

“Moneyball” for the Wildland Fire System

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The wildfire management community has made great strides incorporating new decision support tools into how it plans for and responds to wildfire incidents. Despite improvements in risk assessment and management at the incident scale, increasing fire activity and critical resource shortages reveal a system under strain in need of strategies that more efficiently allocate scarce resources across incidents while promoting the well-being of the firefighting workforce upon which the system relies. A scaled-up infusion of data-driven analysis and decision-making could enhance the performance of the entire wildfire management system.



In recent years, the wildfire research and management communities have demonstrated great success in translating advanced analytics to wildfire management operations. With the objective of supporting safer and more effective response, scientists and analysts are using new tools to provide critical information on landscape and community risks, environmental hazards to fire personnel, and fire control opportunities. To date, use of these tools has supported [incident response planning](https://www.iawfonline.org/article/2020-01-path-strategic-wildland-fire-management-planning/) (<https://www.iawfonline.org/article/2020-01-path-strategic-wildland-fire-management-planning/>) on dozens of landscapes throughout the western United States as well as [response strategy development](https://www.iawfonline.org/article/engaging-the-fire-before-it-starts-a-case-study-from-the-2017-pinal-fire-arizona/) (<https://www.iawfonline.org/article/engaging-the-fire-before-it-starts-a-case-study-from-the-2017-pinal-fire-arizona/>) on more than 200 large, complex wildfires. This paradigm that seeks more and better data and that blends analytics with the expertise and intuition of fire managers is colloquially referred to as “Moneyball for fire” (<https://twitter.com/bcmassey/status/1309141822728474628>),” borrowing inspiration and insight from the [sports analytics revolution](https://sloanreview.mit.edu/audio/why-sports-still-leads-the-analytics-revolution/) (<https://sloanreview.mit.edu/audio/why-sports-still-leads-the-analytics-revolution/>).

Strategies, Resources, and System Strain

In addition to information on risks and opportunities, how managers arrive at and implement wildfire response strategies can be highly dependent on the availability of suppression resources. These resources are moved around the country by regional and national coordinating centers in response to demand and priority, often resulting in complex and extensive patterns of travel over long distances (Figure 1). Effective functioning of the wildfire system is largely premised on allocating these shared resources to meet the time-sensitive demands of local managers so they can implement their preferred (and ideally analytics-informed) strategies.

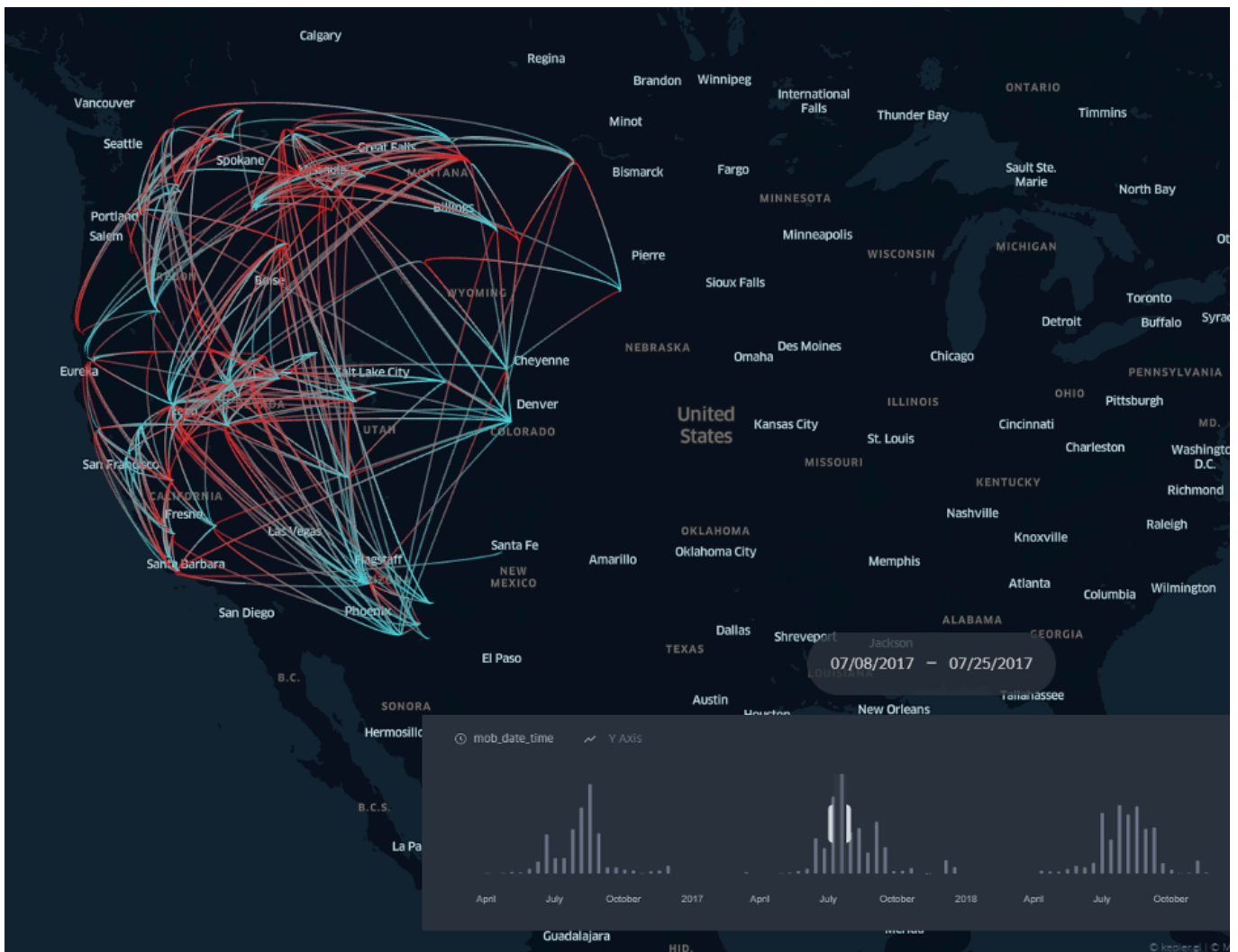


Fig. 1. Historical movement of fire personnel and equipment during a portion of the 2017 fire year. The red end of each arc indicates the personnel destination. Source: Image made by Jude Bayham & Erin Belval (2021).

It is becoming more evident that this system is showing signs of strain. Increasing fire activity combined with challenges with workforce recruitment and retention, among other factors, have led to greater resource scarcity and greater workloads, which can result in unfilled resource requests and missed opportunities for achieving management objectives as well as fatigue and burnout. A changing climate and more people moving into fire-prone areas are likely to exacerbate this strain on the system.

Analytics for the Fire System

These management challenges present a rich context for innovation and delivery of actionable analytics to help the wildfire system better protect landscapes, communities, and responders. Scaling up analytics to improve assignment and allocation of fire personnel and equipment to fires could help local managers better achieve desired fire outcomes. That is, the promise of “Moneyball” extends beyond the scale of the incident by informing problems such as: (1) prioritization at national and regional levels across incidents, (2) agile deployment of resources to incidents, and (3) balanced workload management. Importantly, some of these systemic problem areas have clear alignment and synergy with the incident-scale analytics. For instance, local information on control opportunities and probability of success can inform discussions of critical resource needs and prioritization. Developing a platform for systemic analytics can also enable greater objectivity and

transparency, can break down information silos, and can facilitate a more forward-looking approach through analysis of leading rather than lagging indicators.

Prioritization. Every year there are periods with high levels of fire activity during which there simply are not enough trained personnel and equipment to go around. During these periods, regional and national managers must make hard decisions about which fires get resources and which do not. Examining the tradeoffs associated

with these resource assignments is critically important. For example, resources may be sent to an emerging fire to rapidly contain it and reduce the future threat posed by that fire. However, in sending resources to the emerging fire, established fires imminently threatening communities could receive fewer resources.

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Historically, the prioritization of fires’ requests for personnel and equipment have been heavily dependent upon the data provided by the team managing each fire. As teams’ priorities and strategies can differ substantially, this data is not consistent across fires. Analytics improved by consistency and coordinated nationally can provide managers with information on projected fire impacts and opportunities for containment in the coming days, using unbiased and objective methods that allow managers to directly compare across incidents. Thus, analytics that better characterize risks and opportunities are valuable because they allow for more robust and complete tradeoff analyses.



Firefighter Crew at Mount Hough Road, Dixie Fire (California). Source: U.S. Forest Service, 29 July 2021.

Agile deployment. Because there is a lag between when the personnel are ordered to the fire and when they arrive, basing deployment decisions on projected fire impacts and opportunities not only provides for more robust decisions, but it also allows personnel to arrive in the right place at the right time to capitalize on containment opportunities. Businesses have exploited analytical methods for delivery to enhance their supply chains, which has substantially decreased delivery time for customers. Reducing the lag between when resources are ordered to a fire and when they arrive can have substantial benefits, and fire analytics could help here by supporting more intelligent routing and prepositioning of resources as well as meeting time-sensitive surge capacity needs. Further, using analytics to “right size” deployments that best align strategic and tactical needs with resource capabilities can help improve likelihood of success while preserving capacity to meet other continuing or emerging needs.

Workload balance. All the wildfire management work that is accomplished on the ground depends upon a workforce comprised of highly qualified personnel. As fire activity has increased, so has the amount of time firefighters spend on assignment. These assignments are physically dangerous and mentally taxing, and the effects of assignments over the course of a season can lead to physical and mental fatigue. Providing adequate opportunities for rest throughout the season is critical to ensuring firefighters’ well-being. Fortunately, with analytics, enhanced dispatch practices can be optimized (https://www.fs.fed.us/rm/pubs_journals/2018/rmrs_2018_belval_e001.pdf) to reduce travel distances while balancing crew fatigue.

Future Directions

Resource deployment is a crucial piece of fire management and advanced analytics can help the system better address the growing challenges of wildfires. However, managers have long recognized that more efficient resource deployment alone is not a comprehensive solution to the problem of increasing damages from wildfire. Long-term solutions (<https://www.forestsandrangelands.gov/strategy/thestrategy.shtml>) will necessarily include a much broader set of coordinated actions that promote resilient landscapes through controlled burning (<https://theconversation.com/planned-burns-can-reduce-wildfire-risks-but-expanding-use-of-good-fire-isnt-easy-100806>) and other landscape management of fuels, fire adapted communities, and planning for wildland fires before they occur. Analytics can also help address these problems, and the Wildfire Risk Management Science Team (<https://www.fs.usda.gov/rmrs/groups/wildfire-risk-management-science-team>) is working with managers to continue to develop an analytics framework (<https://link.springer.com/article/10.1007/s40725-019-00101-7>) and facilitate its deployment within the USDA Forest Service and other fire management organizations.

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