up to a Type 2 or 1, as managers believed this would require ordering and turning over operational control to an IMT made up of people from outside the local area. Doing so increases the pressure to implement direct control strategies and tactics, which managers may not desire. However, Type 3 fires are somewhat limited in how large they can become or how many people can be assigned before the complexity level has to be increased. Together, these dynamics create an inherent ceiling to how large most fires managed for OTFS can become, with the related effect of reducing the scale of potential benefit that these fires can provide on the landscape.

Risk and institutional culture

AAs overcame risk aversion to managing fires for resource benefit as well as discussing the realised benefits on fires managed for suppression in several ways. The personal and professional ethic held by the AAs to utilise wildfire to achieve an objective besides suppression was among the strongest motivators and carried over from the pre-2009 framework. Motivational drivers were expressed variously as deep-seated personal philosophies stemming from a naturalistic upbringing while others saw overcoming barriers as a professional duty bolstered by years of experience, especially if they had participated in wildfire events where damage had been done to communities and they believed restored fire regimes could be a preventative action.

The presence of a local organisational culture that embraced using wildfire to achieve multiple benefits was a key facilitator in making the decision to both implement a non-suppression strategy and to feel they could openly explain that decision to the public. In many ways, this could be considered as required, as many other attributes are founded on it. For example, in locations with a strong culture for managing fires for multiple objectives, we often found a history of supportive planning efforts, especially when Forest LMPs actively supported the use of fire as a restoration tool. Other types of plans included programmatic prescribed fire environmental analysis, which greatly increases the chance wildfires may be counted towards fuels reduction accomplishment targets, or pre-fire spatial planning like PODs. Sometimes planning was as simple as District staff having discussions throughout the season regarding where and when they thought they could manage natural ignitions.

Although local organisational culture had the power to override wider, regional or national scale influences, managers developed greater confidence when they perceived that the risk was being shared across multiple levels of the organisation. Specifically, this often meant District AAs were more confident when they knew their next-level supervisor at either the Forest Headquarters or the Regional Office supported their local decision. Several locations mentioned their use of formal risk sharing processes. Typically, these were a structured conversation early in the wildfire with staff at both the local and regional offices. These conversations ensured that local managers understood they would receive adequate operational and sociopolitical support if the wildfire resulted in adverse outcomes. The only Region we saw this formalised into a policy was the Southwestern Region; however, Forests in other Regions followed similar processes.

One theme we saw repeatedly was managers relating decisions to actions that reduced risk for firefighters and the public, which was a factor also observed in the pre-2009 research, although to a lesser extent than post-2009. This is consistent with multiple safety and risk-related initiatives the USFS has implemented in the last several decades, including the 'safety journey', the 'five rights' and enterprise risk management (Thompson *et al*. 2016*b*; Flores and Haire 2021, 2022). The most expressed facilitator we found was when managers thought implementing direct control actions (fighting the fire directly on the perimeter) was unsafe. Culturally, this is a reversal of the long-held view that direct fireline tactics are the safest option. More recently, indirect tactics (placing control lines away from the perimeter) have grown increasingly common, both as a matter of reducing fatigue for firefighters and increasing focus on protecting specific values (e.g. structures), and because extreme fire conditions have not allowed it (Plucinski 2019).

Many managers we spoke to often justified these large-scale firing operations as necessary to restore fire at landscape scales. However, neither media coverage nor USFS policy overtly acknowledges the use of indirect suppression strategies, particularly tactical firing operations, as a potentially net positive scenario for landscape resilience outcomes. By employing risk management reduction as the primary reason for their strategic choices, the current policy allows managers to legitimately achieve landscape scale objectives while publicly advocating a full suppression strategy. Although perhaps a useful outcome from a management perspective, this raises concerns about whether such distinctions are understood by the public. Also, this communication pattern may create a mixed message when individuals are told the fire is employing a full suppression strategy when they do not see traditional suppression tactics being implemented.

Application of fire under changing conditions

Discussions around the fire environment and outcomes were focused on fuels and fire behaviour in a more deliberate and sophisticated way than seen in the pre-2009 results (Fillmore *et al.* 2021). Managers related great concern about potential fire effects, especially when the strategy was to manage to achieve resource objectives. Discussions frequently turned to their desire to achieve specific and measurable outcomes, often likening desired outcomes to those seen in prescribed fire plans. This desire was often linked to their individual risk appetite, in that if a manager was willing to take the risk of using an OTFS strategy, or even publicly state the benefits of a wildfire that had been suppressed, managers felt such risk should be justified by a certain level of ecological gains. Even in cases where ecological benefits will be gained, managers appear to be unwilling to use OTFS if they perceive sociopolitical risks or negative public feedback. However, the extent to which this influences their decision making is unclear.

The influence of ongoing drought also concerned many managers who feared that their fire could result in a higher burn severity than ecologically appropriate. Interestingly, several AAs decided to manage a wildfire for OTFS despite the ongoing presence of drought and climate change. We attribute this to some managers and unit cultures having greater comfort with riskier strategies when they may result in positive ecological outcomes. However, interviewee comments also suggest that some managers are sensing that the drought may never actually end (owing to climate change), in which case there is little reason to wait for that 'perfect year', as those years are no longer going to arrive with enough regularity to be able to manage for it. In several cases, participants reported observing fire effects that were surprisingly favourable, leading them to question the actual difficulty in managing fires when in a drought state. In a sense, these managers may represent an 'early adopter' approach to managing fires under changing climatic conditions.

The importance of relationships

Concerns related to the sociopolitical environment were mostly consistent pre and post-2009, with some important exceptions. As before, managers maintained a high level of concern about smoke affecting downwind communities, with managers often anticipating local community reactions related to smoke from prior experiences. Such anticipation also affected pre-fire messaging and the level of openness managers could relate with regarding potential ecological benefits. The sentiment of numerous AAs was that the best time to discuss ecological benefits was outside the fire season, and not while the fire was actively burning, as they perceived the inherent tension associated with a fire as obstructive to education. Also, by engaging with the community after the fire, an AA could appear to be standing on the side of fire suppression and risk avoidance if fire outcomes included damage to property or resources. However, if the fire did provide tangible ecological benefits, those benefits could be discussed after the fire when fear and tension related to the fire were absent.

As seen in other research, AAs were well attuned to the connection between their decision latitude and the status of relationships with land users, local politicians and the public at large (McCaffrey and Olsen 2012; Davis *et al.* 2022; Huber-Stearns *et al.* 2022). Besides the policy framework, the presence or absence of pre-existing relationships between managers and the community appeared to be among the most important decision factors related to managing a fire for OTFS. Most AAs we interviewed seemed to either understand this intrinsically or had learned it through experiences during and after previous fires. Although some AAs welcomed interacting with the public and seemed to embrace it, others saw it as a burden and sought to avoid it regardless of fire outcomes. In the latter case, they seemed to prefer suppression strategies.

The most positive relationship experiences interviewees described was when they were working directly with advocacy groups who had an interest in specific areas (e.g. a mountain range, community, or watershed). These groups had the advantage of being tightly tied into the local community and local politics. In areas with a strong culture of managing fires for multiple objectives, these groups often performed the bulk of the community outreach instead of the USFS. Overall, we were told that this led to fewer sociopolitical issues related to wildfire events, assured consistent messaging and reduced conflict with local community members who were vocally opposed to OTFS fire management strategies. Other than meeting regulatory requirements, having constructive relationships with those who would be most directly affected by any wildfire was regarded as one of the most important facilitators for managing with OTFS.

Implications to wildfire management outside the United States

Although the current analysis was in the context of United States wildland fire management, with a focus on USFS AAs, we contend that salient generalities can be considered in global wildland fire management. Numerous countries have wildfire management governance and cultures analogous to the US experience, such as those operating in Canada, Australia and throughout southern Europe, (Hyde *et al.* 2017). Many countries are developing new management structures to deal with increasing risks of wildfires due to changing climate (Gazzard *et al.* 2016; Smith *et al.* 2016). As such, we contend that the six KTAs discussed in the present study could be broadly applied to both established governance and that now emerging, especially if their policies allow for different response strategies based on objectives. The factorial difference and similarities should be explored in future comparative research.

Conclusions

The research in this article provides a broad understanding of the complex considerations that go into wildland fire response decisions and in doing so lays the groundwork for improved and better-informed wildland fire management. It validates the presence of wildfire decision factors that were first identified in the pre-2009 literature and updates our understanding of wildfire decision factors to the current moment when fire managers are being faced with greater complexity, risk and ambiguity than ever seen before. It also provides a framework for wildfire decision making that has wide applicability and could provide a useful reference for managers who wish to ensure that key factors have been considered before determining a final course of action. Over longer time scales, the framework could help managers and decision makers identify weaknesses and potential leverage points in planning and implementation efforts, particularly for facilitating fires managed with OTFS. For instance, this research could assist the USFS to more systematically assess the factors that influence field-level decision making and thereby be better positioned to make institutional changes that can foster a culture of actively managing wildfire more closely aligned with stated management goals (US Forest Service (USFS) 2022).

A greater understanding of factors considered in the decision environment is important because researchers, managers and policy makers need to have a more robust comprehension of the decision environment under which federal land managers are operating. It is one thing to suggest courses of action, or ways in which managers should be approaching their decisions, and it is another to know whether that is even applicable or available under the modern decision environment with its multiple and often contradictory pressures.

We frequently heard participants use the phrase 'all fires are managed', which is intended to suggest that all wildfires in the US on federal lands trigger a response strategy. However, as we saw deliberately described proposed end states to all fires in our data set, it may be more appropriate to instead suggest that 'all fires are suppressed' with the only distinction being under what timeframes and with what resource intensity that is accomplished. Another oft-used phrase among firefighters is that 'all fires go out eventually'. In many ways, the federal response acknowledges this fact, but wishes to intervene in the natural span of a fire to gain outcomes that are socially palatable. Reframing the intent of wildfire strategies in terms of timeframes, spatial extent and the number of resources leveraged to accomplish that end state may be a more constructive way forward when engaging in messaging with the public.

Though we determined the presence of many factors that influence these decisions, we also found the lines between wildfire management strategies are becoming blurred to the extent that differentiating among them has largely become an academic exercise rather than something that translates well into the realities of real-time fire decision making. The data presented here are a starting point for future research that may more fully describe both the KTAs and individual decision factors. We would expect that as policies are updated and fire cultures evolve in response, some of these factors will continue to persist, while others will not.

References

Borchers JG (2005) Accepting uncertainty, assessing risk: decision quality in managing wildfire, forest resource values, and new technology. *Forest Ecology and Management* **211**, 36–46. doi:10.1016/j.foreco.2005.01.025

Bowman DMJS, Williamson GJ, Abatzoglou JT, Kolden CA, Cochrane MA, Smith AMS (2017) Human exposure and sensitivity to globally extreme wildfire events. *Nature Ecology & Evolution* **1**, 0058. doi:10.1038/s41559-016-0058

Boyatzis R (1998) 'Transforming qualitative information: thematic analysis and code development.' (Sage Publications, Inc: Thousand Oaks, CA)

Bryman A (2015) 'Social research methods', 5th edn. (Oxford University Press: Oxford)

Calkin DE, Venn T, Wibbenmeyer M, Thompson MP (2012) Estimating US federal wildland fire managers' preferences toward competing strategic suppression objectives. *International Journal of Wildland Fire* **22**, 212–222. doi:10.1071/WF11075

Christiansen V (2021a) 'Chief's 2021 Letter of Intent for Wildland Fire.' (USDA Forest Service: Washington, DC)

Christiansen V (2021b) 'Chief's 2021 Letter for Wildfire Resources.' (USDA Forest Service: Washington, DC)

Cortner HJ, Taylor JG, Carpenter EH, Cleaves DA (1990) Factors influencing Forest Service fire managers' risk behavior. *Forest Science* **36**(3), 531–548.

Davis E, Huber-Stearns H, Caggiano M, McAvoy D, Cheng A, Deak A, Evans A (2022) Managed wildfire: a strategy facilitated by civil society partnerships and interagency cooperation. *Society & Natural Resources* **35**, 1–19. doi:10.1080/08941920.2022.2092803

Fillmore SD (2023) Towards a Theory of Default Suppression: Decision Making in the Context of Full Suppression and Managed Wildfires on Federal Lands, USA. Doctoral Dissertation, University of Idaho, Moscow, ID, USA ProQuest Dissertations Publishing, 30310692.

Fillmore SD, Paveglio TB (2023) Use of the Wildland Fire Decision Support System (WFDSS) for full suppression and managed fires within the Southwestern Region of the US Forest Service. *International Journal of Wildland Fire* **32**, 622–635. doi:10.1071/WF22206

Fillmore SD, McCaffrey SM, Smith AMS (2021) A mixed methods literature review and framework for decision factors that may influence the utilization of managed wildfire on federal lands, USA. *Fire* **4**, 62. doi:10.3390/fire4030062

Flores D, Haire E (2021) The development of an organizational safety culture in the United States Forest Service. *Journal of Forestry* **119**, 506–519. doi:10.1093/jofore/fvab025

Flores D, Haire ER (2022) The US Forest Service Life First safety initiative: exploring unnecessary exposure to risk. *International Journal of Wildland Fire* **31**, 927–93. doi:10.1071/wf21099

Gazzard R, McMorrow J, Aylen J (2016) Wildfire policy and management in England: an evolving response from Fire and Rescue Services, forestry and cross-sector groups. *Philosophical Transactions of the Royal Society B: Biological Sciences* **371**(1696), 2015034. doi:10.1098/rstb.2015.0341

Gibbs G (2007) 'Analyzing qualitative data [published online 01 January 2012].' (Sage Publications) Available at https://methods.sagepub.com/book/analyzing-qualitative-data [verified 28 February 2023]

Gisev N, Bell JS, Chen TF (2013) Interrater agreement and interrater reliability: Key concepts, approaches, and applications. *Research in Social and Administrative Pharmacy* **9**, 330–338. doi:10.1016/j.sapharm.2012.04.004

Hand MS, Wibbenmeyer MJ, Calkin DE, Thompson MP (2015) Risk preferences, probability weighting, and strategy tradeoffs in wildfire management. *Risk Analysis* **35**, 1876–1891. doi:10.1111/risa.12457

Hiers JK, O'Brien JJ, Varner JM, Butler BW, Dickinson M, Furman J, Gallagher M, Godwin D, Goodrick SL, Hood SM, Hudak A, Kobziar LN, Linn R, Loudermilk EL, McCaffrey S, Robertson K, Rowell EM, Skowronski N, Watts AC, Yedinak KM (2020) Prescribed fire science: the case for a refined research agenda. *Fire Ecology* **16**, 11. doi:10.1186/s42408-020-0070-8

Huber-Stearns HR, Davis EJ, Cheng AS, Deak A (2022) Collective action for managing wildfire risk across boundaries in forest and range landscapes: lessons from case studies in the western United States. *International Journal of Wildland Fire* **31**, 936–948. doi:10.1071/WF21168

Hunter ME, Iniguez JM, Lentile LB (2011) Short-and long-term effects on fuels, forest structure, and wildfire potential from prescribed fire and resource benefit fire in Southwestern forests, USA. *Fire Ecology* **7**, 108–121. doi:10.4996/fireecology.0703108

Hyde JC, Yedinak KM, Talhelm AF, Smith AMS, Bowman DMJS, Johnston FH, Lahm P, Fitch M, Tinkham WT (2017) Air quality policy

and fire management responses addressing smoke from wildland fires in the United States and Australia. *International Journal of Wildland Fire* **26**(5), 347–363. doi:10.1071/WF16154
Iniguez JM, Evans AM, Dadashi S, Young JD, Meyer MD, Thode AE, Hedwall SJ, McCaffrey SM, Fillmore SD, Bean R (2022) Comparing geography and severity of managed wildfires in California and the Southwest USA before and after the implementation of the 2009 policy guidance. *Forests* **13**, 793. doi:10.3390/f13050793
Katuwal H, Dunn CJ, Calkin DE (2017) Characterising resource use and potential inefficiencies during large-fire suppression in the western US. *International Journal of Wildland Fire* **26**, 604–614. doi:10.1071/wf17054
Kolden CA (2019) We're not doing enough prescribed fire in the Western United States to mitigate wildfire risk. *Fire* **2**, 30. doi:10.3390/fire2020030
Lawton FJ (1954) The role of the administrator in the federal government. *Public Administration Review* **14**, 112–118. doi:10.2307/972636
Maguire LA, Albright EA (2005) Can behavioral decision theory explain risk-averse fire management decisions? *Forest Ecology and Management* **211**, 47–58. doi:10.1016/j.foreco.2005.01.027
McCaffrey SM, Olsen CS (2012) Research perspectives on the public and fire management: a synthesis of current social science on eight essential questions. General Technical Report, NRS-104. 40 p. (USDA Forest Service, Northern Research Station: Newtown Square, PA)
McHugh ML (2012) Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)* **22**, 276–282.
Miller JD, Collins BM, Lutz JA, Stephens SL, van Wagtendonk JW, Yasuda DA (2012) Differences in wildfires among ecoregions and land management agencies in the Sierra Nevada region, California, USA. *Ecosphere* **3**, 80. doi:10.1890/ES12-00158.1
Moore R (2021) 'Chief's Wildland Fire Direction.' (USDA Forest Service: Washington, DC)
National Interagency Fire Center (NIFC) n. d. Incident Management Situation Report. Available at https://www.nifc.gov/nicc/sitreprt.pdf [verified 1 March 2023]
National Wildfire Coordinating Group (NWCG) (2001) Review and update of the 1995 federal wildland fire management policy. (National Interagency Fire Center: Boise, Idaho, USA)
Nichols TR, Wisner PM, Cripe G, Gulabchand L (2010) Putting the Kappa statistic to use. *Quality Assurance Journal* **13**, 57–61. doi:10.1002/qaj.481
Noble P, Paveglio TB (2020) Exploring adoption of the Wildland Fire Decision Support System: end user perspectives. *Journal of Forestry* **118**, 154–171. doi:10.1093/jofore/fvz070
Noonan-Wright EK, Opperman TS, Finney MA, Zimmerman GT, Seli RC, Elenz LM, Calkin DE, Fiedler JR (2011) Developing the US Wildland Fire Decision Support System. *Journal of Combustion* **2011**, 168473. doi:10.1155/2011/168473
North M, Collins BM, Stephens S (2012) Using fire to increase the scale, benefits, and future maintenance of fuels treatments. *Journal of Forestry* **110**, 392–401. doi:10.5849/jof.12-021
North MP, York RA, Collins BM, Hurteau MD, Jones GM, Knapp EE, Kobziar L, McCann H, Meyer MD, Stephens SL, Tompkins RE, Tubbesing CL (2021) Pyrosilviculture Needed for Landscape Resilience of Dry Western United States Forests. *Journal of Forestry* **119**, 520–544. doi:10.1093/jofore/fvab026
O'Connor CD, Thompson MP, Rodríguez y Silva F (2016) Getting ahead of the wildfire problem: quantifying and mapping management challenges and opportunities. *Geosciences* **6**, 35. doi:10.3390/geosciences6030035
Parsons DJ, Landres PB, Miller C (2003) Wildland fire use: the dilemma of managing and restoring natural fire and fuels in United States wilderness. In 'Proceedings of Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management'. (Eds KEM Galley, RC Klinger, NG Sugihara) Miscellaneous Publication no. 13. pp. 19–26 (Tall Timbers Research Station: Tallahassee, FL)
Patton M (2002) 'Qualitative research and evaluation methods', 3rd edn. (Sage Publications: Thousand Oaks, CA)
Philpot C, Schechter C, Bartuska A, Beartusk K, Bosworth D Coloff S, Douglas J, Edrington M Gale R, Lavin MJ, Rosenkrance LK, Streeter R, van Wagtendonk J (1995) Federal wildland fire management policy and program review. (US Department of Interior, US Department of Agriculture: Washington, DC)
Plucinski MP (2019) Fighting flames and forging firelines: wildfire suppression effectiveness at the fire edge. *Current Forestry Reports* **5**, 1–19. doi:10.1007/s40725-019-00084-5
QSR International (1999) NVivo 12. Available at https://qsrinternational.com/nvivo/nvivo-products/
Rapp C, Rabung E, Wilson R, Toman E (2020) Wildfire decision support tools: an exploratory study of use in the United States. *International Journal of Wildland Fire* **29**, 581–594. doi:10.1071/WF19131
Reid AM, Fuhlendorf SD (2011) Fire management in the National Wildlife Refuge System: a case study of the Charles M. Russell National Wildlife Refuge, Montana. *Rangelands* **33**, 17–23. doi:10.2111/1551-501X-33.2.17
Richards L (2014) 'Handling qualitative data: a practical guide', 2nd edn. (Sage Publications: Thousand Oaks, CA)
Riley KL, Thompson MP, Scott JH, Gilbertson-Day JW (2018) A model-based framework to evaluate alternative wildfire suppression strategies. *Resources-Basel* **7**, 4. doi:10.3390/resources7010004
Roese NJ, Vohs KD (2012) Hindsight bias. *Perspectives on Psychological Science* **7**, 411–426. doi:10.1177/1745691612454303
Ryan GW, Bernard HR (2000) Data management and analysis methods. In 'Handbook of qualitative research', 2nd edn. (Eds ND Denzin, YS Lincoln) pp. 769–803. (Sage Publications: Thousand Oaks, CA)
Saldaña J (2016) 'The coding manual for qualitative researchers', 3rd edn. (Sage Publishing: Thousand Oaks, CA)
Seidman I (2013) 'Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences.' (Teachers College Press: New York, NY)
Seielstad C (2015) Reconsidering wildland fire use: perspectives from the Northern Rockies. In 'Proceedings of the large wildland fires conference,' 19–23 May 2014, Missoula, MT. (Eds RE Keane, M Jolly, R Parsons, K Riley) Proceedings RMRS- RMRS-P-73. pp. 207–212. (USDA Forest Service, Rocky Mountain Research Station: Fort Collins, CO)
Shuman JK, Balch JK, Barnes RT, Higuera PE, Roos CI, Schwilk DW, Stavros EN, Banerjee T, Bela MM, Bendix J, Bertolino S, Bililign S, Bladon KD, Brando P, Breidenthal RE, Buma B, Calhoun D, Carvalho LMV, Cattau ME, Cawley KM, Chandra S, Chipman ML, Cobian-Iñiguez J, Conlisk E, Coop JD, Cullen A, Davis KT, Dayalu A, De Sales F, Dolman M, Ellsworth LM, Franklin S, Guiterman CH, Hamilton M, Hanan EJ, Hansen WD, Hantson S, Harvey BJ, Holz A, Huang T, Hurteau MD, Ilangakoon NT, Jennings M, Jones C, Klimaszewski-Patterson A, Kobziar LN, Kominoski J, Kosovic B, Krawchuk MA, Laris P, Leonard J, Loria-Salazar SM, Lucash M, Mahmoud H, Margolis E, Maxwell T, McCarty JL, McWethy DB, Meyer RS, Miesel JR, Moser WK, Nagy RC, Niyogi D, Palmer HM, Pellegrini A, Poulter B, Robertson K, Rocha AV, Sadegh M, Santos F, Scordo F, Sexton JO, Sharma AS, Smith AMS, Soja AJ, Still C, Swetnam T, Syphard AD, Tingley MW, Tohidi A, Trugman AT, Turetsky M, Varner JM, Wang Y, Whitman T, Yelenik S, Zhang X (2022) Reimagine fire science for the Anthropocene. *PNAS Nexus* **1**(3), pgac115. doi:10.1093/pnasnexus/pgac115
Smith AMS, Kolden CA, Paveglio TB, Cochrane MA, Bowman DM, Moritz MA, Kliskey AD, Alessa L, Hudak AT, Hoffman CM, Lutz JA, Queen LP, Goetz SJ, Higuera PE, Boschetti L, Flannigan M, Yedinak KM, Watts AC, Strand EK, van Wagtendonk JW, Anderson JW, Stocks BJ, Abatzoglou JT (2016) The science of firescapes: achieving fire resilient communities. *BioScience* **66**(2), 130–146. doi:10.1093/biosci/biv182
Steelman T (2016) US wildfire governance as social-ecological problem. *Ecology and Society* **21**, 3. doi:10.5751/es-08681-210403
Steelman TA, McCaffrey SM (2011) What is limiting more flexible fire management-public or agency pressure? *Journal of Forestry* **109**, 454–461.
Steelman TA, McCaffrey SM, Velez ALK, Briefel JA (2015) What information do people use, trust, and find useful during a disaster? Evidence from five large wildfires. *Natural Hazards* **76**, 615–634. doi:10.1007/s11069-014-1512-x
Stephens SL, Collins BM, Biber E, Fulé PZ (2016) US federal fire and forest policy: emphasizing resilience in dry forests. *Ecosphere* **7**, e01584. doi:10.1002/ecs2.1584

Stevens JT, Boisrame GFS, Rakhmatulina E, Thompson SE, Collins BM, Stephens SL (2020) Forest vegetation change and its impacts on soil water following 47 years of managed wildfire. *Ecosystems* **19**, 1547–1565. doi:10.1007/s10021-020-00489-5
Thompson M, Bowden P, Brough A, Scott J, Gilbertson-Day J, Taylor A, Anderson J, Haas J (2016*a*) Application of wildfire risk assessment results to wildfire response planning in the Southern Sierra Nevada, California, USA. *Forests* **7**, 64. doi:10.3390/f7030064
Thompson MP (2014) Social, institutional, and psychological factors affecting wildfire incident decision making. *Society & Natural Resources* **27**, 636–644. doi:10.1080/08941920.2014.901460
Thompson MP, MacGregor DG, Calkin DE (2016b) Risk management: Core principles and practices, and their relevance to wildland fire. General Technical Reports, RMRS-GTR-350. 29 p. (USDA Forest Service, Rocky Mountain Research Station: Fort Collins, CO)
Thompson MP, Wei Y, Calkin DE, O'Connor CD, Dunn CJ, Anderson NM, Hogland JS (2019) Risk management and analytics in wildfire response. *Current Forestry Reports* **5**, 226–239. doi:10.1007/s40725-019-00101-7
Thompson MP, O'Connor CD, Gannon BM, Caggiano MD, Dunn CJ, Schultz CA, Calkin DE, Pietruszka B, Greiner SM, Stratton R, Morisette JT (2022) Potential operational delineations: new horizons for proactive, risk-informed strategic land and fire management. *Fire Ecology* **18**, 17. doi:10.1186/s42408-022-00139-2
Thompson MP, Belval EJ, Bayham J, Calkin DE, Stonesifer CS, Flores D (2023) Wildfire response: a system on the brink? *Journal of Forestry* **121**(2), 121–124. doi:10.1093/jofore/fvac042
US Forest Service (USFS) (2022) Wildfire Crisis Implementation Plan. FS-1187b. (USDA Forest Service: Washington, DC)
USDA USDI (2009) 'Guidance for Implementation of Federal Wildland Fire Management Policy.' (United States Department of Agriculture and United States Department of the Interior: Washington DC)
USDI USDA (2022) 'Interagency Standards for Fire and Fire Aviation Operations.' (National Interagency Fire Center: Boise, ID)
Wibbenmeyer MJ, Hand MS, Calkin DE, Venn TJ, Thompson MP (2013) Risk preferences in strategic wildfire decision making: a choice experiment with US wildfire managers. *Risk Analysis* **33**, 1021–1037. doi:10.1111/j.1539-6924.2012.01894.x
Wildland Fire Leadership Council (WFLC) (2014) The National Strategy: the final phase in the development of the National Cohesive Wildland Fire Management Strategy. Available at https://www.forestsandrangelands.gov/strategy/thestrategy.shtml [verified 28 February 2023]
Wilson RS, Winter PL, Maguire LA, Ascher T (2011) Managing wildfire events: risk-based decision making among a group of federal fire managers. *Risk Analysis* **31**, 805–818. doi:10.1111/j.1539-6924.2010.01534.x
Young JD, Evans AM, Iniguez JM, Thode A, Meyer MD, Hedwall SJ, McCaffrey S, Shin P, Huang C-H (2020) Effects of policy change on wildland fire management strategies: evidence for a paradigm shift in the western US? *International Journal of Wildland Fire* **29**, 857–877. doi:10.1071/WF19189
Zimmerman T (2011) Change as a factor in advancing fire-management decisionmaking and program effectiveness. In 'Proceedings of the second conference on the human dimensions of wildland fire'. (Eds McCaffrey SM, Fisher CL) General Technical Report, NRS-P-84. pp. 14–23. (USDA Forest Service, Northern Research Station: Newtown Square, PA)

Data availability. Portions of the data that support the findings of this study are available from the corresponding author on reasonable request. However, the personally identifying information of interview participants is protected under the provisions of human subject research in compliance with University of Idaho Institutional Review Board guidelines and is not available.

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