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Brief Communications

Wildfire Response: A System on the Brink?

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Abstract

Increasing wildfire activity, decreasing workforce capacity, and growing systemic strain may result in an interagency wildfire-response system less capable of protecting landscapes and communities. Further, increased workloads will likely increase hazards to fire personnel and amplify existing problems with recruitment and retention. In the face of elevated risks and degraded capacity, it is imperative that the wildfire-response system operate efficiently. Viable solutions are urgently needed that enable the system to do more with less and that manage not only for landscapes and communities but also the health and wellbeing of the fire personnel on whom the system relies. Achieving this will likely require rethinking how the interagency wildfire-response system can more adaptively and intelligently deploy fire personnel by leveraging enhanced logistics, operations, and proven fire analytics.

Study Implications: As society grapples with increasing wildfire damage to landscapes and communities, the capacity of the interagency system in the USA designed to protect landscapes and communities from wildfires is degrading. A stressed system will be less capable of protecting life, property, and resources, and increased workloads will likely increase hazards to fire personnel and amplify existing problems with recruitment and retention. We argue that solutions are attainable through increased attention to performance and through more anticipatory, adaptive, and intelligent deployment of fire personnel across fire incidents and around the country.

Keywords: suppression, risk management, performance, effectiveness, efficiency

Wildland firefighting is one of the most hazardous and grueling occupations. Society asks these men and women to work long hours in often dangerous conditions on assignments that can last for 14 days or more, and then after just a few days rest, to deploy again and again for weeks or months at a time (USDA Forest Service 2021a). Behind these personnel and equipment often celebrated in the media is a complex interagency response system that prioritizes and allocates their movement and use in response to wildfire activity across the USA. It is imperative that this response system operate effectively and efficiently and manage not only for healthy landscapes and communities but also the health and well-being of the personnel on whom the system depends.

Although increasing wildfire activity and risk to landscapes and communities is well studied, the risks that increasing fire activity pose to the wildfire-response system has received less attention in the literature. The 2020 and 2021 fire years laid bare a system under strain—widespread resource scarcity, critical resource shortages, fatigue, and burnout—put simply, "the system was not designed to handle this" (O'Brien and Campbell 2021; USDA Forest Service 2021b, pg. 1; USDA Forest Service 2021c; Grassroots Wildland Firefighters 2022). Climate change, expanding human development, and other factors will undoubtedly increase extreme wildfire activity and exacerbate strains on the system (Abatzoglou et al 2021; Balch et al. 2017; Radeloff et al. 2018).

Perhaps nowhere were the systemic impacts of wildfire response more evident than on the 2021 Dixie Fire (figure 1). The fire exhibited extremes in total and peak workload (measured in assigned personnel), suppression effort (measured in length of containment line built), travel demand (indicated by inbound assignment arcs from fire personnel stationed across the country), and suppression cost. Regarding cost, this single fire event exceeded one-third of the five-year average annual suppression costs considering all fires spanning entire years, more than doubled the previous record for a single event (Soberanes Fire), and exceeded 2020 Forest Service expenditures on hazardous fuels reduction. Extreme resource sinks like the Dixie fire can strain the capacity of the entire system by limiting contemporaneous availability and taxing future readiness. Further, resource strain can exacerbate existing organizational dysfunctions that are embedded in normal work operations, such as taking unnecessary risks related to driving, mop-up, and aviation (Flores and Haire 2022).

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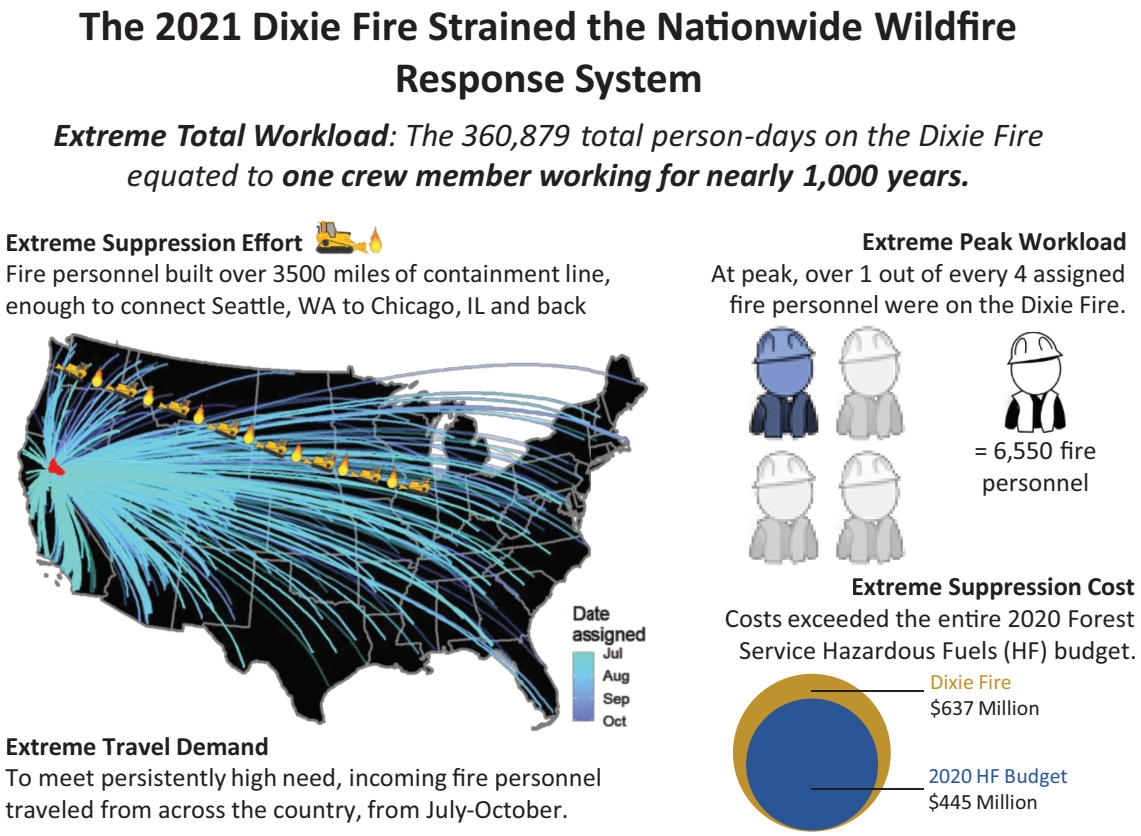

Figure 1. Illustration of the systemic impacts and magnitude of the 2021 Dixie Fire, as measured by estimates of total and peak workload, suppression effort, travel demand, and suppression costs. Data from the National Interagency Fire Center, National Incident Feature Service, and the USDA Forest Service.

Efforts to mitigate risks posed by events like the Dixie fire are proceeding along several fronts, including significantly accelerating the pace and scale of hazardous fuel reduction and forest restoration (USDA Forest Service 2021c). However, implementation of sufficient action could take a decade or more and faces multiple barriers to realize at scale (Schultz et al. 2019; Miller et al. 2020). In the interim, wildfire response will remain the linchpin to protect landscapes and communities (Thompson et al. 2018). These growing demands of the wildfire response system come at a time when the federal wildland firefighting workforce is "stressed like no other time in our history" (USDA Forest Service 2021a, pg. 2). Challenges with recruitment and retention and concerns over mental and physical health, among other factors, underscore the need to refocus on managing workforce and workload burdens in the face of a rapidly changing future (Navarro et al. 2019; USDA Forest Service 2021a; Flores et al. 2022). To be clear, there are many important issues around firefighter health and well-being to address (e.g., pay and access to health services), but here we limit our focus to system operation, performance, and workload.

Effectiveness and Efficiency

How the response system performs in the face of increasing strain and scarcity and in coordination with a growing network of actors will be a critical determinant of far-reaching fire outcomes, ranging from utility disruptions to structure loss to recreation closures to water quality impairment (Steelman et al. 2019). Despite legislative requirements to analyze the effectiveness of wildfire suppression operations (Public Law 115-141, Division O, Section 104; H.R. 1625), there has been little systematic investigation of incident response performance, and persistent gaps in data and understanding remain (Plucinski 2019). One notable exception is the USDA Forest Service Aerial Firefighting Use and Effectiveness Study, which found that drop effectiveness can be as low as 43% for large air tankers (USDA Forest Service 2020). In another study that focused on ground resources, on average, only around 33% of all completed fire containment lines successfully held at the fire perimeter (Gannon et al. 2020). Although useful for establishing a baseline, these findings raise questions about what constitutes attainable or acceptable levels of effectiveness.

Even less is understood about the performance of the broader interagency system that prioritizes and allocates resources across incidents and geographic regions. Because the degree of top-down prioritization and allocation varies with the degree of scarcity in the system, because managers are incentivized to order more resources than they may need, and because resource scarcity is increasing, there is due concern over ineffective use of resources (Donovan and Brown 2005). Ineffective use on one extreme could stem from excessive resource ordering, particularly early in the season when resources are largely available, and on the other extreme from an inability to mobilize the amount and type of resources requested by managers (potentially due to scarcity created from excessive use elsewhere), rendering them unable to implement

preferred strategies. In the case of the former, effectiveness could be enhanced by more diligently monitoring operations and reallocating resources to where they can be put to more productive use. In the case of the latter, effectiveness could be enhanced through greater emphasis on timely, risk-informed prioritization and more agile, right-sized, and right-timed deployments to capitalize on windows of opportunity.

In the face of more extreme wildfire events and extreme workloads, solutions will require not only deploying more resources, but also deploying them more strategically and adaptively. Because large long-duration wildfires are inherently resistant to control, efforts to contain fires often fail unless they are coordinated with quiescent weather and align with natural or built features (Finney et al. 2009; Katuwal et al. 2016; Gannon et al. 2020). Therefore, national, regional, and incident decision processes may need to be modernized to assimilate advanced fire analytics that provide richer information on factors such as containment probability and suppression difficulty and that shift from prioritizing for rapid containment to prioritizing for time-sensitive, critical needs (Calkin et al. 2021; Thompson et al. 2022). The shift away from prioritizing for rapid containment may in some instances lead to longer and more complex incidents with greater workload demand but should also reduce workload and unnecessary exposure by limiting actions that are unlikely to succeed. These tradeoffs merit further investigation. Further, resource allocation processes could integrate longer-term workload forecasting and balancing and develop system-level performance measures related to factors such as workload balance, miles traveled, and indices of exposure (Belval et al. 2018, 2022). Ultimately, increased effectiveness of operations at the incident scale and increased efficiency of prioritization and allocation at the system scale can be self-reinforcing.

Slack and Scarcity

Wildfire managers face uncertain decisions regarding whether to pursue high-risk, high-reward strategies, and may see well-designed plans fail due to sudden or extreme shifts in weather. For these and other reasons, building in slack is essential. Although there has been some study of the role of redundancy in incident management organizations (Nowell et al. 2017), there has been very little analysis of the role of redundancy in fire operations. For example, managers routinely build contingency lines should primary containment lines fail, but without any consistent standards or informational basis to determine optimal contingency strategies.

In addition to redundancy, slack can also be built in by dampening time pressures and expanding decision spaces. There is substantial value to be gained in this space through upstream assessment, planning, and cross-boundary collaboration that can summarize risks and management opportunities in operationally relevant ways and that can facilitate proactive communication and coordination (Dunn et al. 2020; Greiner et al. 2020). Leveraging these tools with scenario planning could buy even more slack, for example, through pre-identifying containment lines under a range of conditions and prioritizing areas where additional mitigation is warranted to enhance responder safety and containment likelihood.

Of course, greater slack at the incident scale can lead to greater scarcity at the system scale. Although this concern may be attenuated during periods of low resource scarcity, a broader temporal horizon is warranted given that factors such as fatigue and exposure accumulate over time; it may be prudent to strategically preserve capacity and fitness for future periods of high demand. In this sense, there can be complex interplay between slack and scarcity; excessive slack can beget scarcity, but strategically inducing scarcity can preserve slack, requiring effective coordination across scales.

The Path Ahead

Proactive, coordinated action to reduce risk and enhance resilience of communities and landscapes is necessary to move away from the current self-perpetuating reactive paradigm towards one where wildfires are not necessarily emergencies or disasters, and where society can sustainably live with fire (Nowell et al. 2017; Thompson et al. 2018; Dunn et al. 2020). Proactive, coordinated action is also necessary to address the design, function, and performance of the wildfire-response system as a critical node in this paradigm shift while adapting to rapidly changing conditions. In this transition period, if not longer, wildfire response may continue to be where most outlays of human and financial capital are spent and where physical and psychological tolls on fire personnel must be addressed.

Strategic opportunities exist within workforce development, resource allocation, risk management, and performance management. Workforce development can align capabilities, capacities, and career paths with the anticipated needs of the future, for example, by expanding staffing to support local and regional cross-boundary fire analysis and planning. Resource allocation can be more agile and adaptive, managing both under and for conditions of scarcity, for example, by expanding use of surge resources for critical incident missions. Risk assessment can meaningfully reduce exposure to operational hazards, capitalizing on emerging technologies for situational awareness and monitoring, for example, by expanding use of maps of snag hazards and safety zone suitability. Performance measurement can expand in scale to the entire system and openly daylight opportunities for improvement, for example, by summarizing fireline effectiveness across a broader set of incidents and geographies. Rethinking and redesigning the wildfire response system may be necessary to achieve policy and management goals, and focusing on effectiveness, efficiency, slack, and scarcity may be a productive way to start that conversation.

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