Fuel Reduction for Firefighter Safety

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Abstract

Federal land management agencies have been appropriated $83 million in 1998 for a federal Hazard Fuels Reduction Program to mitigate the risks, costs and consequences of wildfire across millions of acres of publicly-owned wildlands. Within the fire management community, widespread agreement exists for the use of landscape-scale prescribed burning to accomplish this task. However, within the U.S. Forest Service, there has been more of an interest in mechancial fuels reduction treatments using commercial thinning for fuelbreak construction to lower the risk of crownfires. Proponents argue that using commercial thinning to reduce canopy densities would increase firefighter safety and prescribed fire efficiency during wildfire suppression, and are necessary treatments to prepare for future prescribed burning. However, we suggest that theses kind of mechanical treatments create their own fire risks and fuel hazards that can potentially cause problems for wildland firefighter safety and prescribed fire efficacy.

We question the assumption that canopy fuel reduction through commercial thinning is necessary or sufficient for reducing wildfire hazards and/or introducing prescribed fire. We cite evidence that logging-induced changes in fuel composition, vegetation, and microclimate can result in increased rate of fire spread, higher fireline intensity, and more severe fire effects. This, in turn, can affect firefighter safety and efficiency, and inflate suppression costs. Instead, treatment of surface and ladder fuels through prescribed fire combined with manual pre-treatments (for example, non-commercial thinning, pruning, and hand-piling) can effectively reduce the risk of corwnfires, increase firefighter safety, and improve ecosystem health. These methods also promise employment opportunities for wildland firefighters and other forest workers.

INTRODUCTION

The federal government has invested millions of dollars in a hazard fuels reduction program to mitigate the risks, costs, and consequences of wildfire across millions of acres of publicly-owned wildlands (Forest Recovery and Protection Act of 1997, S. 1467.IS). Using prescribed fire, Congress wants to reintroduce natural fire into ecosystems for both ecological restoration and hazard fuels reduction. Because reduction of hazard fuels may decrease the frequency and ferocity of wildfires, this program also has promise to increase firefighter safety. Although funds are not supposed to be used for timber projects or commodity production, mechanical fuels treatments (including commercial logging and thinning) can be precursors to prescribed burning where fuel loads are demonstrated to be too high for entry (S. 1467). How land managers apply the fuels reduction program will have the greatest impact on the safety of wildland firefighters.

This program could be successful and actually reduce wildland fuels making fires less intense and safer to control. Alternatively, the program could be bungled through mismanagement and actually produce more flammable fuels, creating a more hazardous condition than we currently have. Also, the program could trigger a rancorous public debate concerning the tools and methods used to mitigate the risks and costs of wildfire. Public controversy could revolve around logging, thinning, road construction, plant community change, air quality, and other issues. This could lead to restrictive strategies and tactics in how wildfires are managed which may impair the flexibility that firefighters need to do their jobs safely and survive. Such conflict could begin to erode the public's current high confidence in and admiration for wildland firefighters. Public discomfort with prescribed burning and wildland firefighting may ultimately tarnish firefighters' sense of self-worth and begin to trammel the team esprit de corps that keeps firefighters safely doing excellent work. For the continued safety of fireline workers, the wildland hazard fuel reduction program must be administered properly.

POTENTIAL FUELS REDUCTION PROBLEMS THAT THREATEN WILDFIRE FIGHTER SAFETY

Table 1 displays firefighter safety elements under physical fire hazards or human influences. Physical fire hazards include terrain, weather, vegetation and stand structure, and fuel load. Human influences include the adequacy of equipment, funding, and training; the command structure and organization; the suppression strategy and tactics: and the firefighting teams' confidence and esprit de corps. Of these eight components, the new federal hazard fuels reduction program will not impact terrain, weather, and the technical adequacy of firefighting equipment. Table 2 outlines concepts beneath the four human influences and two physical fire hazards.

Table 1: Threats to Wildland Firefighter Safety:

Physical Fire Hazards Human Influences
Terrain Equipment, funding, and training*
Weather Command and organization*
Fuel load*
Suppression strategy and tactics*
Vegetation and stand structure*
Confidence and team esprit de corps*
* may be impacted by the new federal hazard fuels reduction program

Adequacy of Equipment, Funding, and Training: If the hazard fuels reduction program uses commercial thinning operations to focus on high value timber areas that don't have an eminent potential for emerging fires, then low value areas, with a high potential for emerging fire, may remain neglected or only marginally protected when fire crews and equipment are prepositioned to favor activity zones. As experienced wildland firefighters know, slash-burning provides limited training for wildfire. After generating abundant slash through mechanical thinning and before disposing of that slash, the program may become stalled due to lack of funding, air quality, or other political concerns. This scenario would leave firefighters worse off as they face both the untreated high risk fuels and vast new areas of slash.

Command and organization: The hazard fuels reduction program can impact wildland firefighter safety by influencing fire management command structure and organization in three ways: logistically, organizationally, and politically. Particularly, these include resource allocation limitations, the inertia of a vested bureaucracy, and political pressure from shifting societal values. Logistically, adequate allocation of limited money and manpower resources may prove difficult. Money shunted to accommodate hazard fuels reduction programs may not be available to sufficiently fund initial attack crews and emerging fire support. Unsupported emerging fires means more strain on available resources and a situational decrease in safety for fireline workers.

Organizationally, many programs become partisanly protected by vested employees. Such employees create bureaucratic inertia that keep the program grinding away even after grave errors become recognized, the program has completed its mission, or conditions change such that the program becomes irrelevant. Vested decision-makers, who derive status and a sense of self-worth from the program, often focus on what is good for the program and can aggressively defend the program against criticism (Hirt, 1994). When criticisms of a program are taken personally, the response action may be unreasoned or reckless and lead to irrational decisions that place firefighters in jeopardy.

Shifting societal values bring immense political pressure to decisions concerning how and where an officer can apply prescribed fire or fight wildfire should the hazard fuels reduction program become a ideological battlefield. Homeowners living adjacent to hazardous brush fields will predictably protest loudly when firecrews, sent off to distant backcountry sites to treat slash in high value timber areas, ignore the low value scrub lands neighboring taxpayers' homes. If the fuels reduction program becomes unpopular with the public, then political pressure may mount and greatly influence which geographical areas can be treated by the program, what kind of activities can be used to attenuate fuels, and which wildfires can be suppressed. Political decisions can place firefighters in hazardous situations when they dictate where, when, and how firefighters must face wildfire.

Suppression strategy and tactics: Inevitably, the hazard fuel reduction program will spawn colorful computer programs that project acres treated and imagine changes in fire behavior. Faith in such computer programs could alter overall strategy of fire suppression and effect the kind of tactical support the fireline worker usually counts on. Firefighters normally rely on certain topographic features to construct defensible firelines. However, many fuel reduction treatment areas may be along Forest Service roads originally designed to access dense timber stands, not aid fire suppression. Firelines may not be allowed in certain areas or located in indefensible areas due to political or administrative concerns. Thus, changed strategies may produce an inflexible fire suppression response that places firefighters in areas that are indefensible and unsafe.

Another strategy employed by the program may use timber harvest to produce vast acreages of fuelbreaks. While fuelbreaks can be very useful in urban interface zones (Omi, 1996), they may become "white elephants" when constructed. In general, once created at considerable economic and ecological cost, fuelbreaks remain rarely monitored or maintained to control the prolific regrowth of flammable brush and saplings. If fuelbreaks become a major component of the hazard fuels reduction, then the program may likely repeat the historic cycle of short-term expensive fuelbreak construction followed by long periods of neglect. Currently in California, thousands of miles of fuelbreaks exist that have been abandoned with virtually no maintenance, no monitoring of their condition, or research on their past use during actual wildfires (Weatherspoon, 1996). This becomes a major safety issue when an incident commander, dependent upon a map with colored areas depicting fuelbreaks, deploys firefighters in a unmaintained, brush-clogged, lethal fuelbreak. Also, vestment in the program may encourage a fatal "can-do" attitude among managers, forcing firefighters to "hold the line" in fixed fuelbreaks.

Table 2: Possible Hazards Fuel Reduction Program Impacts on Wildland Firefighter Safety.

Adequacy of Funding and Training:

∑ absorbs funding: slash burning in high value timber areas may absorb funding and neglect prescribed burning in low value areas.
∑ limits prescribed burning areas: slash burns provide limited training and experience for wildfire in non-activity areas.
∑ neglects areas of low timber value: when activity zones are favored, areas of high potential for emerging fire may be inadequately supported. Confidence and team esprit de corps:
∑ erode the public's current high confidence in and admiration for wildland firefighters.
∑ public discomfort with prescribed fire and wildfire fighting may ultimately tarnish firefighters' sense of self-worth.
∑ fireline workers' failure of confidence in the program and its administering commanders.
∑ failure of the team esprit de corps that keep firefighters safely doing excellent work.

Command Structure and Organization:

∑ logistical: allocation of limited resources leaves fireline workers marginally supported.
∑ organizational: vested bureaucratic inertia makes irrational decisions that jeopardize firefighters.
∑ political: shifting societal values limit where and how prescribed burning used and how wildfires suppressed, firefighters unsafely deployed. Changes in vegetation and stand structure:
∑ change in species size, age, and composition.
∑ opened canopies alter microclimate, drier fuels.
∑ change in vertical structure of fuel.
∑ increase in roads may increase disturbed areas, insect infestation, and plant disease.
∑ increase in roads also may increase arson or other human-caused fires.

Suppression strategy and tactics:

∑ fire suppression strategy altered, based on theoretical fuels reduction projections.
∑ some common tactics disallowed, use political rather than geographic anchor points.
∑ firefighters deployed in unmaintained fuelbeaks. Changes in fuel models:
∑ increased fire intensity and rate of spread.
∑ thinning without burning increases fuel load.
∑ more growth and early maturing of flashy fuels.
∑ increase in effective fuel bed depth.
∑ hotter, drier, windier sites, longer fire windows.

Confidence and team esprit de corps: Why do wildland firefighters choose this profession? While each individual's reasons vary, some constant common themes point to strong esprit de corps. Firefighters value self-actualization, camaraderie, performing a service to society, protecting lives and property, and protecting resources. This esprit de corps, so vital to work performance and safety, derives from a shared pride in their work and summons firefighters' incredible endurance on the eternal fireline during day after day of unspeakable physiological stress. Camaraderie is a source of endurance and pride, but it's the linchpin of safety as well. Firefighters have a shared sense of heroism, an automatic inclination to ensure the safety of fellow comrades. This sense of belonging, doing a good job and doing what is right, could become trammeled if firefighters begin to think less of themselves because of the work they do.

Wildland firefighters may begin to lose their personal confidence and commanding sense of duty should they begin to lose their hero status with the public. For example, if firefighters are used mainly for slashburning following controversial commercial thinning operations, then this may begin to erode the public's current high confidence in and admiration for wildland firefighters. Public discomfort with the prescribed fire program and with wildfire fighting in general may ultimately impact firefighters' sense of self-worth, duty, confidence, and pride. Once firefighters strongly question the appropriateness of what they are doing, they may well have a failure of confidence in the program and its administering commanders. This may lead to internecine bickering among crewmembers opposed to or in support of the program. Because the team esprit de corps keeps firefighters safely doing excellent work, erosion of this spirit becomes perhaps the most important safety issue. Disgruntled and alienated fireline workers do not make safe workers. They are likely to be quarrelsome and unreliable and make lethal errors during times of critical stress.

Changes in vegetation and stand structure: The hazard fuels reduction program can impact wildland firefighter safety by changing the vertical structure of fuel and plant species composition, age, and size. If mechanical thinning becomes a major component of the program, then not cleaning up the debris represents the greatest threat to firefighters. In controlled tests that simulated wildfire occurrence, Weatherspoon and Skinner (1995) found that uncut stands suffer the least fire damage, followed by partial-cut stands with fuel treatment; but partial-cut stands with no fuel treatment had the most damage.

Concern for crown fires exists for some seral pine stands where the forest canopy becomes effectively continuous with the forest floor, due to fire exclusion, allowing suppressed, shade-tolerant firs to develop into ladder fuels. Initiation of crown fire behavior is a function of surface fire intensity, the height of the canopy above ground, and the canopy's moisture content (Van Wagner, 1977). To be effective, the program should focus on reducing surface fuels and increasing the height to live crown (by pruning or removing brush and saplings) as a first priority. A decrease in crown closure by thinning should be a second priority. However, these priorities become reversed when land managers thin mature trees to derive income from the project (van Wagtendonk, 1996). Because crown fires are extremely rare and short-lived occurrences and represent a very small percentage of fires encountered (Van Wagner, 1993), the increased acreage of prolific brush continue to be a greater danger to firefighters.

Commercial thinning of mature trees to reduce stand densities and gain economic return alters the microclimate and inevitably changes fire behavior. In FARSITE fire behavior computer simulations, stands with canopy cover of 40% or less function the same as open stands (Finney et al., 1997). Thinning causes more solar radiation to reach the forest floor and results in lower fuel moisture, higher windspeeds, and faster brush and grass growth and maturation. These hotter, drier, and windier sites also forestall local natural succession as the site becomes taken over by lighter fuels and highly flammable brush. Reduced fuel moistures extend the periods of high fire danger with rapid fire spread and high fire intensity (Weatherspoon and Skinner, 1995).

Under closed canopies, the natural compaction of heavy fuels and their low surface area-to-volume ratio, such as downfall and thick duff, suffocates oxygen and usually produces creeping, smoldering fires. Because of increased brush growth, and needles from residual trees that hang in the brush, opened canopies effectively transform vertically compact fuel into vertically expanded flashy fuel where combustible energy becomes instantaneously exposed to oxygen. Thus a change in vertical distribution of fuel can transform creeping, smoldering fires into running conflagrations (Agee, 1997). According to "Common Denominators of Fire Behavior on Tragedy Fires," fatalities occur when "fires respond quickly to shifts in wind direct or wind speed" and fatalities result from flare-ups and "flare-ups generally occur in deceptively light fuels."

If the hazard fuel reduction program begins to treat areas by pushing in roads, several other well-known problems associated with roads may threaten firefighter safety. An increase in roads also may increase arson or other human-caused fires. Also, the dead fuel condition could become exacerbated because an increase in roads may increase disturbed areas, insect infestation, and plant disease (US Forest Service, 1997).

Changes in fuel models: Rothermal (1972) and Albini (1976) developed thirteen timber, slash, shrub and grass fuel models represented in Table 3. Only those fuel models pertinent to the West have been included (grass fuel model 2 is placed under the shrub class). Important parameters for firefighter safety include fire intensity (measured by flame length in feet) and rate of spread (chains per hour). When targeting sites for treatment to reduce hazard to firefighters, land managers would have the greatest impact on fuel model 4. Converting fuel model 4 to fuel model 5 could have a four-fold reduction in the rate of spread and fire intensity.

Table 3: Fuel Model Rate of Spread and Fire Intensity

a) Fuel Model
b) Rate of Spread (chains/hour)
c) Fire Intensity (flame length, ft)
d) Plant Community and Treatments

Timber:

a) 10 b) 7.9 c) 4.8 d) overmature, deadfall, insects-disease

a) 9 b) 7.5 c) 2.6 d) ponderosa closed canopies

a) 8 b) 1.6 c) 1.0 d) healthy lodgepole, spruce, fir

Slash

a) 11 b) 6.0 c) 3.5 d) light partial cuts and thinning

a) 12 b) 13.0 c) 8.0 d) medium-heavy partial cuts and thinning

Shrub

a) 4 b) 75.0 c) 19.0 d) over-mature chaparral and brush

a) 6 b) 32.0 c) 6.0 d) maturing brush, sage, pinyon-juniper

a) 2 b) 35.0 c) 6.0 d) (grass model) open pine and shrub

a) 5 b) 18.0 c) 4.0 d) young green stands and shrub

Table 4 presents the total fuel, dead fuel, and live fuel in tons per acre for the timber, shrub and slash fuel models. The fuel bed depth is given in vertical feet. While most fuel management focus on the total fuel tons per acre, the fuel bed depth is probably more important for firefighter safety. Converting any timber fuel model into a slash fuel model triples the fuel bed depth. If the timber fuel models are converted to brush fuel models, the fuel bed depth increases seven fold. A 3.5 feet fuel bed depth, for example, places many firefighters chest-deep in brush.

Table 5 presents the change in the rate of spread and change of intensity when the timber fuel models, 8, 9, and 10 (horizontal axis) become converted to other fuel models (vertical axis). In general, when timber sites become converted to slash or brush sites the rate of fire spread and fire intensity increase. Many forest managers advocate converting fuel model 10 into something else because the fuel load in fuel model 10 increases as insects and disease cause tree mortality. Yet, fuel models 8 or 9 may be incorrectly identified as fuel model 10 and mechanically thinned. This would increase hazard to firefighters when the potential fire intensity and rate of spread become altered without good purpose. Prescribed fire alone can convert fuel model 10 to fuel model 9, in the case of ponderosa pine, or fuel model 8, in the case of lodgepole, fir or subalpine fir. Hotshot crews routinely prescribed burn dense forest stands without mechanical thinning. Nevertheless, some land managers believe that many sites must be thinned using mechanical means before using prescribed fire.

Depending upon the severity of thinning and whether the resultant slash remains unburned, a fuel model 10 becomes converted to fuel models 11 or 12. If the thinning is quite severe and the resultant slash is burned, then this fuel model, originally identified as 10, becomes converted to fuel model 5, in the brush class, or fuel model 2, in the grass class. If, for whatever reasons, these sites remain without further prescribed fire treatments, then they may mature into a fuel model 4.

Table 4: Fuel Model Fuel Loading

Fuel

Model Total Fuel

dead & live

<3"(tons/acre) Dead fuel

1/4"

(tons/acre) Live Fuel

Foliage

(tons/acre) Fuel bed

depth

(feet) Plant Community and Treatments

Timber 3.1 average 2.5 average 0.7 average 0.5 average

10 12.0 3.0 2.0 1.0 overmature, deadfall, insects-disease

9 3.5 2.9 0 0.2 ponderosa closed canopies

8 5.0 1.5 0 0.2 healthy lodgepole, spruce, fir

Slash 23.1 average 2.8 average 0.0 average 1.7 average

11 11.5 1.5 0 1.0 light partial cuts and thinning

12 34.6 4.0 0 2.3 medium-heavy partial cuts and thinning

Shrub 7.5 average 2.5 average 2.3 average 3.5 average

4 13.0 5.0 5.0 6.0 over-mature chaparral and brush

6 6.0 1.5 0 2.5 maturing brush, sage, pinyon-juniper

2 4.0 2.0 0.5 1.0 (grass model) open pine and shrub

5 3.5 1.0 2.0 2.0 young green stands and shrub

SOME SOLUTIONS THAT CAN DIMINISH POTENTIAL THREATS TO WILDFIRE FIGHTER SAFETY

If the hazard reduction program begins to absorb funding and resources, fire crews must aggressively fight for funding to use prescribed fire in the areas most critical to firefighter safety. Each region's firefighting resources should be distributed in a manner that corresponds to potential wildfire, not according to activity slash disposal. Because slash burns provide limited training and experience for wildfire in non-activity areas, crew managers should resist letting their crews become merely slash disposal crews. Crew superintendents should demand training that includes prescribed understory burns in areas similar to potential wildfires.

Crews should use their best experienced judgment before taking an assignment, especially when evaluating actions that are said to be "good for the program." Full public disclosure of the project's objectives can help insulate the crew against hostile public reaction to the activity. Real fire behavior will not be changed by the new hazard fuel reduction initiative or its computer simulations. If certain common firefighting tactics become disallowed and illogical anchor points proposed, the program will lose support when crewmembers realize that they work in unsafe conditions. Should the hazard fuels reduction program erode the public's current high confidence in and admiration for wildland firefighters and cause consequential disgruntlement among crews, supervisors must ensure that all viewpoints are heard. Supervisors should encourage a full and honest debate among their crews over the merits of the program, demand full disclosure to the public from managers vested in the program, and reject patronizing or bureaucratic euphemisms.

Table 5: Fuel Model Conversion by Heavy Thinning or Fire

Converted to Fuel Model 10 Fuel Model 9 Fuel Model 8 Possible Scenarios

Fuel Model RoS1 FL2 RoS1 FL2 RoS1 FL2

10 0 0 + 0.4 + 2.2 + 6.3 + 3.8 no treatment, no fire, insects-disease.

11 - 1.9 - 1.3 - 1.5 + 1.3 + 4.4 + 2.5 not burned yet, or lop and scatter.

12 + 5.1 +3.2 + 5.5 + 5.4 + 12.4 + 7.0 not burned yet.

9 - 0.4 - 2.2 0 0 N/A3 N/A3 desired condition, constant fire.

8 - 6.3 - 3.8 N/A3 N/A3 0 0 desired condition, constant fire.

4 + 67.1 +14.2 + 67.5 +15.5 + 73.4 +18.0≥ 60% of canopy removed, no fire.

6 or 2 + 25.6 + 1.2 + 26.0 + 3.4 + 31.9 + 5.0≥ 60% of canopy removed, some fire.

5 + 10.1 - 0.8 + 10.5 + 1.5 + 16.4 + 3.0≥ 60% of canopy removed, constant fire.

1. RoS = Change in the Rate of Spread (chains per hour).

2. FL = Change in Flame Length (Fire Intensity) in feet.

3. N/A = Not Appropriate because requires a tree species composition change.

Open canopies mean microclimate changes such as more wind, more brush, and drier fuels. Fire crews must rely on their experience when reviewing proposed changes in plant species age, composition, and vertical structure of fuel. Fuel reduction plans that do not focus on surface fuels, or that increase flashy fuels and extend the window of opportunity for wildfire, are not worth participating in. To avoid crown fire, consuming surface fuels must be the first priority, followed by raising the height of the canopy above the surface as a second priority. Reducing stand density using mechanical means is the most expensive and least effective way to avoid crown fires. Because roads increase disturbed areas, insect infestation, plant disease, and arson, building roads for the purpose of fuel reduction does not make sense. Firefighters should be wary of hidden agendas that lurk in fuel reduction schemes that include road construction.

When recovery of the economic value of this "fuel" becomes a part of hazard fuels reduction, it may soon drive the system. Because timber stands converted to slash or brush pose more risks, firefighters should take any opportunity to demonstrate that they have the skills to efficiently reduce surface fuels in closed canopy areas using prescribed fire. For consuming fuel, there is no substitute for prescribed fire. Using drip-torches as brushes to paint a fiery landscape, firefighters have the techniques to reduce hazard fuels.

The federal hazard fuels reduction program could be a very good thing for wildfire fighters. The program offers a great opportunity for long-term employment. If it is done properly, the program can reduce the most extreme of the hazardous fuels and make the working environment for wildland firefighters much safer.

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