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A Qualitative Study on the US Forest Service's Risk Management Assistance Efforts to Improve Wildfire Decision-Making

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Abstract: To support improved wildfire incident decision-making, in 2017 the US Forest Service (Forest Service) implemented risk-informed tools and processes, together known as Risk Management Assistance (RMA). The Forest Service is developing tools such as RMA to improve wildfire decision-making and implements these tools in complex organizational environments. We assessed the perceived value of RMA and factors that affected its use to inform the literature on decision support for fire management. We sought to answer two questions: (1) What was the perceived value of RMA for line officers who received it?; and (2) What factors affected how RMA was received and used during wildland fire events? We conducted a qualitative study involving semi-structured interviews with decision-makers to understand the contextualized and interrelated factors that affect wildfire decision-making and the uptake of a decision-support intervention such as RMA. We used a thematic coding process to analyze our data according to our questions. RMA increased line officers' ability to communicate the rationale underlying their decisions more clearly and transparently to their colleagues and partners. Our interviewees generally said that RMA data analytics were valuable but did not lead to changes in their decisions. Line officer personality, pre-season exposure to RMA, local political dynamics and conditions, and decision biases affected the use of RMA. Our findings reveal the complexities of embracing risk management, not only in the context of US federal fire management, but also in other similar emergency management contexts. Attention will need to be paid to existing decision biases, integration of risk management approaches in the interagency context, and the importance of knowledge brokers to connect across internal organizational groups. Our findings contribute to the literature on managing change in public organizations, specifically in emergency decision-making contexts such as fire management.

Keywords: risk management; decision support; fire management; forest policy; organizational change

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1. Introduction

Increased wildfire extent, severity, and complexity require risk-informed decision-making to effectively balance safety for firefighters, protection of values at risk, and achievement of social and ecological objectives [1,2]. The US National Cohesive Wildland Fire Management Strategy recognizes the concurrent need to facilitate safe and effective response, support fire-adapted communities, and promote resilient fire-adapted landscapes [3]. Managing for these multiple goals is an enormous challenge rife with ambiguity and competing objectives for different stakeholders that vary for any given fire incident [4]. Beyond the incident management timeline, when short-term hazards are often relatively more apparent, wildfire decision-making has social and ecological implications,

for example for ecosystems, budgets, and community safety over the long-term. To balance among values at risk, there is a well-recognized need to move beyond aggressive suppression tactics, which perpetuate fuel accumulation and fire exclusion from fire-prone ecosystems [2]. At present, US Forest Service (Forest Service) fire management and decision-making prioritizes short-term over long-term risks [5,6]. Changing this will require updating leadership direction, incentives, and other agency institutions to promote more long-term considerations [4].

Fire management also presents tremendous risk management challenges related to the deployment of resources. As a result of increased expenditures directed towards wildland fire response, the Forest Service, the largest fire-management organization in the United States, faces ballooning fire-management expenses that comprise around two thirds of the agency's budget and compromise all other aspects of the agency's mission, necessitating increased vigilance about resource expenditures [7,8]. At the same time, in the face of the tragic loss of firefighters' lives, federal agencies have been forced to reflect on and redouble efforts to ensure the safe engagement of firefighters and reduction of unjustifiable risks to their lives and wellbeing [9].

In summary, fire management requires balancing multiple considerations over multiple time frames, in a world where short-term fire exclusion is both beneficial and problematic, and where decision-makers consistently face pressures to focus on short-term, rather than long-term objectives [4]. Together, these considerations have invigorated the exploration of more strategic, risk-informed innovations to support decision-makers during wildfire incident response [10]. Risk management is grounded in an analytical and proactive approach that aims to explicitly identify goals and incorporate long-term considerations into decisions to respond to immediate threats. Principles include integrating risk management into all organizational processes; accounting for uncertainty; problem solving in a systematic, structured, and timely fashion; using best available data for decision-making; adapting processes for contextual variability; encouraging transparency and inclusiveness; adapting and responding to change; and promoting continual improvement [11].

In the context of wildfire incident response (i.e., the development of a response strategy and tactics during an active fire incident), strategic risk management informs planning and decision-making to improve safety and effectiveness [1,11]. In practice, line officers (i.e., personnel with decision-making authority) and other fire managers using a risk management approach would follow a structured process that fosters communication, helps evaluate tradeoffs, and improves transparency [12]. Embedding data-driven analytics into the risk management process supports decision-making during incidents by providing more operationally relevant and empirically credible information [11]. Some examples of fire analytics include weather forecasts, safety zones, and escape routes, suppression difficulty maps, and fire control location probabilities. Incorporating analytics does not replace making real-time adjustments based on human judgement but can inform more strategic response decisions. Infusing risk management in the fire-management system has potential to enhance decision-making, improve wildfire response safety and effectiveness, and usher in a needed change in US wildfire management [13].

1.1. Risk Management in the US Forest Service

In 2016, the Forest Service Executive Leadership Team introduced *Life First,* making a commitment to prioritize firefighter safety and minimize unnecessary exposure [14]. In response to this direction, Forest Service wildland fire leaders launched Risk Management Assistance teams to provide decision support grounded in risk management principles to line officers and fire managers. The Risk Management Assistance Teams (RMAT), formed in 2016, subsequently abbreviated their name to Risk Management Assistance (RMA). RMA teams traveled to certain wildfires during 2017 and 2018 to augment analytical capacity for enhanced risk-informed decision-making. RMA teams provided on-the-ground support and virtual assistance to line officers acting as Agency Administrators (AAs) on

fires, and used various tools and analytical products to improve decision-making and increase accountability of resources on wildfire. These tools include incident timelines, hazard maps, suppression difficulty index assessments, identification of potential control locations, and risk trade-off analysis exercises (see Table 1). During the first two years of operations, RMA teams traveled to fires nationwide at the requests of the AAs and occasionally as a result of encouragement by leadership at Forest Service Regional Offices (administrative units that oversee multiple national forests across multiple states). RMA shifted to a fully virtual mode of assistance in 2019 and 2020; this was unrelated to COVID-19. RMA support has increased steadily over these first four years, providing assistance to 11 incidents in 2017 (all onsite) and to 66 incidents in 2020 (all virtual) [15]. Although the call for improved data and science to support wildfire response decision-making is not new, the RMA approach was a novel attempt to expose line officers to a greater depth of knowledge, expand their ability to use risk management principles and analytics, and support their ability to effectively balance experiential knowledge and judgement with the best available data and analytics in decision-making.

Table 1. Most common RMA tools and analytical products offered. Adapted from [15].

Tool Name	Description of Tool
Incident Timeline	Helps justify and visually display key decisions and resource use throughout a fire event. Sample information includes fire size, cost/expenditures, number of personnel, percent containment, directed strategy, relative risk assessment, assigned incident management team, structures threatened/destroyed, and decision status.
Resource Timeline (added after 2018)	Similar to the incident timeline but displays the specific type of resources (such as camp crews, dozers, masticators, helicopters, and water tankers) by date. It also includes fire size, cost to date, number of personnel, and percent containment.
Management Direction Alignment Table	Helps decision-makers ensure that incident objectives, Wildland Fire Decision-Support System course of action, leader's intent, and the incident action plan align with the unit's land and resource management plan(s). Sample categories or emphasis areas include general fire management, safety/risk management, cultural resources, infrastructure/private property, smoke, silviculture/vegetation ecology, wildlife/fisheries, soils, range, wilderness, and watershed.
Course of Action, Trade-off Analysis Exercise	Provides the framework for helping decision-makers systematically consider tradeoffs around different fire-management strategies; supports selecting an appropriate course of action based on ratings of risks to firefighters, public safety, and other values identified by decision-makers.
Aviation Use Summary	Helps decision-makers quantify and track aviation use on a fire. It spatially tracks the use of different types of aircraft, including helicopters, large air tankers, and scoopers. The information displayed can track the use of retardant and help guide subsequent analysis of the associated environmental impacts.
Suppression Difficulty Index (SDI) Map	Displays how complex wildfire-related operations may be based on factors such as modeled fire behavior, responder mobility, available fuel breaks, and time to create line. Higher values on the SDI scale indicate more hazardous situations or areas [16].

Potential Control Locations (PCL) Map	Shows the likelihood of fire stopping in a given area based on historical fire perimeters and other model drivers (such as fuel transitions, road networks, rate of spread, and suppression difficulty). Higher probabilities indicate better containment opportunities under current fire conditions [16,17].
Season-ending Analysis (added after 2018)	Describes the probability of a season-ending event, such as pulses of rain or snow, lower temperatures, and higher relative humidity.
Mop-up Hazard Map (known as the Snag Hazard Map before 2019)	Helps reduce firefighter exposure and costs by identifying hazardous conditions (slopes, overstory vegetation) to avoid. Fire intensity data also helps prioritize areas for mop-up. Snag hazard is estimated using a mathematical relationship between Forest Inventory plot data and landscape characteristics [18].
Ground Evacuation Map and Injury/Illness Information	Provides travel time estimates from different locations in the proximity of a fire to the nearest care facility. It accounts for considerations such as road availability or conditions, slope, vegetation type, and driving speeds. These maps can also include updated information about injuries and illnesses associated with the fire.
Exceedance Probability Curves	Uses information from regional Quantitative Wildfire Risk Assessments (QWRA) and Fire Spread Probability (FSPro) outputs to estimate the probability of a fire reaching highly valued resources within a given time period. The curves allow for the comparison of incidents relative to one another regarding likely outcomes (positive and negative), such as which fires in a given time frame have the highest likelihood of loss or ecological benefit. The information helps prioritize resources based on risk [19,20].

The Forest Service is currently expanding its risk-informed decision-support toolbox with the emergence of multiple recent and updated initiatives. For example, some forests are developing Potential [wildland fire] Operational Delineations (PODs), a spatial summary of areas on the landscape likely to hold fire, to help coordinate wildfire operations and summarize risk ahead of the fire season [21,22]. PODs use some of the same analytical tools as RMA. A recent exploration of the Wildland Fire Decision-Support System (WFDSS) reports that the utility of the System to support risk-informed decision-making could be improved by incorporating prefire planning tools such as PODs [23]. Other examples of Forest Service initiatives that are focused on improving decision-making and coordination include the Shared Stewardship Strategy [24], Scenario Investment Planning [25], the National Cohesive Wildland Fire Management Strategy [26], and the Wildfire Risk to Communities mapping effort [20]. It remains to be seen if and how these initiatives will be integrated, but it is worth noting a general trend towards improving strategic decision-making based on improved coordination, communication, and integration of science and data analytics.

1.2. Managing for Organizational Change

Public organizations, such as the Forest Service, are often working in complex environments with ambiguous goals, high levels of risk and uncertainty, and stakeholders or political overseers with disparate priorities [27]. In such organizations, managers face pressures of legitimacy more than those of efficiency, and often rely on a mixture of old and new processes and technologies [28]. Over the last few decades, there has been a growing emphasis on efficiency and performance assessment in public organizations; lessons from the private sector and a greater emphasis on risk management to promote efficiency, improve decisions, and increase transparency reflect this trend [28].

Many public organizations face environments thick with rules, which can make change difficult to achieve or to track, particularly in large, multi-level organizations with ambiguous or competing goals [29,30]. In such organizations, many factors affect efforts

to promote organizational or policy change. For any organization intervention such as RMA, both the content of change efforts and the process of implementing them matter [29].

Multiple factors will affect the reception and use of new processes and sources of information for decision support. Variables include how data are presented and interpreted and by whom, characteristics and relationships of the individuals who are intended to use or benefit from an intervention, structural factors that are pervasive throughout an organization, such as incentives or communication about goals, and other more local contextual factors, such as local biophysical characteristics or local collaborative stakeholders groups that affect practice [31–34]. In the case of new scientific tools in particular, acceptance and integration of analytic tools and approaches into practice takes more than technologic solutions [11]. As Shah et al. (2012) write, "Investments in analytics can be useless, even harmful, unless employees can incorporate that data into complex decision-making" [35] (p. 23). Often in such cases there is a need for people, sometimes referred to as boundary spanners or knowledge brokers, who can work across organizational levels and at the science-management boundary to facilitate integration of science into decision processes [31,36].

At the individual level, line officers (i.e., agency decision-makers who in this case were the intended targets of RMA) bring to bear their unique background, receptivity to new ideas and input from others, personal experience, and risk tolerance during wildfire decision-making. Individuals also may have their own biases or rely on certain decision-making heuristics [37]. Fire-management personnel also face a variety of incentives, such as performance assessment approaches, and pressures from communities or political representatives to prioritize short-term safety that can affect efforts such as RMA [4].

These factors interact with other organizational institutions and characteristics. Promoting organizational change requires clear communication from leadership about the need for and rationale behind interventions, a plan to execute changes, building internal and external support, and integrating new processes and tools with existing systems [38]. A lack of resource availability and a perceived lack of internal support can disincentivize line officers to embrace changes and, in the context of fire management, to manage for long-term land and resource objectives [39]. Existing networks and relationships, incentives, training opportunities, and team dynamics also affect how interventions are used [30,40].

Local context also matters. In general, effective communication practices among fire managers, partners, and members of the public before and during a fire may create opportunities for more flexible fire-management strategies [41]. These can be facilitated by prior collaborative efforts. For example, PODs workshops bring together agency staff and partners who use local knowledge and analytical data to consider different fire-management objectives and options outside of the emergency contexts [2]. Early research on PODs indicates they have potential to support improved communication and more flexible fire response options in some places [22]. Local biophysical characteristics also matter, as some landscapes may present more opportunities for safe engagement with fire or for allowing fire to burn to meet resource objectives.

1.3. Summary and Research Questions

With these factors in mind, we conducted this research to understand the perceived value of RMA and various factors that affected its use during incident management. Specifically, we asked: (1) What was the perceived value of RMA according to the line officers who received it? In addition, (2) What factors affected how RMA was received and used during wildland fire events? As an effort to use data analytics and risk management approaches to improve wildland fire decision-making, this research is important for revealing the complexities of embracing risk management, specifically in the context of US fed-

eral fire management, but also in other similar fire management or emergency management contexts. It has value for the literature on managing change in public organizations, with a specific investigation into the context of fire management.

2. Materials and Methods

We conducted a qualitative research study, using semi-structured interviews, during the summer of 2019. This is an appropriate methodology for investigating questions about nuanced and interrelated contextual factors about specific cases or topics, particularly in cases like this, when the research topic is relatively new and unexplored. Qualitative work is not meant to create generalizable data about trends, although it can set the stage for future quantitative research, something we address more in our discussion below. Rather, this work was intended to reveal some of the contextualized and interrelated factors that affect wildland fire decision-making and the uptake of a decision-support intervention such as RMA.

We began our work by reviewing the relevant documents accessible from the Forest Service's RMA website [15], which provided background information on RMA and documentation for 2017 and 2018 fire incidents that RMA teams supported. We conducted several preliminary informational interviews with RMA designers to provide us with additional background information on the intent of the effort. We then contacted all line officers who received RMA in 2017 and 2018. We conducted semi-structured, confidential phone interviews with 16 line officers who acted as AAs on wildland fire events and received RMA during 2017 and 2018; we identify each interviewee in our findings with a unique number after interview excerpts. Our interviewee sample represented line officers from about half of the 27 onsite RMA fires during these years. Semi-structured interviewing relies on an interview guide, with a list of questions to ask all interviewees, but it also allows for flexibility to discuss topics that emerge during the interview and are of particular relevance for that interviewee. Interviews ranged from approximately 30–75 min. All interviews were recorded and transcribed by a third-party transcription service (Rev.com). Towards the end of our interviews, we approached saturation regarding our research questions and were not hearing substantially new information.

We then used Dedoose, a qualitative and mixed methods analysis software program, to assign codes to segments of text. Coding is a social science process for analyzing text that allowed us to identify themes in our interviews, collate excerpts for these themes across many interviews, and then analyze our findings across hundreds of pages of interview text. We began with large, overarching themes based on our questions (e.g., "perceived value" of RMA), and then we coded for emergent sub-themes in these categories (e.g., under "perceived value," themes such as "increased likelihood of success," "improved communication," or "mentoring" emerged). We also coded for contextual factors that would affect the use of RMA, based on our literature review, inductively building sub-themes (e.g., "leadership," "incentives," "local politics," and "biophysical conditions") as we analyzed our data. The role of risk-related decision heuristics emerged as a third major thematic area in our data that we coded for. Our coding approach allowed us to analyze and organize data related to our research questions, with themes informed by the theoretical literature, while also identifying emergent themes that we may not have expected. Although we focus on our line officer interviewees in this paper, we also conducted interviews with those who delivered RMA and other fire-management personnel on several fires; more information on those data is available in [42].

3. Results

3.1. What Was the Perceived Value of RMA to the Line Officers Who Received It?

Most line officers interviewed believed that RMA augmented their capacity to analyze strategic alternatives. In particular, line officers often valued the discussions during incident response that were facilitated by RMA teams and informed by RMA analytical

products (e.g., maps of suppression difficulty, evacuation maps, and tools to track fire retardant drops from planes). Line officers especially valued the products that allowed them to consider a variety of values at risk and tradeoffs among different strategies in a structured, communicable format. As one line officer explained, "Those deliberate conversations about what truly are the values at risk—that is what I took away from RMAT" (4). Another explained, "[The RMA process] outlines those tools that we can use to look at the situation differently. It's those tools as well as the process…that dialogue and being able to lay out all of those values on the table so that you can talk about them together (6)." A couple line officers noted that as fire management becomes more complex, with large numbers of fires burning at once, limited resources, and multiple jurisdictions involved in wildfire management, each jurisdiction may prioritize different values at risk. RMA, these people said, offered a big-picture perspective for strategically working through these complexities and managing risk and resource use.

About half of the line officers described how they valued the depth and abundance of experienced line officers arriving on the scene with RMA, while also recognizing how that particular model of assistance would not be sustainable in the long run. Interviewees discussed how sharing knowledge, experience, and ideas with experienced lined officers proved worthwhile for building confidence in decisions and providing real-time learning opportunities. Several interview participants highlighted the importance of this exercise for those less-experienced line officers; especially on complex incidents, line officers could confirm their thinking with more experienced people on the RMA team. Several line officers said this also provided them with a sense of political support within the agency for their decisions on wildfire, in light of the seniority of some of the RMA team members. One line officer explained, "Our decisions now have even larger ramifications potentially, and it's wise to [have] another experienced forest supervisor, [agency administrator], and the technical folks that you can get advice and information from to help make better decisions" (3). Another person said, "Having RMA [teams] be there is an insurance policy, because [Washington] DC and the leadership back there, they really rely on us out in the field to figure this stuff out. But when you start spending hundreds of millions of dollars on one fire, there's a lot of questions that get asked…. It's an insurance policy that you're making good decisions" (15).

Most interviewees said that RMA teams provided evidence to support line officers' decisions, but they did not say that the RMA information or process changed their decisions. Instead, line officers referenced the validation of decisions that were already made, resulting in line officers feeling increased confidence in their decisions. One line officer mentioned, "RMA(T) gives you a high degree of confidence that your decisions are sound. When you reach a decision, you are confident it's the right one given the circumstances (2)." Another stated, "We were already well on our way. It was more of a validation, but it brought up the main concerns (12)." A few line officers perceived the RMA team's role in validating decisions as redundant, particularly from the perspective of fire staff, and also said that when RMA teams arrived after decisions had been made in the WFDSS, it was difficult to change course. For example, one interviewee said, "The timing could not have been worse…. It made for a very stressful situation working with RMAT…. Once you've already gone down that path as an agency, your buy-in is pretty high in what you've set forth in that decision" (16). A few line officers said that the dynamics of having RMA come after decisions had been made led them to feel second-guessed.

About half of line officers appreciated the platform RMA provided for a transparent and open discussion with local partners, while a few other interviewees said this was not useful because partners ranked values at risk differently. A few interviewees mentioned the value of RMA tools to facilitate discussions with land managers from other jurisdictions or internally within the agency, whether it was explaining to regional office leadership the rationale behind decisions or working more closely with incident commanders to decide on incident tactics. For example, people stated:

> "I brought in my partners to listen to all of the presentations that were given by RMAT because my partners had all this mistrust. When I'm talking partners, I'm talking county commissioners, tribal reps, environmental leaders, industry leaders…. They all got to see [RMA data] in real time—they were in the room. That helped bridge this gap of mistrust, and it set the tone for the rest of the summer (15)."
>
> "The challenge is all politics are local. Being able to use fire for resource benefit is really about having that conversation in a very deep way with partners, communities, well ahead of smoke in the air. RMAT can give you some intel and tools and rationale to do so (4)."
>
> "The discussions we had with the [incident commanders] were shaped by knowledge we gained from the RMAT around what that longer-term strategy needed to be (8)."

A couple line officers thought some of the RMA tools, such as the trade-off analyses, were subjective in nature. These line officers said that some RMA products relied on too many assumptions and did not accurately reflect on-the-ground or present conditions, raising questions about the value of local and experiential knowledge versus the offered data analytics from RMA teams. For instance, one line officer described an incident in which emergency and evacuation data were presented by RMA teams that did not account for current conditions. They said: "The material was not [what were] actually the on-the-ground conditions. When you're wrapped up in the analytics, you miss the real world, real-time information, adding risk to the situation (13)."

3.2. What Individual, Organizational, and Other Local Factors Affected How Risk Management Assistance Was Used during Wildland Fire Events?

At the individual level, about half of interviewees cited individual line officer personality as a major component that affected receptivity to RMA. Some line officers described their openness to mentoring and science, and to incorporating more refined analytics such as RMA products into fire-management decisions. An interviewee said, "It's an individual thing. I think you have to have folks to welcome outside opinions and who are open to that and aren't offended by someone coming in and feel like their toes are being stepped on" (5). Another said, "For my personality type, I'm always a student. I know I don't know everything. It was great for me to have a candid conversation, one on one with [an experienced line officer]" (15).

About half of interviewees also said that knowing about RMA before the season started or knowing someone personally on the team made them more comfortable with RMA. Although there was not agreement about this, some interviewees perceived RMA as relatively more beneficial for line officers with less fire experience and for more complex fires. For instance, one interviewee stated: "RMAT is a great tool, but not for all fires, and not for all agency administrators…. It's good to bring [RMA] in occasionally with experienced [AAs] because it does get you to think differently, but I don't think it should be all the time.… RMAT is good in the right circumstances and for the right agency administrator" (16).

At the organizational or inter-organizational level, several line officers said a complicating factor is that there are different opinions among fire-management personnel about acceptable levels of risk to firefighters to protect homes or other values. A line officer said, "At the end of the day, the meat of the conversation is what's that level of risk we're willing to put our folks at in order to protect that value?" (6). In addition to different understandings of risk and resource values, a few interviewees said different agencies have different thresholds with the level of risk they are willing to take for certain values at risk. Essentially, there is a spectrum of how aggressively firefighters will attack a fire depending on the agency, team, and conditions. Some noted that the Forest Service is relatively

more supportive of using fire to achieve resource benefits compared to state fire-management agencies also involved in fire response. To address this issue, interviewees suggested that a next step could be better risk management training within the agency and improved communication about efforts such as RMA across agencies, which is important when multiple agencies are involved in managing a complex fire.

Another question that arose for our interviewees was whether agency decision-makers felt they could objectively consider a range of actions. A couple of individuals said there is support within the Forest Service for using indirect approaches to fire management, but this can vary across regions. A few interviewees noted they would not necessarily have as much access to resources if they chose indirect approaches, particularly if those tactics did not go as planned. Another line officer explained, "If someone gets hurt when they're suppressing…they were doing their job and putting the fire out, so it's okay. If I made a decision to back folks off to the ridge lines and manage risk or manage a fire for resource objectives and somebody gets hurt, that's my fault because I chose to do this other action" (1).

A few interviewees described the influence of local political dynamics, which they said complicate the RMA approach to objectively looking at different fire-management strategies. One interviewee explained, "It's much easier to talk to your community and your politicians…and say, 'You know what? We did everything we could to put that fire out. It's not our fault that it got big….' When we have those less obvious options for managing a fire for a resource objective or managing a fire with reduced risk to firefighters, like choosing to do something other than a really aggressive initial attack, it's a lot harder to communicate that to the public and not feel like you're going to get shot" (1). Another interviewee elaborated on this and noted that local history and partner relationships also interact with these dynamics. This interviewee stated, "I would say it depends on the agency administrator at what their relationship is with those local folks…,what the history of fire is in that area…, and…how that agency administrator communicates the thought process to those—it doesn't even have to be elected officials—it can be informal community leaders, because that can often times change perception or change what's possible" (6).

A few interviewees also said that options are limited by local biophysical conditions and past fire experiences. They said in communities that have faced a lot of fire or where fire management has gone poorly in the past, they must choose more aggressive strategies. One interviewee explained, "It feels like here, that if we don't catch something in initial attack, then we're dealing with it until it's a season-ending event sort of thing…. the way that things align with topography and weather and history here…there's definitely local factors that can influence [your decisions]…. We've had large fires four out of the past five years here. And I think those kinds of things, both from the public and from an internal sort of sense, kind of influence decisions" (10).

Interviewees said that introducing RMA principles pre-season could mitigate tensions and stress associated with the team arriving during a fire. A few interviewees said that PODs processes can incorporate some of the pre-season work to integrate RMA principles. In their own words, interviewees said: "It doesn't feel like the right time and place to be trying out new things. Stressful environments are not where we do our best learning…. I felt that this was something we should be trained on and teaching in the sand table exercise, not the day that the fire is actually burning" (14). Another interviewee explained, "We have thought that some of the tools and the mapping would be helpful in sort of pre-season planning to really understand…what our strategy might be, whether it [would] be planning future vegetation treatments or what roads would make good fire breaks" (9).

In reference to the concern about a lack of local knowledge, some interviewees said the future of RMA requires having RMA-type analytical capacity available through personnel at the regional or forest level. As some explained, in certain instances, "Line officers as well as [fire-management officers] kind of scoffed at the idea of an outsider coming in

to tell you what was best for your forest" (7). Another interviewee said, "I think it would be good to have that kind of skillset ideally on each forest…. It's nice to have that skillset more locally because they have that local knowledge, and they understand a little bit more of what we're getting at" (1).

4. Discussion

Our two research questions focused on the perceived value of RMA from the perspective of the line officers who received it, and the factors that affected how line officers used RMA on various fires. Our data set included interviews with line officers who received RMA in person in 2017 or 2018. These findings should be understood in this context, as these were the first two years of RMA, which continues to be offered remotely.

The primary goal of RMA was to support line officers in using risk management approaches and data analytics as they considered how to deploy resources and engage a fire. Our interviewees did not indicate that these tools changed how they responded to incidents. Instead, our primary finding was that RMA increased line officers' ability to communicate the rationale underlying their decisions more clearly and transparently to their colleagues and partners, although not everyone felt this way. This has value given the complexity of demands managers face in public organizations, particularly in the context of fire management, where they face pressures for efficient resource use and also must respond to divergent stakeholder interests [4]. In such situations, transparency and rationale communication can be valuable, as it is impossible to satisfy all stakeholders and the legitimacy of decisions is always under scrutiny [28].

Both the organizational change management literature and the literature on integrating data into decision-making indicate that to use new information and processes effectively, people need to understand the rationale behind new analytical tools and be able to integrate them into existing processes and decision-support systems; another important factor is building internal and external support for and understanding of processes [38]. These factors support our conclusion, based on our research, that if RMA is to continue it will be particularly important for leaders to explain the rationale behind it, introduce tools pre-season so people are familiar with how to use them, and work to integrate them into existing processes such as WFDSS. Responses to RMA also will continue to vary based on the experience and receptivity of the individual line officers engaging with it, as all change initiatives are met with a mix of people who embrace change or resist it at the outset. Attention will also need to be paid to how RMA affects others' identities, roles, and receptivity if it is to be successful [43]. This is particularly relevant in the case of RMA, which was meant to elevate, and therefore change, the role of line officers vis-a-vis incident commanders.

Our interviewees emphasized that not all agencies will share the same fire-management objectives and priorities. RMA may support improved communication in this context, but this will be an ongoing tension to navigate, given that personnel from multiple agencies are typically involved in managing and responding to a fire. In the face of increasingly complex fires crossing multiple jurisdictions, where command of a fire may be shared jointly across AAs from different land management agencies, RMA tools will need to be introduced and potentially become a shared approach used by the interagency fire-management community. Interviewees also said that local factors, such as topography, forest type, and history of fire, as well as political support from local agencies, stakeholders, and political representatives all affect how an agency administrator responds to a fire event and the range of options they consider. Considering these factors, efforts to implement RMA approaches will need to be context-specific [30].

RMA brings scientific data into the fire-management context, where interviewees described local relationships and tacit and experimental knowledge are highly valued. Our interviewees generally said that RMA data analytics were useful, particularly during the 2018 fire season, when line officers had pre-season exposure to the information being pre-

sented to them and how to use it. In cases where new scientific information is being presented, trainings to support understanding of complex information and connect scientists and managers are important facilitators of successful change [38,44]. In particular, we suggest that understanding complex information, such as the outputs generated from machine-learning algorithms that underlie some of the RMA data analytics [17], will likely require conversation and relationship-building with scientists to understand the nature of the information outside of the emergency management context. In addition, knowledge brokers who have relationships at multiple levels and in different communities throughout an agency are important for helping people understand how to integrate different knowledge types [31,36].

We also consistently heard about the potential value of embedding knowledge of RMA with people locally who have relationships with local fire personnel and line officers. After the work we completed for this article, we conducted a small case study on a 2019 fire where RMA was used remotely [42]. On this fire, fire-management personnel from the national forest where the fire was located had experience with RMA tools and processes. They were able to access RMA data analytics remotely from those in the scientific community who develop the RMA analytics. The local staff members were then able to present those tools and run RMA processes, such as trade-off analyses. This type of approach, where local staff who are familiar with RMA integrate it into the incident management context, is how RMA likely will be used going forward. Future research should investigate the efficacy of this approach.

A final factor we observed is the bias that several line officers discussed with us towards aggressive attack and using all available resources to stop a fire. This exists in tension with the goal of RMA to consider whether and how to use resources effectively and with the greatest chance of success. It also runs counter to the Forest Service's stated interest in returning fire to fire-prone landscapes when possible [4]. In any fire-management situation, line officers balance several personal risks to their own careers and local relationships, given that they, and not external support staff or incident management teams, are the ones who continue to work in leadership roles in the places where they manage fires. In other words, line officers are balancing professional considerations, social pressures, and political pressures in addition to the array of personnel and land management considerations during any fire incident. If these factors are not explicitly incorporated into decision-making discussions, this compromises the ability to understand how RMA is used.

5. Conclusions

This study has value in building an early understanding of RMA as an organizational intervention that may be in place for multiple years. It also provides a window into incident management dynamics, where more research is needed. At the same time, our study has several limitations. Interviewees said they had difficulty remembering details of fires more than a year back. We also recognize every fire and management context are different, and we were working with a small sample size and perspectives from line officers only. A larger dataset over a longer period of time will be necessary to understand how RMA impacts fire management. We recommend if RMA continues that researchers work with the Forest Service to construct a survey instrument to track progress going forward. This should be built with individuals who have expertise in survey design, organizational change theory, and science translation in management contexts. Such a survey could continue to track decision biases generally, the effects of leadership, team dynamics, pre-season exposure to science, or differences in viewpoints between AAs and incident management teams and how these affect the use of RMA. We also would recommend research into the preconditions (e.g., exposure to RMA, past experience with fires or RMA, the development of PODs, relationships with scientists involved in developing RMA, or professional background) that affect the use of RMA. Tracking the perceived utility and long-term effects of RMA on decisions would be valuable and require a larger dataset. Such

efforts will have value for supporting more effective decision-making in fire management and augmenting our understanding of organizational change initiatives in the context of emergency response.

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