Fire Management today

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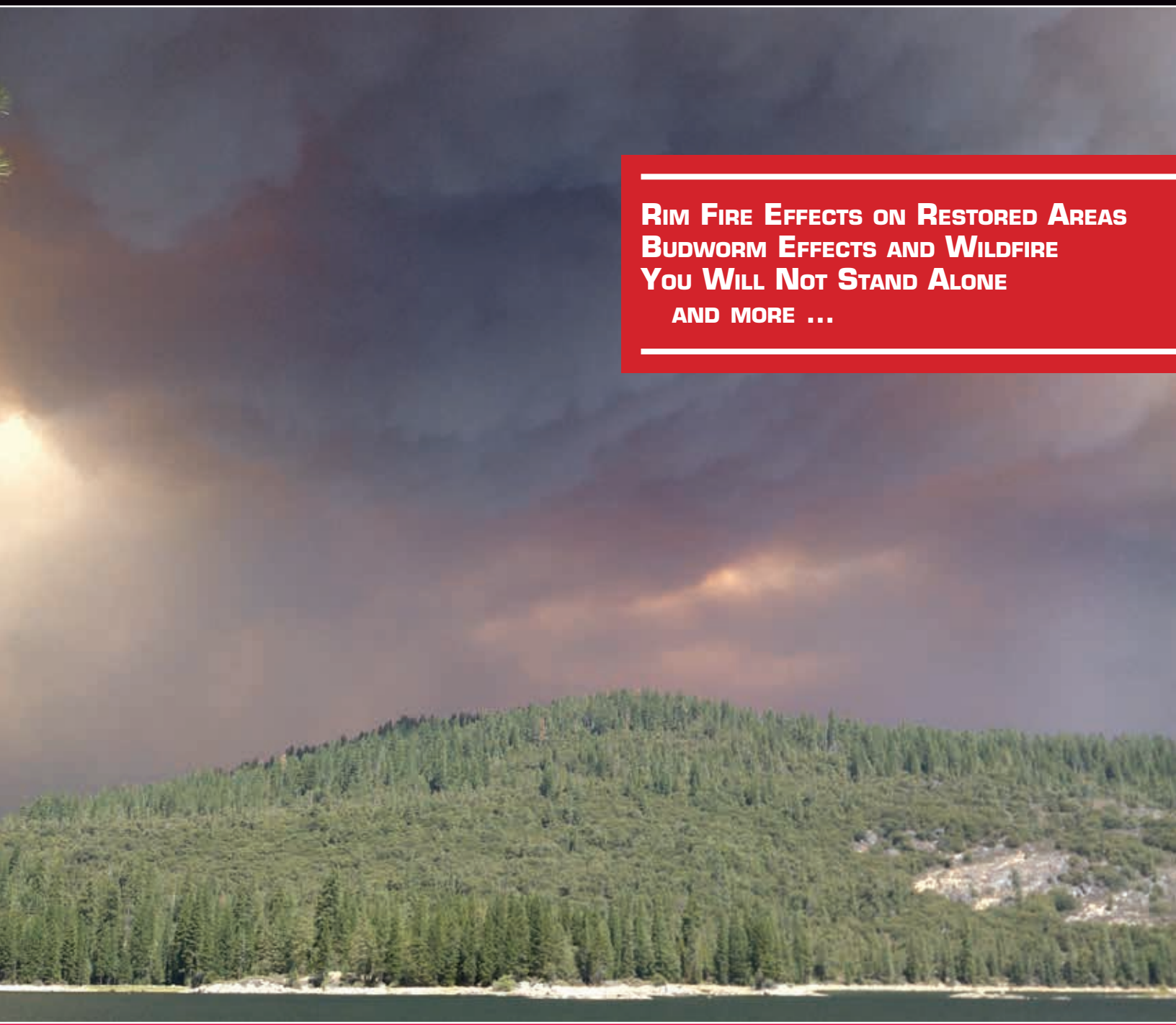

Rim Fire Effects on Restored Areas
Budworm Effects and Wildfire
You Will Not Stand Alone
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On the Cover:

Rim Fire in 2013, with the smoke plume in the background and Lake Eleanor in the foreground, taken from the south shore. The area across the lake burned later that day. Photo: Jamie Lydersen, Forest Service.

The USDA Forest Service's Fire and Aviation Management Staff has adopted a logo reflecting three central principles of wildland fire management:

- *Innovation:* We will respect and value thinking minds, voices, and thoughts of those that challenge the status quo while focusing on the greater good.
- *Execution:* We will do what we say we will do. Achieving program objectives, improving diversity, and accomplishing targets are essential to our credibility.
- *Discipline:* What we do, we will do well. Fiscal, managerial, and operational discipline are at the core of our ability to fulfill our mission.

Firefighter and public safety is our first priority.

Contents

Anchor Point

By Shawna A. Legarza, Psy.D.
Director, Fire and Aviation Management
USDA Forest Service

Thank You, Team!

In retrospect, I want to say thank you for your service during the 2017 fire season! Thanks for all your dedication and hard work throughout the year!

Shawna A. Legarza, Psy.D., Director, Fire and Aviation Management, Forest Service

We had a busy 2017 fire season; we made good decisions and worked well together with our cooperators. While every fire is unique and every fire season has its challenges, I am reminded each day working in this job of the value of our employees who work diligently day in and day out protecting our natural resources and serving the public. As we work through the 2018 fire season, I encourage all of you to continue to lead in your respective areas, learn about new challenges, and really take time out for yourself when you need it.

My leader's intent for 2018 is:

1. Engaged leadership—Continue to be an engaged leader in whatever area you work in. Continue to learn, rise to challenges, and be a leader.
2. The alignment of communication—Help provide the most accurate communication up the chain, down the chain, and across the chain. Ask questions if you are unsure, ask for feedback, and offer clarity and respect to all.
3. Self-leadership—Continue to take good care of yourself so you can lead others. Self-leadership is you leading yourself through both challenging times and successful times. Self-leadership is understanding yourself and knowing when you need to take time out, get clarity, and live in the present.

I am honored to be your national director of Fire and Aviation Management, and I look forward to our continued success in many challenging areas.

Please take good care! ■

Rim Fire Severity in Forests With Relatively Restored Frequent Fire Regimes*

Jamie M. Lydersen, Malcolm P. North, and Brandon M. Collins

Forests that evolved under the influence of frequent low-severity fire have undergone dramatic change following a century of fire suppression, including a buildup of surface fuels; greater density of small, shade-tolerant trees; and a loss of spatial heterogeneity (Lydersen and others 2013; Parsons and Debenedetti 1979; Scholl and Taylor 2010). Following these changes, a greater proportion of the fires in low- and mid-elevation forests are burning with high severity than they did historically, and high-severity fires are burning larger patch sizes in these forests than before (Mallek and others 2013). These uncharacteristically large and severe wildfires have significant impacts on sensitive wildlife habitat (North and others 2010), air quality (Fowler 2003), and greenhouse gas concentrations (Liu and others 2014; Muhle and others 2007). In addition, the costs of fire suppression and postfire rehabilitation associated with these fires continue to increase (NIFC 2013).

Jamie Lydersen is a biological science technician, Brandon Collins is a research forester, and Malcolm North is a research scientist for the Forest Service, Pacific Southwest Research Station, Davis, CA.

Contemporary forests with restored fire regimes should burn with a lower proportion of high-severity fire under most wildfire conditions.

Research in Relatively Restored Forests

Restoration of forests with altered structure due to a history of fire suppression is of high interest to managers and stakeholders of Sierra Nevada forests (North 2012). Since the late 1960s, following the recognition of fire as an important ecosystem process, Yosemite National Park has made use of prescribed and wildland fires burning under moderate weather conditions to meet management objectives (Stephens and Ruth 2005; van Wagtendonk 2007). This has resulted in a number of forest stands in the park with repeated burning at frequencies and intensities similar to the historical fire regime (Collins and Stephens 2007; Lydersen and North 2012). There is considerable interest in characterizing ecosystem structure and function within these stands because frequent-fire reference conditions under recent patterns of climate are rare (Stephens and Fule 2005).

Under a frequent low-severity fire regime, forests are characterized spatially by diverse sizes of tree clumps interspersed with forest gaps and widely spaced single trees (Larson and Churchill 2012; Show and Kotok 1924). This heterogeneity was likely the product of an intact fire regime that allowed fires to burn under a range of weather and fuel conditions (Skinner and Taylor 2006). In addition to creating and maintaining spatial heterogeneity, repeated fire in these forests maintains a lower fuel load and tree density (Webster and Halpern 2010). Collectively, these forest conditions have been associated with increased resilience in relation to environmental stressors (such as drought, insects, and disease) and wildfire (Stephens and others 2008). Contemporary forests with restored fire regimes should burn with a lower proportion of high-severity fire under most wildfire conditions, as compared to areas

* This article is a condensed and slightly edited version of a previously published article in *Forest Ecology and Management* (Lydersen and others 2014). For more detail on study methods and relevant literature and for the full presentation of results, you can access the article in its entirety at <http://www.treesearch.fs.fed.us/pubs/46372>.

with ongoing fire suppression that have not burned in over a century. However, even areas that have recently burned in multiple low- and moderate-severity fires have a persistent legacy of tree densification due to fire exclusion before the reintroduction of fire in these stands (Collins and Stephens 2007; Collins and others 2011). The question remains as to whether these relatively restored forests are resilient in relation to wildfire burning under extreme weather conditions.

The 2013 Rim Fire is the largest fire on record in the Sierra Nevada and the third largest in California. It burned 257,313 acres (104,131 ha), mostly forest stands, including reburned stands in Yosemite National Park with a diverse recent fire history. The Rim Fire occurred under extreme drought and fire weather conditions, with notably unstable weather occurring soon after ignition, leading to 2 days of extreme fire growth characterized by a large smoke plume. Plumes often form when atmospheric conditions are unstable, resulting in erratic fire behavior that is driven by the fire's own local effects on surface wind and temperatures. The effects of such fires often exceed the influence of more generalized climate factors measured at nearby weather stations (Werth and others 2011). In this study, we took advantage of a unique opportunity to use extensive on-the-ground measurements collected prior to the Rim Fire in forests that previously experienced at least two low- to moderate-severity fires to explain observed fire effects in stands with relatively restored fire regimes. The objective of our study was to identify factors that influenced Rim Fire burn severity in these forests. Note that this study does not compare fire effects between previously burned and unburned areas.

We assessed the influence of forest structure, fuel load, topography, fire history, and weather on satellite-derived fire severity, using field data from 53 plots collected 3–4 years prior to burning in the Rim Fire (fig. 1; table 1). Field data were collected in 2009 and 2010 as part of a study on topographic variation in forest structure in Sierra Nevada mixed-conifer forests with a frequent low-severity fire regime that was active or restored (Lydersen and North 2012). Fire severity for the Rim Fire was calculated using the relative differenced normalized burn ratio (RdNBR) (Miller and Thode 2007) based on imagery collected following fire containment in 2013. Random forests and regression trees were used to assess relationships between Rim Fire severity and a variety of covariates, including topographic, forest structure, fuels, weather, and fire history variables. The analysis was performed twice, with and without plots that burned under plume conditions.

Variables Influencing Fire Behavior

Out of 53 plots, 12 (23 percent) were classified as burning at a high severity in the Rim Fire.

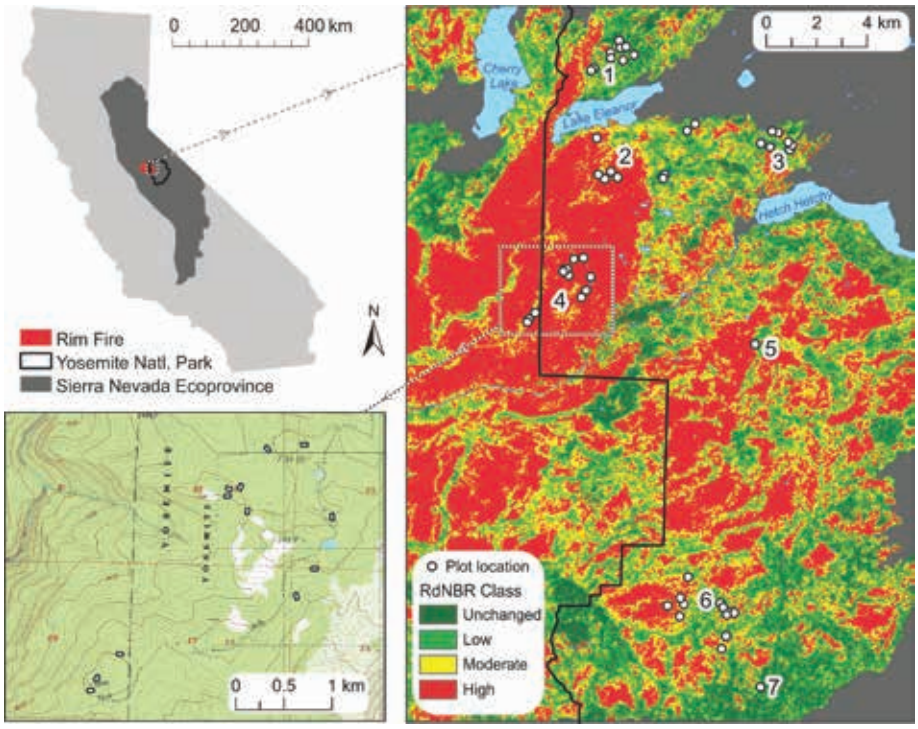

Figure 1—*Location of study areas from Lydersen and North (2012) that burned in the Rim Fire in California's Sierra Nevada Mountains. Inset on right shows the area where the Rim Fire crossed the boundary into Yosemite National Park, corresponding to the area within the black-and-white dashed box on the map of California. Numbers represent study areas 1–7, shown in table 1. Fire severity shown is for the Rim Fire. Inset on the bottom left shows the plot locations at the North Mountain study area in relation to site topography, corresponding to the area within the black-and-white dashed box on the severity map inset. Dimensions of the plots after addition of a 32.8-foot (10-m) buffer are shown. RdNBR = relative differenced normalized burn ratio.*

Table 1—Study areas (from Lydersen and North (2012)), by number of plots, previous fire history, elevation, size, and RdNBR (numbers correspond to figure 1). Note that some study areas had multiple fire histories.

Study area (#)	# of plots	Recent fires[a] (yr)	Elevation (ft [m])	Size (ac [ha])	RdNBR Avg. ± St. Dev.[b]
N. Eleanor (1)	9	1986, 1999	5,590–6,550 (1,700–1,200)	1,500 (610)	68 ±70
S. Eleanor (2)	9	1978, 1996	4,880–5,840 (1,490–1,780)	2,500 (1,000)	500 ±397
Laurel Lake (3)	9	1978, 1991, 2005	5,940–6,350 (1,810–1,940)	900 (360)	124 ±108
North Mountain (4)	4	1950, 1987, 1996	4,990–5,080 (1,520–1,550)	4,900 (1,980)	718 ±148
North Mountain (4)	3	1987, 1996	5,020–5,220 (1,530–1,590)	--	851 ±163
North Mountain (4)	2	1993, 1996	5,120–5,200 (1,560–1,580)	--	1,232 ±25
North Mountain (4)	3	1994, 1996	5,260–5,320 (1,600–1,620)	--	520 ±85
Cottonwood Crk (5)	1	1996, 2009	5,860 (1,790)	100 (40)	202
Aspen Valley (6)	10	1983, 1998	5,080–5,920 (1,550–1,800)	3,000 (1,200)	454 ±173
Aspen Valley (6)	1	1983, 1990, 1998	5,360 (1,630)	--	483
Aspen Valley (6)	1	1983, 1990, 1999	5,540 (1,690)	--	1,017
Gin Flat (7)	1	1989, 2000, 2002	6,550 (2,000)	250 (100)	262

[a] Includes fires from 1949 to 2011.
[b] RdNBR = relative differenced normalized burn ratio; St. Dev. = standard deviation.

Plots that had previously burned within 14 years of the Rim Fire burned mainly at low severity, whereas those that had not seen fire in over 14 years burned predominately at moderate to high severity.

Seventeen plots (32 percent) burned at moderate severity, and the remaining 24 plots were classified as unchanged or having burned at a low severity. Elevation, followed by plume effects, had the most influence on observed fire severities in our plots (fig. 2). Burning index, time since the last fire, and shrub cover were also highly associated with differences in fire severity. When plume-dominated fire plots were removed from the random forests analysis, many of the same variables remained highly ranked (fig. 2), indicating that their effect was not entirely due to correlation with plume-dominated burning. The variables identified as important in both analyses were shrub cover, burning index, elevation, years since last fire, proportion of shade-intolerant species, duff depth, and white fir basal area.

Plots that burned on plume-dominated fire days had higher severity overall. Among plots

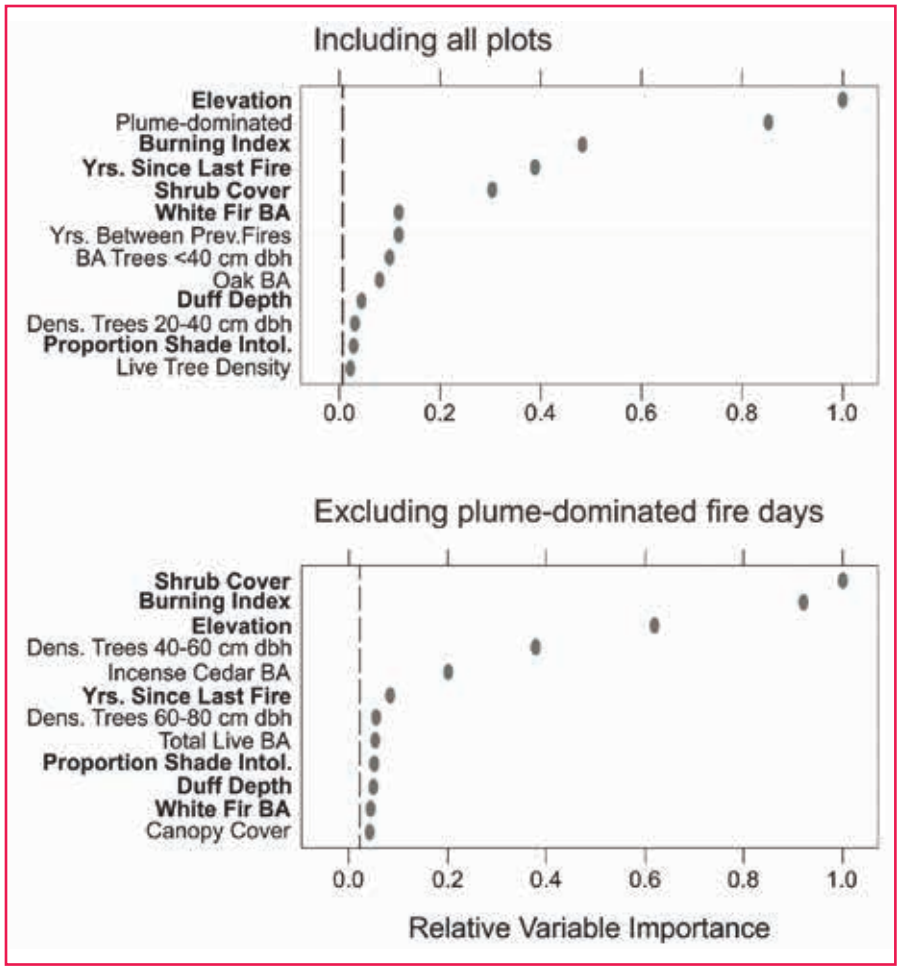

Figure 2—*Variable importance ranking of the influential variables on observed fire severity, as determined by random forests analysis. Variables with importance values higher than the absolute value of the lowest negative importance value (dashed vertical line) are considered influential. The upper chart shows results when all plots were included in the analysis; the lower chart shows results after excluding plots burned on a day when the Rim Fire was plume dominated. Variables in bold text appear in both charts. BA = basal area; dbh = diameter at breast height.*

that burned after the plume subsided, greater shrub abundance was associated with greater fire severity. Elevation was negatively correlated with Rim Fire severity, with lower severity observed in plots above 5,558 feet (1,694 m) in elevation. Plots that had previously burned within 14 years of the Rim Fire burned mainly at low severity, whereas those that had not seen fire in over 14 years burned predominately at moderate to high severity (fig. 3).

Fire Resistance in Relatively Restored Forests

Our study suggests that even fire-restored forests may not be resistant to high-intensity wildfire that escapes suppression during extreme weather conditions. All of our plots previously burned at low to moderate severity in the recent (1949–2011) fire record (table 1); high-severity burning during the Rim Fire left new high-severity burn patches in this landscape. Fire severity in reburns can depend strongly on the severity of previous fires (Parks and others 2013). Although areas that burned with high severity in previous fires are more likely to reburn with high severity, researchers have found a less consistent pattern for areas previously burned at low or moderate severity (Holden and others 2010; Parks and others 2013; Thompson and Spies 2010; van Wagtendonk and others 2012). Our study supports their finding. Char height from previous low- to moderate-severity fire was not associated with Rim Fire severity in our plots. Instead, we found that time since last fire, shrub cover, elevation, and the burning index were associated with Rim Fire severity (fig. 2), indicating that the interaction between fire history, understory, and fire weather influenced fire effects.

Most of the plots classified as high severity (10 out of 12) burned on a day when the fire was plume dominated and exhibited unprecedented fire growth for this region. The high burning index value of 85 recorded on this day reflects the greater potential for more intense fire behavior, but the contribution of high fuel loads outside our study site to fire energy presumably also contributed to the transition to plume-dominated fire. Local factors related to the plume's influence on surface wind dynamics, including increased speed and turbulence (Rothermel 1991; Werth and others 2011), likely affected fire intensity in our plots and may not be reflected in the burning index value derived from a weather station 12 miles (19 km) away. Interestingly, many plots burned at high severity despite multiple previous burns, suggesting the influence of the

plume on fire behavior and, ultimately, fire severity. This suggests in turn that extreme fire behavior can overwhelm well-designed fuel treatments, as demonstrated in other extreme fire events (Finney and others 2003). Perhaps the extreme burning conditions created when untreated areas burn under weather conditions favorable to plume formation can create enough inertia to maintain high fire intensity in previously burned areas despite the ameliorated fuel conditions.

Time since fire and the burning index were also highly related to Rim Fire severity (fig. 2), in line with results from other studies on reburns (Collins and others 2009; Parks and others 2013; van Wagtendonk and others 2012). In our study, plots that had a previous fire within 14 years of the Rim Fire burned predominately at low severity (fig. 3), regardless of weather conditions. The reason might be that a longer time since the previous fire allows for the accumulation of surface (dead woody and live shrub/herbaceous) and ladder fuels, which then contribute to greater flame lengths and, ultimately, higher severity fire effects. For plots where the previous fire was more than 14 years earlier, burning under extreme fire weather conditions (with a burning index greater than 75 and on the day of plume-dominated burning) produced mainly high-severity fire effects, whereas moderate-severity burning occurred under milder conditions. This suggests that even in areas without recent fire activity, fires allowed to burn under conditions that are not extreme can benefit the ecosystem, assuming that moderate-severity fire effects are a desired objective (Collins and others 2011).

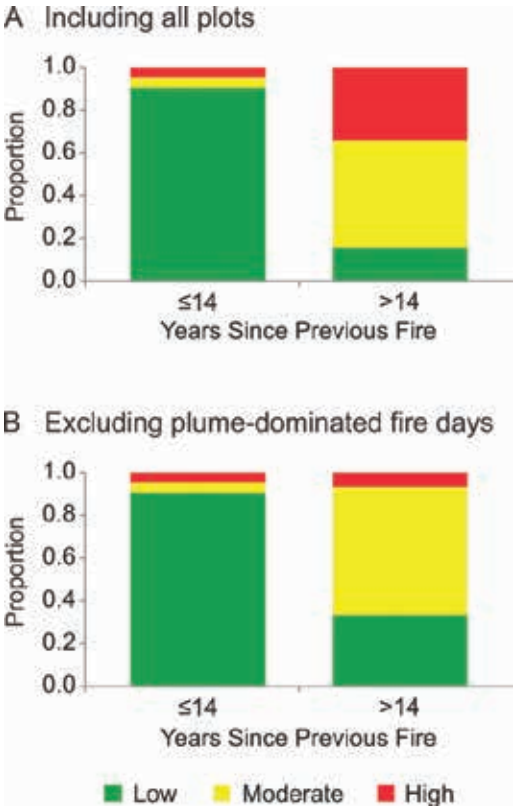

Figure 3—*Fire severity classes observed in plots reburned by the Rim Fire, by time since the previous fire. A comparison of A (showing all plots) to B (excluding plots burned on a day when the Rim Fire was plume dominated) suggests that plots without a fire in the previous 14 years are more susceptible to high fire severity during a plume-dominated fire.*

The inverse relationship of elevation and fire severity observed in our study was the opposite of what has been reported for other western forests (Parks and others 2013), but this may be due to the different vegetation, which also varied with elevation. Some of the lower elevation plots in our study corresponded to a drier vegetation type with greater shrub cover and sparser forest cover. The greater shrub cover coupled with sparser canopy may lead to an overestimation of fire severity, because consumption of the shrub layer might be high yet overstory mortality low, particularly in plots categorized as having moderate fire severity (Miller and others 2009). Without field data or some measure of overstory mortality and shrub regeneration, it is hard to determine to what extent high RdNBR values reflect ecological change, such as shifts in species composition or vegetation type (Holden and others 2010).

Implications for Management

Our results suggest that even in forests with a restored fire regime, wildfires can produce large-scale, high-severity fire effects under the type of weather and fuel conditions that often prevail when wildfire escapes initial suppression efforts. During the period when the Rim Fire had heightened plume activity,

Results suggest that forests with restored frequent-fire regimes are resistant to wildfire under fire weather conditions that are less than extreme.

10 of the 17 plots burned were classified with high fire severity and 7 were classified with moderate severity. No low fire severity was observed, regardless of fuel load, forest type, or topographic position. High fire severity appears to have been exacerbated by the longer time period since the previous fire (greater than 14 years) in these plots.

Areas that burn at high severity often grow back as montane chaparral rather than forest. They are likely to reburn with high severity in future fires, preventing or delaying the return of tree cover (Parks and others 2013; Thompson and Spies 2010; van Wagtendonk and others 2012). Management actions can help conifer regeneration (Collins and Roller 2013); however, the vegetation trajectory of the high-severity burn patches found in the lower elevation sites in this study is uncertain, given projections of increasing wildfire activity, particularly since lower elevations may have higher burn probability (Parks and others 2011). Long-term monitoring of these patches could provide useful insight.

Plots located at higher elevations (5,590–6,550 feet (1,700–2,000 m)) and those that had burned more recently burned predominately at low severity, despite drought conditions at the time of the Rim Fire. Results suggest that forests with restored frequent-fire regimes are resistant to wildfire under fire weather conditions that are less than extreme. To effectively influence fire behavior, agencies should coordinate fuel reduction and wildfire policies across large landscapes if neighboring jurisdictions are within the same potential "fireshed." ■

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Success Stories Wanted!

We'd like to know how your work has been going! Let us share your success stories from your State fire program or your individual fire department. Let us know how your State Fire Assistance, Volunteer Fire Assistance, Federal Excess Personal Property, or Firefighter Property program has benefited your community. Make your piece as short as 100 words or longer than 2,000 words, whatever it takes to tell your story!

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Western Spruce Budworm and Wildfire: Is There a Connection?

Daniel G. Gavin, Aquila Flower, Greg M. Cohn, Russell A. Parsons, and Emily K. Heyerdahl

In the interior Pacific Northwest, extensive defoliation of mixed-conifer forests during outbreaks of western spruce budworm (WSB) may leave the visual impression of a tinderbox with trees primed to burst into flame. But is this the case?

We addressed this question with funding from the USDA/U.S. Department of the Interior Joint Fire Science Program (project 09–1–06–5). Here we summarize our three recent publications exploring the potential relationship between WSB outbreaks and fire. We used a multimethod approach to explore potential disturbance interactions that might cause one disturbance to change the occurrence or severity of the other. We used tree-ring records to see whether WSB and fire are related in time and computer modeling to see how defoliation could affect crown fire behavior.

Study Design

WSB is the most damaging defoliator in western North America. Caterpillars emerge in the early spring and feed on the new foliage of many short-needled conifer species, especially Douglas-fir, grand fir, and white fir. Outbreaks of WSB may last for a decade or more and extend over hundreds of miles. A study of a large outbreak in the 1980s showed that, in most areas, fewer than 25 percent of the canopy trees were killed, but mortality rates may be high for smaller trees (Powell 1994). Widespread synchronous outbreaks have been tied to climate, but previous studies have reported conflicting results regarding the specific climate conditions driving this phenomenon (Flower and others 2014a).

> Western spruce budworm is the most damaging defoliator in western North America.

Detecting synergisms between disturbances is difficult because both WSB outbreaks and wildland fires occur sporadically over large areas and are strongly modified by forest composition and climate. Efforts by Meigs and others (2015) to map and quantify the spatial overlap of the two kinds of disturbances (fig. 1A) are complicated by the fact that fire is naturally more common in low-elevation ponderosa pine forests, whereas WSB outbreaks occur at higher elevations in mixed-conifer forests. Other studies have found that even when WSB and fire don't occur in a stand at the same time, they can still affect each other (fig 1B). Analyses of late 20th-century outbreaks in British Columbia (Lynch and Moorcroft 2008) and in Oregon and Washington (Preisler and others 2010) found decreased fire risk for 3 to 7 years following a WSB outbreak. However, modern records of disturbance are limited because fire suppression and logging have

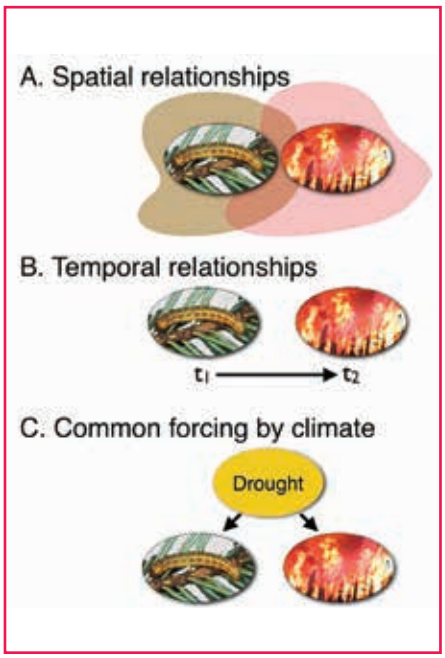

Figure 1—*Western spruce budworm outbreaks and wildfire are disturbances operating across landscapes and through time. You can test their association by examining their spatial overlap (A) or temporal leads and lags (B), but apparent synergisms between the disturbances may be the result of a common climatic forcing (C).*

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decreased fire frequency and have led to an increase in the density of conifer species preferred by WSB, thereby intensifying WSB damage (Wickman 1992). Climate can also confuse the relationship between the two disturbance types because it can be difficult to differentiate interactions between fire and WSB from the reactions of each to a common climate driver (fig 1C).

These issues motivated us to isolate the different factors affecting the dynamics of WSB outbreaks. Accordingly, we:

1. Created a multicentury tree-ring record of WSB outbreaks and assessed the climate conditions that caused outbreaks to initiate;
2. Created a multicentury fire history record and compared it to both our WSB record and to climate records; and
3. Used a physics-based fire behavior model to address the effect of defoliation on torching and crowning potential if the two disturbances were to overlap in space and time.

Tree-Ring Records

The tree-ring record gives a detailed annual history of disturbances and their connection to climate over the past few hundred years. Many studies have revealed the strong connection between climate and forest fires by comparing the dates of fire scars preserved in tree rings with independent tree-ring reconstructions of temperature or precipitation (Falk and others 2011). Other studies have reconstructed the occurrence of WSB defoliation by identifying periods of reduced growth in the rings of trees that survived defoliation (Swetnam and others 1995). However, prior to our study, no one has analyzed the temporal relationship (for example, leads or lags) between both fire and WSB records at the same sites. We reconstructed 3 centuries of WSB outbreaks from tree rings at 13 sites along a 249-mile (400-km) transect from eastern Oregon to western Montana, reconstructed fire histories at 10 of those sites, and compared both records with previously published tree-ring reconstructions of moisture availability.

> We concluded that budworm outbreaks had no discernible effect on the probability of fire occurrence and vice versa.

Our tree-ring records revealed several new findings. We detected an average of 12 outbreaks per site, with a trend toward longer and more severe outbreaks in the era of fire exclusion after 1890. Between 1739 and 2000, 17 outbreaks synchronously affected more than half the sites. Both local and regionally synchronous outbreaks tended to occur at the end of multiyear drought periods (Flower and others 2014a). We detected an average of seven fires per site, with fires becoming almost entirely absent after around 1890. We found no association between fire and multiyear trends under previous climate conditions; rather, fires were simply more likely to occur during single dry years (Flower and others 2014b). Thus, while drought affected both WSB outbreaks and fire, it affected them differently.

We used a suite of statistical tests to analyze the synchrony between fire dates and the initiation dates, duration, and intensity of WSB outbreaks (Flower and others 2014b). These tests all revealed that wildland fires had no bearing on the timing of WSB outbreaks (fig. 2). We concluded that WSB outbreaks had no discernible effect on the probability of fire occurrence by changing fuels and that wildland fires had no discernible effect on the likelihood of a WSB outbreak by altering host tree density. Thus, although both types of disturbance may increase in a future of rising drought and climate variability, we found no precedent for their occurrence growing in a synergistic way.

Fire Behavior Modeling

Although WSB outbreaks may not increase the probability of fire occurrence, they can affect how fires burn. To understand how WSB and fire might interact, we examined the effect of WSB on the potential for trees to torch and crown during wildfires. The indirect effects of WSB are likely important, such as the accumulation of coarse wood in the understory over long periods of time, but they are difficult to model due to high spatial variability. So we focused instead on the most direct effect of WSB: reduction of foliage density in the canopy.

The effects of defoliation on fire behavior occur at fine temporal and spatial scales, and traditional operational fire models do not have the parameters to capture the effects at such fine scales. We therefore used a computational fluid dynamics model, the wildland–urban interface fire dynamic simulator (WFDS), to address

complex interactions between fire and fuel (Mell and others 2009). The experimental design was straightforward: For a range of defoliation levels of a moderate-sized Douglas-fir tree, what was the effect of WSB defoliation on canopy consumption, given a range of surface fire intensities?

We consistently found that defoliation reduced the vertical and horizontal propagation of fire (Cohn and others 2014). Trees defoliated by less than 30 percent torched after some crown fuels ignited at a threshold level of surface fire intensity, whereas trees defoliated by 50 to 80 percent did not have sufficient canopy fuel to sustain a crown fire. We modeled a wide range of surface fire intensities, including the high intensities predictable from maximum increases in accumulated surface fuels; even at these high intensities, defoliation had the same impact on torching and crowning. Potential variation in branchwood moisture did not have a significant effect on torching in our simulations.

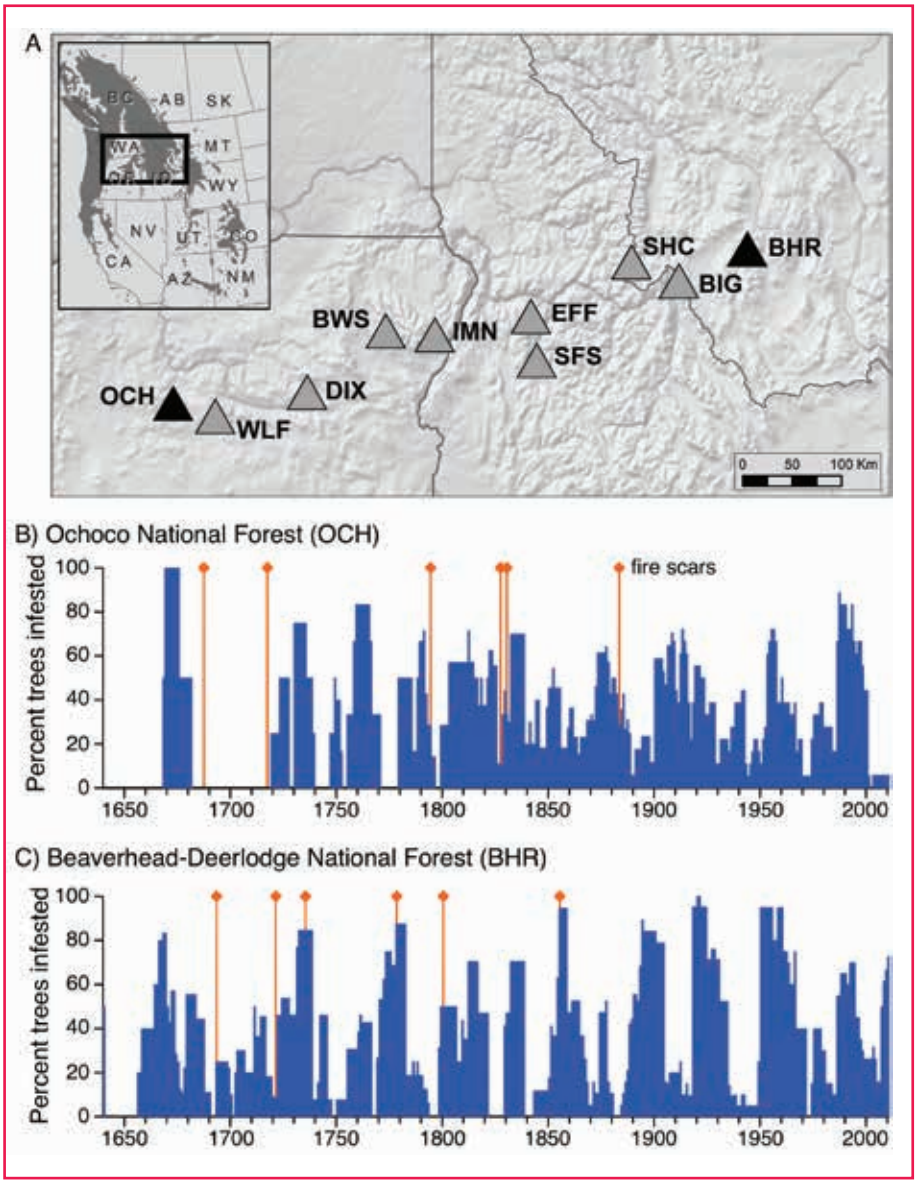

Figure 2—*The map shows the locations of 10 sites with western spruce budworm (WSB) outbreaks (A), including the Ochoco National Forest (OCH) and Beaverhead–Deerlodge National Forest (BHR); the inset map of the Western United States (A, upper left) shows the range of WSB host tree species. The graphs (B and C) show tree-ring reconstructions of WSB outbreaks in relation to wildland fires for two of the sites (OCH and BHR); the percentage of trees with distinct growth reductions due to WSB outbreaks (the blue bars) is superimposed on fire dates detected at the same sites (the red lines). We found no temporal relationship between WSB outbreaks and fire.*

The WFDS model is state-of-the-art in terms of exploring the partial effect of defoliation on crown fire, and it agrees with coarse-scale models used previously. Another study found that defoliated stands had increased surface fuel loads and increased canopy base heights (Hummel and Agee 2003). Using the Fire and Fuels Extension to the Forest Vegetation Simulator, that study predicted small changes to surface fire intensity and critical flame length, with no significant change in torching or crowning potential.

Extrapolating Results: Reduced Tree Mortality

Taken together, the tree-ring and modeling studies suggest a lack of synergism between WSB outbreaks and wildland fires. However, a different kind of synergism may exist: Defoliation might dampen the severity of a subsequent wildfire. To explore this possibility, we used existing empirical equations that show the probability of mortality due to defoliation (fig. 3A) and the probability of mortality due to crown scorch (fig. 3B), combined with the simulated results of canopy consumption at different levels of defoliation (fig. 3C), to extrapolate the summed probability of mortality under a

range of surface fire intensities and defoliation levels (fig. 3D). The results suggested a distinct "fireproofing" effect of defoliation: The increased risk of mortality by WSB is more than compensated for by reduced foliage consumption during moderate surface fire intensities. For example, trees with 50-percent defoliation have a distinctly lower probability of mortality when surface fires are less than about 74 kilowatts per square foot (800 kW/m^2).

However, we considered only the partial effect of defoliation on fire occurrence; we did not take into account other effects of WSB outbreaks, such as mortality of small trees. Of course, field observations are required to test our prediction. Remotely sensed burn severity maps, in combination with prior surveys of insect effects, could address this issue. One such study of the 2003 B&B Complex Fire in Oregon showed that prior defoliation had a marginal effect on reducing fire severity that was not statistically significant (Crickmore 2011). However, an analysis by Meigs and others (2016) of all post-WSB fires in Washington and Oregon from 1987 to 2011 showed that there is

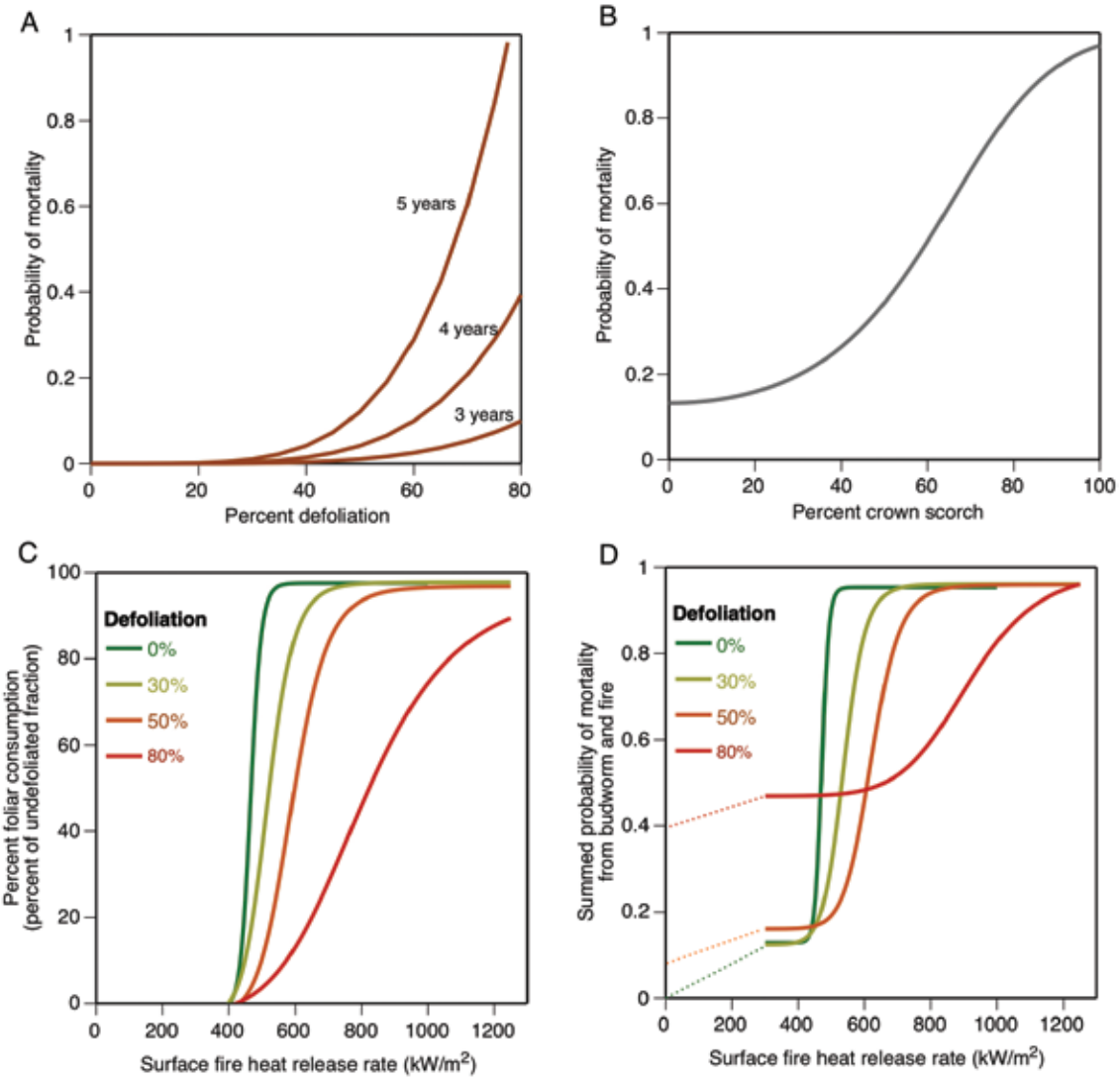

Figure 3—*(A): The probability of mortality as a function of defoliation by western spruce budworm (WSB) sustained over 3 to 5 years (Alfaro and others 1982). (B): The probability of mortality as a function of crown scorch using the equation from Ryan and Amman (1994) for a tree with a diameter of 19 inches (49 cm), a height of 39 feet (12 m), a canopy base height of 6.6 feet (2 m), and a bark thickness of 0.9 inch (2.4 cm). (C): The percentage of live foliage consumed in model runs of the wildland–urban interface fire dynamic simulator for the tree described for (B). The curves are logistic regression lines fit to data in Cohn and others (2014). (D): The summed probability of mortality from WSB and fire, assuming 4 years of defoliation (A) and the crown scorch estimated from (C) entered into the Ryan and Amman (1994) equation (B). Increasing surface fire intensity results in rapid torching (and mortality) of undefoliated trees (green line), but defoliation reduces crown scorch and thus mortality probabilities.*

The results suggested a distinct "fireproofing" effect of budworm defoliation, with reduced foliage consumption during moderate surface fire intensities.

a statistically significant reduction in fire severity that persists for up to 20 years following an outbreak. Thus, the effect of defoliation on crown fire behavior modeled by Cohn and others (2014) appears to be confirmed by the analysis of burn severity data by Meigs and others (2016).

Fireproofing Effect?

It may seem reasonable to assume that extensive defoliation, causing sustained low levels of tree mortality in mature trees, should have a measurable effect on wildfire occurrence. However, fire is a highly variable disturbance in itself, and it is highly sensitive to specific climate and winds during the fire event. The scale of fuel changes wrought by WSB may be too small to affect subsequent fire probability in ecosystems where fire is limited by fuel moisture and ignition sources rather than fuel availability. Our data show that these two disturbance types do not share similar histories, despite a common link to drought events.

Nevertheless, we hypothesize a "fireproofing" effect on host trees from defoliation due to WSB outbreaks. Although such an effect has been detected statistically from recent fire events (Preisler and others 2010; Meigs and others 2016), the inferred processes at play remain to be studied in detail at the site scale. ■

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Coping With Tragedy: You Will Not Stand Alone

Kristel Johnson

In October 2006, five employees from the San Bernardino National Forest in southern California died while battling the Esperanza Fire. Extreme fire behavior pushed the flames towards the crew, engulfing them within minutes. This loss was particularly significant for the San Jacinto Ranger District because many of the employees, including the crew from Engine 57, had been friends since childhood.

Esperanza Fire Memorial Program, November 5, 2006. Source: Forest Service.

How does a unit survive such a profound loss and move ahead as a learning organization? Forest employees saw value in compiling their hard lessons learned for future responders, ultimately developing both an interagency guide and a weeklong course that describes the resources, policies, and leadership skills needed to get through incidents involving serious injuries or fatalities. The course was developed in memory of the Engine 57 crew—Mark Loutzenhiser, Jess McLean, Jason McKay, Daniel Hoover-Najera, and Pablo Cerda—and of all of our colleagues who have been lost in the line of duty. "You Will Not Stand Alone" (YWNSA) can be considered a phoenix rising from the ashes because the content emerged from the hearts of people who experienced real loss.

> The course is designed to prepare "our best" for "the worst," ensuring that no one will ever stand alone in the wake of tragedies.

"You Will Not Stand Alone" Overview

As an organization, we in the Forest Service are seeing an increase in employee deaths, suicides, posttraumatic stress disorder, cumulative stress, and burnout. Prior to YWNSA, if you worked on fatality incidents, you had no clear guidelines for navigating through death notifications or investigations. You had no instructions for moving through grief, for informing survivors of the support resources available to them, or for identifying symptoms of compassion fatigue in colleagues. For years, we have done our best to wade through fatality incidents, but we have long needed a comprehensive, interagency approach that includes cooperating agencies, community resources, and support organizations like the Wildland Firefighter Foundation.

Vicki Minor, founder and executive director of the Wildland Firefighter Foundation, had this to say about YWNSA:

> The Wildland Firefighter Foundation has been working with fallen and injured wildland firefighters for 18 years. I was humbled to be asked to be part

Honoring firefighter Gregory Edwin Pacheco, October 5, 1999. Pacheco was killed on a wildfire on the Cleveland National Forest in California. His casket was flown home to New Mexico on a Forest Service aircraft. Photo: Forest Service.

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> of the "You Will Not Stand Alone" cadre. This class is highly educational, and one thing I know for sure—our wounded healers are more powerful than people who learn out of a book. What has amazed me most out of this program is the healing that is happening because of the cadre and the people who have been magnetized to this program. The healing is far reaching, from the Forest Service into the interagency fire community. Because [of] what I know has been happening, I strongly endorse this program and encourage this class [to] be experienced by many more. As hard as we try to prevent death and injury, Mother Nature is unforgiving at times. Preparedness is always better than staggering reaction when situations take us places we never wanted to be.

YWNSA is the first nationwide attempt to create a comprehensive guide to help responders maneuver through incidents involving fatalities or serious injuries. YWNSA stresses the importance of pre-incident planning and training and offers suggestions on how to support employees and family members when an incident occurs. It is designed to prepare "our best" for "the worst," ensuring that no one will ever stand alone in the wake of tragedies.

Tom Harbour, former Director of Fire and Aviation Management in the Forest Service's Washington Office, had this to say about the course:

> As it has been said, "True doctrine, properly understood, changes behavior." "You Will Not Stand Alone" has been developed by those who recognized that, in times of stress and tragedy, we need tools derived from a sound doctrinal basis to help us cope and then thrive. The strength of the course lies not in the strong content but in the storytelling and linkage that springs from a connection between those attending and those presenting. Each of the participants—cadre and class—comes with a purpose and leaves strengthened. I have been fortunate to see the origin and growth of the class. The power of the course has moved its impact into every part of the country. We in wildland fire are a distinct sisterhood and brotherhood. We care for one another. A loss for one is a loss for many. This course, and the people who are associated with it as cadre and class, show us that we stand together.

The course was developed in memory of all of our colleagues who have been lost in the line of duty.

Following is a brief overview of the topics covered in YWNSA.

Topic Areas

Agency Administrator's Guide to Critical Incident Management. Line officers are responsible for managing critical incidents within their jurisdictions, which starts with looking out for their employees. A leader's response—or lack of response—can have long-term adverse impacts on employees, their families, the community, and the agency at large. A proactive approach that establishes intent and a unified effort to intervene on an employee's behalf demonstrates care and respect.

In 2008, the National Wildfire Coordinating Group published the Agency Administrator's Guide to Critical Incident Management. YWNSA compiles information from this guide and other resources to direct those handling line-of-duty deaths, off-duty deaths, serious accidents, and serious injuries. The roles and responsibilities of the agency administrator and support personnel are defined, including for the family liaison, hospital liaison, funeral liaison, public information officer, benefits coordinator, and chaplain. The course establishes guidelines for the notification process and offers information related to investigations, the coordinated response protocol, and support resources such as critical incident stress management (CISM).

Modified Incident Management Organization. Fires and incidents that we typically respond to are defined geographically, and our actions are based on known protocols, tactics, and operational procedures. Responding to a line-of-duty death is more abstract in that human relationships and the grief process become the focus of our actions. The Incident Command System can be adapted to meet the complex demands that arise from a variety of incidents. A modified "short" incident management team (IMT) is commonly used during fatality incidents.

YWNSA offers an overview of the Incident Command System, outlines the responsibilities of IMT members, and offers suggestions on how to restructure the traditional IMT for fatality incidents. Agency leaders are encouraged to give training opportunities to those who are interested in joining modified IMTs before a critical incident occurs.

Agency Guidance for Initial Support, Memorials, and Funerals. The Forest Service aims to give immediate assistance to the families and coworkers of those who die or are seriously injured in the line of duty. It is crucial for managers to engage in the response; lack of support from managers—or even a perceived lack of support—can adversely affect employee productivity, workplace morale, and even personal lives.

San Bernardino National Forest employees at the Esperanza Memorial Service on November 5, 2006. Photo: Forest Service.

In 2014, the Forest Service published the Death and Serious Injury Handbook, which contains standard operating procedures for responding to fatalities and serious injuries of employees, contractors, and retirees both in and outside the line of duty. The objective of the guide is to create and maintain an environment of management excellence where employees are empowered to assume authority and take responsibility commensurate with their capabilities. The policy is based on the following principles:

1. Encourage and reward responsible risk taking, creativity, and innovation. Challenge employees to develop new ideas and test improved ways of doing business on a continuous basis.
2. Try out new ideas and approaches. If they don't work, treat them as learning experiences rather than as performance failures.
3. Place emphasis on guiding, educating, advising, and encouraging employees rather than regulating and controlling their behavior.
4. Treat individual talents as important organizational assets.
5. Give employees opportunities to exercise independent judgment.
6. Engage employees in frequent and routine safety discussions that increase awareness of safety-related matters and encourage dialogue about unsafe conditions.

The YWNSA instructor cadre exemplifies these principles. The course was developed by field employees who recognized the gaps in our agency response to fatality incidents and the importance of learning how to respond before an incident occurs. The course gives an overview of agency policies on donations; award ceremonies; monuments; family travel and per diem; employee attendance at funerals or memorial services; inventory and return of personal items; autopsy expenditures; and transportation of the body and escorts, as well as other miscellaneous costs. The course includes excerpts from the Forest Service Manual and Handbook and the Death and Serious Injury Handbook, including guidance on attendance and leave, uniform policy, and travel.

Honor Guard members at the memorial service for Gabe Pomona, Big Bear Hotshot Captain, March 4, 2011. Photo: Seth McKinney, Forest Service.

Hospital and Family Liaisons. Unexpected deaths invoke a unique set of emotional challenges that must be processed and dealt with. Survivors often experience a sense of unreality, helplessness, and unfinished business. Feelings of guilt and self-recrimination may abound. There may also be an intensified need to blame someone. Survivors want to understand what happened and try to bring some meaning to their loss. During this time of profound stress, family members will likely be overwhelmed with all kinds of information and decisions that require immediate resolution.

The family and hospital liaisons are volunteers who form a bridge to support services for the grieving family. They themselves also support the family and assure Forest Service officials that the family's needs are being met. Without a doubt, these are some of the most demanding and important roles in the incident support organization.

It is important that those who serve in the liaison position are sensitive to the needs of the bereaved family and respectful of their family structure, dynamics, and belief system. Liaisons bring solace, calm, and compassion to an emotionally charged environment. The liaison is not a decision maker but rather a facilitator. The family itself should make all decisions regarding funeral and memorial arrangements, and its wishes should take precedence over the Forest Service's wishes.

Jason McKay Memorial Service, November 3, 2006. Steve Seltzner, Forest Service founder of the Honor Guard (retired), with Crystal McKay and Jody McKay, sisters of Jason McKay, killed in the line of duty on the Esperanza Fire. Photo: Forest Service.

Anniversary site visit with the Esperanza families (Engine 57), October 26, 2013. Left to right: Kristel Johnson, Forest Service; Ceil McLean, mother of Fire Engine Operator Jess McLean, killed in the line of duty; Chris Fogle, Forest Service. Photo: Maria Loutzenhiser, by permission of Kristel Johnson, Forest Service.

> Each of us has a role to play in building a more resistant and resilient workforce and creating a better path towards recovery.

An important part of pre-incident planning is to identify and train people in key positions, such as the family and hospital liaisons, before their assistance is needed. Education related to CISM, grief, peer support, and internal policies is helpful. A basic knowledge of processes related to human resources benefits through the Office of Worker's Compensation Program and other resources, such as the Wildland Firefighter Foundation and Public Safety Officer's Death Benefit, is also helpful.

Another important role for the family liaison is to assess the long-term needs of the family, such as for counseling services, financial support, legal services, and other kinds of assistance. The liaison puts the family in touch with the appropriate support services.

Liaisons should establish healthy boundaries and balance their liaison duty with their own personal, family, and professional needs. Liaisons can pay an emotional price if self-care is not taken seriously. Fatigue, strained family relations, job difficulties, and depression are common side effects.

We must take care of those who we have asked to serve in this capacity. Agency administrators should decide how long it is appropriate for support personnel to serve. There should be a distinct end date to the assignment, a transition period with the family, and a long-term strategy for the forest or district to interact with the family. This plan must be clearly communicated to everyone involved. It is not uncommon for family and hospital liaisons to form lifelong relationships with the families they support, but they still need a formal end date to their assignment.

Working With the Media. Fatality incidents are complex and highly visible. They attract significant political and media interest and must be handled with great respect. No matter how remote a critical incident is, media representatives will likely show up. The role of the public information officer is to provide accurate, timely, and respectful information that is in line with the family's wishes. The role of the agency administrator is to plan before the incident to ensure the highest level of support for the public information officer and successful media relations.

Suggestions include designating a crisis communication team; creating contact lists, including a list of qualified public information officers; developing a communication plan template; naming an agency spokesperson; identifying Joint Information Center locations; and becoming familiar with agency policies related to social media as well as planning ahead for social media interest.

Tom Knappenberger, former media liaison for the Pacific Northwest Region. Photo: Forest Service.

Notification. Few tasks can be as difficult as telling a family that their loved one was killed in the line of duty or that he/she sustained life-threatening injuries. No words can capture the enormity of this responsibility, which is assigned to the notification officer, whose actions and words will reflect on the Forest Service for years to come.

The presence of a notification officer demonstrates genuine concern for employees and their families. Proper notification can establish rapport with the next of kin and open a doorway for the agency to give additional support through the family liaison. Improper notification can cause an irreparable rift.

Notification officers should expect the unexpected, because they don't know how a family will respond. Some people collapse; others might swing a punch. It is important for an agency representative to be present during a death notification. In some States, the sheriff's office must make the initial notification, but it is important to have a Forest Service representative with the sheriff when the family is approached, if possible. Such tasks require a great deal of coordination.

Agency and Survivor Support. People who give emotional support in the wake of critical incidents face many challenges. Death and tragedy are difficult topics to discuss. Support personnel should expect the experience to be quite uncomfortable; these matters require an ability to work with other people at a deep emotional level.

First responders are routinely exposed to traumatic events in the course of their duties. Therefore, they are at increased risk of long-term problems from traumatic stress. YWNSA defines traumatic events, normal responses, the situations that increase the risk of developing a stress disorder, and when it is time to seek professional help. The degree to which an organization is able to survive such trauma and heal effectively depends on practical coping strategies and resources.

Anniversary site visit with the Esperanza families (Engine 57), October 26, 2014. Photo: Forest Service.

The Forest Service can improve the ability of employees at all levels by monitoring the ongoing stress that responders experience and supporting positive coping strategies. Support personnel can intervene and prevent the long-term effects of stress through resources such as CISM, a peer-led approach to crisis intervention developed specifically for first responders.

CISM was developed 25 years ago by Jeffrey T. Mitchell, a clinical associate professor at the University of Maryland's Emergency Health Services Department, and George S. Everly, Jr., a professor at Harvard Medical School and Johns Hopkins University. Both had extensive experience working with first responders.

A basic principle of CISM is that first responders already know how to cope with stress. They live with it every day as individuals and as part of a group, but the impacts of critical incidents are so powerful that they overwhelm the coping skills of well-trained, experienced people. CISM peer supporters are often accompanied by a mental health professional. Responders are encouraged to talk about the incident and related signs and symptoms of stress. It is validating for responders to know that sleeplessness, an inability to focus, and reliving parts of the incident are common reactions to traumatic incidents.

The peer support program has shown that talking with a colleague who understands the traumas of the job can alleviate the body's response to stress and allow the responder to recover more quickly. First responders are a culture in and of themselves; within that culture, they are very protective of each other. The healing process works best if they talk with people they trust.

YWNSA addresses stress reactions, different types of stress, CISM, peer support, and a variety of basic stress management and

crisis intervention techniques. It also gives information on suicide awareness, prevention, and intervention; and it lists numerous support resources.

Resilient Leadership, Compassion Fatigue, and Burnout. Resilient leaders have the ability to motivate and inspire others during times of crisis. They tend to remain adaptable and calm under pressure and also help others adapt to or rebound from adversity. They establish group cohesion and create conditions that motivate people to follow. Resilient leaders base their actions on a thoughtful, realistic assessment of the situation; then they act with decisiveness. Such leaders demonstrate vision, optimism, perseverance, emotional intelligence, and personal responsibility. They foster the health of the organization by building a more resilient culture.

We can reduce the vulnerability of responders and increase their resilience through preparedness, training, and creating a more resistant workforce. Information is power, and it protects responders by preparing them for the experience.

Specific situations can increase one's vulnerability to traumatic stress, such as having no control over the volume of calls, having to respond to numerous calls, and being involved long term in emergency management. Stress is cumulative, and continued events can lead to compassion fatigue and burnout, prevalent among emergency responders.

Compassion fatigue, also known as secondary traumatic stress, entails anxiety from helping or wanting to help others during crisis situations. People can be traumatized by their exposure to distressing stories without ever actually being physically threatened or harmed themselves. Compassion fatigue can express itself through anger without cause, blaming others, chronic lateness, depression, mental or physical exhaustion, frequent headaches, gastrointestinal problems, feelings of hopelessness, hypertension, increased irritability, low self-esteem, sleep disturbances, and workaholic tendencies.

The family and hospital liaisons are volunteers who form a bridge to support services for the grieving family.

Burnout, another variation of stress, can be thought of as physical and psychological exhaustion. It slowly erodes a person's sense of well-being, self-confidence, and psychological health, but it can be hard to recognize because of its slow onset. Burnout results from situations that make a person feel chronically overwhelmed, frustrated, or angry.

YWNSA offers ideas for coping and stress prevention related to compassion fatigue and burnout.

Benefits for Survivors. Benefits are very complex. It is essential that Forest Service personnel understand the benefits program to help family members navigate through the onslaught of paperwork that follows a line-of-duty death or a disabling injury. Families affected by critical incidents can be faced with immediate economic hardship in addition to profound loss and emotional stress. They may need help understanding the benefits that are available to them to receive immediate financial support.

The benefits counselor is responsible for outlining the benefits process to the family liaison and surviving family members. He or she works closely with the family liaison to explain potential benefits, supply the required forms, assist with completing them, discuss claim timelines, and describe the effects of deposits and redeposits for civilian and/or military service.

In addition to the benefits package, numerous support mechanisms are available to the family. For example, the Wildland Firefighter Foundation may play a key role—depending on the circumstances—by offering financial support to the family before the benefits arrive. The Employee Assistance Program is available to families for immediate and long-term support. Death benefits from the Public Safety Officers' Benefits Program are available to survivors of fallen law enforcement officers, firefighters, and other emergency service personnel.

Investigations. A number of investigations are required by the Forest Service as well as by Federal regulations. In recent years, the Forest Service has moved from a blaming culture to a learning culture. One example is the facilitated learning analysis, which is a peer review process that allows employees to learn from unintended outcomes and promotes risk mitigation. Information gathered from these reviews is used by the

agency or agencies only for accident prevention.

In 2014, the coordinated response protocol was designed to control access to incident personnel, eliminate redundancy within the investigation process, and make the investigation process as painless as possible. The protocol, which replaced the serious accident investigation team, takes effect when an accident warrants a Chief's-level review, usually when a death or the hospitalization of three or more employees has occurred. The learning review is not used as the basis for disciplinary action or to place blame on employees.

YWNSA also covers important information related to Federal agency and employee liability, including Kalkines and Garrity warnings, the Federal Tort Claims Act, OSHA violations, civil and criminal investigations, and administrative investigations.

Honor Guard. Employees from the San Bernardino National Forest formed the Honor Guard in 1999 to pay respect to their colleagues who were killed in the line of duty. The Honor Guard now comprises Forest Service employees from around the Nation who bring a wealth of diversity, experience, and compassion to their duties. Their display of honor and respect promotes emotional healing for the family as well as employees. Multiple agencies have Honor Guard programs that work cooperatively to support each other.

The Forest Service Honor Guard Handbook outlines the appropriate use of the Honor Guard; how to request the Honor Guard; the approval process; and detailed

National Fallen Firefighters Memorial at Emmitsburg, MD, in October 2013. Photo: Forest Service.

Honor Guard standards, with emphasis on honoring family requests. As a select part of a high-performance team, members display an attitude of dedication, dignity, and pride in the Forest Service.

Continued Support. The turmoil created by a critical incident can affect the family and employees for a long time. Trigger points such as holidays, birthdays, jury trials, photographs, investigations, and the anniversary date of the accident may cause emotions to resurface for years. Families can become dependent on the agency, but careful planning and decisive actions can help facilitate the healing process for everyone involved.

It is not uncommon for deep emotional bonds to form between the family and support providers. The family looks to liaisons and others for emotional support and guidance and to keep the memory of their loved one alive. Employee well-being must be taken into consideration because continued involvement requires personal sacrifice. The agency administrator is responsible for setting an appropriate timeframe for support personnel to stay involved in an official capacity. The timeframe needs to be clearly communicated to the family.

Building a Resilient Workforce

At the Forest Service, our goal is to manage critical incidents through an interagency approach, with agencies and people from different backgrounds solving problems together through an open exchange of skills, ideas, and resources. Our doctrinal approach promotes sound and commonsense decision making.

Steve Goldschmidt, Forest Service Honor Guard member (retired). Photo: Forest Service.

Traumatic events such as fatalities and serious injuries are never tidy and never convenient. By nature, these incidents do not follow any rules or pattern. In human terms, they are the cruelest of incidents to deal with. The best that we can do is prepare "our best" for "the worst" by giving solid guidance and a clear process to follow and by engaging good people who know what to do and when to do it. By planning for potential tragedies and providing the proper support afterwards, we can better serve people, support families, represent the agency, and do good things even in the worst of circumstances.

Each of us has a role to play in building a more resistant and resilient workforce and creating a better path towards recovery. We all have the opportunity to effect change, provide support resources, and move forward as a professional, continuous-improvement organization.

YWNSA addresses all facets of a loss; it contains strong emotional content and tends to evoke strong emotional reactions. Keynote speakers include people personally affected by fatality incidents.

The course was delivered for the first time in April 2013 in Sacramento, CA. Since then, it has steadily grown. In 2014, it was delivered in Regions 5 and 6, with the intent of developing an instructor cadre in Region 6. In 2015, the course was delivered in Regions 5, 6, and 3 while developing an instructor cadre in Region 3. In 2016, the course was delivered in Regions 3, 5, 6, and 2 while developing an instructor cadre in Region 2.

YWNSA has been evaluated by the National Advanced Fire Research Institute (NAFRI), and a national steering committee is in development, chartered under NAFRI. Course delivery dates are listed on the National Fire Training website at <https://nationalfiretraining.nwcg.gov/>, with requests to deliver the course in Regions 1, 4, 9, and 10 in 2017.

This course has the ability to change Forest Service culture in a very positive way. It can help bring employees truly to believe that the agency has their back and will not leave them standing alone during times of adversity. It can mobilize agency employees to be part of the change in our organization by engaging them in fostering employee health and well-being.

For more information, please contact Kristel Johnson, YWNSA Cadre Lead/Author, San Bernardino National Forest, tel. 909-553-2776, email kmjohnson@fs.fed.us. ■

Unplanned Wildfire in Areas With Slash Piles

Alexander M. Evans and Clinton S. Wright

Each year, fuel treatments reduce the likelihood of uncharacteristically severe wildland fire in overstocked stands across millions of acres in the United States. Typically, these treatments target small-diameter trees for removal, producing large amounts of unmerchantable material and increasing surface fuels. Currently, few commercial markets for this woody material exist, so it is commonly piled and burned onsite. Occasionally, unplanned wildfires burn piles before managers are able to burn them under controlled conditions. Little has been written or documented about piles burned during wildfires, making it difficult to assess the threat posed by unburned piles.

In an effort to better understand the prevalence, causes, and impacts of unplanned burning of piles, we reviewed the available literature and interviewed managers from across the country. A review of the literature suggests that treated units with unburned slash piles and untreated units with ladder fuels will experience similar fire behavior and effects. What follows is a first step that will hopefully call attention to the issue and help frame incisive questions for future research.

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Why Are There Unburned Piles?

Piles are built and left to dry because green wood burns poorly. For example, the Forest Service's Lake Tahoe Basin Management Unit in California states that it takes about 18 months for piles to dry sufficiently for effective consumption when burned.

> Piling and burning is common in the WUI, where the proximity of homes makes broadcast burning more challenging.

Weather also delays burning; material cut in the spring or summer is often left until conditions are safe for burning. In many areas, managers burn piles when there is snow on the ground to prevent unwanted fire spread. Lack of snow can delay pile burning. The Coalition for the Upper South Platte in Colorado was unable to burn thousands of piles during the winter of 2012–2013 because snow depth did not meet its pile burn guidelines (Steiner 2014). In many forests, there is a backlog of unburned piles because of limitations imposed by air quality restrictions, unfavorable weather conditions, available resources, and even funding (Bailey 2014; USDA Forest Service 2014).

Piling and burning is common in the wildland–urban interface (WUI), where the proximity of homes makes broadcast burning more challenging. However, piles in the WUI can be a target for arson. In 2006, for example, at a California campground, arsonist-ignited piles required a handcrew, engine, and helicopter to contain the fire at 1.4 acres (0.6 ha) (Jacobs 2014).

Do Piles Affect Fire Behavior?

One of the key questions is whether or how fire behavior changes in the presence of unburned piles. From the perspective of a wildfire, unburned piles are simply redistributed fuels. Boles and branches from the canopy aggregated into piles contain the same amount of fuel in a different arrangement. An assessment of the 2007 Angora Fire in California stated that the convective and radiant heat output in untreated stands and stands with piles would be similar because the same amount of fuel would burn (Murphy and others 2007).

However, piling fuels can change fuel moistures by converting live fuels to dead fuels, which can affect flame length, fireline

intensity, burning duration, and other aspects of fire behavior. Moving biomass from standing trees to piles decreases canopy bulk density, ladder fuels, and canopy continuity, which can reduce fire intensity and severity.

Yet reducing stem and canopy density opens the stand to higher wind speeds and increased fire behavior. For example, the 2010 Fourmile Canyon Fire in Colorado burned more intensely through stands with piles than through adjacent untreated stands in the Gold Hill area because of increased wind speeds in the thinned stands (Graham and others 2012). An experimental burn at Nenana Ridge in Alaska that mimicked wildfire conditions showed that a stand with windrowed fuels had a lower maximum temperature but longer heating time than a stand with a lop-and-scatter treatment (Butler and others 2012).

In some cases, even though the piles had not been burned before wildfires occurred, fire behavior was less active than in an untreated stand. In 2004, for example, the Cal Hollow Fire threatened the community of Central, UT. A fuel break had been put in place in the pinyon–juniper forest above the community, but the fire occurred before the piles generated during fuel break installation could be burned under controlled conditions (USDA Forest Service 2013). The fire was in the tree crowns when it approached the fuel break, but it dropped to the surface in the treated area, although it did burn intensely in the piles. Retardant drops and other suppression activities successfully contained the fire before it could enter the community (McAvoy 2004).

Slash burned under controlled conditions in March 2013 as part of a Joint Fire Science research project on the ecological effects of pile burning at the Santa Clara Pueblo, NM. Photo: Alexander Evans, Forest Guild.

Similarly, during the 2005 Camp 32 Fire in Montana, the untreated stand supported an active crown fire, but when the fire entered the stand with unburned piles it switched to a passive crown fire (Hvizdak 2014; USDA Forest Service 2006).

Wildfire in stands with unburned piles may have more spotting, as was observed when large landing piles ignited during the 2008 American River Complex Fire in California, causing torching of nearby trees and spotting (Safford 2008). During the 2013 Rail Fire on the Modoc National Forest in California, the rate of spread of the fire front decreased when the wildfire encountered a treatment where material had recently been piled. However, the uncured (or green) piles contributed to

spotting, which ultimately made containment difficult (Heald 2014). In contrast, during the Angora Fire, spotting distance in stands with unburned handpiles was shorter than in untreated stands (Murphy and others 2007).

In addition to generating embers, piles can also be receptive to embers from other sources. For example, the 2013 Andrews Creek Fire in Oregon ignited piles in a recently thinned Douglas-fir stand. The fire then spotted from pile to pile but did not spread far outside the footprint of the piles (Skrip 2014).

One of the key questions is whether or how fire behavior changes in the presence of unburned piles.

The Tin Cup Fire in August 2007 on the Bitterroot National Forest in Montana as it moves through a stand that had been thinned and piled and was slated to be burned in fall 2007. Photo: Tobin Kelley, Forest Service.

How Do Burning Piles Affect Wildfire Control?

In terms of wildfire control, ease of access to the affected area may influence operational success. In cases where there is good access (that is, proximity to roads and trails) for staging suppression activities, wildfires in stands with piles may be easier to control than in comparable untreated stands, particularly if the piling activities reduced the horizontal continuity of the surface fuel layer. However, where access is difficult, wildfires in piles may be more difficult to control than fires in untreated or lop-and-scatter treatments because of the intense heat generated by burning piles.

When the Angora Fire burned an area with piles, the fire resisted control because access was difficult; however, an area with piles that burned during the American River Complex Fire was accessible by a public road, giving suppression personnel better access for firefighting apparatus and therefore making the fire easier to control (Safford 2008). Similarly, safe, successful fire suppression in an area with piles on the 1999 Alder Fire in Grand Teton National Park, WY, was made possible by escape routes (via paved road) and ready access to plentiful water supplies (McFarland 2014). The fast-moving 2008 Jack Fire burned through an area with piles of western juniper in Lava Beds National Monument in northern California. When ignited by the wildfire, the piles burned very intensely, but the fire was contained with minimum-impact strategies such as use of existing roads and water rather than ground-disturbing methods (Augustine 2014; Farris 2014). When the 2007 Tin Cup Fire in Montana entered treated areas, it moved from a crown to a surface fire, even though not all of the piles had been burned before the fire front arrived at the piled area (Bitter Root RC&D 2014).

Do Piles Alter Wildfire Effects?

Unburned piles add to the wide array of factors that govern the effects of wildfires on the residual stand. An area with handpiles that burned during the Angora Fire had slightly lower severity because of wider crown spacing when compared to similar completely untreated stands (Murphy and others 2007).

The 2011 Wallow Fire in Arizona affected both stands with a lop-and-scatter treatment and stands with piles that had yet to be

burned. Although both types of treatments resulted in canopy mortality, mortality in the piled treatment was concentrated around the pile locations (particularly for landing piles), whereas the lop-and-scatter treatment was associated with complete mortality (Bostwick and others 2011; Palmer and others 2011). In some areas that burned in the Wallow Fire near Nutrioso, AZ, the delayed mortality of the overstory trees near piles appeared to be driven by the long fire residence time associated with the burning piles (Bigelow 2014).

A review of the literature suggests that treated units with unburned slash piles and untreated units with ladder fuels will experience similar fire behavior and effects.

In a number of cases when wildfire encountered unburned piles, the effects were worse than in similar untreated stands. On the 2007 East Zone Complex Fire in Idaho, tree mortality was higher in an area burned with piles than in comparable untreated areas (Hudak and others 2011). When the 2011 Cougar Fire in California reached accumulations of trees cut by feller-bunchers and left to cure, the result was higher fire severity (Farris 2014; Safford and others 2012). Wimberly and others (2009) studied unfinished fuel treatments that burned in the 2005 Camp 32 Fire and the 2006 Warm Fire in Arizona. Although their analysis did not focus specifically on the impact of unplanned fire in piled fuels, they found that thinning without treatment of the resulting slash increased burn severity. An analysis of the 2007 Tin Cup Fire found that crown burn effects were similar between partially treated units with slash piles and untreated units with ladder fuels (Harrington and others 2010).

Where topography drives an increase in fire intensity, fuel treatments are often overwhelmed. For example, during the 2012 Little Bear Fire in New Mexico, burnout operations sent fire uphill into a stand where handpiled fuels had yet to be treated. The result was high levels of mortality in the residual stand (Kuhar 2012).

Research Needs

Based on our review of the available reports and interviews with managers, it appears that unplanned fire in areas with piles is not common. Our search uncovered only 20 examples in the last decade. Although our review of the literature and our limited survey of the management community might reflect a significant underestimate, the fact remains that it is three orders of magnitude smaller than the total number of wildfires that occur each year. Therefore, wildfires in areas with piles remain a minor occurrence in the broader context. Even in cases like the East Zone Complex Fire in Idaho, where 156 acres (63 ha) of piles did burn in a wildfire, another 954 acres (386 ha) of piles had been burned under controlled conditions before the wildfire arrived (Hudak and others 2011). Piles do not always exacerbate wildfire activity and severity; there are also cases where, either because of location (easier access) or the rearrangement of surface fuels across the larger stand (disrupting horizontal fuel continuity), unburned piles increase control opportunities and potentially reduce wildfire severity.

We consider this report to be a first look at the issue of wildfires burning areas with piled fuels. Given the dearth of information and quantitative study, we suggest that the topic warrants additional inquiry. A more indepth investigation of the area affected could help define the scope of the issue. A simple inventory of the total area with piles and of the annual area with piles burned during wildfires would be a good place to start. Planned experiments should also be initiated and opportunistic postfire measurements taken to assess how the presence of piles—and the corresponding changes in stand structure and surface fuels due to fuel treatments—affect fire intensity and severity. Land managers can then better weigh the risks and benefits associated with piling as a fuel treatment.

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Prescribed Fire Training Center Surpasses 1 Million Acres

Joseph P. Ferguson and Greg Seamon

On April 16, 2015, the Prescribed Fire Training Center (PFTC) in Tallahassee, FL, reached an impressive milestone. Two training modules conducted burns that pushed the Center's cumulative accomplishment past 1 million acres. The two pivotal prescribed burns occurred on Loxahatchee National Wildlife Refuge and Catfish Creek Preserve State Park, both in Florida.

PFTC began providing experiential training in prescribed fire to wildland fire professionals in January 1998. Since that date, 2,028 attendees have come through the Center, participating in 2,903 individual prescribed burns. As of May 4, 2015, the burn area stood at 1,003,055 acres (405,220 ha) (table 1).

Table 1—Prescribed Fire Training Center accomplishments, by year.

			Burn area	
Year	Modules	Burns	Total (acres [ha])	WUI[a] (acres [ha])
1998	9	112	59,836 (24,215)	6,582[b] (2,664)
1999	12	190	82,837 (33,523)	8,600 (3,480)
2000	15	197	74,595 (30,188)	3,142 (1,272)
2001	15	145	46,605 (18,860)	6,615 (2,677)
2002	19	158[c]	42,599 (17,239)	9,997 (4,046)
2003	23	214	54,853 (22,198)	27,152 (10,988)
2004	21	159	47,175 (19,091)	27,025 (10,937)
2005	14	120	36,590 (14,807)	18,211 (7,370)
2006	17	147	49,452 (20,013)	15,752 (6,375)
2007	17	161	41,036 (16,607)	12,176 (5,146)
2008	17	178	59,420 (24,046)	15,572 (6,302)
2009	19	177	78,192 (31,643)	38,631 (15,633)
2010	18	162	66,245 (26,808)	18,933 (7,662)
2011	17	176	45,301 (18,333)	18,093 (7,322)
2012	9	96	28,356 (11,475)	15,435 (6,246)
2013	16	172	70,279 (28,441)	26,079 (10,554)
2014	18	157	56,168 (22,730)	11,920 (4,824)
2015[d]	18	181	63,515 (25,704)	15,245 (6,169)
Total	294	2,903	1,003,055 (405,922)	288,578 (116,783)

[a] Wildland–urban interface.
[b] Estimate; detailed numbers not collected.
[c] Estimate; detailed numbers not collected.
[d] As of May 1, 2015.

Prescribed Fire Training Center Mission

The mission of PFTC is to provide opportunities for Federal, State, local, and tribal government agencies and other entities to build skills and knowledge in prescribed fire. Students gain valuable experience and confidence in applying fire on the ground.

Over 200 cooperating host units across the Southeastern United States mentor participants by offering their lands for learning opportunities. The prospect of working on National Wildfire Coordinating Group task books is one of the cornerstones of the PFTC program.

Wildland fire students come from all over the world to take advantage of this unique training opportunity. As of May 2015, 49 States were represented in the student rolls, with only Rhode Island missing. In addition to students from all corners of the United States, PFTC had also hosted

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Students gain valuable experience and confidence in applying fire on the ground.

Stefano Macrelli igniting a prescribed fire from an airboat on the Loxahatchee National Wildlife Refuge in Florida on April 16, 2015. Photo: Prescribed Fire Training Center.

John Cataldo burning at Catfish Creek State Park in Florida on April 16, 2015. Photo: Prescribed Fire Training Center.

62 international students from 17 countries: Australia, Belize, Canada, Dominican Republic, France, Germany, Ghana, Guatemala, Honduras, Italy, Mexico, Namibia, Portugal, Scotland, Spain, Sweden, and Trinidad.

In addition to the 20-day sessions for prescribed fire practitioners, PFTC offers an annual 6-day workshop geared to line officers from the Federal agencies. This Agency Administrators Workshop gives valuable insight and training to line officers and also meets Forest Service and U.S. Fish and Wildlife Service requirements for certifications in prescribed fire.

PFTC has also held past workshops geared specifically to unit fire management officers and resources specialists.

Partnerships Are Key

Since the day PFTC opened for business, partnerships have been the key component of its success. A coalition of eight agencies make up the national interagency partnership that is PFTC: the Forest Service; the USDI Fish and Wildlife Service, National Park Service, Bureau of Land Management, and Bureau of Indian Affairs; the Florida Forest Service; the Tall Timbers Research Station; and the U.S. Department of Defense. These agencies furnish the funding, staff, and support to keep PFTC going.

But the true foundation of PFTC is the many local sites that offer opportunities for burns and training. Too numerous to name, these include national forests, wildlife refuges, and parks; State parks and preserves; water management districts; The Nature

Conservancy preserves; military bases; State forests; university and nongovernmental organization research stations; and even private landowners through State forestry agency mitigation burns.

From Mississippi to North Carolina, PFTC has agreements in place to allow the movement of modules to where the current burning window is open. This ability to stay fluid by moving modules and keeping them burning throughout the session is unique. It ensures the success of PFTC, making this such a valuable program.

For more information about PFTC, or if you want to become part of the second million acres, visit the PFTC website at <www.fws.gov/fire/pftc/>. ■

The million-acre (2015, session 4) trainees and field coordinators during orientation at the Joseph W. Jones Ecological Research Center in Florida. Photo: Prescribed Fire Training Center.

The true foundation of the Prescribed Fire Training Center is the many local sites that offer opportunities for burns and trainings.

Deputy District Ranger Roderick Alfred from the Inyo National Forest ignites a prescribed burn on the Ocala National Forest during the fiscal year 2015 Agency Administrator Workshop. The burn took place on October 30, 2014. Photo: Prescribed Fire Training Center; Joe Ferguson, Southeastern Fire Associates, Blountstown, FL.

Insurance and Wildfire Mitigation: What Do We Know?

James R. Meldrum, Chris Barth, Patricia A. Champ, Hannah Brenkert-Smith, Lilia Falk, and Travis Warziniack

There is much interest in the role of insurance in encouraging homeowners to mitigate wildfire risk to their properties. For example, the Fire Adapted Communities Coalition characterizes the insurance industry as a "nontraditional stakeholder" that "may reduce future wildfire-related insurance claims by educating homeowners on Firewise principles and providing incentives for policy holders completing the work" (Mowery and Prudhomme 2014). Indeed, the Insurance Institute for Business and Home Safety has contributed substantially to the science of wildfire risk mitigation. However, little is known about the relationship between insurance policies, communications from insurance companies, and wildfire risk mitigation on individual properties.

Homeowners insurance could relate to wildfire risk mitigation for many reasons. Most homeowners carry insurance on their residential property. If insurance premiums correspond to expected wildfire losses, properties facing high wildfire risks will be more expensive to insure than other properties, all else being equal. Homeowners can reduce their wildfire risk in many ways, including maintaining defensible space and using noncombustible building materials. Such activities lower expected wildfire losses, so the potential for reduced insurance premiums could encourage homeowners to invest in such activities. Insurance companies could also attach requirements for wildfire risk reduction to insurance coverage. Furthermore, they could raise awareness and influence behavior by denying coverage to high-risk properties.

Research shows that homeowners are often unaware of the implications of potential hazards on their insurance options.

However, if the effect of wildfire risk on homeowners insurance is to influence behavior, homeowners must be aware of that effect. In this article, we draw on survey data from numerous communities in Colorado to investigate the relationship between insurance and wildfire mitigation. We ask: Are homeowners aware of any effect of wildfire risk on their insurance coverage? If so, does homeowner awareness of the effect of wildfire risk on insurance coverage relate to awareness and concern about wildfire risk? And most importantly, does homeowner awareness of the link between wildfire risk and insurance coverage relate to homeowners taking steps to reduce the risk of wildfire?

Data From Colorado Communities

We examined responses to household-level surveys in five different locations throughout Colorado. These surveys addressed homeowners' thoughts about wildfire risks on their property. As figure 1 shows, surveys occurred in different years: Colorado Springs in 2003, Boulder and Larimer Counties in 2010, the Log Hill Mesa community in Ouray County in 2012, and four out of five fire protection districts in Delta County in 2013. Table 1 provides details about the surveys and the study populations.

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We examined responses to household-level surveys in five different locations and years: Colorado Springs in 2003, Boulder and Larimer Counties in 2010, the Log Hill Mesa community in Ouray County in 2012, and four out of five fire protection districts in Delta County in 2013. As figure 1 depicts, the surveyed communities are distributed throughout Colorado.

All five surveys solicited homeowners' thoughts about wildfire risks on their properties and their knowledge about the relationship between their homeowners insurance and wildfire risk. Table 1 gives further details about the surveys and the study populations. We focused in particular on the Delta County surveys in the wildland–urban interface (WUI), which are described in more detail in Meldrum and others (2015a).

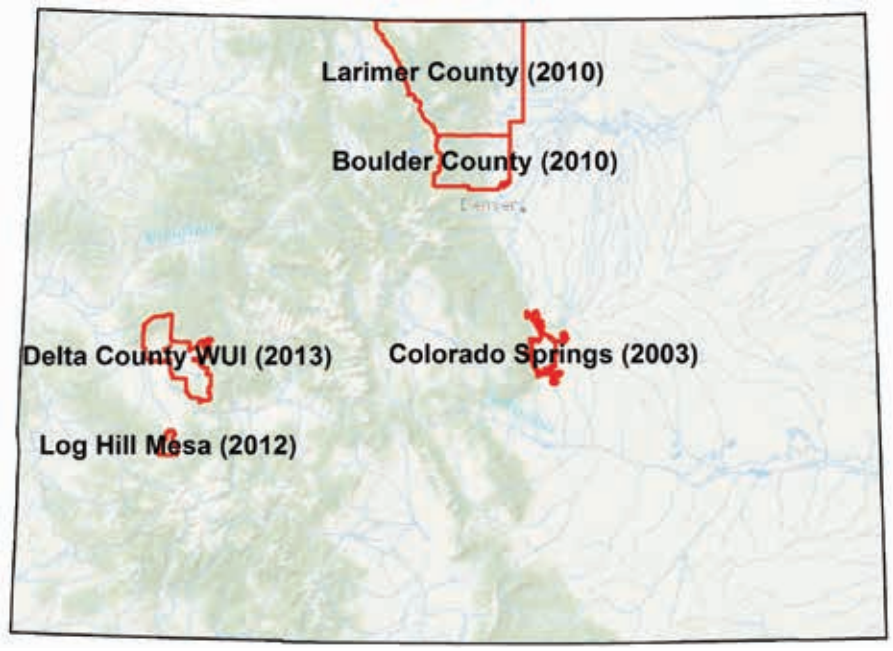

Figure 1—*Survey data pertaining to communities located in the wildland–urban interface throughout Colorado, as shown in red on the map: Colorado Springs (2003), Boulder and Larimer Counties (2010), Ouray County (2012), and Delta County (2013).*

Were homeowners aware of any effect of wildfire risk on their insurance coverage?

All five surveys asked about insurance coverage and how respondents thought wildfire risk affected their coverage. For example, figure 2 shows responses to a series of questions from the 2013 survey of Delta County WUI communities. The figure shows the type of relevant information collected, although the specific questions asked varied across the different surveys.

In the Delta County WUI survey, few respondents (18 percent) reported any known effect of wildfire risk on their homeowners

Table 1—Details from five surveys on wildland–urban interface (WUI) homeowners' knowledge about the relationship between wildfire risk and their homeowners insurance, by location.

Data	Colorado Springs	Boulder County	Larimer County	Log Hill Mesa, Ouray County	Delta County
Survey year	2003	2010	2010	2012	2013
Number (response rate)	43 (52%)	259 (66%)	185 (62%)	291 (62%)	681 (58%)
Sample frame	Households in Colorado Springs WUI that sold from July 2002 to September 2004	Respondents to previous survey (2007, 36% response rate) of random sample in Boulder County's fire-prone areas	Respondents to previous survey (2007, 36% response rate) of random sample in Larimer County's fire-prone areas	All households in Log Hill Mesa community, Ouray County	All households in the WUI of Delta County

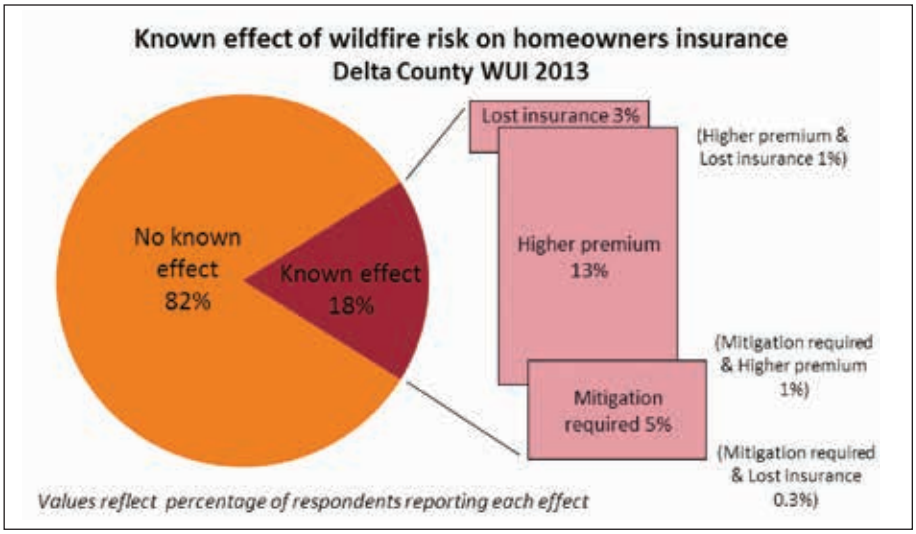

Figure 2—*Survey responses regarding knowledge of wildfire risk on homeowners insurance coverage in the wildland–urban interface of Delta County, CO, in 2013. Most respondents were not aware of any effect of wildfire risk on their homeowners insurance. (Three percent of respondents noted multiple effects, so the subcategories of "Known effect" do not add up to the 18-percent total.)*

insurance. The most commonly noted effect (13 percent of respondents) was facing a higher homeowners insurance premium because of wildfire risk. Anecdotes notwithstanding, few respondents (3 percent) noted that an insurance company had either canceled or refused to renew their policy because of wildfire risk. For another 5 percent of respondents, their homeowners insurance company required wildfire risk mitigation as a condition of issuing a policy. (Because a small set of respondents (3 percent) noted multiple effects, these categories do not add up to the 18 percent total.)

The remaining 82 percent of Delta County WUI respondents knew of no effect of wildfire risk on their homeowners insurance. As figure 3 shows, this general result is similar across the surveys. In all cases, most respondents—ranging from 72 percent in Boulder County to 95 percent in Log Hill Mesa—were not aware of any effect of wildfire risk on their homeowners insurance. This might include people who correctly knew that there were no effects as well as people who were affected but did not know it. Either way, the widespread lack of awareness of any effects of wildfire risk on homeowners insurance undercuts any expectation that insurance played a role in homeowners' decisions related to wildfire risks at the time of the survey.

The findings were despite circumstances that might have focused homeowner attention on wildfire risks:

- The Colorado Springs survey followed a comprehensive wildfire education campaign by the Colorado Springs Fire Department, which included online publication of parcel-level wildfire risk ratings;
- The Boulder and Larimer County surveys closely followed Boulder County's Fourmile Canyon Fire in 2010, which destroyed 169 homes; and
- The Log Hill Mesa and Delta County surveys were part of efforts to engage the public in developing local community wildfire protection plans.

Under other circumstances, homeowner awareness of the impacts of wildfire risk on insurance might have been even lower.

Did awareness by homeowners that wildfire risk affected their insurance coverage relate to their awareness of and concern about wildfire risk?

Next, we focused on the relatively small group of respondents who

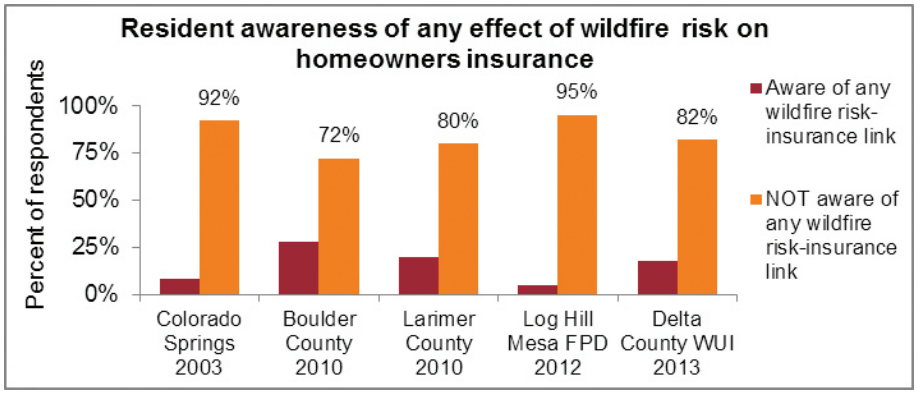

Figure 3—*Percentage of homeowners aware of any effect of wildfire risk on their homeowners insurance in five surveys across Colorado, based on relevant questions asked in each survey. Across all five surveys, most respondents were not aware of any effect of wildfire risk on their homeowners insurance.*

were aware of a link between wildfire risk and their insurance coverage. Did their perception of and concern about wildfire risks differ from those of respondents who were unaware of any connection?

Figure 4 compares the two groups of respondents to the Delta County WUI survey. Error bars show 95-percent confidence intervals, so nonoverlapping error bars indicate statistically significant differences between groups; in other words, when the error bars overlap, there might not be any meaningful difference between the average responses of the two groups.

The figure shows that awareness of a link between wildfire risk and insurance coverage was indeed associated with perceiving greater wildfire risks, but only in certain ways. Specifically, the respondents who were aware of an effect of wildfire risk on their homeowners insurance were more likely to believe there was a greater-than-50-percent chance that their home would be destroyed by a wildfire on their property. They also were more likely to rate their property's overall wildfire risk as "high" or above, although that tendency was only weak. Perhaps not surprisingly, they also were more likely to state they were concerned about wildfire.

Anecdotes notwithstanding, insurance coverage denials due to wildfire risks were not substantial in any of the surveyed communities.

However, few respondents in either group believed that there was a greater-than-50-percent chance of a wildfire occurring on their property in the year following the survey. In other words, respondents who were aware of a link between wildfire risk and their insurance coverage were no more likely to think that a wildfire might affect their property, but they were more likely to think that there was a greater chance of adverse consequences if a fire did indeed occur.

Did awareness of an effect of wildfire risk on insurance coverage relate to wildfire risk reduction activities by homeowners?

Measured differences in risk perceptions and concern translated into few differences in wildfire risk-reduction actions. We saw this by linking the Delta County WUI survey data to parcel-level rapid wildfire risk assessments.

In the rapid assessments, a wildfire professional rated 10 property attributes related to wildfire risk, many of which can be influenced by homeowner actions. Each parcel was assigned an overall wildfire risk rating based on the 10 characteristics. Previously, we showed that survey respondents and the professional often assigned different ratings to the same properties (Meldrum and others 2015b). In particular, respondents often rated their properties' overall risk lower than the professional did. Here, we compare residents' knowledge of the insurance implications of wildfire risk with their properties' observed wildfire risk characteristics.

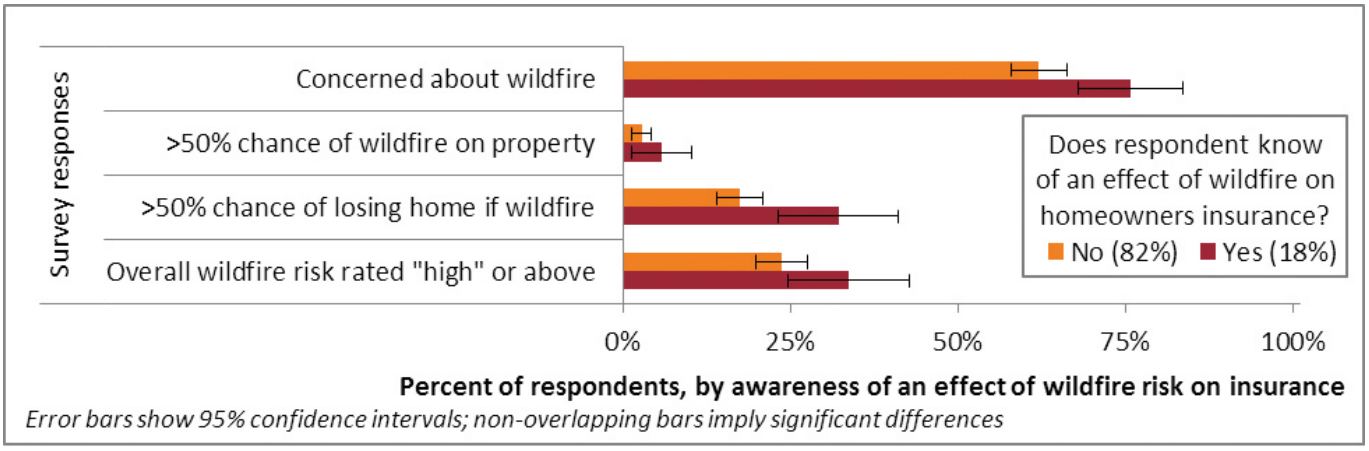

Figure 4—*Comparison of select survey responses between survey respondents who were aware of an effect of wildfire risk on insurance coverage with those who were not, based on Delta County wildland–urban interface data. Risk perceptions and concern about wildfire differ between the two groups.*

Figure 5 shows results for five of these attributes, comparing the same two groups of respondents as in figure 4. Notably, most attributes did not meaningfully differ between the two groups. Respondents in both groups were more likely than not to have their wildfire risk rated "high" or above. They also were more likely than not to have cleared at least 30 feet (9 m) of dense vegetation away from their homes. Respondents in both groups were also just as likely to have either a noncombustible deck or no deck at all. Similarly, the two groups did not differ with respect to other attributes not shown here.

Most respondents in all five surveys—up to 95 percent—were not aware of any effect of wildfire risk on their homeowners insurance.

Only two attributes significantly differed between the two groups. First, respondents aware of a link between wildfire risk and their insurance coverage were less likely to have combustible siding (such as vinyl or wood shake shingles). This might reflect a behavioral response to awareness of a link between wildfire risk and insurance coverage, or it could reflect other differences between the two groups.

Second, respondents aware of a link between wildfire risk and their insurance coverage were more often surrounded by higher risk background vegetation, such as dense trees and brush instead of grasses or light brush. Because this attribute pertains to vegetation beyond the respondents' property lines, it does not reflect homeowner behavior. Instead, the difference could reflect differences in targeting by insurance companies or perhaps differences in the extent to which homeowners pay attention to information about wildfire risk and insurance.

Low Impact of Insurance on Behavior

Overall, our analysis leads to three main conclusions:

1. Few respondents in the surveyed communities were aware of any impacts that wildfire risks might have on their insurance. Therefore, insurance does not likely influence risk-related decisions for most people in these communities.
2. Awareness of a link between wildfire risk and insurance coverage is associated with greater concern about wildfire and a greater perceived risk of losing one's home to a wildfire. This could mean that links between wildfire risk and homeowners insurance raise homeowner awareness about wildfire risks; but it also could mean that the more concerned residents are about wildfire, the more attention they pay to its potential impacts on their insurance. Either way, researchers have consistently found that homeowner

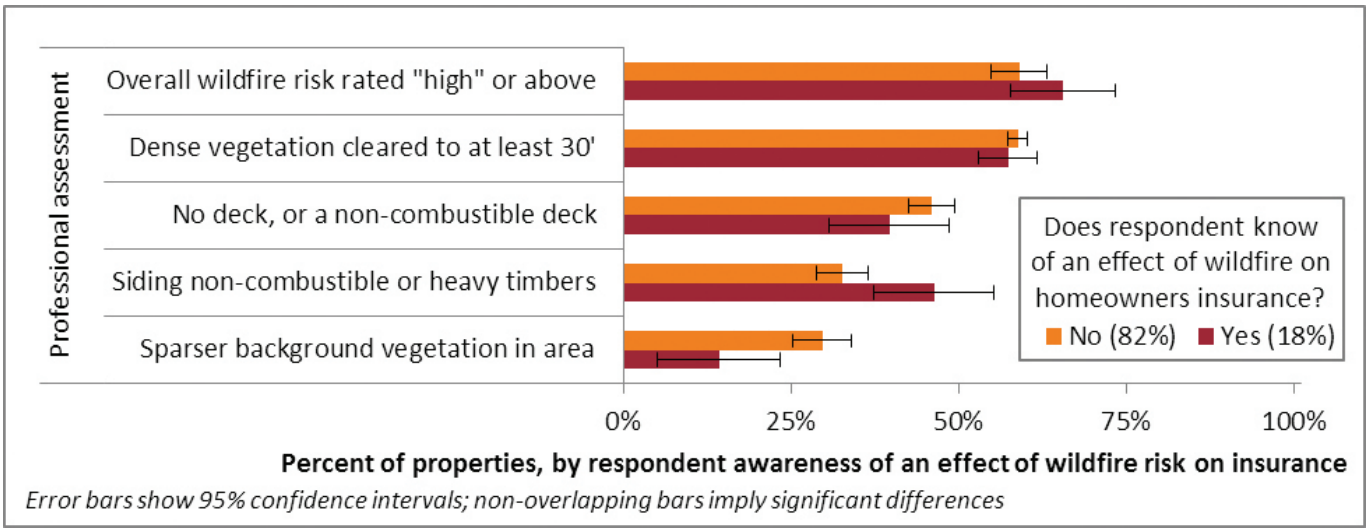

Figure 5—*Comparison of select risk-related property attributes between properties belonging to survey respondents who were aware of an effect of wildfire risk on insurance coverage and properties belonging to those who were not, based on Delta County wildland–urban interface data. Most attributes were rated similarly between the two sets of properties.*

concerns and risk perceptions related to wildfire do not alone suffice to generate risk reduction activities.

3. Accordingly, being aware of the potential impacts of wildfire risk on insurance does not lead to substantial wildfire risk reductions in the surveyed communities. Otherwise, we would expect to have seen differences in the assessed property characteristics, particularly those more easily and cheaply manipulated by homeowners. Instead, we found only limited evidence of such differences.

In short, our findings suggest limited to no change in behavior by homeowners who know that wildfire risk affects their homeowners insurance.

A few caveats and limitations apply. All communities surveyed were in Colorado, and Colorado has experienced significant wildfires with record numbers of homes lost in recent years. The patterns observed might not be generalizable beyond the communities studied. Moreover, the parcel-level rapid wildfire assessments do not reflect a full inventory of a property's wildfire risks; rather, they focus on key characteristics related to a structure's potential defensibility and survivability during a wildfire event (see Meldrum (2015a)). That said, we find little evidence to suggest that signals about wildfire risk from the insurance industry affect homeowner behavior.

In conclusion, our findings suggest that insurance might be an effective mechanism for raising awareness about wildfire risks, at least among people who attend to the details of their insurance policies. However, they also suggest that additional steps—such as perhaps providing information about specific actions needed or offering resources to overcome other barriers—are needed if homeowner awareness about wildfire risk is to translate into measurable risk reduction outcomes. Whether such steps are best taken by insurance companies or by other entities, such as community groups, regional wildfire risk programs, or government extension agents, remains an open question. ■

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Contracting Without Getting Burned

Ed Delaney

Contracting helps Federal fire managers get things done. The Federal fire organizations contract for supplies, services, and—in some cases—construction and specialized services such as architecture and engineering. From buying Nomex, fusees, driptorch fuel, and meals-ready-to-eat to accessing the largest air tankers and helicopters, contracting is the key to getting the resources needed to fight fires and to manage incidents of other types.

Contracting for incidents operates under special rules. A huge number of contracts are awarded to support incident management—a topic for another day. My purpose here is to give a brief overview of how Federal contracting works in nonemergency situations and how you can speed things up and avoid getting burned by things going wrong.

Contracting Officers

With a Government Purchase Card and appropriate training, some fire staff can make micropurchases under the current $3,500 limit for supplies. My focus is instead on purchases made through a purchase order or a contract. Without summarizing all of the applicable laws, regulations, policies, and practices, I hope to give you basic knowledge that can help you get your job done and avoid crossing the line that gets Federal employees in trouble.

Firefighters use a terra torch to help ignite a prescribed fire on February 16, 2017, on the Cleveland National Forest in California. Proper contracting is the key to obtaining terra torches and other firefighting equipment on time and in the right place, without unauthorized commitments and conflicts of interest. Photo: Olivia Walker, Forest Service.

> Unless you are a contracting officer, you can get into serious trouble in communicating with a contractor.

First, it is important to know that there is a Federal job series responsible for originating, managing, and closing out purchasing contracts. Most fire managers will rely on a GS–1102 contract specialist to contract for supplies, services, and the like. A contract specialist with a certificate of appointment, known as a contracting officer's warrant, is authorized to sign contracts and/or agreements. The specialist is known as a contracting officer (abbreviated as CO—or as CONO in the Incident Qualifications and Certification System). The warrant sets the limits within which the contracting officer can contract with private firms and sometimes with other agencies.

When he submitted this article, Ed Delaney was the lead fire contracting officer for the Bureau of Land Management in Oregon and Washington.

Unauthorized Commitments

Why is this important? Unless you are a contracting officer, you can get into serious trouble in communicating with a contractor (or potential contractor). A common error, which might seem trivial, is called an unauthorized commitment—"directing" a contractor to do something, provide something, or not do something without having the authority to do so. There is a process for authorizing a commitment after the fact, known as ratification. But if you make an unauthorized commitment, even if it is later ratified, you will probably get an official warning documented in your personnel file.

For example, suppose you order a pumpkin—a soft-sided watertank for helicopter bucket work—through your contracting office. However, after the contract is signed and priced, you remember that you meant to have your unit identifier stenciled on the side of the tank to keep it from disappearing on a large incident, where your equipment might be used long after your unit is demobilized. Stenciling could probably have been included in the price negotiated by the contracting officer for the original order, so you ask the supplier to add the stenciling.

In the broad scheme of things, you might be saving the Government money and hassle. You probably see yourself as being helpful and doing the right thing. But if stenciling is not in the original contract, you are making an unauthorized commitment because you are not authorized to modify the contract. If the contractor then creates stencils, uses a special paint, or does anything else to change the order and add to the cost, you can be held personally liable for costs, in addition to getting an official warning placed in your personnel file.

Independent Government Estimates

Another way to get in trouble while communicating with a potential contractor is to share information about a contract before it has been awarded or about the specifics of another contractor's products or processes after it has been awarded. For example, you might need to move a dozer by truck. If getting the dozer moved by next Friday will save your unit a lot of money, it might seem to be in the Government's best interests to just call and get it moved, right? Each day that slips by increases the likelihood that your unit will lose money.

To get the job done, however, you need to create what contracting officers call an independent Government estimate. First, you need to get three quotes for doing the work (called market research). Next, you write a statement of what your estimated costs will be and how you came up with the estimate.

So you've found the lowest price, you've written an independent Government estimate, and now you are waiting to get your job through the contracting gauntlet. To help speed things along, you might decide to call the low bidder and get the name of the driver who will be assigned. You describe where the dozer is and where it's to go.

Meanwhile, the contracting officer advertises the job and goes through the procurement process. Advertising might generate an even lower bid, which the contracting officer chooses for the work. The bidder you've been speaking to might call to find out when to pick up the equipment, acting on the mistaken belief that the Government has accepted his or her offer. By asking the bidder for information beyond pricing, you have made an unauthorized commitment. You have disclosed that his or her bid was the lowest you found in your market research, thereby revealing what's called source selection information. It might seem like you're just helping the process along, but you've actually committed a pretty serious breach of Federal regulations.

> If you make an unauthorized commitment to a vendor, you will probably get an official warning documented in your personnel file.

Organizational Conflicts of Interest

Inappropriate communication can disqualify the most qualified vendor if you let another vendor begin any part of the work before signing a contract. You might know a vendor and really want him or her to do a job for you. But if you ask him or her to do preparatory work or write up specifications for you, you are giving the company a

Another way to get in trouble while communicating with a potential contractor is to share information about a contract before it has been awarded.

competitive advantage in the official bid solicitation. That is an organizational conflict of interest.

Say you have a dispatch center that needs to be updated. All of the electronics have been sourced, but the console, cabinets, and furniture need to be purchased and installed. Your ideal furniture contractor has kept up with dispatch center upgrades; knowing what radios you have, the contractor offers to come in, measure the spaces, and prepare plans that include all of the correct fittings and wiring.

By giving the contractor access to your space and extra time to put together specifications for you, you have given him or her a competitive advantage, creating an organizational conflict of interest. When the contractor learns that the opportunity to bid on the job might be gone due to an organizational conflict of interest, he or she can contact the contracting officer and present a mitigation plan. Unless the contracting officer approves the plan, the contractor can be declared ineligible to compete. Without going through all the pertinent details, regulations, and case law, it's simply best to recognize the potential for an organizational conflict of interest and to decline the contractor's offer of help. Then, alert your contracting officer.

Getting the Right Information

In each of these cases, good intentions and the desire to get the best for your unit can get you into trouble. Like taking risks associated with a prescribed burn, you might think your actions are perfectly reasonable, but it's best to check with the experts, anyway. A call to your meteorologist might warn you of gusty winds that could push your prescribed burn out of control. Similarly, a call to your contracting officer can keep bad things from happening to you for lack of information.

Be safe! ■

Interagency Partnership Mitigates Wildfire Risk in Georgia

Holly Krake, Mike Ward, and Mike Davis

On a breezy March afternoon, the sounds of traffic rushing by on Interstate 75 traveled easily up the base of a rocky mountain in northwestern Georgia called Dug Gap Mountain. On a narrow ridgetop, a group of wildland fire managers and the local fire chief looked out onto the surrounding national forest from a communications site covered by towers and antennas.

Fire managers assess newly created defensible space and continuity of fuels in newly treated forest areas. Photos: Holly Krake, Forest Service, 2015.

By altering the arrangement and continuity of fuels, the partners planned to change the behavior of a potential wildfire.

This time, they were focusing on the forest that they were not seeing rather than the forest that they were. In fact, the closest continuous fuels and fuel loading started some 300 feet (91 m) away from those critical communications towers.

"What a success!" exclaimed Dalton City Fire Chief Bruce Satterfield. "Without this fuels treatment, a careless cigarette from the Interstate could have ruined this place."

A Critical Site

A fire ignited by a cigarette could have raced up the mountain and destroyed communications for nearly 600,000 people and countless emergency responders. Agreeing on the critical values at the site, the group continued to discuss other potential wildfire mitigation work needed in the area.

This conversation was one of many in a series of open discussions about wildfire risk in northwestern Georgia that began several years ago. Starting in the spring of 2013, the Forest Service joined the National Park Service and local agencies in agreeing that this critical communications site would be at risk in the event of a wildfire. The partners also agreed that the site would be very difficult to protect due to the steep terrain, access limited to a single point, lack of defensible space, and heavy fuel loading.

Unable to mitigate the terrain or access concerns, Forest Service fire managers began to plan and discuss tools for increasing defensible space and reducing fuel continuity on nearby national

Holly Krake is a public affairs specialist and Mike Davis is the forest fire management officer for the Forest Service, Chattahoochee–Oconee National Forest, Gainesville, GA; and Mike Ward is the prescribed fire and fuels specialist for the National Park Service, Southeast Region Fire Management, Atlanta, GA.

forest land. Top concerns included firefighter safety, cost-effectiveness, and impacts on the nearby wildland–urban interface (fig. 1).

By altering the arrangement and continuity of fuels, the partners planned to change the behavior of a potential wildfire, getting it to drop out of the canopy and midstory onto the ground. The newly created defensible space will make controlling a wildfire both safer and more effective.

Mobilizing Resources

Through an existing partnership agreement, the Chattahoochee–Oconee National Forest was able to use a compact track loader owned and operated by the National Park Service's Southeast Region Fire Management. The loader, known as the "Getter," is equipped with a specialized mastication head.

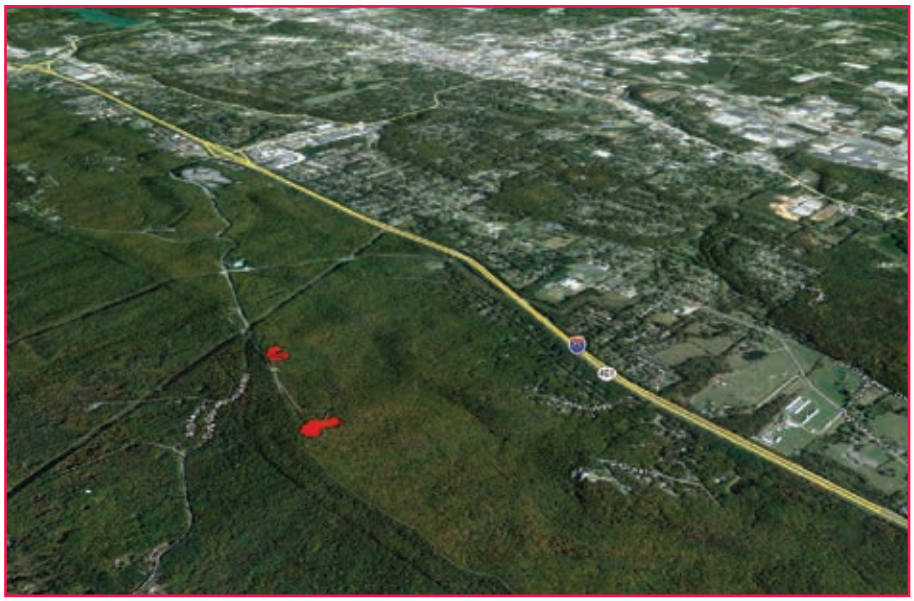


Figure 1—*Map of critical infrastructure areas (in red) treated for fuels on the Chattahoochee–Oconee National Forest near Interstate 75 and the community of Dalton, GA. Source: Forest Service, 2015.*

More than 24 tons of hazardous fuels were shredded at the communications site in northwestern Georgia. Photos: Dequincy Gordon, Forest Service, 2015.

The project had cost about $10,000 while protecting an estimated $50 million worth of critical infrastructure.

Working side by side with Forest Service handcrews, the Getter shredded its way through more than 24 tons (22,000 kg) of woody material and undergrowth at the communications site. Using the Getter increased firefighter safety by eliminating firefighter exposure to hazards during handpiling of materials and the subsequent burning of piles. With more than 40 antennas perched across the narrow ridge, hand work would also have required diverting firefighters from responding to wildfires and meeting other needs across the district.

The site's importance crossed boundaries, both governmental and nongovernmental. Through interagency partnerships, the agencies accomplished the work in a safe, timely, and cost-effective manner.

Although minor work remained to be completed, fire personnel from both the Forest Service and National Park Service were pleased with the cost-effectiveness of this wildfire risk mitigation effort. At the time this article was written, the project had cost about $10,000

The project triggered conversations regarding an "all-lands approach" aligned with the National Cohesive Strategy for Wildland Fire Management.

while protecting an estimated $50 million worth of critical infrastructure. Moreover, the costs would be exponentially higher if communications were interrupted for major commercial users such as Norfolk Southern Railroad and Verizon Wireless.

An "All-Lands" Conversation

The fuels treatment project at the communications site on Dug Gap Mountain stimulated conversations with non-Federal partners, including State emergency management agencies. Discussions began regarding an "all-lands approach" aligned with the National Cohesive Wildland Fire Management Strategy.

In addition to housing the antennas of many commercial vendors, the site also contains the communications for State emergency management, local emergency medical services, fire departments, the State highway patrol, and the county sheriff. Dug Gap Mountain provides interoperability to multiple State and Federal agencies in Georgia and Tennessee on a daily basis.

By partnering to protect critical communication infrastructure, the National Park Service and Forest Service increased firefighter safety, laid the groundwork for an effective suppression response, and set the stage for further partnerships in wildland fire management across agency boundary lines. ■

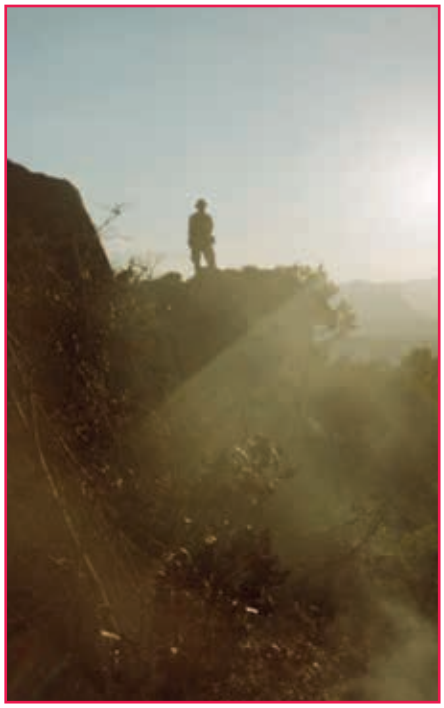
Becoming Authentic: The Heart of Leadership in Wildland Fire Management

Alexis Waldron and Mike Alarid

The wildland fire environment is entering a new age of complexity in terms of not only the biophysical fire environment but also the social environment. More and more attention is being paid to the human side of fire and the role that leadership plays in the performance, safety, and well-being of firefighters.

In the early 2000s, the National Wildfire Coordinating Group's Leadership Subcommittee introduced three core leadership values—duty, respect, and integrity—as a basis for shaping the kind of leaders we as fire professionals would like to follow. The core leadership values are associated with 11 principles.

However, evidence suggests that more than following the 11 principles outlined under duty, respect, and integrity is needed to truly become an accomplished leader (Waldron and Ebbeck 2015). Leadership necessitates interconnectedness—the understanding of others and the subsequent development of relationships. Peter Drucker, a famed scholar known as the father of modern-day management, may have stated it best when he said that "management is doing things right [what is done]. Leadership is doing the right things [the way and why we do things]" (Peter Drucker Quotes 2016). Drucker understood that, whereas management is the vehicle to making organizations function, leadership is the driver to making organizations function well.



Sup's Rock. Photo: Alexis Waldron, Forest Service, 2004.

The guiding leadership document for the U.S. wildland firefighting service, titled *Leading in the Wildland Fire Service,* substantiates Drucker's comment (NWCG 2007). Leadership is defined on page 1 as "the art of influencing people in order to achieve a result." If leadership is truly an art of influencing people, then the values of duty, respect, and integrity alone only get us to the starting block. Leadership is as much about the way and why things are done as about what is actually done.

> Leadership is as much about the way and why things are done as about what is done.

In essence, duty, respect, and integrity are the bricks, and the way and why behind them are the mortar that holds them together and makes them function. The strength and usefulness of the structure (leadership) depends upon the strength of the mortar that holds the pieces together. The mortar must be authentic and cannot be faked; otherwise, the structure will give way. Authenticity is characterized by high self-awareness, value-driven decisions, personal growth, and honesty and transparency with oneself and others. The aim of this article is to shed light on the heart of leadership in wildland fire and the why, way, and importance of authentic leaders in the wildland fire service.

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Why Lead?

Waldron and Ebbeck (2015) reported that wildland fire leaders often feel isolated and alone in their roles; what's more, they carry more responsibility than their subordinates, feel pressure to succeed, are criticized for mistakes, and believe that their actions are not always understood or appreciated by those they lead. With these often heavy burdens, why would anyone want to lead?

In the simplest terms, according to wildland fire leaders, "We lead because leading is where we make a difference" (NWCG 2007). As one leader was quoted as saying, "The burdens of leadership are often heavy, but the world's a better place because we have borne them." Authentic leaders lead not because it is easy but because it is a way to better themselves, those they lead, and the environment they affect.

Other leaders lead for various reasons, including as a means to advance their careers, to gain qualifications, or to make more money. Some fall serendipitously into leadership roles because of circumstances. Others want to exert power over others, are driven by ego, or use leadership positions as a crutch for personal insecurities.

With this in mind, three key questions arise:

- Why do motives matter?
- What is the difference between the motives of authentic leaders and those of other leaders?
- What does this have to do with performance?

Motives

A distinguishing characteristic of authentic leaders is that they are motivated from the inside out and their decisions are steered by a moral compass. In a study of 10,000 West Point graduates over the course of their careers, former Brigadier General Tom Kolditz found that those who were motivated by intrinsic reasons (such as a desire to make a difference, serve and help others, or grow and develop personally) were much more likely to lead successfully than those who were motivated by extrinsic reasons (such as a desire for pay increases, job promotions, and increased status) (Kolditz 2014).

Mopup in the desert. Photo: Alexis Waldron, Forest Service, 2005.

A distinguishing characteristic of authentic leaders is that they are motivated from the inside out and their decisions are steered by a moral compass.

With that said, being authentic and consistently operating from motives that come from within is often much more difficult than being easily swayed by outside influences. Kolditz found that if graduates who had purely intrinsic motives began to acquire extrinsic motives, it would poison their success and growth. Therefore, another critical aspect of authentic leaders is consistency. In research with wildland firefighters, Waldron and Ebbeck (2015) found that consistency was at the core of one of the key leadership characteristics in wildland fire management—integrity. Consistency in our motives must deeply resonate within us so that even in some of the most trying times leaders have a solid guiding beacon.

Developing and Maintaining Authenticity

In examining exemplary leaders such as our own Paul Gleason—or Mahatma Gandhi, Nelson Mandela, Mother Theresa, and the famous coach John Wooden—certain commonalities become apparent:

- Authentic leaders have had a tremendous influence not only on those directly around them but also on exponentially more.
- Authentic leaders have held a steadfast commitment to their values, as manifested through their actions and words.
- At the heart of the influence, actions, and words of authentic leaders was genuine care, compassion, and concern for the well-being, development, growth, and overall betterment of those under their charge.

Wildland firefighters who had been through burnovers, entrapments, and close calls expressed this last commonality as "care and compassion;" they deemed it critical for leaders to possess (Lewis 2008).

The Heart of Authenticity

Genuine "care and compassion" (different in meaning from the dictionary definitions of "care" and "compassion") are at the heart of the best leaders in wildland fire management. Capturing the meaning of the phrase in a single word is difficult, but it is just that—*heart*. Heart is the driver behind great leaders' desire to continually better themselves and those they lead. Put simply, heart is *why* they lead and directs the *way* they lead.

This does not mean that it is always "easy" to lead or that leadership consists exclusively of care bears, hugs, and sunshine.

Genuine care and compassion are at the heart of the best leaders in wildland fire management.

Sometimes the kindest thing one can do is to let someone who is drowning know that they need to start swimming and encourage them to do so, helping them to swim. True compassion is often difficult; it requires thought, concern, and making decisions that at times can be difficult for a leader or a follower. Compassion is ultimately about pushing others and yourself to be better.

Compassion for yourself is critical to finding peace and resilience within yourself. By learning to forgive yourself and accepting the fact that you're human, you can heal deep wounds and bring yourself back from difficult challenges. Authentic leaders act with compassion because it will benefit others, solve problems effectively, fulfill themselves at a deep level, and create the interconnectedness required for true leadership. Notably, compassion also establishes a true leader's intent, allowing followers to understand the meaning behind the words a leader says because everything that leader has done has reinforced the why behind it.

Performing from the heart does not look exactly the same from one leader to the next. Consistent leaders take the time to understand, reflect on their own motives and values, and truly commit themselves to the values and motives that make them better people and better leaders. This rarely, if ever, fails to include caring and compassion for others. The authenticity of leaders can be felt by those around them and is easily distinguished from false or superfluous motives. For instance, duty, respect, and integrity—as expressed from the heart—might sound like the following (from one fire manager):

- Instead of telling someone it's his or her *duty,* show him or her the importance of duty through example and successes.
- When you further someone's well-being through your own daily actions on behalf of his or her body, mind, and spirit, he or she will understand the true meaning of *respect* and will become respectful themselves.
- *Integrity* is doing the right thing, but compassion is having the integrity to do the hard thing or make the hard decision for the benefit of the total person.

Ignite the spark. Photo: Alexis Waldron, Forest Service, 2009.

Taking time to reflect, understand, and commit to the internal motives that make us better often leads to serendipitous events (finding agreeable things or events not sought for) and better outcomes. Employees will be more willing to engage, will go the extra mile without being asked, and will perform better individually and collectively under your charge and in the course of their careers. For an authentic leader, greater success and fulfillment is often a result.

Authentic Leadership

In interviews as they entered retirement, when great fire leaders have been asked how they did what they did, they often couldn't describe it, except to say that it was like developing an art form (as stated at the opening of *Leading in the Wildland Fire Service*). In becoming an artist, technique can take the artist only so far; influential art comes from the artist who understands the techniques and has the skills but performs them authentically. As Simon Sinek has said, "People don't buy what you do—they buy *why* you do it" (Sinek 2009).

Leaders must therefore go beyond the mechanics of leading to articulate the compelling, genuine, authentic *why* for others to follow. To lead to their fullest potential, leaders must lead authentically from the heart. ■

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Managing Vehicle Traffic in Smoke

Editor's note: *The piece is adapted from 6 Minutes for Safety, a program and website managed by the 6 Minutes for Safety Subcommittee under the guidance of the NWCG Risk Management Committee.*

Smoke can cause safety hazards for traffic near wildland fires (both wildfires and prescribed fires), especially at night. Before an incident or project, local planning documents should include the following traffic-related items:

- Name, locate, and give phone numbers for local units with law enforcement and traffic control responsibilities in the smoke-affected areas. Review any local agreements with these agencies.
- List important public roads that might be affected by smoke.
- Locate enough equipment and trained personnel to control traffic, including warning signs, communications equipment (preferably not using the active fire frequency), and vehicles equipped with warning or flashing lights.
- List and give phone numbers for radio and television stations that can issue traffic advisories for the smoke-affected area.
- Give alternative traffic routes as part of the incident/project traffic plan.
- List traffic routes that are subject to temperature inversions and such contributing factors as fog and ice.
- After listing potential smoke-related problems:
  - Tell the incident commander, burn boss, or agency administrator about severe smoke.
  - Notify local law enforcement units and highway departments of a potential problem.
  - Carry out preplanned actions, such as posting smoke warning signs.
  - Ensure that proper equipment is ready and appropriate personnel are briefed on contingency plans and are available to control traffic.

Standard Firefighting Orders*

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.
4. Identify escape routes and safety zones and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.
7. Maintain prompt communications with your forces, your supervisor, and adjoining forces.
8. Give clear instructions and insure they are understood.
9. Maintain control of your forces at all times.
10. Fight fire aggressively, having provided for safety first.

18 Watchout Situations

1. Fire not scouted and sized up.
2. In country not seen in daylight.
3. Safety zones and escape routes not identified.
4. Unfamiliar with weather and local factors influencing fire behavior.
5. Uninformed on strategy, tactics, and hazards.
6. Instructions and assignments not clear.
7. No communication link with crewmembers/supervisors.
8. Constructing line without safe anchor point.
9. Building fireline downhill with fire below.
10. Attempting frontal assault on fire.
11. Unburned fuel between you and the fire.
12. Cannot see main fire, not in contact with anyone who can.
13. On a hillside where rolling material can ignite fuel below.
14. Weather is getting hotter and drier.
15. Wind increases and/or changes direction.
16. Getting frequent spot fires across line.
17. Terrain and fuels make escape to safety zones difficult.
18. Taking a nap near the fire line.

* The Ten and Eighteen are from the Forest Service's Fire and Aviation Management website on risk management at <https://www.fs.fed.us/fire/safety/10_18/10_18.html>.

Guidelines for Contributors

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