# **Mobile Emergency Communication for Effective Wildfire Evacuation: Exploring Methodological Approaches**



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#### Summary

Evacuating during wildfires in the Wildland-Urban Interface (WUI) presents challenges due to alert and warning issues and varying levels of hazard and risk awareness among residents. Simulations incorporating warning messages can enhance the understanding of evacuation scenarios and help identify effective procedures. Current research often emphasizes fire behavior, traffic flow, and perceptions of protective actions; however, few studies investigate how mobile emergency messaging affects evacuation outcomes. The Marshall Fire highlighted the critical need to study the relationship between wildfire spread, traffic congestion, and the role of emergency alerts. Integrating fire behavior models with traffic simulations provides insight into how conditions influence evacuation dynamics. While modeling these factors separately has generated valuable knowledge, there is growing recognition of the need to examine them collectively. To address this gap, interviews were conducted with emergency managers from local agencies to assess concerns and strategies regarding the use of Wireless Emergency Alerts (WEAs) during wildfire evacuations. These discussions aimed to understand how such alerts are utilized, what challenges are present, and how their effectiveness might be evaluated. Topics included hazard identification, emergency communication, and evacuation planning from a disaster management perspective. The insights gained support ongoing efforts, including those by the National Weather Service, to enhance public warning systems for wildfires.

#### Wireless Emergency Alerts (WEAs)

One of the most established opt-out systems in the United States is the Wireless Emergency Alerts (WEA) system, which operates through the Integrated Public Alert and Warning System (IPAWS) developed in 2012. WEA transmits geotargeted, text-like messages for various emergencies, including AMBER alerts, public safety alerts, and national alerts. These messages are sent via broadcast radio waves from local cell towers, and their reception depends on factors such as the user's wireless carrier, device type, and geographic location. Users can receive WEA messages in either English or Spanish, depending on their device settings. Originally limited to 90 characters, WEA messages were expanded in 2019 to 360 characters, allowing for more detailed content (Figure 1).

#### Figure 1 Recommended WFA Content

Source		Hazard	Hazard			Location	
<ul> <li>Who is sending the message?</li> </ul>		• What even	• What event is occuring?			• Where the hazard is occuring?	
	Guidance • Recommen actions to t	ded protective ake		Time • When to take actions			
Despite the system's capabilities studies indicate that $WFA$							

Despite the system's capabilities, studies indicate that WEA remains underutilized for wildfire emergencies throughout the United States. This was particularly evident during the Marshall (Figure 2) and NCAR Fires in Boulder County, Colorado, where differences between commercial and government alert systems revealed disparities in their reach and effectiveness in notifying at-risk communities.

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#### The Marshall Fire: A Case Study

The Marshall Fire occurred on December 30, 2021, in Boulder County, CO, destroying 1,084 homes and seven commercial properties as the fire moved through the suburbs of Superior and Louisville (Figure 2). While the fire began at 11:05 am, the first mobile evacuation alerts were released via the

Everbridge System at 12:15 pm, as outlined in the after-action report. Multiple news reports indicate that the first

Everbridge alert was released to 215 people 42 minutes after the fire started. Door-to-door evacuations and discourse on social media played a key role in alerting the community shortly after the fire began. However, the rapid spread of the fire and heavy smoke significantly affected the evacuation process.

#### After-Action Report:

- Deemed the outcome of the evacuation a relative success, given the scenario that unfolded
- Provided multiple areas of improvement, especially related to the alerts and warnings, including the implementation of IPAWS to disseminate WEAs



#### LA Fires: Usage of WEAs + Evacuation Challenges





**Challenge:** Rapid dissemination of evacuation alerts into a community with only a few entry and exit points during extreme fire behavior, which resulted in gridlocked traffic and people abandoning their cars to flee on foot.

Figures 3, 4, 5, and 6 were taken from PBS.warn.org on Tuesday (1/08/2025) at around 4 pm in Los Angeles.

Messages disseminated:

- Evacuation alerts
- Evacuation warnings
- Fire warnings



Interviews were conducted with experts in wildfire evacuation and emergency communication, specifically local emergency managers who interact with and have real-time experience regarding the interactions of all these factors. High-level alerting officials from fire-prone states in the Western US—Washington, Oregon, Montana, Idaho, and Colorado—were involved in this process from November to December 2024, using a snowball sampling method for interviews.

During interviews with emergency managers, we asked whether Wireless Emergency Alerts (WEAs) had been considered in evaluating evacuation strategies and if they had suggestions for assessing the impact of WEAs on evacuation timing and traffic flow.

#### Methods





Figure 7. Dynamics of **Interagency Coordination** 

#### WEA Usage and Challenges

Results supported a strong and positive relationship with the National Weather Service and other federal agencies. Interagency partnerships

- play a huge role in pre-fire coordination (Figure 7) Weather reports/
- forecasting, vegetation reports, public vs private land monitoring
- Continued partnerships will be crucial for effective pre-fire coordination and monitoring

Findings also suggested that WEAs are recognized as an incredibly powerful tool for emergency communication, extensively integrated with various wildfire procedures across the states. However, challenges associated with using WEAs impact emergency managers' confidence in the system.

- Frequently mentioned challenges included:
- Geotargeting capabilities and overshoot
- Topographic variation, rural areas, and lack of cell service
- Seasonal population fluxes
- Language translation and accuracy - Timing of the dissemination process

#### **Design and Evaluation of Evacuation Strategies**

Feedback and suggestions from Ems:

- Using cellular data to estimate behavioral response times would require large-scale public participation studies and surveys to ensure accuracy.
- Utilizing cell data would come with significant assumptions.
- The financial and technical resources needed for this kind of modeling and simulation would likely exceed the capacity of many local emergency management agencies.

These findings underscore the importance of ongoing National Weather Service efforts to tailor fire weather warnings and incorporate them more directly into evacuation planning. Based on the interviews, continuing this research could offer significant benefits to small, underresourced communities and more densely populated, complex areas within the wildland-urban interface.

More wildfires are expected to occur in the heavily populated wildland-urban interface, and we know Wireless Emergency Alerts are among the most powerful emergency communication tools. Devastating fires over the past few years, such as the Marshall Fire, Lahaina Fire, and more recently the LA Fire, highlight the importance of wireless emergency alerts and their role in effective evacuations. However, given the complexity of wildfires in the WUI, these recent fires also illustrate the necessity of integrating WEAs into the analyses, merging traffic simulations (specifically focusing on evacuation strategies) with wildfire modeling (Figure 8).

Emergency Alerting: Mobile-Based Alerting System

To accomplish a project that integrates the above variables, several recommendations can be made moving forward: • Live end-to-end testing of WEA capabilities and integration with evacuation simulation. • Continue efforts to improve the efficacy of WEAs, thus enhancing the trust of alerting officials and emergency managers.

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#### Conclusion



#### Figure 8. Integration of Emergency Communication, Wildfire Modeling, and Traffic Simulations

#### Recommendations

Emphasize the importance of open discussions between agencies and highlight the benefits of interagency coordination.