12.1 First Conference on Fire Weather, Technology, and Risk - 105th AMS Annual Meeting
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Life-saving Collaborative Fire Warnings and Wind-shift Forecasts During the Disastrous Texas Panhandle and Oklahoma Wildfires of February 2024

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1. INTRODUCTION

On 26-27 February 2024, devastating wildfires in the Texas Panhandle and western Oklahoma burned 5,552 km^2 (1,371,920 acres) and threatened thousands of people. While two civilians tragically lost their lives in the fires, the number of deaths was low compared to past wildfire disasters in the same geographic region. Similar wildfire outbreaks that also burned more than one million acres (≥4,047 km^2) impacted many of the same communities in 2006 and 2017, but caused mortality rates that were two orders of magnitude higher than those observed during the 2024 firestorm. This reduction in mortality occurred despite the fact that the 2024 fires directly threatened more people and homes. One factor that may have contributed to the relatively low number of fatalities in 2024 was use of a novel fire warning paradigm that leveraged a multi-agency integrated team. In addition to collaborative fire warnings, forecasts of a dangerous wind-shift were communicated up to 30 hours in advance.

This paper details the role of National Weather Service (NWS) meteorologists in collaborating successful fire warning operations, as well as proactive communication of wind-shift forecasts and fire evolution, with fire analysts and emergency management officials during the disastrous February 2024 wildfires.

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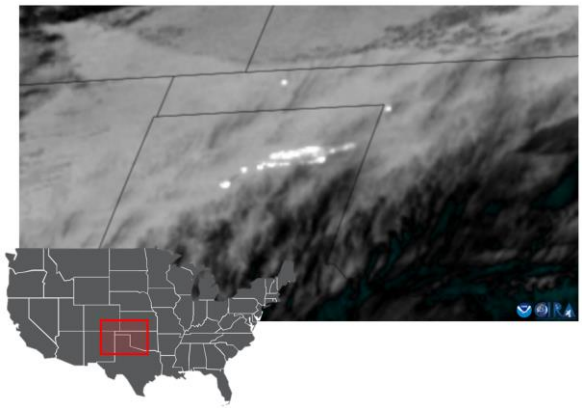


Figure 1: GOES-16 shortwave infrared view of wildfires in Texas and Oklahoma at approximately 1915 UTC 27 February 2024.

2. INTEGRATED TEAM FIRE WARNINGS

Between 2019 and 2023, meteorologists at the NWS Weather Forecast Office (WFO) Norman, Oklahoma (OUN) collaborated with fire analysts at Oklahoma Forestry Services (OFS) and Texas A&M Forest Service (TAMFS) to develop and demonstrate an Integrated Warning Team (IWT, Uccellini 2019) approach to fire warnings (FRWs, Lindley et al. 2019a, 2023a, 2023b, 2024a). In this paradigm, multi-disciplinary collaboration follows a prescribed workflow to achieve effective fire hazard messaging in real-time operations. First, meteorologists, fire analysts, and state emergency management officials coordinate the weather and fuel contributions to the pre-fire environment. Once NWS meteorologists identify warning-candidate

fires that meet specified satellite-based remote sensing guidance thresholds for IWT coordination within the previously identified fire environments, they send “Potentially Dangerous Fire Detected” notifications to state forestry and emergency management agencies. Fire analysts then corroborate the threat via on-site personnel, and in some cases use fire spread modeling to determine values at risk. If the fire is confirmed to present an imminent threat to life and property, fire analysts- usually working within a unified command structure- request that the NWS disseminate a geotargeted fire-scale warning. Warnings are conveyed to the public through NWS communication networks, and can be relayed through Wireless Emergency Alerts by emergency management agencies.

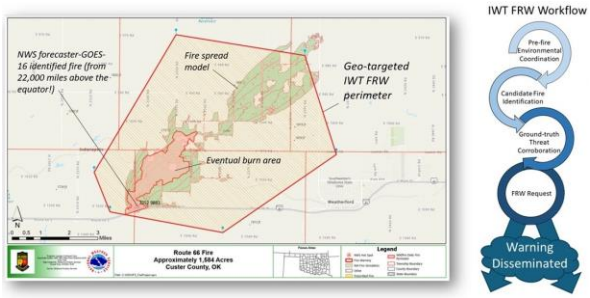


Figure 2: Annotated example IWT FRW and the IWT FRW workflow.

Early successes of this warning paradigm were highlighted in a joint press conference conducted by NWS Director, Ken Graham, and OFS Director, Mark Goeller, at the National Weather Center in Norman, Oklahoma, on 16 February 2024 (NOAA 2024a). Days later, the novel warning technique was utilized for the first time at multiple NWS offices, as OUN and WFO Amarillo, Texas (AMA), disseminated 20 IWT FRWs at the request of partner state forestry agencies and emergency management officials during the disastrous wildfires of 26-27 February 2024 (Lindley et al. 2024b).

Carter et al. (2025) conducted detailed analyses of census data relative to perimeters of the February 2024 fires in comparison to those from the 4,460 km^2 (1.1 million acres) 12 March 2006 and 5,088 km^2 (~1.3 million acres) 6 March 2017 outbreaks. Their study found that 4.2 times more people and 3.8 times more housing units were within the February 2024 fire perimeters compared to the 2006 and 2017 fires, yet mortality rates were two orders of magnitude lower– 0.04% in February 2024 versus an average of 2.77% for the two previous outbreaks. While it is difficult to attribute the reduction in mortality directly to the use of IWT FRWs, feedback from local and state officials suggests that the collaborative and multi-disciplinary warnings saved lives.

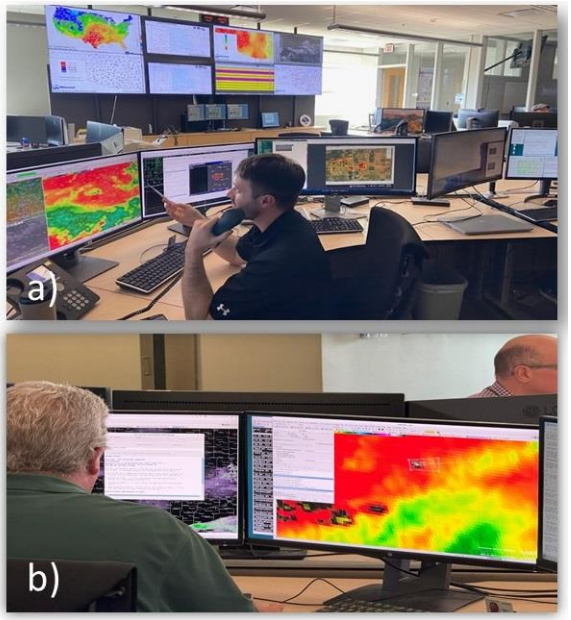


Figure 3a-b: OUN meteorologists monitor wildfires via satellite and coordinate IWT FRWs on a) 26 February and b) 27 February 2024.

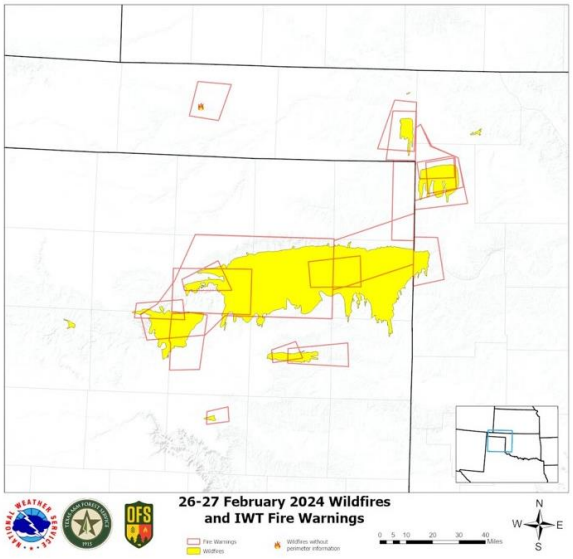


Figure 4: 26-27 February 2024 fire perimeters (yellow) and IWT FRWs (red polygons).

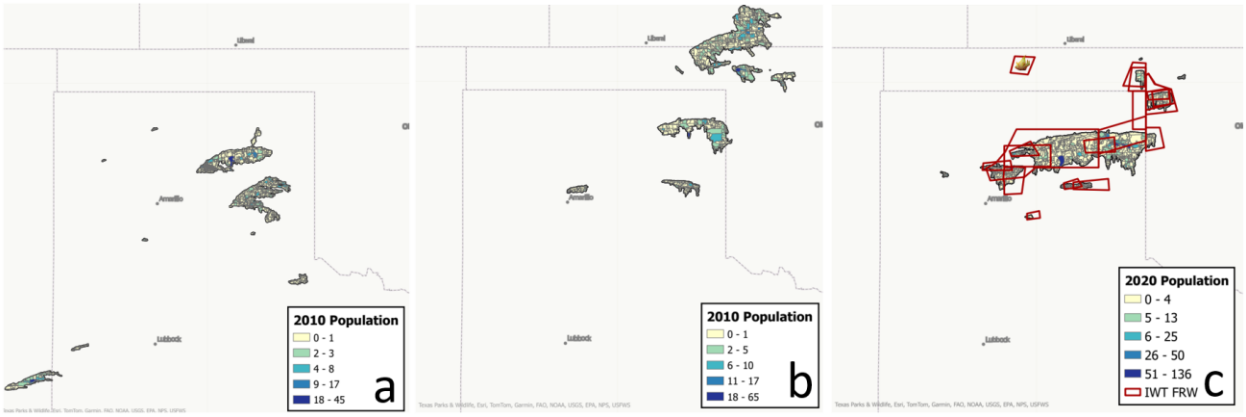


Figure 5: Census data analyses of population within the fire perimeters from a) 12 March 2006, b) 6 March 2017, and c) 26-27 February 2024. Adapted from Carter et al. 2025.

Table 1: Vital statistics from in-fire perimeter census analyses for the 2006, 2017, and 2024 firestorms. Adapted from Carter et al. 2025.

Date	Fatalities	At-risk Homes	Mortality (%)
12 Mar 2006	12	330	1.90
6 Mar 2017	6	974	3.64
No-IWT FRW Outbreaks (average)	9	652	2.77
26-27 Feb 2024	2	2,577	0.04

Select partner feedback on the use of IWT FRWs is reported below:

"At the community level, the fires that we experienced on the 26th and 27th [February 2024] were the most proactively warned fires in U.S. history." Mark Goeller, Oklahoma Forestry Services Director and State Forester.

"The effort and coordination between NWS offices, local and county emergency management, and forestry agencies for Fire Warnings, I believe, saved lives." Luke Kanclerz, Texas A&M Forest Service, Predictive Services, Department Head.

"Fire warnings were issued very quickly with Forestry coordinating with the National Weather Service while we were conducting the on-the-ground evacuations. Those warnings were updated as the fire progressed. We had no fatalities." Scott Barrett, Assistant Chief of the Gage, Oklahoma, Volunteer Fire Department.

"I thought the IWT Fire Warning process worked very well. It provided great assistance in getting the message out to those that needed to evacuate and prepare. The whole process provided a great service to our community." Keith Shaddon, Beaver County, Oklahoma, Emergency Manager.

3. WIND-SHIFT FORECASTS

Changes in wind speed and direction are a commonality in wildland fire fatalities (National Wildfire Coordinating Group 1997). Further, abrupt wind-shift interactions with ongoing large wildfires are consistent with the conceptual model for megafire (wildfires ≥404.7 km^2 or 100,000 acres) evolution on the southern Great Plains (Lindley et al. 2019b).

Meteorologists from OUN and AMA, along with fire analysts from OFS and TAMFS, recognized the potential for a strong northerly wind-shift to result in adverse effects on wildfires late on the 27th as early as 1500 UTC 26 February 2024, approximately four hours before fires ignited across the region and 30 hours prior to arrival of the wind shifting-front. Messaging

within the Southern Great Plains Wildfire Outbreak Working Group (SGPWO WG, a real-time multi-agency online collaboration forum between NWS meteorologists and state forestry fire analysts in Texas, Oklahoma, and Kansas) stated, *"An important risk factor will include the aggressive frontal passage that will infringe upon critical/locally extreme fire weather. Should fires become established…this would present a distinct threat."* This discussion accompanied a 10% probabilistic outlook for the occurrence of significant wildfires ≥20 km^2 (5,000 acres) within 40 km of a point in vicinity of the eventual outbreak area (Fig. 6a).

Once fires emerged on the landscape during the afternoon and evening (local time) of the 26th, coordination within the SGPWO WG reflected *"Increasing concern* [and] *escalation toward megafire candidate must be considered.* [The cold] f*ront may present a distinct threat to life and property"* by late on the 27th. Significant wildfire probabilities were increased to 50% over the northeastern Texas Panhandle and northwestern Oklahoma at 0300 UTC 27 February 2024 (Fig. 6b).

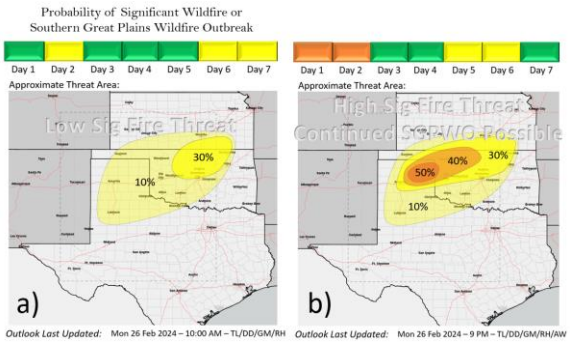


Figure 6a-b: SGPWO WG probabilistic significant wildfire outlooks posted at a) 1500 UTC 26 February 2024 and b) 0300 UTC 27 February 2024.

At 1430 UTC 27 February 2024, discussion within the SGPWO WG began to emphasize the danger of expected wildfire/wind-shift interactions later in the day, stating *"Fire conditions are shaping up to be particularly dangerous in vicinity of these fires today…as an abrupt and potentially very dangerous northerly wind shift interacts with the fire grounds"* (Fig. 7a).

As the frontal passage became increasingly imminent, an urgent mesoscale update was posted at 2042 UTC 27 February 2024 within the SGPWO WG forum and relayed in NWS Chat, which stated, *"Exceedingly dangerous wind shift is imminent on the fire complex in the central/northeastern Texas Panhandle and far northwestern Oklahoma! Effects on the fire grounds should be expected as early as 3:15-3:30 pm* [LST]. *This is a life threatening situation for responders and the public! It is likely that the initial wind shift will be associated with exponential fire growth and a sudden acceleration in the rate of spread for the Smokehouse megafire. All interests within at least 6-15 miles south of the Smokehouse Fire's 45-60 mile right flank should prepare for life threatening fire conditions within the next 2-3 hours"* (Fig. 7b). In addition, AMA conducted livestream social media updates that kept the public and first responders informed on progression and timing of the front as it approached the fires throughout the day. A 2203 UTC Facebook Live by AMA described how the Smokehouse Creek Fire's southern flank would imminently begin to spread south across three counties.

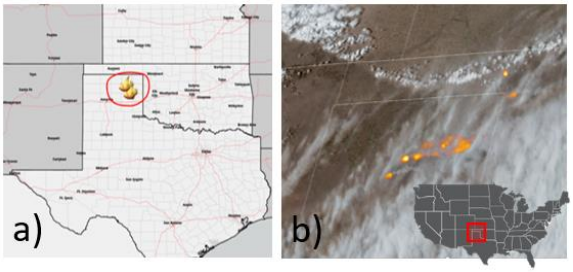


Figure 7a-b: SGPWO WG mesoscale update graphic posted at a) 1500 UTC 26 February 2024 and b) GOES-16 imagery showing fires (orange) and the advancing wind-shift (thin cloud line) at 2042 UTC 27 February 2024.

A Cooperative Institute for Severe and High-impact Weather emergency management/social science researcher was embedded with a wildland task force in western Oklahoma during the wildfire outbreak. The researcher reported

that the 2042 UTC mesoscale discussion had an impact on decision making, and that *"The emphasis on responder safety really hit home. This also seemed to change the outlook and expectations on the remainder of the day."*

Ultimately, the Smokehouse Creek Fire became one of the largest contiguous wildfires in modern U.S. history after the wind-shift dramatically altered and enhanced its spread toward the south along its >190 km right flank. A civilian motorist was killed shortly after the wildfire/wind-shift interaction (National Interagency Coordination Center 2024). In addition, the same frontal wind-shift accelerated the nearby Windy Deuce Fire to 575 km^2 (142,144 acres), and likewise propelled the Catesby Fire in northwestern Oklahoma to near megafire proportions at 367 km^2 (90,580 acres).

4. DISCUSSION

This paper provides a high level and concise summation of life-saving integrated fire-scale warnings and wind-shift predictions during the 26-27 February 2024 Plains wildfire outbreak that were recognized by the American Meteorological Society's 2025 Special Award for an Exceptional Specific Prediction. The fire services documented here are not yet standardized in operational practices across wildland fire agencies, or even within the NWS. They were, however, evaluated by NOAA's Fire Weather Testbed in June 2024 for possible future implementation (NOAA 2024b; Leonard 2024).

The authors of this paper, most of whom are operational practitioners representing multiple weather and fire/land management entities whose missions intersect at the protection of life and property, take this opportunity to implore policy makers to adopt similar collaborative science-based approaches to the provision of proactive public-facing warnings for dangerous fires. Such solutions are how we save lives in wildfire emergencies and mitigate disasters. Renowned fire historian, Stephen Pyne (2020), wrote, *"if an agency stays only within its jurisdictional boundaries, it will fail."* Instead, we must *"address how fire really exists, and not how select sciences can handle it"* (Pyne 2007). In the IWT FRW paradigm discussed here, meteorologists and fire analysts collaboratively use knowledge of the holistic weather and fuels fire environment and satellite-based technology in a science first responder capacity to influence public reaction to impending threats and critical decision making by incident managers. It is simply "good government" to work across local, state, and federal jurisdictions to diagnose and communicate these dangers with one unified voice when minutes matter most.

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REFERENCES

Carter, J. B., M. A. Fox, R. D. Smith, A. M. Ward, D. Hogg, and M. J. Krocak, 2025: Commentary on Retrospective demonstrations of an integrated team approach to fire warnings for western United States wildfire disasters. *J. Operational Meteor.* Commentary, in press.

Leonard, D., As wildfire rage, forecasters test new way to warn people near flames. The Washington Post. July 27, 2024. [Available online here]

Lindley, T. T., D. L. Andra, R. D. Smith, T. S. Curl, A. B. Zwink, D. A. Speheger, R. R. Barnes, D. C. Daily, B. R. Smith, and P. G. Witsaman, 2019a: Proposed implementation of warn-on-detection fire warnings for public and firefighter safety. 5th Conf. on Wea. Warnings and Communication, San Diego, CA., Amer. Meteor. Soc. [Available online here]

____, D. A. Speheger, M. A. Day, G. P. Murdoch, B. R. Smith, N. J. Nauslar, D. C. Daily, 2019b: Megafires on the Southern Great Plains. *J. Operational Meteor.*, **7** (12), 164-179, doi: https://doi.org/10.15191/nwajom.2019.0712

____, M. A. Fox, R. D. Smith, D. A. Speheger, A. B. Zwink, R. R. Barnes, D. C. Daily, B. R. Smith, C. M. Gravelle, P. Reiter, 2023a: An integrated warning team approach to fire warnings. 14th Symp. Fire and Forest Meteor., Amer. Meteor. Soc. [Available online here]

____, M. A. Fox, R. D. Smith, D. A. Speheger, A. B. Zwink, R. R. Barnes, D. C. Daily, B. R.

Smith, C. M. Gravelle, P. Reiter, 2023b: An integrated team approach to fire warnings. Conference Notebook, *Bull. Amer. Meteor. Soc*., **104** (9), 665-667.

____, A. B. Zwink, D. A. Speheger, D. C. Daily, B. R. Smith, P. T. Schlatter, R. W. Walbrun, W. Rasch, M. S. Elliott, M. E. Jeglum, R. L. Heffernan, H. E. Hockenberry, and S. W. Bieda III, 2024a: Retrospective demonstrations of an integrated team approach to fire warnings for western United States wildfire disasters. J. Operational Meteor., **12** (5), 54-71, doi: https://doi.org/10.15191/nwajom.2024.1205.

____, D. C. Daily, M. A. Fox, D. A. Speheger, C. Mask, L. Kanclerz, A. Ward, M. Gittinger, R. L. Heffernan, Z. Tolby, M. Pavolonis, and S. W. Bieda III, 2024: Fire detections and warnings likely saved lives in historic U.S. wildfires. Wildfire Magazine, Q3 2024 p20-28.

National Interagency Coordination Center, 2024: Wildland fire summary and statistics annual report 2024. [Available online here]

National Wildfire Coordinating Group, 1997: Historical wildland firefighter fatalities 1910-1996. National Interagency Fire Center, PMS #822, NFES #1849. 45 pp. [Available online here]

NOAA, 2024a: WFO Amarillo and WFO Norman collaborative fire warning success story. NWS Insider. March 18, 2024.

____, 2024b: NOAA tests next-generation wildfire detection and warning tools. July 22, 2024. [Available online here]

Pyne, S. J., 2007: Problems, paradoxes, paradigms: triangulating fire research. Inter. *J. of Wildland Fire*, **16** (3), 271–276. CrossRef.

____, 2020: To the last smoke: an anthology. The University of Arizona Press. Tucson, AZ, 437 pp.

Uccellini, L. W., and J. E. Ten Hoeve, 2019: Evolving the National Weather Service to build a weather-ready nation: connecting observations, forecasts, and warnings to decision-makers through impact-based decision support services. *Bull. Amer. Meteor Soc.*, 100, 1923– 1942, CrossRef.