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Rethinking the Wildland Fire Management System

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In the western United States and elsewhere, the need to change society's relationship with wildfire is well-recognized. Suppressing fewer fires in fire-prone systems is promoted to escape existing feedback loops that lead to ever worsening conditions and increasing risks to responders and communities. Our primary focus is how to catalyze changes in fire manager behavior such that responses are safer, more effective, and capitalize on opportunities for expanded use of fire. We daylight deep-seated, systemic drivers of behavior, and in so doing, challenge ingrained ways of thinking and acting that may be inconsistent with current intentions around wildland fire management. We pose the questions of whether all fires are emergencies that require rapid deployment and concentration of suppression resources, whether rhetoric and actions align with policy and guidance, and whether we can unambiguously define and measure what a safe and effective response looks like. Using the Forest Service of the US Department of Agriculture (USDA) as a relevant test case for systemic investigation, we argue that fundamental changes in how the fire management community thinks about, learns from, plans for, and responds to wildland fires may be necessary. Our intention is to initiate a broader dialog around the current and future state of wildland fire management.

Keywords: risk management, systems thinking, restoration, resiliency, suppression

It is increasingly apparent that in many places around the globe, society must forge a new relationship with fire (Moritz et al. 2014; Curt and Frejaville 2017; Otero and Nielsen 2017). In the western United States, a changing climate, expanding human development, and accumulating fuels (among other factors) require new approaches that manage for resilience by suppressing fewer fires and accelerating forest restoration (Stephens et al. 2016; Schoennagel et al. 2017). Perpetuating business-as-usual attempts to exclude fire from systems that evolved with frequent fire will in some cases simply amplify feedbacks that increase long-term risks, (i.e., the "fire paradox") (Calkin et al. 2015; Olson et al. 2015; Ingalsbee 2017). If void of significant social and managerial changes, the future of wildland fire management in the western United States likely entails increasing costs, damages, and loss of life (Thompson et al. 2016a).

While any progress toward sustainable solutions will necessarily be multifaceted (cross-boundary collaboration and planning, community adaptation, etc.), a key biophysical requisite is reintroducing fire to fire-prone systems (North et al. 2015a; Hessburg et al. 2016; Boisramé et al. 2017; Prichard et al. 2017). Forest management approaches such as forest thinning remain a valuable tool in the toolkit; however, application of fire is often necessary for hazardous fuel reduction and forest restoration treatments to be effective (Schwilk et al. 2009; McIver et al. 2013; Fischer et al. 2016; Kalies and Kent 2016). Further, feasible scales for application of mechanical treatment and prescribed fire are often dwarfed by the area that burns from unplanned ignitions annually (North et al. 2012; Collins et al. 2013; North et al. 2015b; Barnett et al. 2016a). Opportunistically managing unplanned ignitions under less extreme weather conditions could in the future limit fire spread and occurrence, alter the extent and spatial pattern of burn severity, and enhance suppression effectiveness (Regos et al. 2014; Parks et al. 2015; Stevens-Rumann et al. 2016; Parks et al. 2016; Thompson et al. 2016b; Stevens et al. 2017). Therefore, changing responses to unplanned ignitions provides a largely untapped but important—if not essential—opportunity to restore landscape conditions and reduce future hazard and risk.

A principle focus here is how best to catalyze desired changes in fire manager behavior in terms of individual fire events, but more importantly in terms of consistent patterns of behavior over time. We do so because, ultimately, changes in fire manager decisions regarding response strategies and tactics will be necessary to change fire outcomes. Helping

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fire managers better arrive at response strategies that reduce unnecessary exposure and increase the probability of success is a primary motivation of this article. So too is helping fire managers better determine where, when, and how to appropriately expand the footprint of fire—in the right places, at the right times, under the right conditions, for the right reasons. A variety of approaches have been proposed, including expanding public support for fire use, developing methods to quantify the effectiveness of suppression actions, strengthening incentives that discourage ineffective suppression actions, streamlining the use of analytics to enhance prefire planning and decision support, and increasing the relevance and flexibility of fire management plans (Steelman and MCaffrey 2011; Plucinski and Pastor 2013; Thompson et al. 2013a; Thompson 2014; Meyer 2015; North et al. 2015a; Fischer et al. 2016; O'Connor et al. 2016; Dunn et al. 2017; Thompson et al. 2017a).

Here, we expand upon these themes by drawing insights from enterprise risk management (ERM) and systems thinking (ST) in order to examine the management organizations responsible for making and implementing wildland fire response decisions. Essential aims and processes of ERM include (1) ensuring that strategy and objectives are aligned with organizational mission, vision, and core values; (2) ensuring that decision makers are well-equipped to effectively manage risks and capitalize on opportunities; and (3) embedding assessment, planning, monitoring, control, learning, and continual improvement into the fabric of the organization (US General Accountability Office 2016; Committee of Sponsoring Organizations of the Treadway Commission 2017). ERM requires that organizations systematically evaluate risks, recognize the systemic nature of some risks, and develop commensurate capacity for risk-informed decision making, especially for high-impact decisions (Thompson et al. 2016a).

We use ST as a lens to understand systemic forces driving fire manager behaviors and the systemic risks that those behaviors present (Sterman 2001; Meadows and Wright 2008; Collins et al. 2013). In Figure 1, we introduce some key themes from ST that motivate and guide our discussion. Our stylized depiction of a coupled human and natural fire-prone system, although simpler than others (e.g., Spies et al. 2014), explicitly accounts for the role of fire managers and their response decisions. We emphasize these decisions in light of their potentially significant impacts in terms of cost and responder exposure and because their accumulated effects over time can alter landscape conditions, influence perceptions and expectations, restrict fire managers' decision space, and ultimately perpetuate a fire exclusion paradigm.

In other words, insofar as fire response decisions can influence landscapes and communities, ST compels us to consider the fire management system, especially in contexts where there is flexibility to change response decisions as a lever for broader socioecological change. A key concept here is that not only do we need to examine the various management systems that have been devised and are in place, but also how these various systems interact with each other and with properties of the larger business environment. Systems thinking can help achieve a core tenet of ERM, that of being proactive rather than reactive, by more fully characterizing the environment in which fire management decisions are made and anticipating factors that may lead to compromised decision making.

In this article, we discuss how cognitive, institutional, and cultural factors influence fire response decisions and ask whether the existing system sets up managers for success in an increasingly complex fire environment. Contextually, we focus on the Forest Service, US Department of Agriculture, which is one of the largest wildland fire management organizations in the world. Although most fire management organizations at state and county levels in the United States have similar challenges in identifying and implementing effective suppression response strategies, their directives are to suppress fires as small and as quickly as possible under nearly all circumstances. The Forest Service, by contrast, has the policy flexibility to pursue a range of responses, including managing fires for ecosystem benefits, which not only complicates the management problem but also creates potential for conflict when managing fires across jurisdictional boundaries.

In recent years, the Forest Service has committed to strengthening its risk management acumen and capacity and is in the initial stages of developing an ERM framework (Thompson et al. 2016a, 2016c; US Forest Service 2017a). The Forest Service is focused on improving fire management because of increasing concerns over responder safety, critiques from oversight agencies, and a severely compromised ability to achieve core missions, including addressing a backlog of forest restoration needs, due to the growing budgetary impacts of fire (North et al. 2012; US Forest Service 2015; Thompson et al. 2016a). Forest Service managers face regulatory barriers that inhibit proactive mitigation in advance of fires (e.g., air quality concerns limiting controlled burning) and during a fire event are often pushed and pulled by conflicting forces (e.g., sociopolitical pressures to "put the fire out," opposing natural resource objectives). When facing time pressures, managers may rely on quick intuitive judgments that inadequately analyze a situation or overlook relevant information (Wilson et al. 2011; Hand et al. 2015). These concerns are compounded given the dynamic and unpredictable nature of wildfire incidents, which renders intuitive judgements unlikely to be consistently reliable (Kahneman and Klein 2009). Cognitive biases combined with misaligned incentives and other factors often lead to excessive use of suppression resources, with accompanying increases in responder

Management and Policy Implications

Changing responses to unplanned ignitions provides a largely untapped but important, if not essential, opportunity to restore landscape conditions and reduce future risk. Effectuating this change in fire manager behavior is challenging because ambiguity and incomplete information surround issues of responder safety, suppression effectiveness, and performance measurement. We propose that by more rigorously researching suppression actions and refocusing on evidence rather than intuition as the basis for management decisions, the US Forest Service could better understand and improve the quality of its management operations. By capitalizing on recent advances in risk management acumen and capacity, the US Forest Service and the broader fire management community can achieve a vision for fire management in the 21st century where decisions and actions are risk-informed, evidence-based, enriched with analytics, and aligned with long-term objectives.

exposure and suppression expenditures (Thompson 2014).

Our discussion begins from the insight that these observed behaviors are a natural result of the Forest Service's fire management system, its culture, values, organizational structure, core assumptions and beliefs, and operating norms and protocols (Thompson et al. 2015; Thompson et al. 2017b). In other words, the decisions of fire managers operating within this system may seem rational given their perceived risks and rewards, even if these decisions from the outside-in appear inconsistent with broader agency objectives (Donovan and Brown 2005). To emphasize these points, we apply the "iceberg model" to the fire management system (Figure 2). Like an iceberg whose bulk is typically unseen below the surface of the water, here the analogy is that behavior on individual events are seen, but generally unseen are the patterns of behavior, system structure, and mental models that underlie those events (Monnat and Gannon 2015). That is, the major drivers of behavior comprise the largest part of the iceberg that is below water. Daylighting these drivers can be difficult and even uncomfortable but often provides the greatest leverage for learning and improvement, especially when

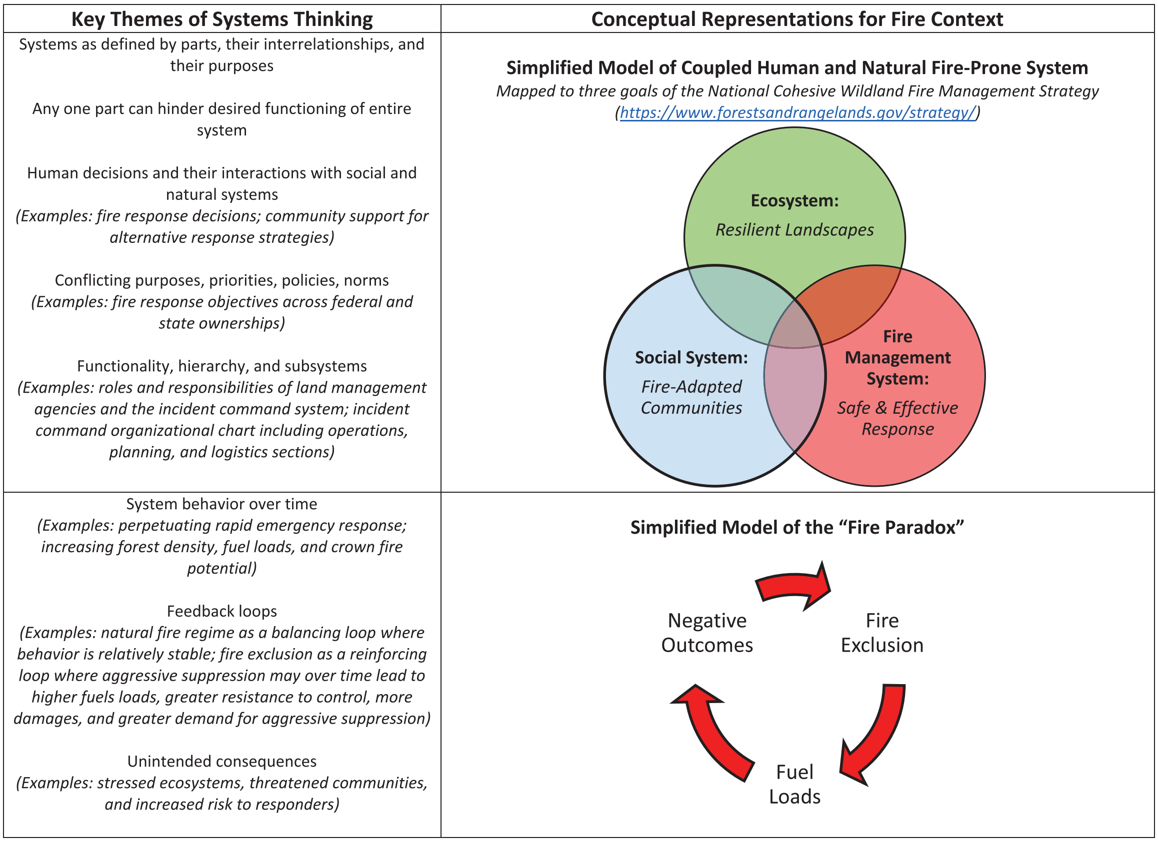

Figure 1. Key themes of systems thinking, along with examples and conceptual representations relevant to wildland fire management.

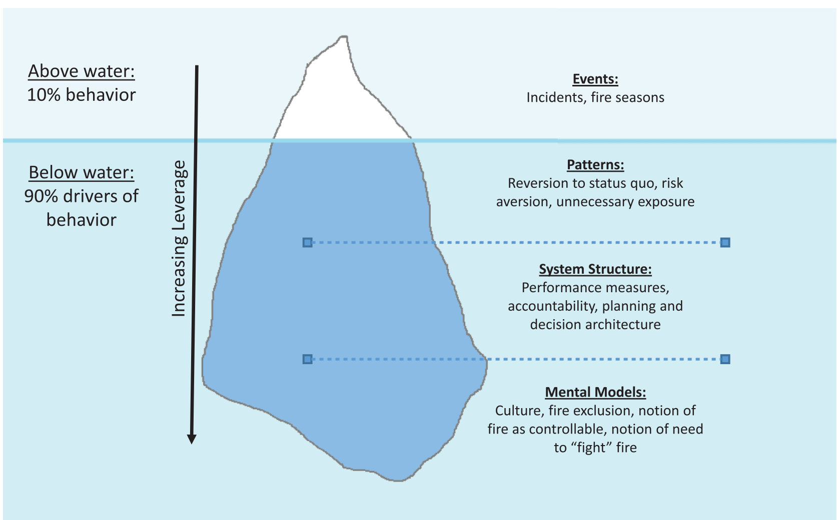

Figure 2. "Iceberg" model applied to fire management system behavior (modified from Thompson et al. 2017b).

ingrained ways of thinking and acting are challenged (Meadows and Wright 2008).

Simply put, fundamental changes in how the US fire management community thinks about, learns from, plans for, and responds to wildland fires may be necessary to close the gap between intentions and actions. We propose that reevaluating the fire management system is a necessary first step to identifying leverage points that could achieve desirable and sustainable changes in behavior. We do not propose that addressing internal factors alone will be sufficient to foster more resilient landscapes and communities; rather, we stress that any comprehensive strategy for change ought to critically examine the fire management system from within. We present a series of interrelated questions with the intention of initiating a broader dialogue around the current and future state of wildland fire management in the western United States.

Is Every Fire an Emergency? Can We Change Default Responses?

How we understand situations in which we find ourselves and how we typically respond to those situations can exert significant influences on decision making, especially when facing complex choices (Johnson-Laird 2010). This can result in the "status quo bias," wherein individuals revert to default behaviors even though those behaviors may be inappropriate given the circumstances, a phenomenon that has been documented among fire managers (Wilson et al. 2011). The default response to an unplanned ignition has tended to be aggressive suppression to contain the fire as quickly and as small as possible, and when that fails during periods of extreme fire weather, to mobilize and deploy additional suppression resources even when control opportunities may be severely restricted.

This pattern of behavior can be explained in part from a perspective that views wildfire suppression as emergency response. Applying the model of emergency response carries an accompanying set of assumptions, such as a need to be decisive, a need to take immediate action, that time is of the essence, that action is better than analysis, and that life is imminently at risk. In some cases, this may be an accurate interpretation of the situation, but in some cases it may not. The emergency response model perpetuates a default response based on automatic intervention (i.e., a bias for action), which often drives a "do whatever it takes" mentality to limit potential negative impacts with few constraints placed on the magnitude of suppression response (Calkin et al. 2015). One of the potentially undesirable effects of emergency response is a tendency to drift into a "sunk cost" situation, thereby continuing to expend resources to achieve an unachievable outcome (McLennan et al. 2006).

A possible alternative to emergency response is incremental intervention on the basis of changing conditions and accompanying risks. Incremental analysis can insert pauses in the evaluation of a situation and help attenuate a sunk cost bias. In areas where imminent threats to public safety do not exist (i.e., much of the forested landscapes managed by the Forest Service) or in circumstances where probability of success is very low, the default could become nonintervention. Managers would be required to successively analyze the conditions under which incrementally increasing levels of intervention are justified, given the values at risk and the exposure of incident responders to the inherent risks of wildland fire. It changes the assumption from one of aggressive action (that leads to analyses to justify why not to intervene) to one of intervention only if needed. We recognize that there will be locations and conditions under which emergency response is absolutely essential, especially where communities and critical infrastructure are threatened, but at the same time, there is ample reason to believe the Forest Service has not taken advantage of historical opportunities for more flexible response (Thompson et al. 2013b; North et al. 2015a).

Resetting default responses could be a powerful tool for changing behavior and would ideally expand the decision space of fire managers while dampening tendencies toward fire exclusion and the minimization of short-term risks over longer-term risks. Similarly, reframing how information is presented (i.e., describing expected fatality rates instead of duration of suppression activity) could induce behaviors more consistent with safety-related objectives (Hand et al. 2015). Importantly, the premise of shifting baselines to nonintervention requires that managers proactively differentiate landscape locations and fire weather conditions under which incremental intervention would be appropriate; we will return to this point later in the article.

What Does Safe Response Look Like?

The Forest Service initiated a series of Life First engagements (US Forest Service 2017b) intended to expand dialogues and highlight areas of concern regarding responder safety. It is a subject infused with controversy and emotion, which is embodied in the following quote from Mark Smith's essay, "The Big Lie" (Smith 2016): "The lie that wildland fire firefighting is safe . . . The lie is so insidious that it permeates the thinking of many fire managers and agency administrators to the point of denial, despite a steady flow of coffins standing as evidence to the contrary . . . If the [interagency policy] definition of safety is meaningless, and in contravention of its true nature, so too will be all the policies, rules, and checklists that flow from it."

There is a clear line of sight between this perspective and the well-known Standard Firefighting Orders, which adorn the back cover of Incident Response Pocket Guides carried by fire responders and which are unequivocally stated to apply to all fire situations (US Forest Service 2017c). Of particular importance is the 10th order, which states: "fight fire aggressively, having provided for safety first." Parsing this order raises questions of inconsistency surrounding guidance and messaging. Is always fighting fire aggressively consistent with the agency's rhetoric and stated fire management objectives? Is the notion that safety is something that can be "provided for" in the operational fire environment consistent with risk management principles? Ensuring near absolute responder safety would mean putting individuals nowhere near the flaming front and rarely, if ever, engaging fires. This would undoubtedly lead to increased risks to the public, natural resources, and property in some cases. A more actionable perspective is to conceive of safety in terms of acceptable or tolerable risks, that is, a balancing of the gains from actions with the risks that taking those actions incur. In some situations, engagement may be prohibitively dangerous regardless of consequences; in others, higher levels of risk might be tolerated, for instance, to protect irreplaceable resources or to buy time for evacuations. This complex balancing act is articulated well by the direction former

Forest Service Chief Tom Tidwell provided heading into the 2017 fire season: "Our strategies and tactics commit responders to operations where and when they can be successful and under conditions where important values at risk are protected with the least exposure necessary . . ." (US Forest Service 2017b). Thus, exposing responders to hazards in order to protect low-value resources while perpetuating feedbacks that increase long-term risks might be beyond the pale. However, implementing the former chief's direction requires clarity and agreement on what types of risks are acceptable and what are not. Does such clarity exist? Do existing operational tools for assessing safety (e.g., the job hazard analysis) begin with evaluating the worthiness of the mission's objective with respect to operational risks, or do they begin with accepting the mission and then working through the safety implications? Building from the ideas introduced earlier, could responders instead avoid engagement as the norm, only initiating suppression actions when a clear set of signals exists indicating that actions are likely to be successful, have a purpose, and limit exposure to hazards?

What Does Effective Response Look Like? How Would We Know?

The fire community has struggled to define meaningful and actionable performance measures for some time (Booz Allen Hamilton 2015). Perhaps the starkest example is the oft-cited metric that initial attack to unplanned ignitions on federal lands is successful 95–98 percent of the time. Peering behind the curtain, however, reveals some illuminating insights. First, natural constraints on fire size (e.g., the episodic nature of weather events conducive to high fire-spread potential) means that there is some nontrivial baseline level of fires that would have extinguished absent human intervention (M. Finney, personal communication). Second, choosing to extinguish those fires that might have spread under nonextreme conditions forecloses opportunities to yield ecological benefits, reinforcing the fire paradox (Calkin et al. 2015; Barnett et al. 2016b). Third, and perhaps most important, this metric is effectively premised on the differentiation of fires on the basis of "wanted" versus "unwanted," a classification that is nonexistent in any federal reporting systems (K. Short, personal communication). Tabulating this metric on the basis of all fires that received a response assumes in effect that all fires are unwanted, seemingly in conflict with Federal Wildland Fire Policy stating that "wildland fire will be used to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role" (Fire Executive Council 2009). This appears to create a powerful cognitive dissonance that possibly perpetuates the fire exclusion paradigm and the model of emergency response. That is, there may be intrinsic problems with how initial attack is conceptualized and executed. The Frog Fatality Report (US Forest Service 2016) aptly summarizes the situation as follows: "In the current wildland firefighting culture, aggressive initial attack is highly valued and is generally the standard operating procedure . . . . Firefighters currently see themselves as most successful when they catch the fire and feel like they've failed when they lose a fire."

Questions similarly exist about suppression effectiveness in the more complex large fire environment (i.e., for those rare fires that escape initial attack efforts or are intentionally managed from detection as a resource benefit fire—the latter is even rarer). Research findings indicate that fire weather can be the dominant influence on containment probability, that managers exhibit wide variability in use of suppression resources when responding to fires with similar characteristics, that managers commit substantial levels of resources after fire growth has largely ceased, and that suppression resources are often used outside of conditions where use is likely to be effective (Finney et al. 2009; Stonesifer et al. 2016; Hand et al. 2017; Katuwal et al. 2017). A critical take is that default responses are possibly ineffective during extreme fire weather and possibly counterproductive during moderate fire weather (while recognizing that quiescent periods of weather may provide critical windows for containment in advance of more extreme weather).

The aforementioned patterns of behavior are sustained in part by insufficient monitoring and investigation of fire management system behavior. Even where possibly ineffective behaviors can be identified, the lack of effective feedback control mechanisms means that system learning and improvement fail to keep pace with the increasing risk and complexity of the fire environment. By more rigorously researching suppression actions and refocusing on evidence rather than intuition as the basis for management decisions, the agency could better understand and improve the quality of its management operations.

Only through development of more robust systems of accountability and performance measurement can effective behaviors be identified, evaluated, and rewarded. An objective and attainable approach to performance measurement could begin by examining environmental conditions that influence probability of success. It has been established that under extreme fire weather conditions, certain types of suppression operations are of little use, exceedingly expensive, and can be highly dangerous. Thus, metrics could, for instance, examine the number and type of assignments leading to active suppression operations under extreme weather conditions, with a target of minimizing these types of assignments. Measures could be downscaled to focus on specific mission types, for example, evaluating aerial retardant drops by factors like wind, topography, and fuel type (Stonesifer et al. 2016). Similarly, evaluation of constructed fire control lines could proceed on the basis of whether they engaged the fire and were effective in restricting fire spread, and if not, why not (Thompson et al. 2016b). Such measures could help improve understanding the conditions under which actions are likely to be successful, while also shedding light on upstream decisions about the timing and location of fire-control activities. Ideally, these measures would inform and incentivize fire managers to restrict engagement under conditions where success is unlikely, thereby reducing unnecessary exposure of fire responders.

Is there a future where the absence rather than the presence of active suppression is rewarded? Could fire managers face positive incentives related to the number of days where suppression resources were not engaged due to weather, the length of perimeter where direct attack was not pursued, or other similar constructs? Is it possible to, in effect, reverse engineer performance measures that subtract away unnecessary exposure and maximize probability of success?

Can Recent Risk Management Successes Be a Springboard for Improvement?

What would adopting ERM look like in the Forest Service? To begin with, the agency would look at the systems it has in place in a new way, using ST concepts and language to look across functional areas and identifying instances where systems interact to product unintended and undesirable consequences when viewed from a larger systemic perspective, despite working fairly well within their own "locally" defined perspectives. More concretely, it would lead to the recognition that escalating costs of suppression and degrading forest conditions pose risks to the core mission of sustaining the nation's forests and grasslands. It would force the agency to critically evaluate how it could better enhance responder safety and capitalize on opportunities to manage fire for resource benefit. It would lead to the recognition that the practice of risk management applies not just to suppression activities but across the organization (and further extends to communication and comanagement with communities, stakeholders, and partners).

Fortunately, there are emerging risk management success stories that the agency could build upon and that directly address several of the issues raised earlier in this article related to improving decisions and outcomes. Perhaps the most relevant example is more rigorous prefire assessment and planning, which helps fire managers stratify the landscape on the basis of risk and predetermine acceptable response strategies and operational priorities accordingly (O'Connor et al. 2016; Thompson et al. 2016d; Dunn et al. 2017). This scenario played out on the Tonto National Forest in Arizona in the 2017 fire season, as illustrated in Figure 3. The top panel shows strategic response zones categorized according to risk-based management objectives. These categories are practical simplifications of a response continuum from resource protection to resource benefit and are intended to facilitate response decisions. These categories are not binding and in no way diminish the flexibility or decision space of managers. They do, however, reset defaults in such a way that aggressive initial attack may no longer be the status quo option in zones where management objectives call for the use of fire.

This example also illustrates how improved planning and monitoring can enhance responder safety and performance measurement. The boundaries of each strategic response zone are potential fire-control locations (e.g., roads, ridgetops), the identification of which facilitates deployments of suppression resources to where they can be safer and more effective. The bottom panel displays daily fire progression contours in relation to pre-identified potential control locations, along with maps of constructed fire-control lines ("hand line"), for the 2017 Pinal Fire. Local fire managers were able to leverage these pre-identified control locations to check fire spread in accordance with land and resource objectives (K. O'Connor, personal communication). The collection of accurate geospatial data on fire-control line construction allows for post hoc evaluation of control line effectiveness, ideally leading to more targeted and discriminating decisions of where to send suppression resources to minimize unnecessary exposure. Two logical next steps are expanding capacity for widespread use of this type of risk-based planning and disseminating incremental intervention as a model for engagement through training exercises.

A last point on ERM relates to being anticipatory of future challenges and roadblocks associated with such a strategic, systemic, organizational redirection. It will be important to discuss with candor the full spectrum of near- and long-term tradeoffs that may arise. It could be the case, for example, that suppression expenditures increase in the near-term, as fewer fires are rapidly extinguished and more fires become longer duration events. The overall expectation however may be that the trend will eventually reverse as both landscape condition

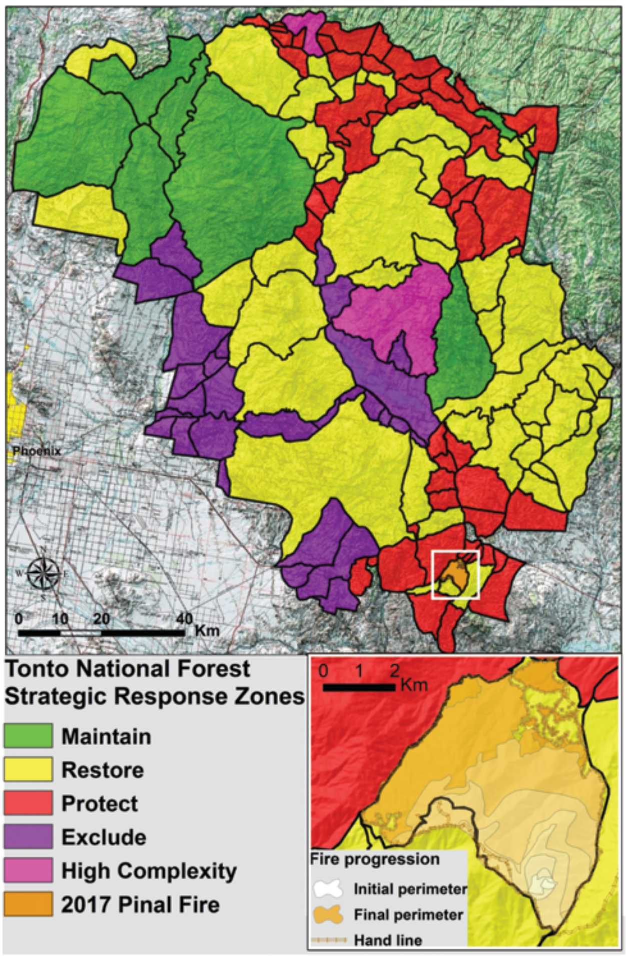

Figure 3. Demonstration of how new analysis tools can help managers more systematically plan for and evaluate suppression response. Specific information highlighted in this figure includes strategic response zones categorized according to risk-based management objectives, pre-identified fire control locations, and daily fire spread of the 2017 Pinal Fire, on the Tonto National Forest in Arizona, US image and analysis provided by Dr. Christopher D O'Connor.

Reactive response to unplanned ignitions → Proactive predetermined range of responses to unplanned ignitions under different scenarios

All fires require emergency response → Some fires require emergency response, under locations and conditions that can be pre-identified

Minimize or exclude disturbance → Capitalize on and leverage disturbance

Justify avoiding intervention → Justify intervention

Reward on the basis of outcomes → Reward on the basis of quality of decisions

Scarcity governs suppression resource use → Risk-risk tradeoff analysis governs suppression resource use

Intuitive expertise governs decision processes → Proactive assessment and planning governs decision processes

Figure 4. Vision for fire management in the 21st century, expressed as transition arcs from the status quo to desired endpoints.

and system behavior set the stage for moderated suppression response. Similarly, increased near-term exposure to smoke may be problematic for public health but must be evaluated in light of the observation that suppression cannot eliminate but rather defers and possibly intensifies smoke exposure (Schweizer and Cisneros 2017). As managers attempt to judiciously expand the footprint of ecologically beneficial fire, there is a nonzero chance that fires could escape containment efforts and cause damage. This underscores the importance of pre-identification of potential control locations to facilitate more rapid containment when warranted to preclude fire from spreading to threaten communities and infrastructure.

The Road Ahead: Continual Improvement

Improving the safety and effectiveness of response to each and every wildfire is essential in pursuit of broader socioecological objectives. To achieve this, it will be important to go "upstream" in the Forest Service to identify broader opportunities for meaningful change, and in doing so, revisiting how organizational culture, structure, and other factors may drive behaviors inconsistent with strategic objectives and the agency's mission. As a starting point, the Forest Service could introduce periodic analyses of doctrine and policy (US Forest Service 2017d) and their relation to current goals and intentions (US Forest Service 2005). Such a review could evaluate the transparency and accountability of fire managers, how risks are shared across levels of the agency, investments in workforce education and capacity, and the adequacy of available information, all with respect to responsibilities imposed upon and pressures faced by managers. Emphasis on acceptability of risk, mindful engagement, and justification of actions based on value and probability of success would necessarily infuse such analyses.

Aligning performance measures, incentives, workforce capacity, and information systems with the agency's intentions around fire will require a clearer articulation of a vision for fire management in the 21st century (Figure 4). Embracing this vision represents significant cultural shifts, challenging notions that fire must be fought, that fire can be eliminated or at least minimized, and that overwhelming displays of suppression response are the safest or the least costly option in the long-term (e.g., Houtman et al. 2013). It may require taking a hard look at the existing organizational structures surrounding planning and decision-making processes, evaluating whether the preconditions are in place for the incident response system to effectively function (Jensen and Thompson 2016), and ensuring that tactical and operational decisions are enriched with analytics and aligned with long-term agency objectives. It will also require recognizing that, in an uncertain world, bad outcomes can result from well-made decisions, and vice versa; supporting the former while avoiding reinforcing the latter are critical to effectively manage risks over time.

Insofar as cultural and institutional factors remain aligned around rapid engagement and extinguishment of wildfire, capacity will be built (and rewarded) around deployments of force instead of deployments of planning, analysis, and mitigation; long-term risks will likely continue to grow. Barring major change, the next generation of fire managers may inherit the same ways of thinking, corresponding competencies, and capacities that have led in part to the problems the agency faces today. Hence, the call to rethink a currently flawed wildland fire management system.

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