Minimize the bad days: Wildland fire response and suppression success

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On the Ground

- Effective wildland fire response and suppression are critical for reducing the size of frequent and severe wildfires, thereby reducing the risk of post-fire conversion to invasive annual grass-dominated plant communities.
- Wildland firefighter safety and strategic deployment of resources are paramount for timely initial attack to prevent incidents from escalating.
- By mobilizing a timely and safe initial response, early detection technologies, strategic networks of fuel breaks, and Rangeland Fire Protection Associations help "minimize the bad days" on the fireline and improve suppression success on a vast and remote landscape.

Keywords: Fire management, Fuel breaks, Fuel management, Partnerships, Wildland fire.

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Introduction

Fire is a natural process with which sagebrush ecosystems have evolved.[1,2] However, a changing climate, land use effects, and annual grass invasion have contributed to high fuel loads, longer fire seasons, more major fire events, and modified natural fire regimes.[3-5] Proliferation of invasive annual grasses present challenges for wildland fire response on Great Basin rangelands by facilitating changes in fire behavior and increasing historical fire activity. Effective fire suppression tactics are critical for reducing the size of frequent and severe wildfires, thereby reducing the risk of post-fire conversion to invasive annual grass-dominated plant communities (see Boyd, this issue).[6]

Although specific management activities may reduce hazardous fuel loads prior to the fire season (e.g., Davies et al., this issue)[7], fires are inevitable on Great Basin rangelands. Wildland firefighter safety and strategic deployment of resources are paramount for timely initial attack to prevent incidents from escalating. These resources not only include crews, engines, incident management teams, and aerial support; also essential are technologies for early detection of wildfires on the vast and remote landscape, strategic networks of fuel breaks to aid wildfire management operations, and local firefighting resources who detect fires early and mobilize in a timely initial response. We describe early detection technologies, proactive planning, and public-private partnerships for wildfire response in southeastern Oregon, part of the northern Great Basin. These strategies may be synergistically leveraged to improve suppression success and "minimize the bad days" on an active fire by safeguarding firefighter and public safety as well as critical natural resources from adverse effects of wildfire.

Rangeland wildfire and response

In the northern Great Basin, invasive annual grasses such as medusahead and cheatgrass (*Taeniatherum caput-medusae* [L.] Nevski and *Bromus tectorum* [L.], respectively) senesce early in the growing season and, therefore, reach fuel moisture contents that readily burn more than four weeks earlier than plant communities not invaded by annual grass.[8] If left untreated, invasive annual grasses accumulate as litter over multiple seasons, creating fuel beds characterized by high fine fuel loads and horizontal fuel continuity. These fuel characteristics increase the probability that an ignition will propagate a fire and fire will spread rapidly.[8-10] Taken together, sagebrush ecosystems invaded by annual grasses experience increased fire frequency, size, and intensity, as well as longer fire seasons (Table 1).[4,10-12]

In addition to fuels and ignitions, topography and fire weather—which includes precipitation, wind speed, temperature, and relative humidity—influence fire behavior and the subsequent suppression operations undertaken. On critical fire weather days and when lightning or human activities start multiple fires, life, property, and resources may be threatened. In southeastern Oregon, keeping wildfire incidents from es-

Table 1

Changes in fuel characteristics and corresponding effects on fire behavior and fire regime. In sagebrush ecosystems, invasive annual grasses such as cheatgrass (*Bromus tectorum* [L.]) and medusahead (*Taeniatherum caput-medusae* [L.]), in general, increase fuel loads, increase horizontal continuity, increase plant tissue flammability, and have a high packing ratio. Adapted from Brooks et al.[11]

Change in fuel characteristics	Change in fire behavior and fire regime
Increased fuel load	Increased fire intensity and longer fire season
Decreased fuel load	Decreased fire intensity and shorter fire season
Increased horizontal continuity	Increased fire frequency and extent
Decreased horizontal continuity	Decreased fire frequency and extent
Increased plant tissue flammability (i.e., low fuel moisture content, volatiles)	Increased fire frequency and intensity; longer fire season
Decreased plant tissue flammability (i.e., high fuel moisture content, minerals)	Decreased fire frequency and intensity; shorter fire season
Change in fraction of a fuel bed occupied by fuels (packing ratio)	Change in fire frequency, intensity, and length of fire season

calating minimizes impacts such as habitat loss for sagebrush obligate species (e.g., greater sage-grouse [*Centrocercus urophasianus*]) and disruption of livestock operations and rangeland-dependent economies.

During incidents, weather, fuel conditions, and topography drive fire behavior. Fire behavior and other circumstances—such as fire suppression resources available for deployment—inform wildfire response tactics. Because wildland fire managers can do little to influence weather, attack strategies seek to control fuels and the location of suppression operations. Direct attack treats actively burning fuels through wetting, smothering, or separating unburned fuels.[13] Direct attack may be used to extinguish a fire or reduce the intensity of a flaming front. In contrast, indirect attack disturbs fuel continuity and brings fire to a location ideal for suppression activities (i.e., limit fire spread and behavior) through fireline construction or use of controlled burnouts.[13] The fuel characteristics of invasive annual grass monocultures typically result in a more contiguous fuel bed that promotes rapid fire spread across the landscape, necessitating rapid mobilization of suppression resources.

Improving wildfire response

Southeastern Oregon is primarily comprised of remote wildlands and complex topography; this often makes fire detection and deploying a timely response difficult.[14] Although wildland fire managers cannot control fire weather and ignitions, suppression success can be increased by detecting fire starts early, using fuel breaks to improve wildfire response operations, and leveraging wildfire response through partnerships with Rangeland Fire Protection Associations.

Early detection strategies for timely initial response

More than 95% of all wildfire starts are contained in the initial attack.[15] The 5% of wildfires that escape and become extended attack incidents are costlier and may threaten lives and resources; as the size, complexity, and duration of an incident increases, more ground and aerial resources may need to be mobilized.[16] When a fire start is first spotted or reported, fire responders conduct a size-up to determine strategy and tactics for initial attack. A size-up includes fire location, fuel type, character of the fire, flame length, position on the slope, wind speed, values at risk, and hazards. Fire managers also inventory available resources for mobilization and assess fire behavior using both current and anticipated conditions (e.g., fuel loading, fuel moistures, Energy Release Component, Burning Index, and the General Fire Weather Forecast). The initial response ensures sufficient resources are ordered, and appropriate tactics are undertaken.

In recent years, early detection technologies have aided responding units in conducting initial remote size ups to inform timely decisions about resource type and allocation for an incident. These detection technologies include the Fire Information for Resource Management System (FIRMS), which uses infrared data delivered via Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) to detect fires and hotspots.[17] FIRMS delivers active fire data via email alerts to users. Tools for early detection are especially useful during multiple fire situations, which can strain the initial attack capabilities of the responding unit.[16]

Between 2009 and 2018, lightning accounted for 68% of fire starts in the Burns Bureau of Land Management (BLM) District in southeastern Oregon. Accordingly, during periods of critical fire weather, fire managers may pre-position fire suppression resources and monitor lightning strikes—using real-time lightning maps—in concert with other tools such as detection cameras. Five ALERTWildfire cameras in Harney and Malheur Counties aid fire managers in discovering, locating, or confirming a fire start, informing managers' decisions regarding resource mobilization or helping them to monitor progress toward containment.[18] For example, the Neals Hill Fire in 2020 was started by lightning and the Burns Interagency Communication Center was able to confirm the rapidly-spreading wildfire using the Steens Mountain ALERTWildfire camera. A combination of these early detection technologies and positioning resources when fire starts can help to decrease response time to incidents in remote locations.

Fuel breaks as "Manmade winnable ground"

In sagebrush ecosystems, invasive annual grasses and other vegetation with low fuel moisture content and high fuel continuity as well as species with volatile oils such as sagebrush, rabbitbrush, and western juniper (*Artemisia* spp., *Chrysothamnus* spp., and *Juniperus occidentalis*, respectively) pose safety and tactical challenges for wildfire managers.[19,20] Because fire weather and fuels drive fire behavior, more crews, dozers, air tankers, or water tenders do not necessarily effectuate control or containment. Fuel breaks modify vegetation to: (1) disrupt fuel continuity, (2) reduce fuel accumulation and volatility, and (3) increase the proportion of plants with higher moisture content.[21] By reducing fire intensity (i.e., flame length) and surface rate of spread, fuel breaks can improve suppression success and manage the impacts of large-scale wildfires in sagebrush ecosystems.[22,23] Importantly, fuel breaks provide safety refuges for suppression resources to engage fast-moving rangeland fires. They may also offer safer travel corridors to the public seeking to evacuate during an incident.

Fuel breaks may be created through mowing, discing, chemical treatments, targeted grazing, or prescribed fire. Vegetative fuel breaks (i.e., "greenstripping") use relatively more fire-resistant bunchgrasses or species such as crested wheatgrass or forage kochia (*Agropyron cristatum* [L] Gaertm. and *Bassia prostrata* [L.] A.J. Scott, respectively). These species disrupt fuel continuity because they characteristically create larger spaces between individual plants. Additionally, promoting species in fuel breaks with high moisture content and low volatile oil reduces ignition probability and fire behavior.[19] Removal of shrubs and western juniper in fuel breaks is especially important because those species typically generate longer residence time, greater flame lengths, and spotting ahead of a flaming front.[21-23]

By modifying fuel conditions in strategic locations on a landscape, fuel breaks can reduce fire behavior (i.e., flame lengths, rate of spread, and spotting; Fig. 1); decreased flame lengths make direct tactics feasible for firefighters. Fuel breaks are defensible firelines that provide safe anchor points for decision-making and suppression operations (e.g., conducting burnout operations), as well as potentially "compartmentalize" wildfires and contain their size and spread on the larger landscape.[22] For example, fuel breaks strategically implemented prior to a fire incident can assist fire managers in preventing a fire from spreading from an area dominated by invasive annual grasses to an adjacent site containing critical resources, such as sage-grouse habitat (see Wollstein et al.).[25]

For fuel breaks to be effective, they must be planned at the landscape-scale and connect relevant access points for resource deployment and timely initial response. Their placement considers topography, vegetation type, ignition density maps, and proximity to existing road systems and suppression resources.[22,24] Additionally, the location of fuel breaks must consider where wildland firefighters can logistically use them, which is informed by Incident Managers' experience and review of past fires and the fire behavior in the area (e.g., Thompson et al.).[26] Although control lines are often created during incident response, planning and implementing fuel breaks in advance allows for collaborative decision-making regarding placement and effects on resources and values (e.g., Wollstein et al.).[25] For example, the Harney County Wildfire Collaborative advanced the BLM Pueblo Mountain Pilot Project, which created a vegetative fuel break along a road corridor in the Burns BLM District. The fuel break aimed to enhance wildfire suppression efforts by improving access to the area for wildland firefighting equipment, reducing shrub cover, and managing fine fuels within the road corridor.

Although fuel breaks can aid wildland firefighters by reducing wildfire size and severity, fuel break construction must be considered in terms of tradeoffs: shrub control and soil disturbing treatments (e.g., discing) can promote annual grass invasion.[27,28] Other concerns include landscape-scale habitat fragmentation, creation of edge effects, and encroachment of introduced species (e.g., forage kochia) in native plant communities.[22,29] Finally, fuel breaks must be economically and practically feasible for the entity charged with implementing and maintaining them. This includes navigating implementation on multiple landownerships within an area and investing in regular maintenance to avoid undesirable changes in vegetation and fuels (e.g., chemical treatments and drill seeding to prevent the spread of invasive annual grasses).[30]

There are some critiques that fuel break construction contributes to habitat fragmentation or loss. There are also concerns that fuel breaks, if not maintained, become a propagule source of invasive annual grass.[29] But in an era of frequent and severe wildfires fueled and perpetuated by invasive annual grasses, fuel breaks can alter fire behavior and improve wildfire suppression success by enabling quicker response times, thereby reducing potentially large overall losses of the sagebrush ecosystem. The tradeoffs of fuel break implementation must be situated in the context of the spatial and temporal scales at which wildfire risk mitigation and recovery take place (see Wollstein et al.).[25]

Public-private partnerships capitalize on local knowledge

The BLM is responsible for fire suppression on BLM land. The agency also assists in suppressing fires deemed to be a threat to BLM lands or instances in which there is a reciprocal agreement with the land manager(s) to assist (e.g., a federal or state agency, or a Rangeland Fire Protection Association). Although 60% of Harney County is managed by the BLM (Table 2), it is challenging for the agency to provide timely response to fire starts on BLM land in remote, difficult to access parts of the county. In recent years, private landowners have had an enhanced role in wildfire response in southeastern Oregon. Remote BLM lands are often leased grazing land or adjacent to ranchers' private land; this contingent of private landowners is often much closer to fire starts and intimately familiar with access points, topographic features, and potential hazards to wildland fire operations.[14] These landowners are also highly motivated to respond to wildfires to protect their livelihoods.

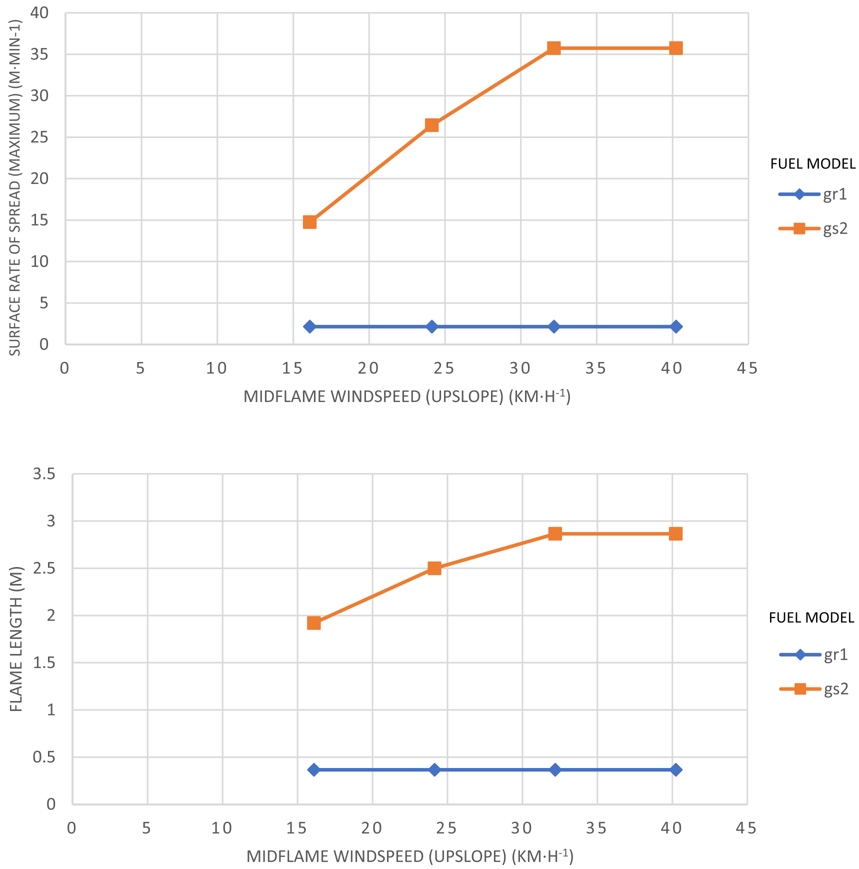

Figure 1. Fire behavior comparisons of typical fuels in the northern Great Basin (gs2 fuel model) and fuels expected in a fuel break (gr1 fuel model). Flame length and rate of spread are both expected to be lower in fuels expected in a fuel break (gr1), making direct tactics an option for firefighters.

Table 2
Landownership composition in Harney County, Oregon.[36]

Landownership	Hectares	Percent ownership
U.S. Fish and Wildlife Service	76,095.85	2.87
U.S. Forest Service	211,671.99	7.99
Bureau of Land Management	1,606,459.13	60.65
Burns Paiute Reservation	311.53	0.01
State	80,047.69	3.02
Private	659,712.48	24.91
Other	14,311.97	0.54
Total	2,648,610.64	

To capitalize on the motivation and knowledge of these private landowners, Rangeland Fire Protection Associations (RFPAs) are non-profit organizations that authorize volunteer landowners (primarily ranchers) to respond to fires on remote private and state lands (i.e., outside designated forest protection districts; Oregon Revised Statute 477.125). Additionally, they may respond to wildfires that occur on federal lands where they have a Memorandum of Understanding (MOU) to act as cooperators with the federal government. Oregon Department of Forestry (ODF) provides training, some financial support, and assistance with grant writing and procuring federal surplus equipment. In 2020, there were 24 RFPAs whose boundaries cover nearly 6.7 million hectares (16.5 million acres) of private, state, and federal land in Oregon (M. Vetter, personal communication, 7 Jul 2021; Fig. 2).

RFPA members possess detailed knowledge of a vast rangeland landscape that can inform agency fire managers' tactics and attack strategies. For example, they can provide information to agency responders on location, condition, and accessibility of roads, fuel breaks, and water sources.[14,33] But incident management is complex and requires coordination of many types of resources (e.g., ground, aerial, different agencies, and landowners).[16] When fires reach a certain size or complexity, incident management is turned over to non-local Type I or II teams. In the past, these teams have not recognized or understood RFPA authority or abilities.[14,31] Furthermore, in some instances, different training standards and poor radio communication between RFPA and incident management teams contributed to conflict on the fireline.[14,32]

To help address these tensions, members of the Harney County Wildfire Collaborative agreed on a RFPA liaison position for southeastern Oregon. The Burns BLM District and Malheur National Wildlife Refuge committed funding and a RFPA liaison was hired in 2018 by the Burns Interagency Fire Zone to focus on the relationships between incident management teams and RFPA members. More recently, ODF and the RFPA liaison offered training and refresher courses to RFPA members akin to basic federal wildland firefighter

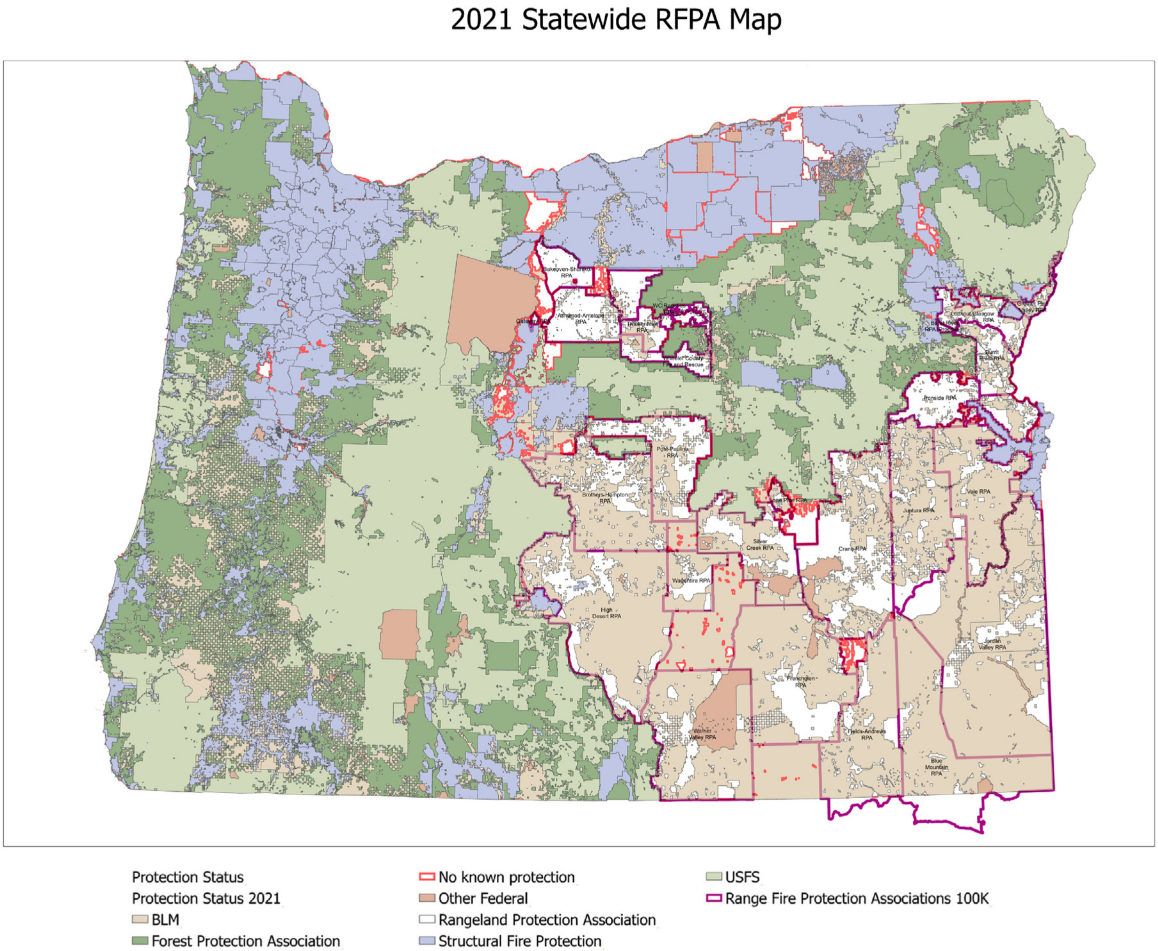

Figure 2. Rangeland Fire Protection Association boundaries and landownerships in Oregon. Credit: Cassie Adamson, Oregon Department of Forestry.

trainings (i.e., National Wildfire Coordinating Group's S-130 and S-190 courses). These trainings have included use of radio communications equipment and integration into the Incident Command system.

In recent years, RFPA members report feeling more comfortable calling in fires to the Dispatch Center and providing initial attack size-ups. They also station RFPA equipment at their ranches or in strategic locations where, in their experience, fire starts are expected to improve timely initial response; incident management teams may call upon or coordinate with these resources. Interpersonal relationships between RFPA members and BLM personnel have been improved through time spent together on firelines and ride-alongs, as well as away from the fireline in trainings, meetings, and social events in the community.[31,33] Additionally, After Action Reviews initiated by the RFPA liaison offer a venue for learning and building common understandings (e.g., how, and why agency fire managers make decisions during incidents). These improved relationships have expanded and extended initial response capacity where fire management has traditionally been centralized within fire agencies.

In summary

Improved wildland fire response and suppression in southeastern Oregon can protect plant communities at risk of transitioning to invasive annual grass following a wildfire event (Johnson et al. this issue)[34] and keep the remaining sagebrush ecosystem intact (Boyd, this issue).[6] Given the comparatively limited resources for post-fire restoration (see Smith et al., this issue),[35] timely and effective fire suppression will aid in slowing the spread of invasive annual grasses and reducing the frequency of severe fires over time. This will allow rangeland managers to focus on fuel treatments to reduce fire risk and rehabilitate sites to exclude invasive annual grasses after a fire. Improved wildland fire response and suppression will aid in achieving these ends: "minimizing the bad days" on firelines occurs through early detection technologies, strategic fuel breaks to improve firefighter safety and tactical success, and partnerships between agency fire professionals and RFPAs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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