Assessing How Fuel Treatments are Considered During Incident Response: An Interim Report

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Research Brief for Practitioner Paper #13: An Interim Report
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ASSESSING HOW FUEL TREATMENTS ARE CONSIDERED DURING INCIDENT RESPONSE

Michelle Greiner, Katie McGrath Novak, and Courtney Schultz

We are conducting research about how US Forest Service (USFS) fuel treatments are considered and incorporated into wildfire response by incident management teams. Our goals are to: 1) understand how forest and fire personnel communicate about existing treatments; 2) understand what treatment characteristics they look for to meet different objectives; and 3) gather recommendations for improving fuel treatments to support incident management. To date, we have conducted 27 interviews with fire and fuel personnel in the western United States. We conducted two case studies of 2020 wildfires where existing fuel treatments were considered in incident response: the Cameron Peak Fire in Colorado and the Bighorn Fire in Arizona. Herein we report on interim findings, while we continue our study looking at additional fires from 2021.

Key Findings

Fire management personnel and fuels planners agreed that existing fuel treatments are useful during incidents for tactical advantage (e.g., initial fire assessment, burnout operations, and access points) regardless of whether the fire directly intersected the treated area. Most interviewees also stated that fuel treatments allow for increased time efficiencies, responder safety, and enhanced containment opportunities. In some cases, treatments are used for contingency planning.

In both case studies, fuel treatment information was shared during the initial incident briefing and then informally passed along to new incident management teams (IMTs). During incidents, the information sharing process was contingent on individual personalities, experience in the local fuel type, leadership direction, and team culture and composition. Some interviewees thought a systematic process to share local fuels data could be useful; others encouraged the integration of decision support tools to support communication about treatments between the agency and other response partners, even before fires start.

When deciding to utilize a treated area during an incident, interviewees said they consider characteristics such as the fuel treatment's age, (which affects whether fuels have grown back), proximity to roads or other sites, connectivity of treatments, and treatment size. Strategic treatment placement and ongoing maintenance are also key elements for optimal treatment utility during a fire. Interviewees emphasized that contextual factors such as weather, fire behavior, wildfire location, resource availability, staff personalities, and unit culture also influence the decision to use a fuel treatment.

Our findings revealed that consistent treatment maintenance, the culture of communication about treatments, local expert knowledge, and unit/team composition are important components of how fuel treatments are evaluated and integrated during incident response. Ongoing challenges for fully capitalizing on fuel treatments during incidents include staffing and equipment limitations, and divergence in leaders' acceptance and willingness to support strategically implementing and using fuel treatments.

Recommendations

The following is a synthesis of the key recommendations our interviewees offered regarding how to best support the integration of existing fuel treatments into wildfire incident response:

- To support fire incident response and integration of treatments, communication before fires start among USFS staff members and potential fire response personnel (including state and local fire response partners) builds relationships, trust, and understanding of the local fuel management plans.
- Direct and purposeful communication among fuels planners and IMTs (i.e., between IMTs and fuels planners, and from one IMT to the next) would allow for more consistent information transfer during incidents.
- The USFS as an organization and forest-level leadership should encourage the integration of decision support tools and resources designed to support coordinated communication during incidents and provide easily accessible fuel treatment information.
- The USFS should commit resources to address staffing and equipment limitations to support strategic fuels planning, implementation, and regular maintenance of treatments to create and maintain fuels treatments that can be useful during future incidents.

Next Steps

We are continuing our investigation with additional case studies of 2021 wildfires that were in proximity to fuel treatments. Interviews are currently in progress. We will issue a final project report in 2023.

More Information

Find reports and other publications about this research at:
https://sites.warnercnr.colostate.edu/courtneyschultz/plpg-practitioner-papers/

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Common Acronyms

AA	Agency Administrator
BHF	Bighorn Fire
CPF	Cameron Peak Fire
FTEM	Fuel Treatment Effectiveness Monitoring
IC	Incident Commander
IMT	Incident Management Team
USFS	United States Forest Service
WUI	Wildland Urban Interface

Common Wildland Fire Management Terminology

Anchor point	"An advantageous location, usually a barrier to fire spread, from which to start constructing a fireline. The anchor point is used to minimize the chance of being flanked by the fire while the line is being constructed."[1]
Burnout operation	"Setting fire inside a control line to consume fuel between the edge of the fire and the control line."[1] Often also called *burnouts* or *burning off*.
Backfire/ backburn	"A fire set along the inner edge of a fireline to consume the fuel in the path of a wildfire or change the direction of force of the fire's convection column."[1] Note: Some of our interviewees used the terms backfire and backburn interchangeably, and for the purposes of this report they are synonymous.
Fuel treatment	"Any mechanical, silvicultural, or burning activity whose main objective is to reduce fuel loadings or change fuel characteristics to lessen fire behavior or burn severity" (Reinhardt et al., 2008, p. 1998). Examples include prescribed fire and mechanical thinning. In this report, we refer to fuel reduction treatments and hazardous fuel treatments as fuel treatments.
Fuel break	"A natural or manmade change in fuel characteristics which affects fire behavior so that fires burning into them can be more readily controlled."[1]
Safety zone	"An area cleared of flammable materials used for escape in the event the line[2] is outflanked or in case a spot fire causes fuels outside the control line to render the line unsafe." "Safety zones may also be constructed as integral parts of fuel breaks; they are greatly enlarged areas which can be used with relative safety by firefighters and their equipment in the event of blowup in the vicinity."[1]
Staging area	"Locations set up at an incident where resources can be placed while awaiting a tactical assignment."[1]

[1] Definitions from the National Wildfire Coordinating Group's (NWCG) *Glossary of Wildland Fire*. Accessed 16 November 2021. https://www.nwcg.gov/glossary/a-z

[2] Line in this context refers to either a control line (all constructed, natural, treated barriers used to control a fire) or a fireline (dug or scraped part of a control line).

Introduction

Fuel treatments, usually consisting of tree removal, mastication, prescribed fire, and pile burning, are used to facilitate wildfire management and minimize the adverse effects of wildfires (Reinhardt et al. 2008, Vaillant & Reinhardt 2017). Fuel treatments can also be used to meet several other land management objectives, including improved wildfire habitat, post logging slash removal, improved responsiveness to wildfire, and protection of highly valued structures and natural resources. The U.S. Department of Agriculture's (USDA) Forest Service (USFS) implements fuel treatments on the National Forest System and neighboring lands nationwide to protect communities and mitigate negative impacts from wildfire.

Fuel treatment effectiveness is typically evaluated on whether treatment interactions moderate fire effects, affect fire behavior, and enhance the safety and effectiveness of fire suppression operations. The USDA and Department of Interior (DOI) Fuel Treatment Effectiveness Monitoring program (FTEM) is designed to document the effectiveness of fuel treatments on fire behavior when a fire interacts with a fuel treatment (e.g., overlaps or is adjacent to a wildfire). A related issue is how existing fuel treatments are incorporated into strategic and tactical decisions during wildfire incident management on USFS lands. While significant work through the FTEM program and other initiatives has focused on the effectiveness of fuel treatments in terms of fire behavior and impacts, gaps remain in understanding how treatments, even if they did not directly overlap with the wildfire, are potentially used during incident responses.

The purpose of this research project is to understand the perspectives, knowledge, and experiences of practitioners in the field (i.e., incident commanders and first responders, fuels planners, line officers) regarding fuel treatments in an incident management context. This is an interim report on our findings to date. In the first stage of our project, we conducted regionally focused interviews to understand general perceptions of how fuel treatments were integrated into decision making. We are currently conducting interviews on specific fires and report herein on our findings from two 2020 fires. Subsequent work will include research on 3-5 fire incidents from 2021 to finalize our study.

This effort was completed in cooperation with the USFS Rocky Mountain Research Station (RMRS). Our research team consists of co-principal investigators Drs. Courtney Schultz (Colorado State University (CSU) and Nathaniel Anderson (RMRS). Research associates Michelle Greiner (CSU) and Katie McGrath Novak (CSU) are leading data collection and analysis. Jim Menakis (USFS) and Dr. Matthew Thompson (RMRS) serve as advisors for this project, assisting with identifying research questions. No USFS employees had knowledge of our interviewees' names or positions. Per our pre-project agreements, CSU retains editorial independence in publishing findings.

Approach

The following are our research questions regarding use and perceptions of fuel treatments in an incident management context:

1. To what extent do treatments during suppression operations align with land managers' intended purpose for those treatments from a design and planning perspective?
2. How do incident commanders, other fire management personnel, and forest personnel communicate about existing fuel treatments and their value during incident response?
3. How do fire managers[3] view treatments and incorporate them into operations, including situations when treatments are not expected to interact directly with fire?
4. What characteristics do fire managers look for when considering using a fuel treatment to support their wildfire management strategy?
5. What recommendations do interviewees have for improving fuel treatments to support incident management of a wildfire?

Beginning in late 2020 and continuing into the summer of 2021, we conducted semi-structured interviews with two groups of people to address our research questions. First, we interviewed two people in each western USFS Region (Regions 1-6) who had experience in both fuels planning and tactical operations. This purposive sample of 12 interviewees is herein referred to as our regional interviewees. These interviews were conducted to gain a broad perspective about the use of treatments to support operations and to identify potential fires for additional study.

Next, we conducted 15 interviews on two 2020 wildfires with individuals who had direct experience with suppression operations and were knowledgeable about how treatments were considered. Fire selection on which these interviews were conducted were based on a compilation of referrals from the regional interviewees as well as regional fuel leaders. We asked our contacts to recommend one or two 2020 wildfires that may have interacted with fuel treatments, including either treatment locations that were burned during the fire or where fuel treatments were used (or not used) during incident response. Our compiled list of recommended 2020 wildfires was then assessed by the project team and USFS fire science colleagues using the criteria shown in Table 1. Our intention was to select fires representative of the different ways fuels are considered during operations.

Table 1 Criteria for the selection of case studies (this structure was adapted from a study by Mackenzie et al., 2012).

Selection criteria category	Criteria
Meets Basic Study Parameters: 2020 wildfires where fuel treatments were used (or not used) in some way during incident response	• Fire footprint primarily on western federal forestland • Proximity to existing USFS fuel treatments (based on referrals or FTEM) • Treatment interactions recorded in FTEM during the time of our sampling period (this criterion was preferred but not necessary due to variable data input)
Research Relevancy and Opportunity: Opportunity for case diversity and study richness	• Minimum of 50,000 acres and 30 days duration • Variety of fuel treatment uses during suppressions (e.g., enhanced containment opportunities, provided firefighter safety, changed fire behavior, treatments not used) • Fires that offer opportunity for regional diversity • Fire recommended by multiple informants
Pragmatic: Practicality of successfully completing interviews	• Support from the Forest Supervisor's Office to conduct the study • Willingness, interest, and availability of staff to participate • Relatively simple regarding jurisdiction and management (e.g., limited joint command and or extreme weather incidents)

[3] For the purposes of this report, the term fire manager includes both fuels and wildfire (aka operations) managers.

For the 2020 fire season, we selected the Cameron Peak fire (n=10), and the Bighorn fire (n=5). Table 2 provides a summary of our interviews. Details of the fires' location and acres burned can be found in Table 3. In early summer 2021, we also strove to conduct interviews on the Slater Fire and Mullen Fire but were unsuccessful at contacting the Agency Administrator (AA) on these fires to move forward; we assume that this was because of the intensity of the early part of the 2021 fire season, leaving people with insufficient time to talk to us about the previous year. We will continue with more cases from 2021 fires to complete this research.

Table 2: Interviewee summary

Interview group	Number of interviewees
Regional	12
Cameron Peak (CPF)	10
Bighorn (BHF)	5
TOTAL	**27**

Table 3: Case study locations

Case Study (wildfire name)	Fire Duration	US National Forest and state	Size of fire (total acres burned)	Acres burned on US national forest land	No. of Interviewees
Cameron Peak (CPF)	August 13 - December 13, 2020	Arapaho and Roosevelt, CO	208,913	173,318 (83% of total burned area)	10
Bighorn (BHF)	June 5 - July 23, 2020	Coronado, AZ	119,978	108,100 (90% of total burned area)	5

Once these fires were identified, we strove to interview at least one Incident Commander (IC), one Agency Administrator (AA), and a forest fuels planner for each case study, as well as three to five additional people suggested to us by these interviewees who could address our questions. The additional interviewees recommended to us included, for example, Fire Management Officers and Operations Section Chiefs. A breakdown of the staff roles we spoke to for each case study and the regional group is provided in Table 4. Interviews of non-federal personnel by referral took place when such personnel were critical in managing incident response. For both fires, some individuals did not respond to our request for interviews. For instance, given limited responses, on the BHF only five people were interviewed, although the information provided was largely consistent among interviewees (exceptions are noted below in our findings). One lesson we learned from this stage of research was that different Incident Management Teams (IMTs) and ICs sometimes have different approaches to using fuel treatments. Thus, for research on future fires we anticipate expanding our interviews to more people from multiple IMTs on a single fire.

Interviews were voluntary and confidential. They were recorded, transcribed, and coded for analysis to identify key themes. We summarized findings for our regional interviews and the themes that we are beginning to identify across different fires. Illustrative quotes from interviewees are provided and speakers are distinguished by confidential identification numbers.

Table 4 Interviewee roles

Interviewee roles [a]	Number of interviewees in role [b]		
	Regional	**Cameron Peak**	**Bighorn**
Incident Commander	5	2	1
Agency Administrator (Includes AA reps and deputy AAs)	n/a	1	2
Fire Management Officer (Includes assistant)	3	1	1
Fuels Planner, Manager, Specialist and Fuels Assistant	8	2	1
Operations (e.g., Operations Section Chief, Division Supervisor, Firefighter, Burn Boss)	11	5	0

[a] On Cameron Peak (CPF) and Big Horn (BHF) fires, these positions refer to the interviewee's role during the fire whereas the regional demographics represents interviewees with current and former experience in that role.

[b] Some people served in multiple roles; thus, this table does not reflect the total number of interviewees in the regional group, CPF, or BHF. Refer to Table 2 for a summary of interview numbers.

Findings

1. Regional Interviews

All regional interviewees said incident commanders (ICs) and other fire management personnel actively consider existing fuel treatments during wildfire incident management. Interviewees said they commonly use treatments for tactical advantage during incidents, using them to conduct burnouts and as access points, particularly when treatments are along roads, or occasionally for other purposes such as staging areas. Some said that any treatments that alter the fuel profile are useful during incidents because they change the risk profile, broaden decision space, and create more options for suppression. As one interviewee explained, "Options, I think, is a keyword there. When you have these [treatments] out away from the fire, you've got options to work with" (6). Another added, "[The treatment] gave us some decision space. . . . It gave us a plan A and plan B, instead of just a plan B" (10). Almost all regional interviewees were positive about the value of fuel treatments in incident management. In addition to the tactical advantages outlined above, interviewees commonly cited the following as benefits of fuel treatments during incidents:

- **Firefighter safety |** Most interviewees said fuel treatments can enhance firefighter safety during incidents by providing easier and safer access points for crews to engage fires and allowing greater opportunity to consider indirect approaches, which are typically less aggressive methods that lessen firefighter exposure to heat and smoke.

- **Resource efficiencies |** Several interviewees explained that the time and resources required to prepare an area during an incident can be reduced or reallocated if the area has been previously treated. For example, one interviewee said, "It sure helps a lot when I get a map and there's already a fuel treatment on a road. And I'm like, 'Oh, great, I don't need to commit resources to that to prep that road or prep that ridge. It's already done'. . . It helps to keep those pressures on resources down if we've got treatments already completed" (8).

- **Opportunity to manage natural ignitions for resource benefit |** Some interviewees in USFS Regions 3 and 4 said that having fuel treatments in place can build better support for the consideration of managing natural ignitions for resource benefit if conditions permit, as opposed to immediately suppress the fire.

Interviewees explained that treatments are typically planned with multiple goals in mind, most commonly including community protection from wildfire, providing tactical advantage during suppression operations, enhancing wildlife habitat, and restoring fire-adapted ecosystems. Most interviewees expressed that implementing treatments during suppression operations is generally aligned with their intended purpose. However, about a quarter of our interviewees explained that this was not always the case. Timber harvests were said to be the priority management goal for the agency, a policy that sometimes dictates the size and placement of treatment areas. Such treatments, they said, sometimes cause increased fire behavior when slash or snags are not properly removed mechanically or with prescribed fire after harvests.

Interviewees said their consideration of how and whether to utilize a fuel treatment during incidents is contingent upon several dynamic variables, such as the fire behavior, fuel type, and the age of the treatment. Interviewees described the primary features they look for when considering use of fuel treatments:

- **Strategic placement |** Almost all interviewees said that strategically placed treatments, particularly those near roads, ridges, or the wildland urban interface (WUI) often offer greater utility during incidents. Fuel treatments near roads and other potential control locations can provide safer firefighter access than treatments in remote or steep areas.

- **Treatment size and connectivity |** More than half of our interviewees expressed that large or contiguous treatments are often more advantageous during fires. Many interviewees, however, expressed that it is difficult to implement fuel treatments that are strategically connected and occur at the landscape-level, noting constraints associated with policy, funding, and habitat preservation requirements. Several interviewees mentioned that planning projects around jurisdictional boundaries can limit treatment size and continuity, therefore constraining their utility during incidents. A few interviewees explained that fire scars, due to their size, are often more reliable during incident response than fuel treatments. Several interviewees agreed that a lack of treatment size and connectivity was a main barrier inhibiting the full potential of utilizing fuel treatments during incidents.

- **Treatment age and maintenance level |** About half of our interviewees said that treatment effectiveness diminishes over time, and that conducting ongoing maintenance of existing treatments is limited by agency funding and capacity. In describing a capacity problem related to maintaining fuel treatments, one interviewee explained, "The problem, if you're going to alter landscapes, especially when [the ecosystem is] used to disturbance really frequently, is that your workload has to double every six to ten years, just for you to maintain that previous investment that you put on places" (1).

Interviewees shared various ideas to help address challenges and improve the utility of fuel treatments during incidents. We grouped the most common recommendations into five topics.

1) **Encourage prompt and coordinated communication during incidents.** Interviews revealed there is not a systematic process within the USFS for obtaining, communicating, and using existing fuel treatment data during incidents. Many said unit culture and leadership styles affect how existing treatment data is integrated during incidents, and that some local forest units and IMTs are more open to sharing and receiving treatment information than others (see Box 1). Almost all interviewees agreed that there is room to improve communication about existing fuel treatments to IMTs. Interviewees suggested that having timely access to fuel treatment data through briefing packets and maps could enhance fuel treatment utility. Some interviewees conjectured that a more standardized process for sharing fuel treatment information during incidents could be valuable.

   Most interviewees said that personnel will scout the area to verify current treatment conditions regardless of having fuel treatment information. This is done not because of lack of trust or aversion to using the information, but rather out of caution. Interviewees noted that local knowledge about treatments is extremely valuable in speeding up the ground-truthing process.

Box 1: Examples of fuel treatment communication processes

"I've been on numerous fires where I spend two or three days just driving all over the place trying to figure out: where are we going to draw that line in the sand, what's the best opportunity for a containment line? [If] this data is provided to you when you first show up, then all you're doing is going out and confirming that these are good locations. Or, these are good locations, but we still need to put some resources to actually put in a hand line, or we need to bring in some equipment to put in a dozer line or do some tree thinning. [Having treatment data readily available] could save me two or three days of work, which time is obviously a critical component when responding to a fire" (2).

"You know how I spoke earlier that each forest has their own way of communicating to a team their fuel treatments and fuel breaks? I wish that there was a way that can be standardized and/or made a higher priority across the whole agency . . . My forest is behind the curve when it comes to that, and it's frustrating that I can go to an incident on another forest and see the products they produce . . . I'm like, 'Man, this is a great product. I wish we could provide this to a team when they come to my forest'" (8).

2) **Explore and invest in pre-fire planning and decision support efforts.** Most interviewees were enthusiastic about the potential for pre-fire planning and modeling efforts to improve the use of fuel treatments during incident management. Interviews referred to multiple planning and decision support approaches that are often used to efficiently share data including treatment maps loaded into the Wildland Fire Decision Support System (WFDSS), Forest Service Activity Tracking System (FACTS), and Potential Operational Delineations (PODs). Interviewees valued the integration of these tools, describing the potential for sharing readily available information about existing fuel treatments.

   A few interviewees were more critical about adopting PODs and other tools that utilize computer models. For instance, some interviewees brought up challenges with the perception that these tools undermine expert knowledge, indicating a need to address the persistent tensions between local knowledge and data-driven models. Some also noted that different forests were at varying stages of developing PODs, and that non-local responders had differential awareness and familiarity about using them during incident response.

3) **Enhance integration with other resource specialty areas during treatment planning and design.** Interviewees noted that in many cases, resource specialists are less supportive or less aware of fuels and fire management, which leads to resistance to strategic planning and implementation of fuel treatments at the scale needed. Interviewees felt that there could be more integration with resource specialists during the design and planning stages of fuel treatments. We heard that direct involvement and exposure to fire management can help foster an understanding of the need to get 'good fire' on the ground and accomplish forest restoration and habitat objectives.

4) **Support and implement landscape-level boundary-spanning efforts.** Interviewees emphasized that addressing the wildfire problem means working beyond their land management boundaries, and that treatments can be more effective if implemented at a larger, cross-jurisdictional level. Some interviewees expressed an interest in tools that would allow them to share fuel treatment information and products more easily among external agencies, states, and other landowners.

5) **Dedicate resources to address equipment and staffing capacity limitations.** Solving capacity issues related to both fuel treatment scale and maintenance would require a dedicated investment and cultural changes within the agency, interviewees said. As a result, interviewees recommended strategically planning treatments that maximize the utility of limited funds, such as by conducting prescribed burns near values at risk and telling the story of fuel treatments to Congress and the public to help sustain funding and workforce needs. We note that recent appropriations for fuel treatments will substantially increase funding, but capacity to implement treatments, connectivity of treatments, and treatment maintenance (e.g., with prescribed fire) will require ongoing attention.

2. Case Studies

In this section we highlight the cross-case findings that we are compiling from interviews on specific fire events. Box 2 provides a fire management overview of the case studies. Figures 1 and 2 provide reference maps and images from each case study. Below the narrative, Table 5 summarizes the key findings across both fires.

Box 2: Case study profiles

We have conducted interviews on two fires to date:

(1) The Cameron Peak Fire

The Cameron Peak fire (CPF) burned over 200,000 acres of steep terrain under extreme temperature, drought, and high wind conditions. Most of the fire (83%) burned in the Arapaho and Roosevelt National Forest and Pawnee National Grassland (ARP) in Colorado. The CPF was managed under a full suppression strategy and had 10 IMTs over the 112 days.[4]The national forest has been working with partners along the Front Range of northern Colorado to increase the scale and scope of forest restoration. Their goal is to create a "ribbon" of interconnected prescribed fire treatments along the Colorado Front Range to stop fires that likely would come west to east with prevailing winds from the high mountains toward communities.

(2) The Bighorn Fire

The Bighorn fire (BHF) started in steep terrain and burned 119,978 acres in the Pusch Ridge Wilderness Area of the Catalina Mountains north of Tucson, Arizona. Ninety percent of the fire burned in the Coronado National Forest, but private and state lands were also affected. The BHF was characterized by its proximity to property, difficult terrain, and extreme weather conditions driving unique fire behavior. The BHF was managed under a full suppression strategy. The fire was initially managed by a Type 3 IMT and was transferred to two Type 1 IMTs and one Type 2 IMT over the course of the fire. The Santa Catalina Ecosystem Management Area, where much of the Bighorn Fire burned, experiences the most visitors in the Coronado National Forest and is the site of many important values at risk. The Coronado National Forest Plan set a goal of treating 25% of the 260,194-acre Santa Catalina Ecosystem Management Area in 10 years using planned and unplanned fire ignitions and mastication techniques (USDA, 2018).

In both case studies, interviewees told us most fuel treatments in proximity to the fire were designed with multiple-use objectives, with wildfire mitigation as the priority. Interviewees did not indicate that they have a specific tactical use for operations in mind when planning and implementing treatments; rather, treatments were implemented with the general goal of providing tactical advantage during wildfire suppression. Treatments in proximity to both the CPF and BHF achieved this goal, according to interviewees.

[4] Our study on the CPF focused on fuel treatment considerations during the first 60 days (August 13 - October 12) before the fire made a second large run under extreme weather conditions starting on October 14.

Figure 1: Perimeter map of the Cameron Peak Fire and photo of a prescribed fire treatment on the Arapaho-Roosevelt National Forest

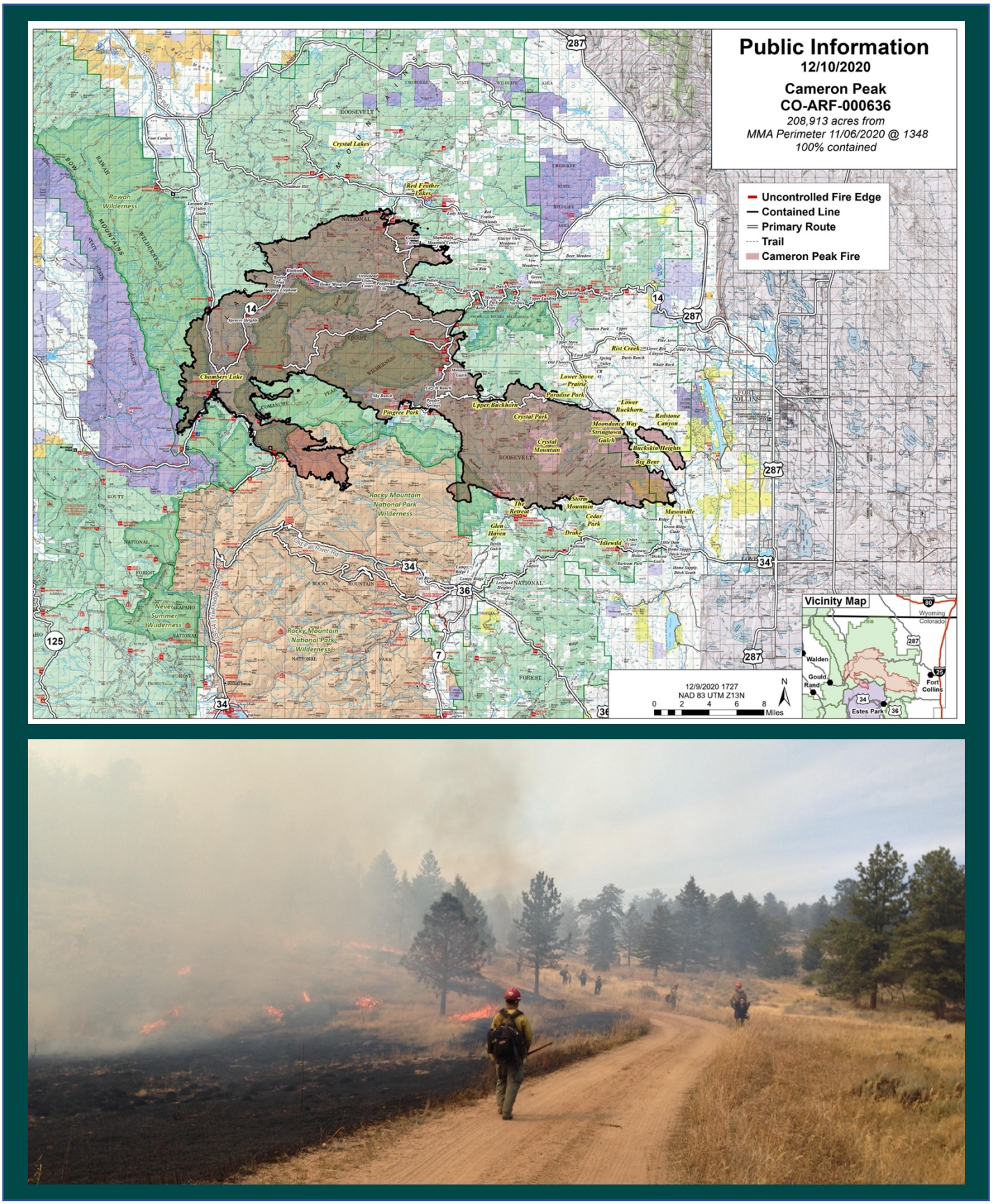
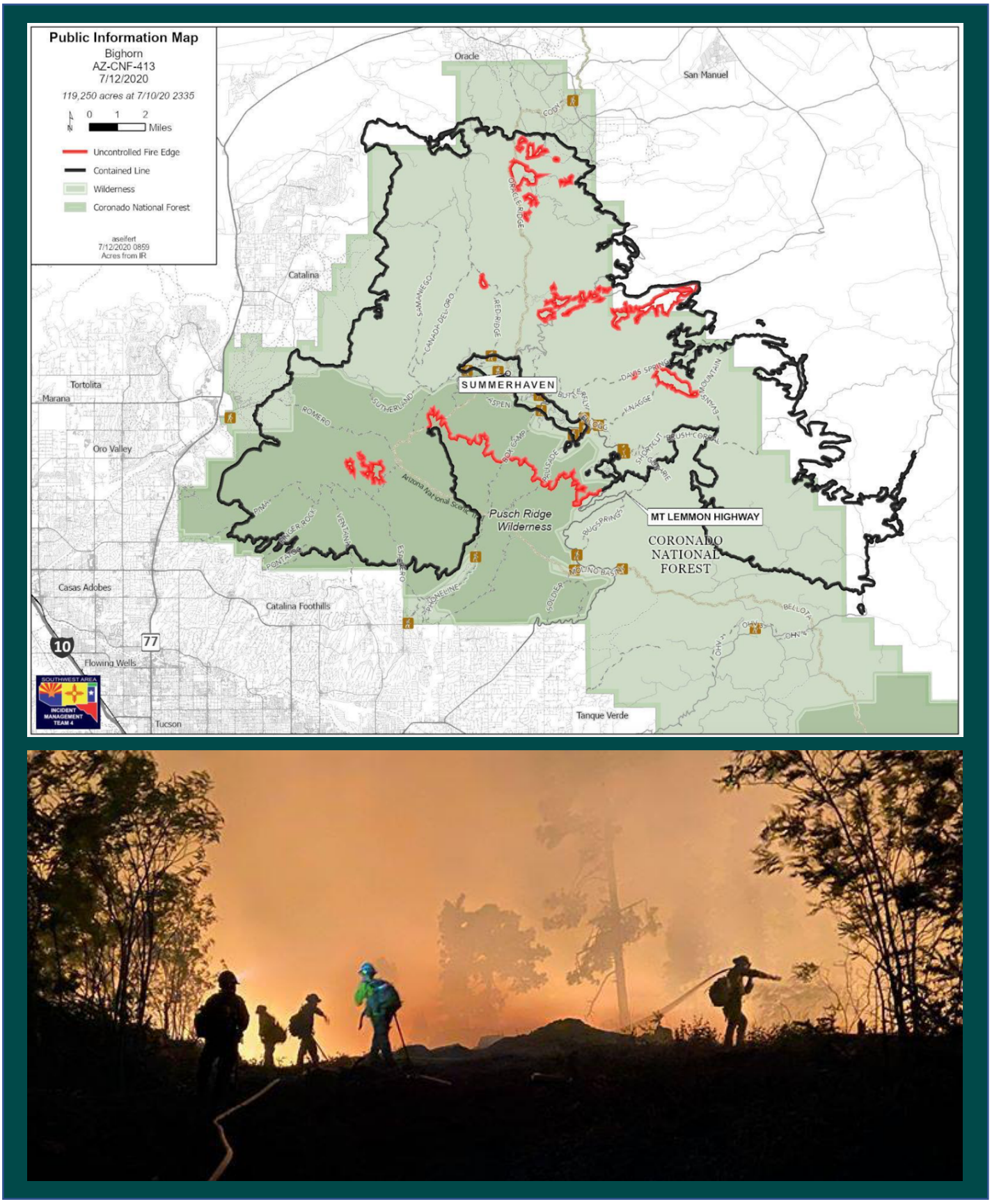


Figure 2: Perimeter map and photo of a nighttime burnout from the Bighorn Fire



Most interviewees from both case studies said IMTs' receptivity to fuels information varied based on team culture, individual personalities, and varying levels of experience and comfort fighting fires in the new ecosystems. Interviewees indicated that there is currently not a systematic process for sharing fuel treatment information among the agency or with external response units during an incident. On both the CPF and the BHF, local staff briefed the first IMT that arrived, then trusted that IMT to relay the information to subsequent incoming IMTs. Some desired a more standardized process for concisely communicating about existing fuel treatments to non-local teams. Some championed the ongoing integration of decision support tools, such as PODs, for efficiently sharing relevant information. Most interviewees on the BHF said incoming IMTs were receptive to new information and local units were open to sharing information. Information sharing was more challenging, however, on the CPF. Interviewees said communication with non-local teams was strained due to numerous IMT transitions and novel COVID-19 restrictions limiting face-to-face interactions; these interviewees felt there could have been more consistent information transfer and quicker agreement about fuel treatment utility among line officers and IMTs. Below, one interviewee outlines the challenges they faced in sharing information with some incoming IMTs on the CPF:

> *"Teams are like individuals, they have personalities. Some are more open to that sort of local integration, others not so much. Teams also have different confidence levels in different fuel types . . . As far as the teams, or individuals on the teams, taking advantage of or listening to some potential opportunities to use these units or treatments, that also was hit or miss . . . convincing the teams that this is going to be the most likely area to be successful, it was a hard sell at times" (13).*

Fuel treatments were commonly used on both fires for burnout operations, as access and anchor points, and provided greater responder security and resource efficiencies. Some interviewees on each fire expressed that the treatments that did not overlap with the fire had utility for use as safety zones and planning contingency lines. For instance, at the time of the BHF, several prescribed burns had been planned on the Coronado but not yet implemented; a few interviewees said that the burn plans for these treatments were used during the BHF to help identify control features and contingency line locations. About half the interviewees from the CPF indicated that burn scars from historical wildfires were viewed as treatments. Although people on the BHF did not utilize fire scars as much as those on the CPF, both sets of interviewees agreed that burn scars often are more effective than mechanical treatments in modifying fire behavior because of their larger size. On both fires, most interviewees believed that fuel treatments were instrumental in protecting values at risk and preventing further property and resource loss.

Interviewees discussed important characteristics and factors that they generally look for when fuel treatment is considered during incident management. This included placement near roads, maintenance status and time since prescribed burning, and other factors such as weather or resource availability (e.g.: staff, equipment):

- Most interviewees across both fires said that treatments near existing features, especially roads, were the easiest to access and work from.
- Interviewees from both case studies agreed that the age and maintenance level of treatments, including application of prescribed fire, were of particular importance when considering the integration of treatments into response. Interviewees from the BHF said that, while older, non-maintained treatments were somewhat useful, they required more time and resources to "freshen up" before use than more recent treatments. Interviewees from the CPF said that prescribed burns completed in the last five years were most effective in directly slowing the wildfire.
- Interviewees from both case studies emphasized that utilizing fuel treatment in wildfire response was dependent on external factors such as resource availability and weather conditions.
- Interviewees from both case studies said that reliable staffing and funding can facilitate planning, implementation, and maintenance of fuel treatments before a wildfire, and help optimize treatment use during wildfires.

A key difference between the two cases regarded the utility of fuel treatment scale during incident response. Although interviewees from both case studies recommended strategically placing and maintaining treatments in locations that will protect the WUI, local conditions such as geographic features and WUI areas contextualized each forests' treatment plans. The Arapaho-Roosevelt National Forest (ARP) is planning large, connected treatments adjacent to the WUI. Meanwhile, in the Coronado National Forest, interviewees indicated that smaller treatments prioritized within the WUI are more strategic for protecting values at risk. Some BHF interviewees were concerned that despite contextual features influencing the optimal size and location of treatments, funding for large treatments were generally favored within the USFS, even when smaller treatments would be more effective for meeting wildfire mitigation goals for certain landscapes. Two suggested reasons for bias toward large treatments were 1) The USFS sets acreage-based targets for forest management work and the easiest way to achieve these goals is through large treatments, and 2) Small WUI treatments are often more costly than large treatments beyond the WUI. One person on the BHF explained:

> *"You just have to paint the picture of the importance and why [our treatments are] small and expensive. The Forest Service has, annually, a target of acres that they're supposed to [treat] every year. . . . So, when we're held at an expectation that we're going to treat a certain number of acres, obviously, it's going to be easier to reach that target with a larger project. But the smaller projects that are weighed up against a multi-million-dollar value are just as important as that bigger project" (27).*

Some interviewees spoke about lack of utility or adverse effects from fuel treatments. One notable observation shared by a BHF interviewee was that fuel treatments were not very useful in the suppression of the BHF because treatments were outdated. They said that the treatments saved crews some time and resources compared to if treatments were not applied, which was consistent with what other interviewees told us. None of the BHF interviewees said that any treatments had adverse effects. A few CPF interviewees indicated that some treatments had unintended adverse effects, such as the wildfire reaching some timber harvests or incomplete pile burn treatments where large amounts of slash on the forest floor remained. In these cases, treatments accelerated fire behavior.

Both sets of interviewees called for increased outreach to promote inter-agency partnerships and community acceptance of fuel treatments, particularly at the WUI. CPF interviewees consistently told us that state and local partners were well-connected with the forest and fuels management staff on the ARP and were engaged with the forest leaderships' fuel management vision and prescribed burn plans. We learned that having these pre-existing relationships and knowledge facilitated communication among local teams and external partners about the practice and value of fuel treatments during the CPF.

Table 5 Fire-by-fire summary of how fuel treatments were used or considered

Research Questions	Cameron Peak Fire	Bighorn Fire
To what extent do treatments during suppression operations align with land managers' intended purpose for those treatments from a design and planning perspective?	Treatments generally aligned with land managers' intended objectives. Most were designed for multiple resource objectives: hazardous fuels reduction, wildlife habitat and forest health improvement, and recreational safety in beetle killed areas. One prescribed fire that was not intended for community wildfire protection provided ancillary benefits during the CPF by giving IMTs time to protect values at risk by mitigating wildfire behavior.	Treatments generally aligned with land managers' intended objectives. Most were designed for tactical advantage in suppressing wildfire. Some were intended to be used for a specific tactic (e.g., one thin and pile treatment was designed to be used for a backfire).
How do incident commanders, other fire management personnel, and forest personnel communicate about existing fuel treatments and their value during incident response?	The first IMT was briefed, and subsequent teams were expected to pass information on. Non-local IMTs were perceived by some local interviewees to be less receptive to using fuel treatments to support operations. Information transfer from team to team was inconsistent due to COVID-19-related restrictions on face-to-face interactions.	The first IMT was briefed, and subsequent teams were expected to pass information on. Both local and incoming teams were receptive to sharing and receiving information.
How do fire managers view treatments and incorporate them into operations, including situations when treatments are not expected to interact directly with fire?	All interviewees said that without existing fuel treatments, there would have been additional home and structure loss. Personnel used treatments to conduct burnout operations, as access points, anchor points to put in indirect lines, and safety zones where crews slept and where equipment was dropped off. Treatments that did not directly interact with CPF were considered as part of contingency plans early in the suppression efforts. Treatments gave personnel tactical flexibility that allowed for some improved security and time efficiencies. There were greater opportunities to protect values at risk. In some places, treatments directly stopped fire progression. Fire scars from previous wildfires were viewed and utilized as fuel treatments.	Almost all interviewees said that fuel treatments were instrumental in suppressing the BHF and protecting homes. Personnel used treatments for contingency lines, safety, and buffer zones. They were also used for burnout operations, escape routes, anchor, and access points. Planned treatments that were not yet implemented at the time of the BHF were useful for strategizing contingency plans. Treatments added security and time efficiencies, aided in fire suppression, and provided greater opportunities to protect values at risk. In some places treatments slowed fire behavior. Fire scars from previous wildfires were not utilized much during the BHF.

Research Questions	Cameron Peak Fire	Bighorn Fire
What characteristics do fire managers look for when considering using a fuel treatment to support their wildfire management strategy?	Age and maintenance of treatments were important. Prescribed burns that had been completed in the last 5 years saw little-to-no fire movement during the CPF. Treatments near roads and on less steep slopes were more useful to work from. Contextual factors, such as resource availability or weather conditions, can impact the utility of treatments; some treatments were not useful during the CPF due to their lack of connectivity, difficult terrain, or extreme weather conditions. There were a few adverse effects from fuel treatments; in one area, slash piles accelerated fire behavior, and in another, increased fuel loading from slash on the forest floor allowed the fire to persist even through major snow events.	Age and maintenance of treatments were important. Older treatments that had not been maintained took longer to prepare for use in firefighting operations. Most interviewees said that, in the Coronado's geographic context, smaller treatments located within the WUI were most useful for protecting high-value WUI areas. Contextual factors, such as resource availability or weather conditions, can impact the utility of treatments; during the BHF, extreme weather conditions and unusual nighttime weather patterns affected the utility of treatments. No interviewees said there were adverse effects from treatments.
What recommendations do interviewees have for improving fuel treatments to support incident management of a wildfire?	On the Arapaho-Roosevelt, prioritize larger fuel treatments adjacent to or within communities and infrastructure, and increase the extent and number of treatments. Regularly maintain treatments. Plan treatments near roads and on less-steep slopes. Plan treatments as a connected system across jurisdictions. Interagency partnerships are important for building cohesion and capacity for large treatments and facilitating cross-boundary treatments. Commit resources to public outreach and education about fuel treatments. Increased staff capacity can support planning, implementation, and maintenance of fuel treatments before wildfires occur, and optimize use of treatments during wildfire response operations.	On the Santa Catalina Ranger District, prioritize maintaining small, high-value treatments near the WUI, and tie treatments into existing treatments on private land when possible. Regularly maintain treatments. Plan treatments near roads. Any treatment that changes fuel continuity and arrangement provides value in giving firefighters opportunities for different strategies. Treatments that utilize prescribed fire, or past wildfire scars, are the most useful. Commit resources to public outreach and education about fuel treatments. Increased staff capacity can support planning, implementation, and maintenance of fuel treatments before wildfires occur, and optimize use of treatments during wildfire response operations.

Summary and Recommendations

Our findings to date revealed that consistent treatment maintenance, consistent practice, and culture of communication about treatments, local expert knowledge, and unit/team composition are important components of how fuel treatments are evaluated and integrated during incident response. A synthesis of the key findings and recommendations from our regional interviews and two case studies is presented below.

Interviewees revealed that fuel treatments can influence incident response and are often used as access and anchor points, to conduct burnout operations, and offer utility during initial fire assessment and contingency planning independent of whether the fire overlapped the treatment. Treatments were also used during operations as safety zones or staging areas. Some interviewees viewed historical fire scars as fuel treatments, saying fire scars can greatly influence suppression strategies because scars tend to be large and cross jurisdictional boundaries.

Interviewees agreed that fuel treatments allow for safer opportunities for engagement, and enhanced containment and time efficiencies during fire response operations. Most interviewees said that treatments can relieve stress around resource limitations during an incident, because responders can safely reduce the number of staff and/or equipment in a treated area and relocate them to areas in greater need.

To decide whether to utilize a fuel treatment during an incident, interviewees considered numerous treatment characteristics, plus contextual factors such as weather, fire behavior, location of the wildfire, resource availability, staff personalities, and unit culture. Fuel treatment characteristics interviewees considered included:

- **Age |** Treatment utility tends to decline with age; well-maintained treatments are more reliable during incidents.
- **Location |** Most interviewees prioritized treatments adjacent to or within communities and infrastructure, along ridges, and on less-steep slopes. Treatments near roads were the easiest and safest to work from.
- **Connectivity |** Connected and cross-jurisdictional treatments offer greater utility during incidents.
- **Size |** On the CPF, large, connected treatments offered the most utility for fire response operations, while smaller treatments within the WUI offered the most utility during the BHF.

Interviewees revealed that the way fuels information is shared and utilized during an incident depends on individuals' personalities, experience in the local fuel type, leadership encouragement, team culture, and composition. For example, interviewees on the BHF perceived that IMTs and senior staff on the fire were very receptive to incorporating treatment information. Meanwhile, CPF interviewees perceived that non-local IMTs were less receptive to utilizing fuel treatments early on; these interviewees saw utility in more formalized information sharing.

Recommendations our interviewees offered to support the integration of existing fuel treatments:

- Communication before fires start among USFS staff members and potential fire response personnel, including state, and local fire response partners, builds relationships, trust, and understanding of the local fuel management plans; this supports communication during incidents and integration of treatments into response.
- Direct and purposeful communication among fuels planners and IMTs (i.e., between IMTs and fuels planners, and from one IMT to the next) would allow for more consistent information transfer during incidents.
- The USFS as an organization and forest-level leadership should encourage the integration of decision support tools and resources designed to support coordinated communication during incidents and provide easily accessible fuel treatment information.
- The USFS should commit resources to address staffing and equipment limitations to support strategic fuels planning, implementation, and regular maintenance of treatments to create and maintain fuels treatments that can be useful during incident response.

Following this interim report, we will conduct additional case studies and continue our analysis with a sample of fires from the 2021 season. We will make minor adjustments to our interview guide and sampling strategy to include emergent themes from this work such as the roles involved in communicating about fuel treatments, and interviewee perspectives on whether and how to formalize communications about fuel treatments during incidents.

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