

Integrated Multiagency National Weather Service Operations during the 14 March 2025 Oklahoma Fire Disaster

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KEYWORDS:

Forecasting;
Operational
forecasting;
Emergency
response;
Forest fires;
Decision making;
Decision support

ABSTRACT: A violent firestorm struck Oklahoma on 14 March 2025. Despite adverse impacts across the state, the devastation may have been worse if not for the National Weather Service's (NWS) demonstration of integrated multiagency operations to enhance decision-making and to protect lives and property. Six weeks before the outbreak, a statewide NWS integrated warning team (IWT) workshop was cohosted by the Cooperative Institute for Severe and High Impact Weather Research and Operations (CIWRO) at the University of Oklahoma. The event introduced a multidisciplinary pilot project between the NWS and Oklahoma Forestry Services (OFS) and trained 175 fire and emergency management personnel on the use of satellite-based fire detections and tactical IWT fire warnings coordinated by meteorologists and fire analysts. Subsequently, an NWS meteorologist was embedded with OFS throughout the 2025 fire season. The collaboration contributed to interdisciplinary probabilistic wildfire outlooks that enabled the mobilization of aircraft and fire suppression resources from five assisting states on 11 March. Hours before the fires, OFS and CIWRO personnel integrated into NWS operations. Side-by-side, meteorologists used satellites to notify responders of emerging fires, while OFS analysts modeled potential fire spread and coordinated geotargeted NWS-disseminated fire warnings. These warnings provided public hazard messaging and informed downwind evacuations. Meanwhile, an NWS meteorologist at the state emergency operations center coordinated Wireless Emergency Alerts and briefed the governor. Preliminary analysis suggests that early satellite-based fire detections helped to save more than \$810 million in property damage. Here, we document insights and challenges of NWS operations that were encountered during this consequential pilot demonstration.

DOI: 10.1175/BAMS-D-25-0136.1

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Manuscript received 9 June 2025, in final form 8 April 2026, accepted 21 April 2026

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1. Introduction

Oklahoma was the epicenter of a violent firestorm on 14 March 2025 (Fig. 1). The outbreak of fast fires (Balch et al. 2024) was tied to a powerful midlatitude cyclone. A 982-hPa surface low over the central United States induced widespread westerly wind gusts $> 25 \text{ m s}^{-1}$ [50–70 kt (1 kt $\approx 0.51 \text{ m s}^{-1}$)]. These winds were aligned with anomalously warm and dry air over the seasonally dormant prairies of Oklahoma. At the time, 71% of the state was experiencing abnormally dry to moderate drought conditions per the U.S. Drought Monitor [National Drought Mitigation Center (NDMC) et al. 2025]. The resultant southern Great Plains wildfire outbreak (SGPWO; Lindley et al. 2014) brought 135 wildfires that burned nearly 846 km² (209 000 acres) across parts of four states. The greatest impacts were in north-central Oklahoma where 515 homes were destroyed. Four deaths and 200 injuries were attributed to the fires (Oklahoma Department of Emergency Management 2025).

NOAA's National Weather Service (NWS) is becoming more nimble, flexible, and mobile, delivering eye-to-eye decision support services to core partners (Uccellini and Ten Hoeve 2019). As the wind-driven flames swept across Oklahoma, the NWS Weather Forecast Office (WFO) in Norman (OUN) conducted integrated operations with key state agencies. In the future, it is anticipated that NWS meteorologists will increasingly participate directly in government functions where their expertise is fundamental to support decisions that protect life and property (Hilderbrand 2014). During the spring of 2025, OUN tested multigovernmental

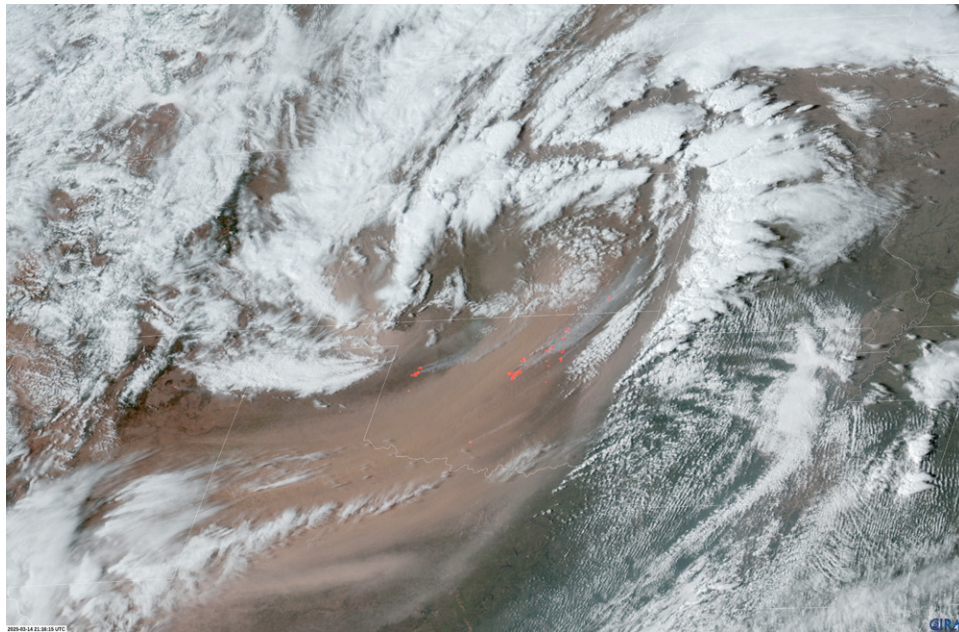


FIG. 1. GOES-East Geocolor (geocolor; 3.9, 2.2, and 1.6 μm) imagery of the firestorm at 2116 UTC 14 Mar 2025. Fire detection hotspots (red; center of figure) are plotted. Also note widespread dust transport and smoke plumes. Image courtesy: Cooperative Institute for Research in the Atmosphere.

agency operations. In this proof of concept, NWS meteorologists embedded with state forestry and emergency management agencies and achieved fully integrated fire detection and warnings during the 14 March firestorm. The pilot documented impacts of interdisciplinary multiagency wildfire response. In part due to the effectiveness of integrated operations, estimated fatality rates were lower than those experienced in similar past wildfire outbreaks, and preliminary postevent analyses suggest that thousands of homes were saved. While the demonstration was successful, it also exposed challenges that meteorologists will face while serving in high-stakes decision-support roles. Despite state-of-the-art collaborative science, exceptional forecasts, warnings, and unprecedented service delivery, the sheer extremity of some weather disasters can render negative outcomes unavoidable (Weyrich et al. 2018).

2. Pilot demonstration

In early 2025, OUN tested the feasibility of embedding NWS meteorologists into critical weather-sensitive fire and emergency management operations. While NWS incident meteorologists (IMETs) have a long history of providing onsite support to incident management teams during large, long-duration campaign fires and events of national interest (Gray 1929; Heffernan 2017), operational integration during rapidly evolving severe wildfire outbreaks has been less common. In response to increasing wildfire risk across the southern Great Plains and growing demands for real-time decision support, OUN and Oklahoma wildfire response agencies initiated a pilot project to evaluate whether embedding meteorologists directly within state forestry and emergency management operations could improve preparedness, situational awareness, and coordinated response during high-impact fire weather events. This included committing a lead meteorologist, an individual with 25 years of experience providing occasional onsite support during extended wildfire episodes, to embed at Oklahoma Forestry Services (OFS) during the 2025 fire season. In Oklahoma, the peak season for large and damaging wildfires typically occurs in late winter or early spring, when vegetative fuels are still dormant prior to the onset of springtime rains associated with the convective severe weather season (Reid et al. 2010; Lindley et al. 2011).

On 30 January 2025, a statewide fire integrated warning team (IWT) workshop was held at the University of Oklahoma (OU). The event was jointly conducted with the Oklahoma Mesonet's OK Fire program (Carlson et al. 2009; Anstedt 2011) and the Cooperative Institute for Severe and High Impact Weather Research and Operations (CIWRO). At the workshop, the piloted integration of NWS and OFS operations was announced, and 175 members of Oklahoma's emergency management and fire services participated in a day-long simulated wildfire outbreak. The goal was to prepare and train emergency managers and fire agency leaders to receive and utilize NOAA/NWS satellite-based fire detections, as well as to collaborate IWT fire warning workflows across multiple agencies. Both of these tactical fire services were previously developed and demonstrated at OUN (Lindley et al. 2016, 2024) and recently evaluated at NOAA's Fire Weather Testbed (NOAA Fire Weather Testbed 2025; Wells et al. 2025). Postworkshop feedback from attendees indicated that NWS satellite-based fire detection hotspot notifications were "extremely helpful" to emergency operations, and nearly 90% of respondents expressed that they gained working knowledge of the IWT fire warning purpose and procedures through workshop participation.

By mid-February, the OUN meteorologist was embedded full time within OFS operations. Objectives of the project were 1) to inform strategic predeployment of firefighting personnel and resources through probabilistic wildfire outlooks, 2) to assist initial attack efforts on newly emerging incidents via satellite fire detection, and 3) to collocate meteorologists, analysts, and request authorities to optimize IWT fire warning workflow efficiency. In the early days of the assignment, the NWS meteorologist and information technology officer worked with OFS geographic information system (GIS) specialists and fire analysts to integrate data

across shared systems and to establish tailored daily statewide forecasts in support of fire management planning. The collaboration produced a customized fire weather dashboard and the visualization of fire spread models in NWS operations.

By 5 March, an analog-based system that compares predicted weather patterns to past wildfire outbreaks produced by the Cooperative Institute for Precipitation Systems at Saint Louis University (Beitscher 2020) initially identified a candidate SGPWO-bearing midlatitude cyclone that was forecast to impact the southern Plains on 14 March. As consistency of weather model output increased and effects of intervening precipitation (observed 25–75 mm amounts over southern Oklahoma and northern Texas on 8 March) were analyzed, confidence increased that the vegetative fuels and meteorological components of the fire environment would align to produce a potential for significant wildfires. On 9 March, an interagency group, including the NWS/OFS liaison and partnered fire analysts working side by side at OFS, highlighted a “moderate probability [30%] of significant wildfires and a SGPWO possible” for 14 March. As the potential event neared, collaborated probabilistic guidance escalated to reflect the building threat and eventually indicated >60% probability of >5000-acre wildfires from central Oklahoma into southeastern Kansas 24 h before the conflagration (Fig. 2). Unique from conventional predictions published by any one agency, which typically focus on either exceedance of critical weather or fuel dryness thresholds independently, this probabilistic guidance leveraged multidisciplinary expertise toward forecasting actual wildfire occurrence and expected fire size to inform better decision-making compared to traditional deterministic red flag warnings. Probabilistic depictions of risks enabled preparatory actions well before the fires. Wildland task forces were mobilized both within OFS and from five assisting states. In addition, Super Scooper CL-415 aircraft arrived in-state on 11–12 March.

In the hours prior to the 14 March fires, fully integrated, multidisciplinary, and multiagency operations were established at OUN (Fig. 3a). The NWS/OFS liaison meteorologist, along with OFS GIS specialists, staffed adjacent workstations centered in the OUN weather operations area. A CIWRO emergency manager (EM) research associate was similarly embedded. As during past high-impact events in Oklahoma, an OUN lead meteorologist was deployed to the State Emergency Operations Center (SEOC) in support of the Oklahoma Department of Emergency Management (ODEM; Fig. 3b).

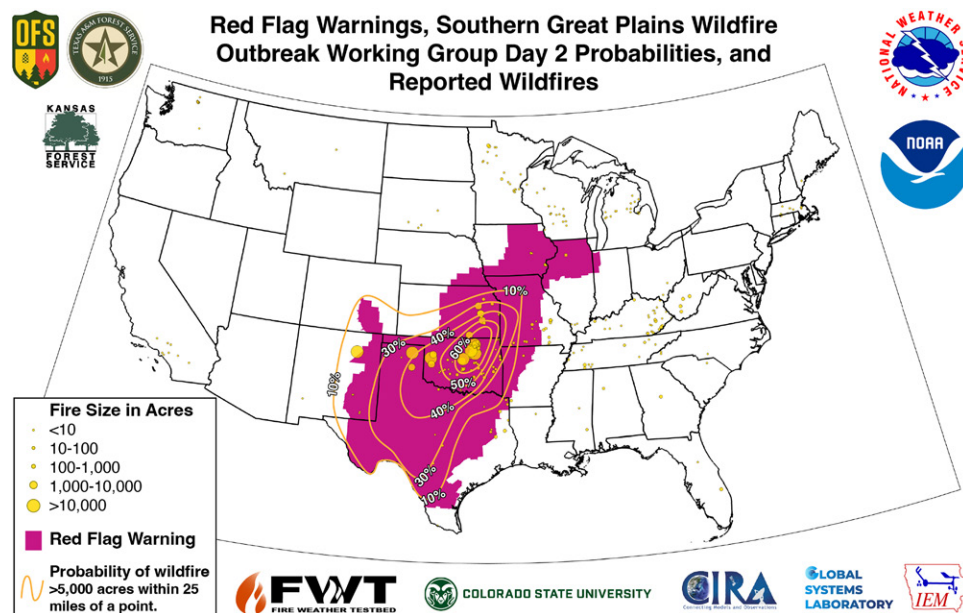


FIG. 2. Map showing NWS red flag warnings, a multiagency working group’s probabilistic significant wildfire outlook, and observed wildfires on 14 Mar 2025.

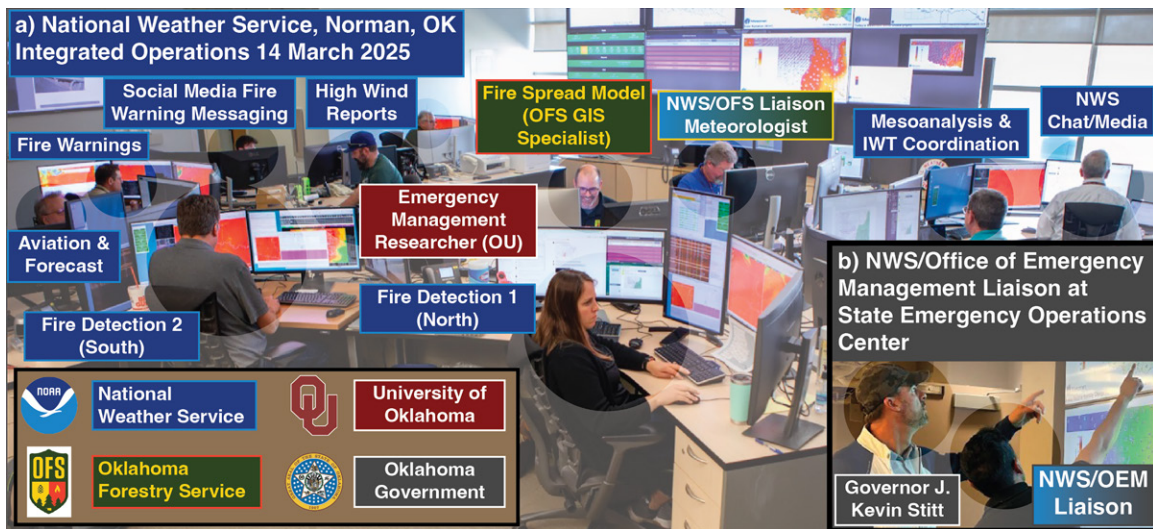


FIG. 3. Integrated operations between NWS, OFS, and emergency management (a) at OUN and (b) at the State Emergency Operations Center during the 14 Mar 2025 firestorm.

As weather conditions deteriorated by late morning, new and existing wildfires began to spread. NWS meteorologists used observations and mesoanalysis tools such as the Warn-on-Forecast System (Lindley et al. 2023; Heinselman et al. 2024; Jones et al. 2024; Hatchett et al. 2024) to monitor and forecast the evolving fire environment. Satellite products including the Next Generation Fire System (NGFS) and intensive manual interrogation of real-time GOES data were used to rapidly detect and notify authorities of emerging hotspots. Hotspot notifications provide responders with newly ignited fire geocoordinates, as well as observed and forecast weather conditions to support prompt initial attack (Lindley et al. 2016). Additional OUN meteorologists monitored GOES-derived shortwave infrared to determine when fire thermal signatures exceeded specified brightness temperatures frequently associated with extreme fire behavior (Lindley et al. 2024). Once such anomalous wildfires were identified, the liaison meteorologist and OFS GIS analyst collaboratively generated real-time fire spread mapping and assessments of values at risk. This intelligence informed OFS fire analysts' evaluation of the necessity for collaborated multiagency threat messaging via tactical IWT fire warnings (Fig. 4) as the on-site CIWRO EM helped to coordinate threats to the public that warranted evacuations. When imminent threats to livelihood and values at risk were identified, OFS fire analysts provided requesting authority for NWS-disseminated IWT fire warnings. The geographies of polygon-based warnings were informed by OFS-generated fire spread modeling to specifically activate the Emergency Activation System for those at greatest risk. With help from the NWS liaison at the SEOC, ODEM activated Wireless Emergency Alerts so that cell phones in the warned area would be notified. When deemed necessary and requested by local authorities, subsequent Evacuate Immediate messages were primarily transmitted by ODEM to communicate evacuation instructions to the public.

In addition to the fully integrated operations at OUN, the liaison meteorologist and OFS GIS specialists supported fire operations occurring at neighboring NWS forecast offices in Tulsa and Amarillo, who also have responsibility for portions of Oklahoma where damaging wildfires occurred. On the 14th, 158 satellite-based hotspot notifications were issued for newly detected and evolving wildfires across the state. Local jurisdictions reported feedback on a subset of 31 fires for which NWS hotspot notifications were provided. Of those notifications, 78% were received prior to dispatch with only one detection (3.2%) deemed a false alarm. Preliminary analysis conducted for seven fires that were initially identified and reported by NWS meteorologists via satellite and subsequently modeled in real time for potential spread reveals that early detections and response contributed toward saving an estimated 14 200 structures and

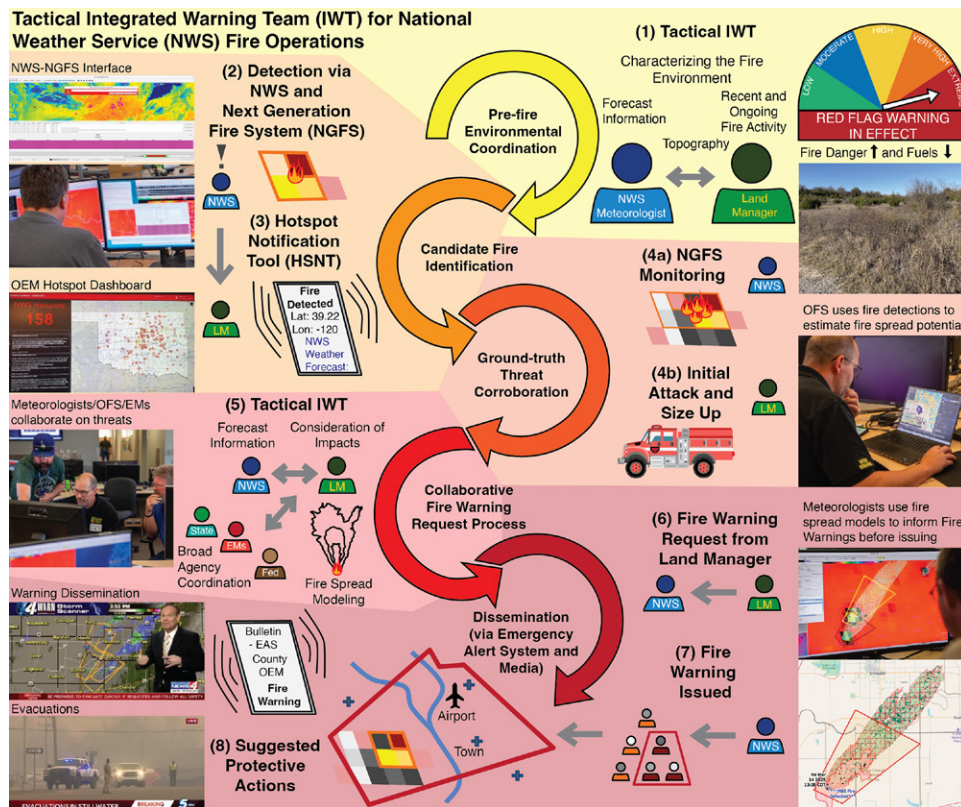


FIG. 4. A tactical IWT for fire operations workflow adapted from Wells et al. (2025) illustrated with photos from 14 Mar 2025.

at least \$810 million in potential property damage during the outbreak. Early satellite-aided discovery, response, and suppression of these fires helped to mitigate total burn areas by an estimated 71% relative to projected worst-case 8-h spread potential as modeled by Technosylva's Wildfire Analyst©. Spread models suggested that an additional 1300 km² (321 306 acres) were at risk, but the fires were ultimately contained at a cumulative 406 km² (100 200 acres).

As an example, the Hickory Hills Road Fire (Fig. 5) was initially detected by NWS meteorologists at 1832 UTC. Chad Weaver, Deputy Chief of Fire Operations for the Edmond Fire Department, said, "we immediately initiated a response . . . as soon as we got the hot spot. We attended the NWS class at OU [the 30 January Fire IWT workshop]. This was the first time we had sent resources on only a hot spot notification." The first 911 call report of the fire was received 4 min later at 1836 UTC. Meanwhile, coordinates provided by the NWS/OFS liaison were used by OFS fire analysts to model an unsuppressed 8-h spread potential of 164 km² (40 534 acres). A multiagency IWT fire warning was disseminated at 1845 UTC, 13 min after initial satellite-based detection. Ultimately, the fire was contained at 26 km² (6495 acres), and 972 structures within the projected fire progression were successfully protected, preserving an estimated \$77.8 million in tax-assessed property value.

NWS WFOs in Amarillo, Norman, and Tulsa combined to disseminate a total of 41 IWT fire warnings, which were collaboratively developed between NWS meteorologists and OFS fire analysts in coordination with local and state emergency management. Analysis of U.S. Census Bureau data within the wildfire perimeters reveals that the four fatalities represent a mortality rate of 0.07%. Consistent with previous evaluations (Carter et al. 2025) of the life-saving efficacy of IWT fire warnings, this represents a two-order reduction from the median 1.2% mortality rate documented for past fatality wildfires in the region. After in-person briefings at the SEOC conducted by an OUN meteorologist and various state government agency chiefs, the interagency coordination employed for tactical IWT fire warnings was praised in the immediate aftermath of the fires by Oklahoma Governor, Kevin Stitt, who said, "Our alert system

The direct integration of meteorologists with OFS operations provided many consequential lessons. Despite the novel approaches to strategic preparation and integrated tactical support employed, hundreds of Oklahoma families lost their homes in the disaster. The Stillwater, Oklahoma, Emergency Manager, Rob Hill, stated, “[We] knew there was an extreme fire danger a week before the wildfires started and Friday would be a potentially bad day for us.” Yet, Stillwater Fire Department Chief, Terry Essary, described, “On the afternoon of 14 March, our community experienced historic fire weather which culminated in the worst fire conditions Stillwater Fire Department has ever experienced. The volume [of structure fires encountered that day] would normally occur over the course of more than eight years.”

Further, meteorologists in a nimble, flexible, and mobile NWS will need to carefully communicate unbiased meteorological information. Their role may be to convey and interpret timely technical and probabilistic data that inform preparatory and mitigative actions before high-impact weather (Guirguis et al. 2025), but decision-making authority resides with governmental officials. Thus, agency leaders must provide commensurate support to meteorologists assigned as brokers of science-based services. Skillfully delivered meteorological briefings should contextualize scientific messaging without being drawn into policy decisions. For example, on the 14th, an embedded meteorologist was asked whether elected officials on travel should return to the state capitol. The meteorologist provided appropriate support for those decisions by characterizing the firestorm as “historic and 10 out of 10” with respect to magnitude and potential impact without explicitly offering an opinion on the issue in question. Training for such interactions exists for the agency’s IMETs and should be expanded across the agency. With imminently life-threatening wildfire emergencies becoming more frequent (Boer et al. 2017; Pyne 2018), the role of embedded non-IMET meteorologists and staff at WFOs should transition toward that of science first responders with skill sets to meet this escalating threat (Lindley et al. 2024).

As an agency, the NWS and its meteorologists embedded on the front lines of emergency response must prepare to deal directly with the consequences of high-stakes decisions made based on weather information they provide. This will place many NWS meteorologists in unfamiliar and challenging situations. While NWS meteorologists are accustomed to stressful severe weather operations within the confines of their forecast offices, those settings are frequently insulated from high pressure face-to-face interactions with decision-making officials during moments of crisis. Such environments are beyond the current experience and training of many NWS meteorologists and may increase the risk of burnout and critical incident stress. Last, meteorologists should prepare to face challenging situations where the best available weather information leads to suboptimal forecasts. Inevitably, some of these inputs will inform decisions and actions that are perceived as misguided and blamed for negative societal outcomes.

When it comes to wildland fire, renowned fire scholar, Stephen Pyne (2020) wrote, “if an agency stays only within its jurisdictional boundaries, it will fail” to successfully address the complexities of wildfire response. Instead, we must “address how fire really exists, and not how select sciences can handle it” (Pyne 2007). While Pyne emphasizes the criticality of multidisciplinary fire response as demonstrated during the 14 March 2025 Oklahoma firestorm, meteorologists and other technical practitioners acting in such capacity must also accept the reality that “science can inform and advise; it will not decide. That synthesis belongs with politics” (Pyne 2004).

Acknowledgments. The authors thank the staffs of Oklahoma Forestry Services, Oklahoma Department of Emergency Management, Edmond Fire Department, as well as Brian Carcione, Tim Oram, Chad Gravelle, Monica Mattox, and Stephen Bieda. We also express our gratitude to the editor and the three reviewers.

Data availability statement. Due to privacy and confidentiality issues, additional details related to analyses of saved values at risk cannot be shared at this time. Archived NOAA satellite-based fire detections can be accessed via the Next Generation Fire System. Red flag warning data were acquired from the Iowa State Environmental Mesonet's archive (<https://mesonet.agron.iastate.edu/>). Fire occurrence data were acquired from the Wildland Fire Interagency Geospatial Services page (<https://wfigs-nifc.hub.arcgis.com/>). U.S. Census Bureau data were used to assess at-risk population.

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