IDENTIFYING THE INFORMATION PREFERENCES OF EMERGENCY MANAGERS DURING FIRE WEATHER EVENTS

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ABSTRACT

As growth of the Wildland-Urban Interface (WUI) places more communities at risk of wildfires in the United States, affected communities must know how to prepare and respond to them. Emergency Managers (EMs) are one of the key figures in community resilience to extreme weather events such as wildfires. As the primary source of weather information for EMs, the National Weather Service (NWS) is working to develop effective methods for communicating accurate weather forecast information to EMs through impact-based decision support services (IDSS). However, there is a current knowledge gap on what forecast information EMs want leading up to fire weather events and how they use it. A mixed methods approach was used in this study to identify the information preferences of EMs during fire weather operations. Quantitative data was collected from a nationwide panel survey of EMs, and qualitative data was collected from interviews with EMs about workflows during hazardous weather. This study found that overall, EMs are most interested in information related to location and timing of a potential wildfire, as well as weather conditions that can affect fire behavior. Additionally, information about fire weather conditions is increasingly important in the hours leading up to elevated fire weather conditions. These findings highlight the type of weather information forecasters should prioritize when communicating with EMs.

1. INTRODUCTION

Recent housing growth trends are responsible for the expansion of areas where human development and wildland vegetation intermingle, known as the Wildland-Urban Interface (WUI), in the United States (Radeloff et al. 2018). This expansion means that an increasing number of Americans are living in elevated wildfire risk areas. Additionally, the majority of wildfires in the United States are human-caused, tripling the length of wildfire season (Balch et al. 2017) when large wildfires are also becoming more frequent (Dennison et al. 2014). As wildfire risk areas expand, it is increasingly important for affected communities to adequately prepare for and respond to potential wildfires. Emergency managers (EMs) are key players in community preparedness and response to disasters. As the NWS works to effectively communicate forecast information to public safety officials such as EMs (Uccellini and Ten Hoeve, 2019), they must know what information is most useful for their audiences in decision-making. As EMs often rely on weather information in their decision-making processes, it is evident that forecasters should know the types of weather information that EMs look for and how they utilize weather information in their workflow. However, there is a knowledge gap on what type of forecast information EMs seek and how they use this information in the context of fire weather.

This paper aims to identify the types of information that EMs look for in NWS forecast information during wildfire events, and how those information preferences may change over the course of an event. This project utilizes data from a nationwide EM survey on fire weather operations and semi-structured interviews with EMs for contextualization of these preferences.

2. LITERATURE REVIEW

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The WUI has grown rapidly in the United States between 1990-2010, with 97% of new WUI areas due to new housing, making it the fastest-growing land use type in the conterminous United States (Radeloff et al. 2018). These recent housing trends mean that more Americans are living in high-risk areas for wildfires. This is especially problematic considering that the majority of wildfires in the United States are attributed to humans (Balch et al. 2017) and people often ignite fires in the WUI (Syphard et al. 2007).

As more communities are expected to face the threat of wildfires, they must know how to prepare and respond to them on both a personal and community level. On the community level, EMs are often the primary figure responsible for disaster response and preparedness (Weaver et al. 2014). While wildfires are mostly started by humans as opposed to natural causes (Balch et al. 2017), weather conditions (such as high wind speeds and low relative humidity) can influence the behavior of an ignited flame (Benson et al. 2008). Therefore EMs must rely on weather forecast information that is timely and accurate to inform operations (Wanless et al. 2023a).

The NWS is continuously evolving to not only provide accurate weather forecasts and warnings, but to connect that information to core partners such as EMs through impact-based decision support services or IDSS (Uccellini and Ten Hoeve 2019). According to the NWS, IDSS "are forecast advice and interpretive services the NWS provides to help core partners, such as emergency personnel and public safety officials, make decisions when weather, water and climate impacts the lives and livelihoods of the American people." (NWSa). One part of IDSS is the Integrated Warning Team (IWT). The IWT, based on the integrated warning system presented by Doswell et al. (1999), consists of partnerships between NWS forecasters, EMs, and broadcast media (Morris et al. 2008). These partnerships are beneficial in protecting life and property. For example, retrospective analyses of wildfire events have shown that the IWT approach to fire warnings (FRWs) supported a possible lead time of up to 55 minutes before the 2018 Camp Fire entering Paradise, California (Lindley et al. 2024).

For the NWS to fully integrate these types of collaborations, however, there are still some challenges that need to be resolved. One of these challenges, as outlined by Fischer and Jasny (2017) is that even when organizations have complementary goals, they do not necessarily work together, especially when they have differing attitudes on the matter. This can lead to critical information being missed because they are not being communicated to the relevant response partners.

Additionally, previous research has indicated that current wildfire decision support tools are likely not being used to their full potential. Studies conducted by Rapp et al. (2020) and Ferguson et al. (2024) found that when fire managers do use these tools, it is to justify decisions that have already been made rather than utilizing those tools in determining the decision itself. For example, fire behavior models may serve as useful "gut checks" for fire managers even if the information didn't change their decisions. While EMs typically have different roles, responsibilities and expertise than fire managers, these studies provide insight into how the wildfire community in general might approach decision support tools that are designed to aid them in these events. However, there is still a research gap on how EMs specifically use information ahead of fire weather events, which this study aims to address.

In order for the NWS to improve decision support tools used by EMs, forecasters must understand the nature of the EM community and their roles in responding to extreme weather events. Weaver et al. (2014) previously conducted a nationwide survey collecting demographic information of EMs, providing insight into the diversity of EMs and the types of communities they serve. While demographic data gives us a better idea of *who* works as an EM, there is still a lack of data on *how* they operate during extreme weather events, including wildfires. Until recently, there was a lack of consistent nationwide survey studies on EMs related to weather, making it challenging for the NWS to understand how EMs incorporate forecast information into decision-making processes. Additionally, different types of hazardous weather might require different types of information. Wanless et al. (2023a) address this gap with the development of the Extreme Weather and Emergency Management Survey (WxEM), an ongoing series of surveys that asks EMs about their use of NWS products and forecast information during various extreme weather events. Previous survey waves covered topics such as severe weather (Wanless et al. 2023b) and compound hazards (Wanless et al. 2023c).

3. METHODS

This study uses quantitative survey data and qualitative interview data, which were collected as part of two larger projects. Data from this study comes from WxEM Wave 7, which covers EM usage of forecast information during fire weather operations (Jolley et al. 2025), and the qualitative interview data comes from another larger project investigating EM workflows (Meister et al. 2025).

3.1 *Survey*

Survey data came from the seventh wave of the WxEM survey, a nationwide panel survey of EMs implemented by the Institute of Public Policy Research and Analysis (IPPRA) at the University of Oklahoma. Wanless et al. (2023a) describes in detail the methodology of participant recruitment. WxEM Wave 7 focuses on how EMs receive, use, and share forecast information during fire weather events (Jolley et al. 2025). This paper focuses specifically on questions from the survey that ask about the types of information that EMs find important and how those information preferences change over time leading up to a fire weather event. The survey opened on February 19, 2025 and responses were collected until March 28, 2025. 292 EMs from across the US completed the survey (Fig. 1).

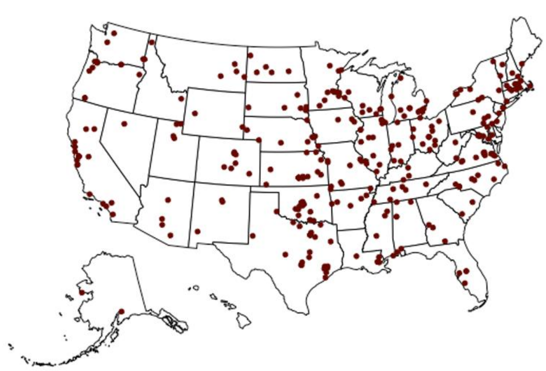

Fig. 1. Geographic distribution of WxEM Wave 7 respondents.

3.2 *Interviews*

As part of a larger EM workflows project, semi-structured interviews were conducted with EMs across five locations based on hazard type: flooding, winter weather, fire weather, severe weather, tropical weather, and extreme heat (Meister et al. 2025, Fig. 2). For each hazard, various types of EMs were interviewed. Specifically, EMs that were considered high resource, low resource, state, or other were interviewed for each hazard type. EMs categorized as “high resource” were typically in urban areas and usually have full EM teams and offices (referred to as “H#”). “Low resource” EMs were typically in more rural areas and usually only have one or two people working in EM roles (referred to as “L#”). For the state perspective, interviewees were selected from a state emergency management agency in the hazard-prone area (referred to as “S#”). EMs categorized as “other” represented various public and private entities (universities, hospitals, etc., referred to as “O#”). Potential participants were identified by a mix of existing relationships, previous research efforts, and locations of interest. A snowballing sample approach was also used to identify potential participants (Goodman 1961). Participants were recruited via email or phone call.

Fig. 2. Geographic locations of EM workflow interviewees based on region-specific hazards.

Interviews were primarily conducted in person, with the exception of a few video conference interviews, from January 2025 through March 2025. In the first portion of the interview, participants were asked general open-ended questions about operations related to the specific weather hazard associated with their region. In the second portion of the interview, participants were walked through a hypothetical timeline where they were shown NWS forecast information graphics regarding that weather hazard. Interviewees were then asked to identify any actions that they would take based on the information provided, along with specifying any additional information that they would need for decision-making. Interviews were recorded and later transcribed using Otter.Ai and then quality checked by researchers. One interview was unable to be recorded and transcribed due to circumstances outside of researchers' control, but detailed notes of the interview allowed for thematic insights.

This study will use five of the interviews from this project specifically focused on fire weather operations and involved EMs located in the southwestern United States. Participants were asked questions about fire weather operations within their jurisdiction, any specific actions they may take when fire weather is forecasted for their area, the sources they consult for fire weather information, and with whom they might share that information. For the second half of the interview, the forecast graphics presented to EMs included general infographics that they might receive from a NWS weather forecasting office (WFO), Red Flag Warnings, Fire Weather Watches, High Wind Warnings, and Fire Weather Outlooks from the Storm Prediction Center (SPC). It should be noted that not all interviewees were presented the exact same graphics.

4. RESULTS

4.1 *General Preferences*

EMs were asked to rank five specific pieces of fire weather forecast information from most important to least important (value of 1 is most important, value of 5 is least important). They ranked location (what area has the greatest fire weather risk), timing (when the fire weather risk is going to occur), duration (how long fire weather conditions will last), conditions (information such as high wind speeds and low relative humidity), and protective actions (how people can prevent fires from starting and spreading) (Fig. 3). Interviewees also discussed general information preferences during fire weather events.

Location was ranked most important overall, with a mean ranking of 2.1. Conditions and timing closely follow, with respective mean rankings of 2.3 and 2.4. With location, conditions and timing being closely ranked together as the most important information attributes, this indicates that EMs are mostly concerned about where fire weather conditions are most likely, when they are most likely, and what those conditions are. These results were also reflected in the interview data. For example, H2 expressed wanting to know more specific location

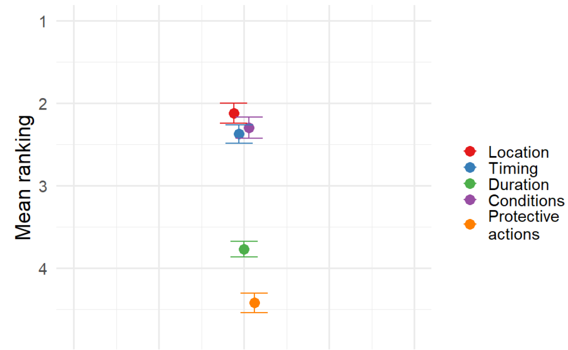

Fig. 3. Mean rankings of overall importance for different information attributes. A ranking of 1 indicates the most important information attribute, whereas a ranking of 5 indicates the least important information attribute.

information, rather than something covering a broad area. When it comes to timing, H2 said, "We all want to know the timing…when's it gonna get here? When's it gonna leave? What days are gonna be the worst?" This statement also shows the desire to know event duration (mean ranking 3.8) as it overlaps with timing information. Looking at a color-coded timeline of elevated fire risk over a five-day period, H2 also suggested including information about weather conditions (temperature, winds, and relative humidity specifically) associated with each day would be helpful. When viewing a Red Flag Warning graphic for their jurisdiction during the interview, H1 remarked, "When does it start? When does it stop? Yeah, wind speed, RH values, things like that are important, but not the prevention tips." This again highlights the need for condition information, while also indicating that protective actions are of less concern. In the survey, protective actions were ranked least important (4.4).

4.2 *Information Preferences Over Time*

To identify if the information preferences of EMs might change at specific points in time leading up to a potential wildfire, the survey asked respondents to indicate the most important information type at five different points in time: 5 days, 3 days, 1 day, 4 hours, and 1 hour before elevated fire weather conditions (Fig. 4). Interviewees were asked about three different points in time: extended pre-event, medium range (24-36 hours), and immediate pre-event/ongoing.

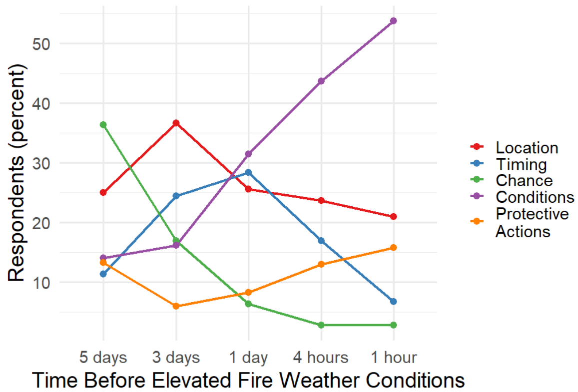

Fig. 4. Percentage of WxEM Wave 7 respondents that chose each information attribute as "most important" at different points in time leading up to elevated fire weather conditions.

Five days before elevated fire weather conditions, chance was the most important type of information (36%). Three days before elevated fire weather conditions, location became the most important information to EMs (36%). This was reflected in the desire for more specific location and chance information in the interviews. When looking at an SPC outlook 3-4 days before a potential event, H2 said that it covers "[s]uch a wide area…I don't trust how specific that's going to be," and affirmed that they preferred working with local scale forecasts for fire weather. They also expressed a desire for the graphic to be more specific in the chances it displays, "the difference between the critical and the sub critical of the elevated. I mean, how exact is that margin?" (H2). This indicates a desire for more specific, local chance and location information in fire weather forecasts.

One day before elevated fire weather conditions, the most important information attribute was conditions (32%), followed by timing (29%) and location (25%). EMs reported that the shift to monitoring fire weather conditions in preparation for a potential wildfire typically happens when either a Fire Weather Watch or Red Flag Warning is issued, which is "roughly the 36 hour or so notice" (S1). The day before a potential wildfire, H2 reported that they are "monitoring, just watching the weather forecast," which could include receiving information that includes any combination of timing, location, and fire weather conditions.

At four hours before a forecasted fire weather event, conditions became increasingly important to EMs (44%), and even more important in the hour leading up to a potential fire weather event (53%). H1 highlighted this in the interview, highlighting that conditions shown on a graphic the morning of an event get their attention: "So this, gets me thinking…hot, dry, wind expected gusts, south southwesterly winds across the region. You know, I'm going 30, gusts 35 to 40. Yeah, that's bad."

Excluding protective actions, all other information attributes decreased in importance in the day leading up to elevated fire weather conditions. In the interviews, EMs indicated that they did not want protective action information for themselves, but to share with the public. When presented with a Red Flag Warning graphic that included fire prevention tips, H2 remarked, "I don't need the fire prevention tips…That's what I tell the citizens that are going to start the fires, not me…"

4.3 *Conditions*

Since EMs preferred condition information leading up to an event, another survey question was analyzed for this project. Participants were asked to select all of the listed weather conditions or indices that they pay attention to once an active wildfire is in or near their jurisdiction (Fig. 5). Wind speed (92%), wind direction (86%), and relative humidity (70%) were the three most commonly reported conditions, suggesting that EMs are primarily paying attention to measurements rather than indices. There is a noticeable gap between how frequently EMs are monitoring conditions and the next most common response, Red Flag threat index (RFTI, 48%). Since wind speed and direction are factors that influence where and how quickly a fire spreads, these results indicate that EMs are monitoring specific weather conditions that influence fire spread.

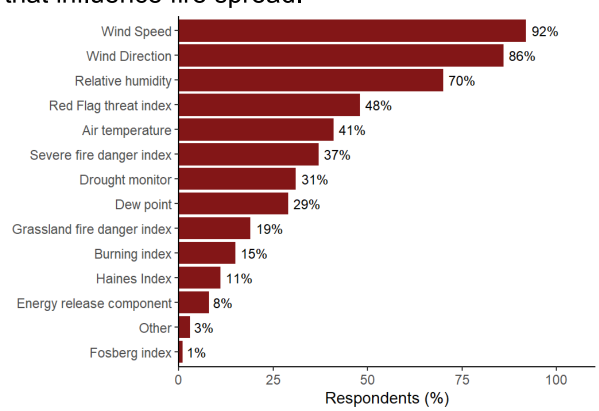

Fig. 5. Weather conditions and indices monitored by WxEM Wave 7 respondents during active wildfire events.

In the interviews, participants also talked about monitoring wind conditions. One jurisdiction talked about a particular tool that they were fond of using to track wind:

"Windy. We love in the EOC, because it can drop a pin and just see the way the winds join, and then switch it to miles per hour and get an accurate speed…that's probably the number one thing we use because it looks good, it's easy to understand, and it's got a halfway decent looking radar. Again, I can't say how accurate it is…from a weather standpoint, but at least it gives us something to look at that a lay person can understand." (H2)

O1 expressed that higher wind speeds can warrant extra attention when fire weather conditions are critical "…Now, if the Red Flag Warning is there, because they are anticipating 60, 70,80, mile an hour winds wake me up, sure." Wind does not necessarily have to be attached a fire-specific product to get an EM's attention, either. O1 also said that "when I see a high wind warning, to me, by default, it's a fire warning." This again highlights the importance of wind information for fire weather. There is a noticeable jump between the three most chosen conditions, wind speed, wind direction, and relative humidity and the next most common condition, Red Flag Threat Index (RFTI). This was reflected in interviews where H4 said that indices can be confusing. "...Red Flag Warning is two indicators into fire danger, but they them by themselves, are not direct indicators in the fire danger, right?". This shows a preference in actual weather conditions over indices.

5. DISCUSSION

Overall, EMs are simultaneously concerned about *where* a potential wildfire is most likely to occur (location), *when* it is most likely to occur (timing), and *how* weather conditions might influence fire behavior (conditions). These are the pieces of information that they primarily use for decision-making purposes such as coordinating resources and staffing their offices. All of these pieces are needed in order for EMs to paint the picture of how to prepare for and respond to potential fire weather events.

Location of potential fire weather is important for planning resource coordination. It is useful for EMs to know not only if their own jurisdiction will experience elevated fire weather conditions, but if nearby jurisdictions will also be affected. When H1 saw that the counties surrounding their jurisdiction were also under a Red Flag Warning, they noted, "That kind of helps…some of the pre planning. If I have something that goes south, I may not be able to pull trucks from [Neighboring Jurisdiction]." It is more difficult to request additional help if response partners are occupied with managing fires in their own jurisdictions, so awareness of how nearby areas will be affected by fire weather can help EMs decide who to rely on for assistance if needed.

Timing is important because EMs need to ensure that their offices are properly staffed ahead of a potential fire weather event. When looking at a forecast graphic that presented a timeline of prolonged critical fire weather conditions, S1 noticed that "the worst of it is over the weekend, when we typically wouldn't have people in the EOC." Knowing the timing of elevated fire weather conditions and when it will be most severe allows EMs to "think about staffing and availability response capabilities and so forth." (S1).

Because EMs use the forecast information they receive to inform their own operations to also inform stakeholders (Cross and LaDue 2021), EMs must also account for the information needs of stakeholders when receiving fire weather forecasts. Regarding information about a Red Flag Warning, S1 noted, "We're definitely taking a few extra seconds…to make sure partners are aware…and talk more specifically about wind speeds and relative humidities and what that could actually mean." While EMs indicated they don't need protective action information for themselves, they share it with stakeholders who do need it. H4 said that "the fire prevention stuff…would be picked up by our communications partners in the city and county, and that would be sent out."

Information preferences also change over time. In the survey timeline, chance was the most important information five days before elevated fire weather conditions, suggesting that EMs mainly want to know the likelihood of an event at this point in time. EMs are unsure about outlook confidence in forecast information this far out because "when it comes to wind and RH…when it's three to five [days]...it's hard to predict that" (H4), and they don't make decisions based on this information. However, H4 also reported, "I use it so I sleep at night…Like, true. It's gonna be nice. Or, you know…maybe we get some moisture this week." Even though EMs might not use this information for decision-making, they might still find it useful for validating general ideas of what to expect in the days ahead, similar to the "gut checks" described in Rapp et al. (2020).

Location was most important three days before elevated fire weather conditions, indicating that EMs want to know if their jurisdiction will be affected. This is around the time that a Fire Weather Watch might be issued for an area, which is when "critical fire weather conditions are possible but not imminent or occurring." (NWSb). Looking at the surrounding counties in a Red Flag Warning, H2 said, "Okay, I suppose it could be helpful to see that everybody around us is in a red flag. But I'm not worried about the other counties. I just want to know about my county…" This statement highlights that they want to know if they even need to care about location.

Condition information first began to be most important to EM survey respondents one day before elevated fire weather conditions, closely followed by timing and location. This is similar to findings from the overall information preference rankings, and suggests that this is the point in time where EMs are gathering the information that they need to prepare for a potential wildfire. This is typically the time that a Red Flag Warning might be issued, which means that critical fire weather conditions are "ongoing or expected to occur shortly." (NWSb). H1 said that the issuance of a Red Flag Warning is the point when "most of the departments up staff" in their jurisdiction. Condition information continues to increase in importance in the hours before a possible Red Flag Warning goes into effect. L1 noted their tendencies for seeking out condition information as they described their process of monitoring various weather conditions such as wind speed and wind direction on the day before forecasted elevated fire weather conditions.

Protective action information was ranked as least important overall by EMs in the survey panel, yet it increased in importance during the warning phase timeframe, which shows that this information becomes more important as the event gets closer. Based on interview findings, EMs do not need this information for themselves when preparing for elevated fire weather conditions (H1, H2). However, as fire risk becomes more likely, information on fire prevention becomes more relevant to pass along to stakeholders. H4 shared that the fire prevention tips attached to the Red Flag Warning graphic would be sent out by local communications and is "great information for me, for the mayor, the chief staff."

When EMs monitor weather conditions during fire weather events, they are most commonly looking at wind measurements, as that can influence fire spread. If a fire starts when wind speeds are high, "it's going to go fast" (S1). Since fast-moving wildfires have also been the most destructive and deadly (Balch et al. 2024), it is imperative to know where and how quickly a potential wildfire could move, especially when residences and resources are at risk.

Another reason EMs might look at wind is because of the impacts that wind could have on infrastructure and resources within their jurisdiction. O1 explains, "...we've got big buildings, we got architecture, we've got research, we've got stuff that wind can do some very significant damage. So we look at wind, and that may dictate…the shutdown of events or activities."

The survey data suggests that EMs are looking at measurements when monitoring fire weather more often than they are looking at fire weather related indices. While indices may be calculated using measurements such as wind speed and relative humidity, "...the Red Flag Warning does not tell any story. It says there's a chance of fire, right? People don't understand. It's humidity, it's wind, it's temperature…" (O1).

EMs are both decision-makers and messengers. As decision-makers, they "need to have the whole picture here" (H4) and prioritize dynamic information that includes the timing, location, and conditions of fire weather to inform operations during those events. These priorities shift in the progression towards a potential fire event. EMs don't rely on extended range fire weather forecasts for decision-making, but they may use them to get a sense of the chance for fire weather conditions in their jurisdiction over the coming days. As elevated fire weather conditions become more likely, EMs begin gathering the information that they need to prepare ahead of a potential wildfire. This can include ensuring that their offices are staffed when fire weather conditions are most critical and informing response partners about the potential impacts of those conditions. In the hours immediately before and during elevated fire weather conditions, EMs pay closer attention to wind measurements to monitor fire spread. As messengers, they must also take into account the information that their audiences need.

5.1 *Limitations and Future Work*

Only five interviews were analyzed in this study. While these interviews came from a larger project on EM workflows, this study focused on five interviews that specifically covered fire weather operations to contextualize our survey findings. This small sample size means that the results here are not generalizable, but provide support to the quantitative results.

Although wind can be an important factor in the size and spread of wildfires, recent events might have caused some EMs to be hypervigilant in monitoring wind conditions. Interviewees were from jurisdictions that experience fire frequently, including catastrophic wind-driven fires that remain in the institutional memory of various EM jurisdictions. It should also be noted that high-impact fire events were also occurring during the time that WxEM Wave 7 data was being collected, which could have affected how EM respondents perceived the risk of wildfires in their jurisdictions and how they might use forecast information during those events.

Differences in regional hazards should also be considered when evaluating the information preferences of EMs. The EMs that were interviewed work in areas where fire weather conditions occur more frequently. EMs that are less experienced with fire weather, however, might be more reactive to information regarding elevated fire risks. Future work could include interviews with such EMs to draw comparisons.

6. CONCLUSION

To help fill the knowledge gap in how EMs use fire weather forecast information, this study used a mixed methods approach to identify forecast information preferences of EMs during fire weather events. Quantitative data from the WxEM Wave 7 survey highlighted specific fire weather information attributes that EMs look for, and qualitative analyses of interviews with EMs about their workflow contextualized the relevance of such information.

This study found that EMs generally look for fire weather forecast information that includes the location and timing of a potential wildfire event in their jurisdiction. In the hours leading up to an event, EMs greatly shift their focus to monitoring fire weather conditions that can influence the impact of a potential fire, particularly wind speed and direction.

EMs are tasked with making critical decisions in a short amount of time based on the information that they receive, so they must receive information that is most relevant to their decision-making. These results highlight the information types and attributes most relevant to EMs in their operations, which may help forecasters craft the information that they share with EMs during fire weather events.

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Data availability statement. Survey instruments, reference reports, and data can be found online (https://dataverse.harvard.edu/dataverse/emsurvey).

Interview protocols and deidentified data are available upon request.

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