Woody Ridge Prescribed Fire Accident Prevention Analysis Report

Southwestern Region
Coconino National Forest
November 16, 2009

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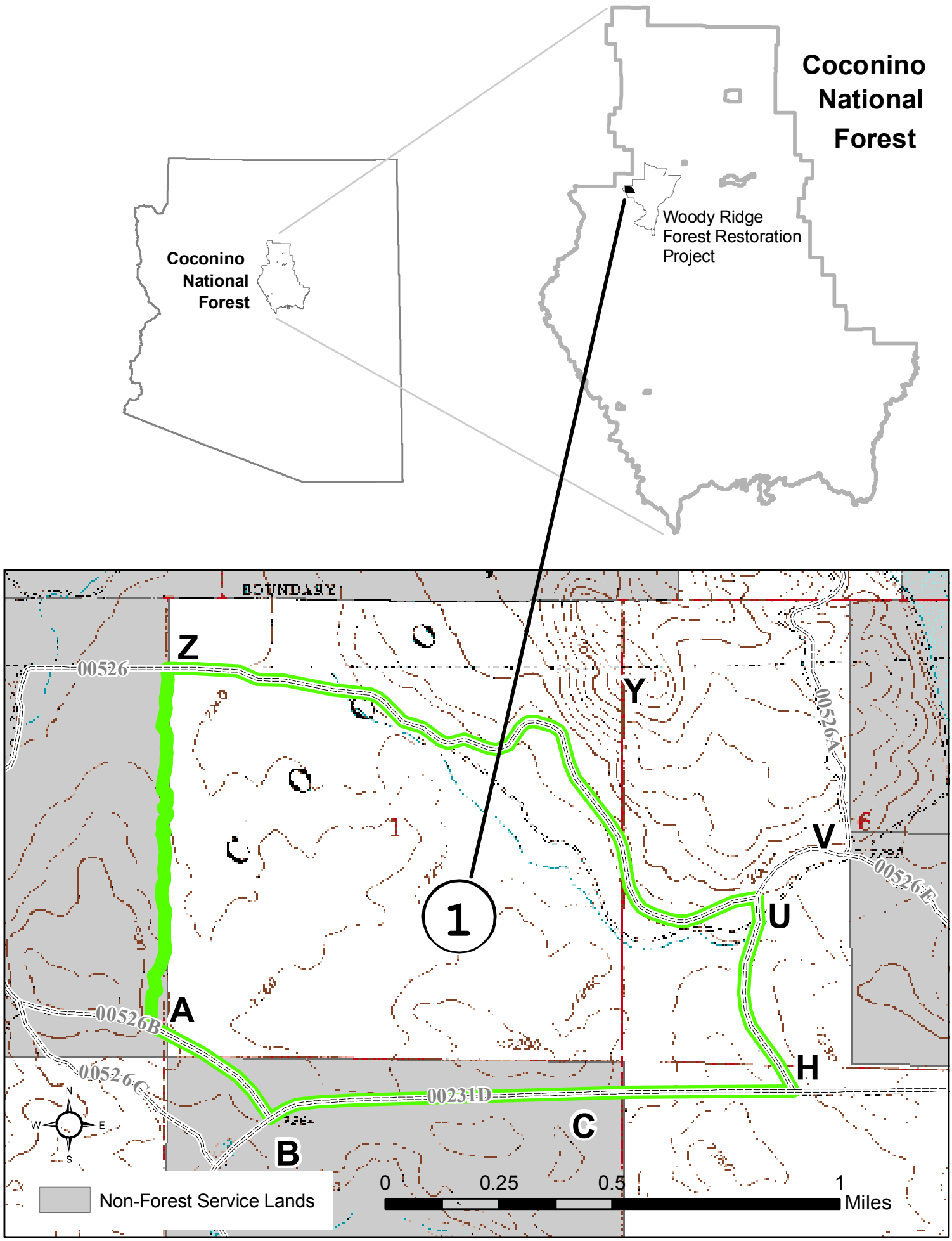
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Executive Summary

The Woody Ridge Prescribed Fire was ignited Tuesday, September 22, 2009 on the Coconino National Forest. The 650-acre project area lies outside Flagstaff, Arizona, on state and National Forest System land. The Woody Ridge Prescribed Fire was one component of the 31,000-acre Woody Ridge Forest Restoration Project designed to reduce fuels and improve wildlife habitat in the wildland-urban interface (WUI) around Flagstaff. The ponderosa pine overstory had been heavily thinned. Slash piles were burned in the winter under snow. Residual fuels were fairly light. The effect of the larger project would be to significantly reduce wildfire intensity in the WUI.

The Districts involved in the project have a long, successful history of prescribed burning and one of the more active programs in the western United States. Together, they burn at least 10,000 acres a year, much of it in small blocks. In Fiscal Year 2009, these districts burned on 78 days. District fire personnel are highly experienced, highly qualified, and consistently exceed fuels treatment targets. Senior fire managers serve on incident management teams in command and general staff positions and most have worked on the local unit for more than 20 years.

The morning of the burn, a District FMO operating under a written delegation of authority approved the Agency Administrator Pre-Ignition Checklist in consultation with the Burn Boss. Winds were strong but favorable for smoke dispersal, a major consideration in the local area. District engine captains served in key leadership positions for the burn, though most senior fire managers were also present. All personnel were qualified for the positions in which they served. Altogether, 37 firefighters participated in the burn that day.

Within the first fifteen minutes of ignitions on the west line, spot fires began to develop. Two firefighters at the west end of the burn unit became involved in containing one of the spot fires. When they realized they could not catch the spot fire, they radioed for assistance. Seconds after that call and concerned for their own safety, the firefighters retreated toward what they believed would be a safer area back toward the main fire. During their retreat, they were hit by a brief but intense pulse of convective heat. Both firefighters suffered airway injuries. Despite their injuries, both rejoined their crew and continued working on spot fires alongside other firefighters for another 15 to 20 minutes.

At about 1000, the two injured firefighters, having difficulty breathing and feeling poorly, decided to go back to their truck. Between 1030 and 1045, they had arrived at and were sitting in their truck, just outside of the burn unit but still in a fairly smoky area. One of them called their supervisor by cell phone to say they needed medical attention. Their supervisor, the Burn Boss, and another senior fire manager immediately responded, meeting the injured at the truck. The decision was quickly made to transport firefighters to a nearby hospital. By 1106 the injured

firefighters were en route to the hospital. Both of the injured employees were treated and released that day, though both continued to experience some symptoms more than a week later.

The accident was locally reviewed through a formal, facilitated after-action review (AAR) process. Many of the lessons learned in the AAR were immediately adopted by the local unit. On September 29, the Coconino Forest Supervisor issued a letter of delegation to an Accident Prevention Analysis (APA) team to conduct an accident investigation focused on larger upstream issues.

The APA process is a human factors approach to understanding unintended outcomes and accident investigations. The process is predicated on both a just culture and an understanding that our employees are inheritors of the production pressures, tools, trainings, artifacts, and systems of the workplace. An APA does not identify causes in the traditional sense (errors, mistakes, and violations) but, rather, approaches the accident from the perspective that risk is ubiquitous and leadership's responsibility is to guide employees to manage the tradeoffs between safety and other organizational goals in alignment with corporate and local leadership values.

The team identified the following key decisions, actions, and behaviors that influenced how risks related to this accident were perceived, understood, and managed on the project:

1. The decision to burn (the go-no go decision) on September 22.
2. The organization and assignment of duties on the burn.
3. The ignition of the test fire during the briefing.
4. The focus on the de-limber pile, and on-scene changes to the firing plan.
5. The lead lighter's decision to retreat to the anchor point.
6. The custom and practice of relying on agency EMTs as medical resources.

Story of Woody Ridge Prescribed Fire

The Woody Ridge Prescribed Fire was ignited September 22, 2009 on the Coconino National Forest. The project area was outside of Flagstaff, Arizona, on state and National Forest System land and was part of the 31,000-acre Woody Ridge Forest Restoration Project (see project map, page 11). The participants included fire management staff and overhead from neighboring ranger districts that burn over 10,000 acres annually. During Fiscal Year 2009, the Districts conducted prescribed burning for 78 days. During this same period, the Forest managed a number of fires for resource benefit totaling over 23,000 acres.

Much of the prescribed fire activity on the Forest involves or affects communities in the wildland-urban interface, either because the activity is adjacent to private property or structures, or because of smoke impact on local communities. The impact of smoke is a contentious issue that has played a major role in determining appropriate burn windows.

Predicted weather for September 22 called for winds favorable to a prescribed fire in the Woody Ridge project area. Prevailing northeast winds from a frontal passage to the north would allow fire managers to conduct the burn and vent smoke southward and away from Flagstaff. Twenty-foot winds were predicted to be 10-15 m.p.h., gusting to 25. The burn block was a partially sheltered ponderosa pine stand. Predicted winds would be within prescription and smoke dispersion would be favorable.

Photo illustrates the fuels typical along the edges of the burn block.

The burn project overhead had spent September 21 finishing up prep work for the project. This included touchup of the drag lines around the fire. A drag line is created by dragging a metal object behind an ATV to create a fuel break in the organic surface material. Many of these drag devices are locally designed and fabricated out of tire rims and rails from railroad track. The Burn Boss and other overhead at the end of the day felt that everything was ready to go and that with the forecasted winds they would have a successful burn.

ATV and locally made tool dragged behind the ATV to create a "dragline"

Assigned resources included five engines from the Districts, a District fire crew, a zone fuels crew, and senior fire management personnel. Captains and battalion chiefs from both Districts comprised the project's overhead positions.

District fire managers and personnel assembled at the project site between 0800 and 0830. Project overhead – Burn Boss, Firing Boss East, Firing Boss West, and Holding Boss – conducted a pre-briefing to assign individuals and units to each group – Holding, Ignitions West, and Ignitions East – and to discuss the order of operations.

The plan was as follows. Around 0930, Ignitions West would begin and proceed northwest from the briefing area (Point B) parallel with the road to a dragline, then north along a dragline. After Ignitions West began establishing their line, Ignitions East would begin, proceeding east parallel with the road to Point H, then north along the unit boundary. Ignitions West was expected to have more smoke exposure for holding and more spotting.

It was a cool and crisp early fall morning, with bright sunshine and brisk winds. Weather observations were taken and a spot weather forecast requested at 0800. Site observations read: temperature: 50^{o} F., relative humidity: 61%, wind speed: 8-10 m.p.h. gusting to 15, wind direction: NE.

Around 0845, the project's 37 personnel gathered for the pre-ignition briefing. According to the standard checklist District personnel use for prescribed fire projects, the briefing covered project objectives, weather, expected fire behavior, smoke, cultural and other resource concerns, assignments, general

operations (ignitions, logistics, holding), communications, safety, public information, and personal protective equipment. The safety message focused on avoiding slips and trips while traversing the burn block. The Burn Boss later recalled that when weather predictions were discussed, there was no specific mention of wind, potential gusts, or their impact on holding and smoke exposure. Individual and unit assignments were given to the Ignitions West, Ignitions East, and Holding groups. A weather observer was also assigned and two individuals were on site as unassigned overhead (OH#1 and OH#2).

Ignitions East group near the test fire about to begin eastward burning operations

During the briefing, OH#2 ignited a test fire in a corner next to the briefing area without first checking with the Burn Boss. Some personnel on site reported that the test fire was a distraction and set the tone for the day, namely, that the prescribed fire would occur and that they needed to "hurry up." Results of the test fire were not documented. When the briefing was over, the Burn Boss signed the "go/no-go" checklist and each group held its own breakout briefings to cover their specific tactics and operations.

Ignitions East finished their briefing first and its 12 igniters lined out and began burning around 0930. Ignitions West followed suit with 13 igniters, and began lighting soon thereafter. The 7 firefighters assigned as holding forces finished their briefing after Ignitions West, and readied themselves. Lighting progressed without incident from Point B.

A few minutes after the West Group began lighting, the Firing Boss grew concerned about the amount of fire being introduced since it was near a large de-limber pile 511' from the line. Ignition operations were immediately suspended. Under the Firing Boss's supervision, interior igniters and other personnel shifted their focus to lining the pile because, if it caught fire, it was likely to spot given predicted winds. All those assigned to the project, including District leadership, shared this concern.

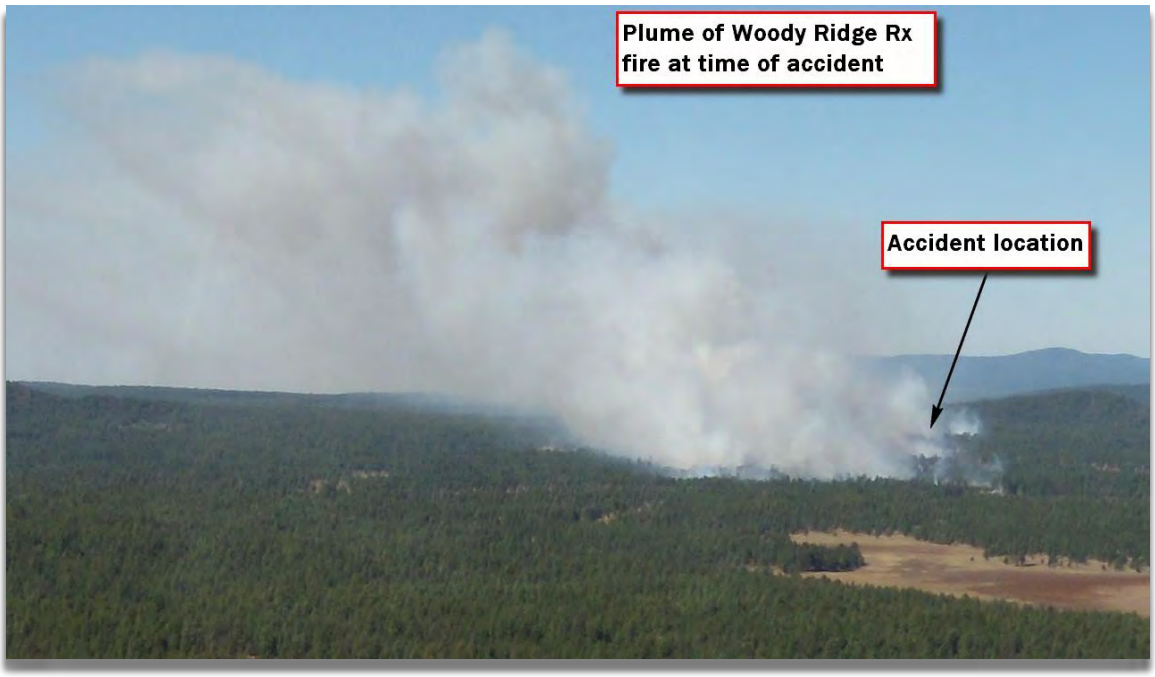

Firefighter standing at de-limber pile.


Firefighter

As this was happening, West Group's lead igniter waiting on the line--Firefighter #1 (FF#1)--saw a spot fire along the dragline. FF#1 quickly went back down the line to the south, donning a face shroud, and attacked the small spot, containing it easily. He then saw a new spot just to the north that was growing. FF#1 requested help from the nearest firefighter (FF#2) who was also a crewmate. Realizing that they would need help, they reported to their Firing Boss via radio that they would be unable to contain the spot. The Firing Boss ordered others to assist and also did so, leaving one person and an ATV with a "drag" to complete the line on the de-limber pile. The distance from the de-limber pile to the spot was described as "a couple minutes' hike." The Holding Boss ordered an Engine and an ATV to the spots and began to travel towards the spots from Point B.

As all these resources were responding, FF#1 and FF#2 built a scratch line around the second spot, flanking directly on the north side. As the first members of the West Firing Group arrived, they couldn't tell what was *spot* fire, and what was *inside* fire. They couldn't see FF#1 or FF#2. The reinforcements started to scratch line along what they thought was the edge of a spot fire. The smoke was intense, some describing it as working in "chocolate milk." After a few minutes of digging, the reinforcements came to the drag line and then realized that they had been digging inside the burn block.

The time spent in the line building effort only delayed them a few minutes, but during this time, FF#1 and FF#2 were working about 100' away from the others and more toward the head of the second spot fire. The smoke was thick and visibility varied from 2' to 10'. Thick smoke in these conditions can be very disorienting. FF#1 yelled to FF#2, "Let's get the hell outa here!" He tugged the arm of FF#2 and they both began making their way back toward the point that they had anchored off the dragline. Within seconds, they were hit by a blast of intensely hot air. Perhaps from the shock of the heat, they both took some hot air into their lungs. The blast was very brief. They both felt the pain in their lungs but then the worst of the heat was gone. Still in thick smoke, they made it to the dragline and were joined by responding crew members from West Group. FF#1 and #2 fell into line with the rest of their crew and went to work building line around the spots.



After a few minutes, FF#1 felt tightness in the chest and short of breath. FF#1 told the Firing Boss who had just arrived, then moved into clean air to rest. FF#2 soon began feeling dizzy, had difficulty breathing, and joined FF#1. This may have gone unnoticed or seemed insignificant to the other crew

members since the heavy smoke had caused other firefighters on the spot to disengage and re-engage as a break from the smoke. FF#2 was sitting out of the smoke and told the Firing Boss, who was an EMT, of a burn on the left cheek. The Firing Boss treated FF#2 with burn gel but saw no sign of singed eyebrows or sideburns. The Firing Boss told FF#2 to take a break and then returned to work on the spot.

During the next 20 minutes, FF#1 and #2 repeatedly tried to work on the spot after resting periodically. FF#1 complained of not feeling well to other crew members and a squad leader. They noticed that FF#1 did not look well and that FF#1's left eye was cloudy and inflamed. The squad leader suggested that FF#1 return to the trucks (Point B) to seek medical assistance but did not relay this information to the Firing Boss. FF#1 agreed and told FF#2 to follow since FF#1 felt they both needed attention. At first, the squad leader thought it odd for FF#2 to be leaving but then felt it wise that FF#2 accompany FF#1. Just before leaving, FF#1 gave the assigned radio to another crewmember working the spot, promising to call the West Firing Boss via cell phone upon reaching the trucks. Within another 20 minutes or so, the reinforcements from West Ignitions and the Holding Group had successfully lined the spots.

Meanwhile, FF#1 and FF#2 left the spot fire and headed east to the de-limber pile. Seeing lights on the road, they turned and walked south through the burned area in a fair amount of smoke. They reached the road about 50' from the point at which the drag line left the road. They continued east toward the briefing site (Point B), attempting to avoid smoke but still felt dizzy and had trouble breathing. At different times, two other firefighters and OH#1 saw them walking on the road back towards Point B. None of these individuals noticed any particular concern with the way the injured firefighters were walking or their appearance. When FF#1 and #2 reached the trucks at Point B, FF#1 called Firing Boss West via cell phone to establish their location and that they needed medical assistance. They then took refuge in a truck. No one was there yet but the other overhead would arrive shortly.

The West Firing Boss, who is the regular supervisor for FF#1 and #2 and an EMT, called the Burn Boss via radio to request they meet so that the Burn Boss could be informed of the situation involving the injured firefighters.

Around 1100, the Burn Boss returned to Point B and found FF#1 and #2 sitting in the truck, looking pale and exhausted. The West Firing Boss and OH#1, on the way through the area en route to the District, joined the group. The three of them discussed the situation. There was no question they needed to get the firefighters to the hospital. The only question was, should they call an ambulance or just transport the injured themselves. It would be quicker to just drive them there and so that was their decision; OH#1 and the Firing Boss transported the two injured firefighters to Flagstaff Medical Center (FMC). Within about 25 minutes, the two injured were admitted to FMC's emergency room for evaluation.

The Burn Boss notified management regarding injury and transportation of the two injured firefighters; this included the FMO who contacted the District Ranger. The District Ranger then followed through with all of the administrative, Office of Workers' Compensation Programs (OWCP), and family contacts needed. While these notifications were made quickly and efficiently, it was not fully understood by all on the fire that the firefighters who were being transported had sustained injuries other than smoke exposure.

One of the senior staff noticed the vehicle leaving the burn and contacted OH#2 to inquire what was happening. Lacking a radio, the senior staff member was unaware of the traffic regarding the injuries. OH#2 had left at 1015 and did not know of the injuries either. So OH#2 contacted the FMO who passed on the information that the firefighters may have suffered burns and smoke inhalation. OH#2 then headed to FMC's emergency room, alerted the triage nurse, and awaited their arrival. When the injured firefighters arrived, OH#2 noticed that FF#1 appeared to be more injured than FF#2, later describing both as extremely pale and walking with difficulty as if dizzy. Both overhead personnel remained with the firefighters to facilitate treatment and serve as contacts for family, as well as assuring that if FF#1 and #2 were referred for burn treatment, burn protocols would be followed. Both firefighters were treated

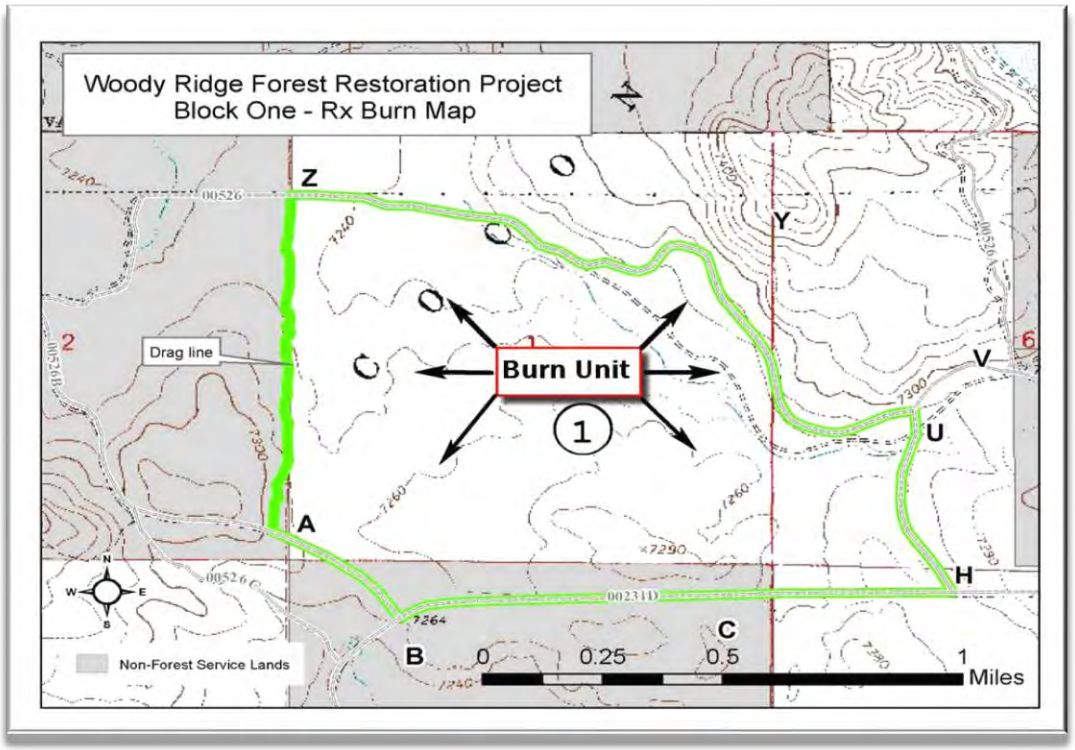
promptly, evaluated for approximately five hours, and released at 1600. Each had the next day scheduled off and thus were not required to report to work. FF#2 returned to work two days later and FF#1 five days later after taking three days of annual leave for personal business.

Remaining resources on the fire lined the spots and, after regrouping, fire leadership discussed the situation, including smoke impacts and spotting and whether or not to continue. They determined that adequate resources and overhead were available on site to continue. The West Group re-briefed and recommenced the project at 1200, completing it around 1600.

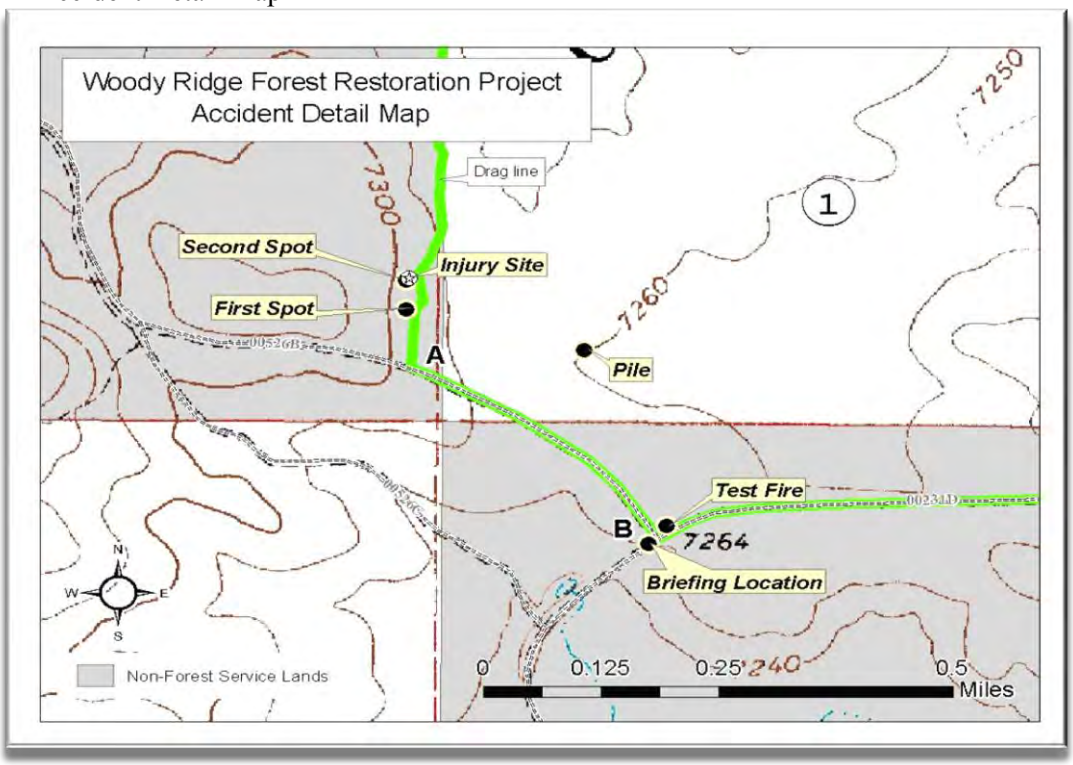
Upon returning to the District, resources learned of the potentially serious nature of the injuries. A District After-Action Review (AAR) was scheduled to be facilitated by a neighboring safety manager. The AAR was conducted and documented. The District Ranger and all the senior fire staff attended and discussed the actions and concerns from the previous day's operations. Subsequently, an Accident Prevention Analysis review was requested by the Forest Supervisor to follow up on the accident and issues surfaced in the AAR, and identify any lessons that could be learned by the agency as a whole.

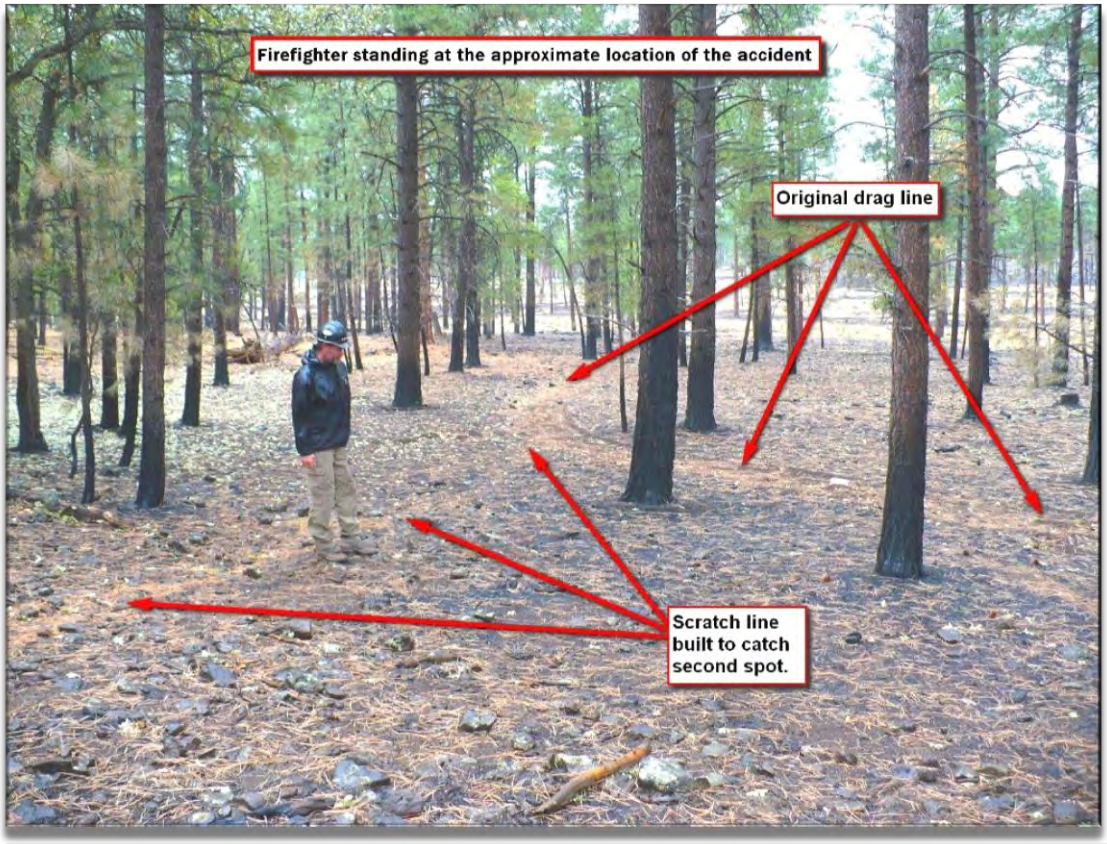
During the course of the APA review, it became apparent through interviews that the injured firefighters were still experiencing respiratory problems 10 days after the injury event and were undergoing continued treatment on an outpatient basis.

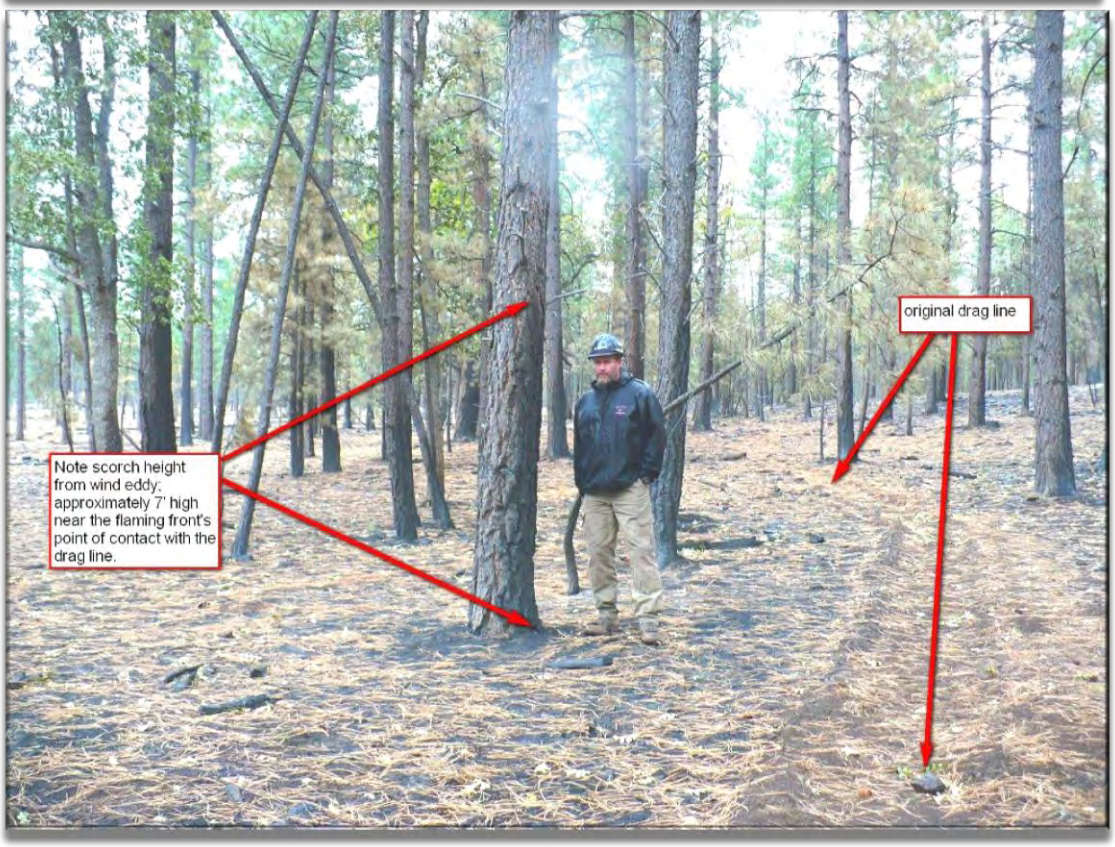
Project map



Accident Detail Map




Firefighter standing at the approximate location of the accident
Original drag line
Scratch line built to catch second spot.


original drag line
Note scorch height from wind eddy; approximately 7' high near the flaming front's point of contact with the drag line.

Lessons Learned Analysis

Every person interviewed for this accident met – and most substantially exceeded – the agency's minimum qualifications for that position. Everyone carried out their duties professionally and was highly motivated to achieve the objectives of the burn efficiently and safely. The decisions involved in carrying out the burn were in accordance with local customs and seemed reasonable – and even routine – to those making them, based on their understanding of the situation, their experience, their training, and their expectations.

Yet an accident occurred. Two firefighters on what seemed to many a fairly routine prescribed burn received a heat pulse hot enough to cause upper airway injury resulting in hospital treatment and left them at less than full capacity more than 10 days after the incident. Other firefighters received enough smoke to report as an injury and receive outpatient treatment.

The presumption of this Lessons Learned Analysis is that when a serious accident happens (such as the injuries on the Woody Ridge burn), the accident should serve as a warning that there are risks in the workplace that we may not be perceiving or managing correctly. Our focus is not primarily on compliance with procedural rules but on risk management choices.

In this particular case, the most serious injuries resulted from a rare combination of events. Chance plays a role in all accidents as it does in all successes. It is not clear that this type of accident can always be prevented and there is limited value in dwelling on how we *should have* prevented this accident. However, we can nurture a learning culture and incrementally become better managers of risk.

The emphasis throughout the APA process is on the conditions which supported the decisions – that is, the culture, organization, and the workplace environment that influenced how employees perceived and interpreted and reacted to risks. The likelihood of an identical accident happening is remote, particularly on the Coconino National Forest. Consequently, we are less focused on *this* accident than we are on the latent conditions incubating for the *next* accident. The team identified the following key decisions, actions, and behaviors. These are the signals or clues to identifying the conditions that influenced how risks related to this accident were perceived, understood, and managed on the project.

1. The decision to burn (the "go/no-go" decision) on September 22.
2. The organization and assignment of duties on the burn.
3. The ignition of the test fire during the briefing.
4. The focus on the de-limber pile, and on-scene changes to the firing plan.
5. The lead lighter's decision to retreat to the anchor point.
6. The custom and practice of relying on agency EMTs as medical resources.

Under the heading of "Cultural, Organizational, and Workplace Conditions," we have attempted to describe why each action seemed to make sense at the time – to see things as they were seen by the people involved so that we can better understand the conditions they faced and the organizational environment in which they operated. By understanding these conditions, we can better address risk management at the organizational level.

1. The Decision to Burn on September 22

Findings as to Risk

- Assumption of risk by the Agency Administrator was not clearly understood and communicated.
    - The District Ranger has delegated authority to District Fire Management Officers and the Fuels Specialist to "determine and sign the daily burn approval" for prescribed burns.
    - The District FMO approved the Agency Administrator Pre-Ignition Checklist on the morning of September 22 after a briefing and discussion with the assigned Burn Boss.
    - The Agency Administrator and District fire managers agree that they do not share the same level of urgency associated with meeting fuels treatment targets.
    - In the field, ignitions began without a clearly articulated "go" decision. The decision was assumed as much as made deliberately.
- The prescription called for winds of 1-12 m.p.h. at mid-flame. Predicted 20' winds were 10-15 m.p.h., with gusts to 30 m.p.h. Observed eye-level winds at the moment of ignition were 10-15 m.p.h., which equates to sustained mid-flame winds of just over 10 m.p.h.
    - Winds increased spotting, risk of escape, and risk to firefighters associated with attacking spots, requiring additional mitigation and changes in firing plans that were not adopted until the burn was underway.
    - Winds increased smoke exposure for firefighters.

Cultural, Organizational, and Workplace Conditions

For several years, District Fire Management Officers on these Districts have completed and signed, as agency administrator, the approval for the burn. This practice originated under a previous district ranger and continued under the current administration. The delegation is documented in a letter signed annually by the District Ranger. The Ranger approved the overall burn plan (in September 2008), and is notified prior to ignition of individual blocks.

These Districts have a very active burning program with a strong track record of accomplishment. They always meet and generally exceed targets. The two Districts burn at least 10,000 acres a year, mostly in small blocks of 100-200 acres. They burned 78 days in FY 2009.

District fire management personnel are highly motivated to accomplish their fuels treatment objectives and targets. They are highly experienced firefighters with a long history in the community. Treatments in the wildland-urban interface are designed to protect communities at high risk of wildfire. A sentiment heard frequently during this review was the desire to "fireproof Flagstaff."

In recent years, smoke management has become a dominant concern. The Arizona Department of Environmental Quality (ADEQ) closely monitors smoke from prescribed burns and issues specific permits for each burn, either the evening before, or the morning of, the burn. Local communities are in frequent contact with agency administrators, interest groups have organized to oppose burning because of health concerns with smoke, and it is not unusual for burns to be scheduled around local athletic events. The distribution of surrounding communities, many of them in basins or valleys where smoke accumulates, makes smoke management complex. Every person associated with the go-no go decision emphasized the challenges of smoke management and the importance of taking advantage of good ventilation days.

Northeast winds were predicted for September 22 – exactly the direction to carry smoke away from Flagstaff. ADEQ approved an unusually large block (650 acres) to be burned that day. The predicted winds were viewed as a good thing.

"Wind is our friend when it comes to emissions control. We do a lot of burning on windy days."

Fire managers shared a belief that smoke management windows and ADEQ approvals are precious and wind is beneficial in dispersing smoke. A strong work ethic with focus on target and mission accomplishment contributed to a sense of urgency. Once given the ADEQ approval, approving the "go/no-go" decision seemed routine.

The District Ranger and acting Forest Supervisor did not share quite the same sense of urgency around targets and burning windows as the fire management staff in the field. Both fire management staff and agency administrators acknowledged that the fire managers were self-motivated to get the job done; agency administrators trusted their judgment and were not directly involved in the "go/no-go" decision.

The consequence of burning on windy days is that it increases firefighters' exposure to smoke. Firefighters accept intense smoke exposure to protect civilians from light or moderate smoke. This tradeoff, never explicitly stated, is reinforced by cultural norms on each side. Local communities are increasingly reluctant to accept any smoke exposure. Meanwhile, firefighters

are taught to accept smoke – even very heavy smoke – as a routine if sometimes unpleasant aspect of their work.

Fire managers recognized high winds as increasing firefighters' exposure to smoke and also the risk of escape. The District had conducted and documented an after-action review on a fire that escaped under similar conditions the previous fall. But risks to firefighter safety from the burn were considered very low. These Districts had completed many burns under similar conditions without serious incident. The safety message at the briefing that morning emphasized slips, trips, and falls.

As the briefing began on the morning of September 22, a fire manager lit a test fire. This was done both to fulfill a technical requirement and to communicate a sense of urgency. The test fire wasn't a "test" per say as there was really no doubt among any of the leadership involved that the burn would, and should, go forward.

2. The Organization and Assignment of Duties on the Burn

Findings as to Risk

- The participation of senior District fire managers in the burn inadvertently undermined the authority of assigned leadership and created an informal organizational environment in which these managers could assign themselves somewhat independently creating unclear roles and responsibilities on the burn.
    - This was the Burn Boss's first opportunity to lead a prescribed burn, having been certified in June 2009. The Burn Boss's assumption was that if there were things not going right, the senior District Fire Managers would speak up; whereas the senior District Fire Manager's assumption was that they should let the Burn Boss manage the entire burn and would only become involved if there was a major incident (e.g., major escape) or the Burn Boss asked for help.
    - Most District/Zone senior fire managers (both FMOs, AFMO, Fuels Specialist) were present for some or all of the burn. Some were assigned and operated as firefighters on ignitions or holding crews. Others were not clearly assigned to a particular role.
    - Most senior managers present on the burn reassigned themselves fairly freely, pitching in wherever needed.
    - Senior managers did not really play a coaching/mentoring role for assigned leadership and this role was not delineated in advance.
- The balance of lighting and holding resources was (as recognized in the AAR) not aligned with risk presented by wind.

- The operations plan assigned as many as 27 firefighters, under two Firing Bosses, to ignitions (15 to Ignitions West, and 12 to Ignitions East), and 7 firefighters to Holding.
- Under the windy conditions present, resources had to be reassigned almost immediately, requiring on-spot adjustments to the plan and organization.

Cultural, Organizational, and Workplace Conditions

The Districts' fire organization is deep and experienced in fire suppression and prescribed fire. Engine captains serve as burn bosses. Most senior managers have more than 20 years' experience in Arizona, serve in command and general staff positions on IMTs, and have conducted hundreds of successful prescribed burns. The Districts work actively to build experience and qualifications among their mid-level leaders by providing assignments (within qualifications) for developing leaders, even when more highly qualified personnel are available.

"What better environment – let your folks take leadership; you're there as backup."

The Districts assign each engine an area of response, within which the Engine Captain is responsible for preparing the block for burning and leading the burn as Burn Boss. This ensures that the Burn Boss is intimately familiar with the ground beforehand and prepared to lead implementation.

On September 21, the assigned engine, along with the fuels crew and other resources, completed preparation of the burn block. The key individuals involved in the events of September 22 had spent the previous day on site and understood the fuels, layout, terrain, and holding lines. The Engine Captain had completed certification as Burn Boss during the summer. This was the Districts' first burn of the fall season and the Captain's first opportunity to lead a burn.

The block of ponderosa pine with a grass understory had been thinned heavily. Slash had been piled and burned in the winter and fuels were relatively light, except in a narrow strip along the west line where untreated State land was included in the burn for operational considerations. The block was larger (650 acres) than usual and smoke management considerations favored completing the burn early, so almost all available District fire resources participated. Most were assigned to ignitions to better meet objectives in the light fuel.

Senior District fire managers were present to provide general support and oversight, to maintain operational participation in their program, and as a security/contingency resource to the Burn Boss and assigned burn leadership. In interviews, each of them stated something along the lines of: "When I'm there, I'm just a torch carrier. The Burn Boss is the leader." But operationally, senior managers reassigned themselves fairly informally, wherever they seemed most needed, and somewhat outside the established burn organization. Some of them were not clearly assigned to any particular role.

Senior leadership on site were serving dual and proper functions. They were there to increase or enhance production and they were there to be defenders against failure. The agency encourages and expects leadership to be actively and visibly involved in wildland fire projects. The issue is that the presence of senior fire management on the project created an unacknowledged cultural dynamic relative to the assumption of risk. The Burn Boss felt that senior managers – at least passively – were monitoring risk. *If they weren't speaking up, everything must be okay*. Meanwhile, the managers felt that they ought to avoid speaking up (unless something very bad was happening) to avoid undermining the Burn Boss's authority.

Two additional conditions--norms common in the agency--added to the casualness of this burn organization. First was a general assumption that prescribed burns are less risky and don't require the same organizational formality as wildfires; that is, *routine project work*. Second was the fact that this project was carried out on their home unit by employees with whom they'd worked for many years.

3. The Ignition of the Test Fire During the Briefing

Findings as to Risk

- A senior fire manager ignited the test fire just as the briefing was getting started and without checking with the Burn Boss:
    - undermining the authority of assigned leadership;
    - distracting from and cutting short the briefing; and
    - minimizing the importance and value of the briefing.

Cultural, Organizational, or Workplace Conditions

A test fire is a required step prior to commencing full-blown ignitions. Policy makers intend test fires as a risk mitigation technique – to observe actual fire behavior, check conditions, and determine if objectives can be being met. Test fires are in fact used this way – when burning under new or unusual conditions or by less experienced teams.

Senior fire managers on the Districts are very experienced with local conditions and fuels. This was a routine burn; they knew how the fire would behave. From their standpoint, the test fire was unnecessary as a test, but was simply a procedural step that had to be checked off.

Since test fires must be completed anyway, senior fire managers sometimes use them as motivational aids. More than one said during interviews that crews tend to stand around for a while gathering up and need a little encouragement to get started. The line needs to be blackened

anyway, the burn needs to be started and completed early and efficiently, and the test fire is a visible mark on the ground.

The test fire achieved its purpose as a motivational aid. Though some participants disagree, most say the briefing was cut short. Breakout briefings (Ignitions East, Ignitions West, Holding) were conducted quickly and ignitions began as each group finished. People got moving. The message was clear: let's get going! No real "go" decision was necessary – there was already fire on the ground.

Across the agency, test fires are used for different purposes: to see if the fire will carry, to see if the fire will accomplish objectives, to test holding. Experienced fire managers operating in familiar fuels and weather conditions will often shortcut this standard. This exposes a values difference (a gap) between policy makers and those who implement the policy.

4. The Focus on the De-Limber Pile, and On-Scene Changes to the Firing Plan

Findings as to Risk

- Very soon after ignitions began, most of the West Group igniters, including the Firing Boss and some senior fire management, diverted action and attention to lining a very large pile of slash left by processing in logging operations:
    - leaving the remaining West Group lighters without operational oversight;
    - requiring immediate changes to the firing plan and;
    - distracting firefighters from the planned course of action.
- Without operational oversight, there may have been insufficient attention to line spacing, resulting in the first two igniters getting too far apart and allowing the second lighter's fire to accumulate heat and momentum in a wider gap of unburned fuel.

Cultural, Organizational, or Workplace Conditions

A very large pile of woody material left by de-limbing operations lies 511' from the west line. This pile was recognized during preparation on September 21, but judged not to present a problem. .

On September 22, with higher winds, everyone interviewed agreed that the de-limber pile presented a threat to holding operations. Fire in the pile would burn for a long time and might throw burning embers far across the line. This was not accounted for in the briefing, but almost immediately after ignitions started.

West Group lighters were closest to the pile and it impeded their operations. Lining the pile wasn't really a holding action, but a completion of preparation. It isn't uncommon for ignitions personnel to clean up minor unfinished preparation work as they run across it during firing operations. And there were plenty of lighters available. It made sense to the Firing Boss to stop lighting and pull most of the lighters over to line the pile. Senior managers went to the pile to help – this was where they were most needed.

Assessment of risk is culturally different on a prescribed fire than on a wildfire. For example, spotting is a greater focus on a prescribed fire where we need to "keep it in the box" to prevent an escape. Likewise, risks to firefighters are assumed to be much less on a prescribed fire, which is thought of more as a project and less as an emergency. One way this is manifested is that on a wildfire, splitting a crew would virtually always involve ensuring leadership was assigned to each resource. On a prescribed fire, particularly on your home unit, the organization is not as structured, creating the potential for span of control and supervision issues. Across the agency, we don't think of prescribed fire the same way we think of wildfire.

5. FF#1'sDecision to Retreat to the Anchor Point

Findings as to Risk

- FF# 1, attacking the spot fire, felt a need to move to safer ground and headed back toward the last known anchor point, taking FF#2..
    - Neither firefighter was aware that they were moving toward an intense heat source (FF#2's fire).
    - Both firefighters were exposed to an unexpected blast of hot air, injuring their airways and causing a minor burn to one firefighter's face.

Cultural, Organizational, or Workplace Conditions

FF#1 & FF#2 determined that they alone would be unable to catch the second spot fire and radioed for assistance. Fire activity was growing more intense and FF#1moved back toward the last known anchor point along the drag line, bringing FF#2 along to protect their safety and regroup with the rest of the crew.

In training and briefings, firefighters are taught to "keep one foot in the black" and to step into the wind away from their fire. FF#1 was doing both – moving into or along the spot fire edge "the known black" and into the wind, back toward the anchor point.

With perfect hindsight, moving north – perpendicular to the spot and toward the head of the fire – might have offered a safer retreat, away from FF#2's oncoming fire. But FF#1's actions were consistent with training and understanding of the present situation. The Firefighters' recognition of the changing conditions was met with the resolve and intention to maximize their safety. There were numerous unknowns that become only clear in hindsight. The oncoming fire was not visible in the very heavy smoke and everything took place in a matter of seconds.

FF#1 had lowered the shroud while working on the spot fire. FF#2 was not wearing a shroud. The blast of hot air hit without warning and both firefighters' airways were injured. FF#2 (without the shroud) also received a mild burn on the cheek. The FF#1 (with the shroud) appears to have received more serious airway injuries. It is possible that the presence of the shroud reduced the instinctive response to protect the airway, but this is a question that has not been answered definitively in the safety community.

Airway injuries from a short pulse of hot air in a non-extreme (non-entrapment) situation are rarely reported. This may be because the combination of events experienced here is very rare. Normal instinctive protection of your airway prevents most such injuries. It may also be that some airway injuries are under-diagnosed and/or underreported.

6. The Custom and Practice of Relying on Agency EMTs as Medical Resources

Findings as to Risk

- Leadership may have unconsciously assumed that the presence of several agency EMTs provided sufficient medical resources to respond to injuries without providing a detailed medical plan or documenting their expectations of the EMTs:
    - assuming more risk mitigation than was, in fact, provided;
    - assuming that care would be provided without an explicit plan;
    - equipment available, including oxygen, was not inventoried or fully utilized; and
    - potentially using EMTs beyond their training, capabilities, and equipment.
- Agency EMTs were generally the same engine captains assigned to key leadership roles on the burn (role conflict).
    - Agency EMTs are implicitly expected – or expect themselves – to perform double roles
    - Firing Boss West, an EMT, saw the two injured firefighters shortly after the incident and treated the facial burn with a topical ointment. The EMT was too distracted by duties as Firing Boss West (responsible for some 15 igniters) to perform a full assessment and did not recognize their airway injuries.

- The injured firefighters were treated and released from the ER after less than five hours and returned to full duty within a few days according to the normal schedule. Ten days later, when interviewed by the APA team, neither firefighter felt that they had fully recovered. Both were still using inhalers to help them breathe.

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Several EMTs (at least four or five) were present on the fire, including Firing Boss East, Firing Boss West, and other engine captains. The medical plan included in the burn plan was general and made no specific mention of EMTs, but it might have been assumed that EMTs could provide first responder medical care in the event of an injury.

Firefighters are often encouraged to get EMT qualifications to help provide safety. EMT qualifications are also perceived as a career enhancer. Having EMTs on hand provides a clear benefit to injured employees. Yet the agency has not established an official role for EMTs – this role isn't identified in their job description.

The common perception that prescribed fires are less risky also affected the medical planning. No formal medical plan or dedicated medical personnel were thought to be necessary for a prescribed burn where the most likely injuries were twisted ankles, falls, and smoke exposure.

Airway injuries from heat pulses are not commonly recognized in situations other than entrapments. Smoke exposure, on the other hand, is an experience shared universally by wildland firefighters, especially on prescribed burns. Firefighters often have to step out of the smoke to get clear air in their lungs. Although the Lead Igniter told a couple of people of not feeling well, this was initially interpreted as a "normal" case of smoke exposure. While there is some discrepancy in what witnesses recall was said by the injured firefighters, the point is that many people were affected by the heavy smoke and some amount of pain was assumed.

Interagency policy on referrals to burn centers has received much recent attention. District personnel on scene at the hospital were knowledgeable, raised the burn center question, and handled it professionally. Yet both firefighters were released to full duty without referral to a burn center (which would be in Phoenix). Similar stories are common among wildland firefighters.

Recommendations

The following recommendations were generated from lessons learned on the September 22, 2009, accident on Woody Ridge Prescribed Fire. The hazards and risks described below have mostly and promptly been addressed locally on the unit that experienced this accident. In the judgment of the APA team, these recommendations are regional and national in scope and application.

1. – Enhance training for prescribed burning leadership with respect to smoke management, protection of airways, and leader's intent for test fires.

- Manage the risks associated with smoke exposure to firefighters.
  Background: On the Woody Ridge Burn, numerous firefighters were exposed to very heavy concentrations of smoke. Some firefighters reported suffering headaches, heavy coughing, and a sore throat for several days following the burn. On the Woody Ridge Burn, highly competent professional expertise was used to protect smoke-sensitive target areas from smoke, yet less emphasis was placed on protection of our employees from that same smoke. Indeed, the impetus to burn on an especially windy day was specifically to decrease risk of smoke exposure to communities – knowing the high winds would ***increase*** the smoke exposure to our employees. This is a common tactic used by prescribed burning managers throughout the agency. The APA team recognizes that Forest Service fire managers have a culture normalizing and accepting the risks of smoke exposure to firefighters even though we do not fully understand the severity or magnitude of these risks. **The APA team recommends a regional and national effort to teach our burn planners and holding, ignition, and burn bosses to actively manage smoke exposure to firefighters.** There are a number of techniques we can teach our fire managers to routinely employ in burning operations, including, perhaps most obviously, frequently rotating holding crews into clean air. Other techniques can be analyzed and addressed through the development of this training.

- Re-emphasize the importance of protecting airways from hot gasses.
  Background: On the Woody Ridge Burn, two prescribed burners experienced respiratory injury when they momentarily breathed in hot air while trying to contain a spot fire. The APA team believes there is value in reminding firefighters and prescribed burners (nationwide) to be vigilant of the risks of injurious hot air in fire environments that do not otherwise seem unreasonably hazardous. Specifically, the **APA team recommends that this accident be used in agency-wide prescribed burning and wildland firefighter refresher training as an example of how quickly employees can get themselves into a very hazardous situation and that they should strive to always be cognizant. As one of the injured firefighters stated, "*It's not the smoke that hurt us. It was the heat!*"**

- Re-emphasize leader's intent, need for, and value and purpose of test fires.
  Background: On the Woody Ridge Burn, the test fire was generally acknowledged to be a perfunctory task. Shortcutting the required test fire protocol frequently seems reasonable in a wide variety of situations, particularly to our most experienced and professional burners and particularly when they are working in familiar fuels and weather conditions. Test fires, when done according to protocols, take time and, in some situations, can take a great deal of time. Experienced burners recognize that test fires are a cost of production and clearly test fires do not always seem to be worth this cost. On the other hand, prescribed fire policymakers and the designers of our interagency prescribed burning protocols intend for the test fire to be the last final check (though often a redundant check) to ensure that the risks of escape and not meeting objectives are being managed. With respect to conducting test fires, there is often a wide gap between how risks are expected to be managed by the procedure designers and how risks are actually managed in the field. **The APA team recommends a regional and national effort to teach our burn bosses and trainees the leader's intent, need for, and value and purpose of test fires.**

2. – Organize to manage prescribed fire as wildland fires.

Background: Due to a number of factors, the Woody Ridge Burn grew in complexity beyond what was anticipated when the Burn Boss and others were preparing the site and contemplating organizational strategies. Organizationally, supervision and span of control became problematic and risks to firefighters increased in ways that were not appreciated nor anticipated. Notably, there are significant differences between how we organize for prescribed burning operations and how we organize for managing wildland fire. The APA team believes these differences were directly related to the Woody Ridge Prescribed Burn accident. Ironically, prescribed burning is almost always conducted by the agency's experts in emergency ***high-reliability organizing***--as was the case in the Woody Ridge Burn.

Because we as an agency recognize the risks associated with wildland fire, we teach, mentor, and expect our fire ground commanders to organize for high reliability. However, as an agency, we presume and operate as if prescribed burning is less risky to firefighters than wildland fire. For example, wildland firefighters receive special hazardous environmental pay; prescribed burns do not. Another way this perception of greater and lesser risk is manifested is the formality of structure and organization, particularly with respect to span of control and supervision. Managing a prescribed burn as a wildland fire would entail, among other things, developing an incident management plan, formalizing roles and responsibilities of unassigned resources, formally involving section chiefs in risk mitigation, providing formal structured and facilitated briefings, and maintaining a very strong emphasis on managing span of control and supervision.

The APA team recommends that the Region and the agency manage prescribed burning projects similar to wildland fire, tightly structured under the Incident Command System, with command and general staff functions identified, and structured organizational control designed to expand as necessary to meet evolving risks. The APA team acknowledges this change might make some prescribed burns more expensive--particularly so for moderate and complex burns. However, the field leadership conducting prescribed burning is by and large already trained and fully competent to do so. Therefore, the transition to managing prescribed fires as wildland fire can be practically immediate both nationally and within the Region.

3. – Provide counsel on the risks and benefits of shrouds and respirators as optional personal protective equipment.

Background: The APA team noted that while both of the injured firefighters on the Woody Ridge Prescribed Fire were in the same location, the firefighter who was wearing a shroud sustained more serious airway injuries than the firefighter who had no shroud. This fact brings to light the national dissonance and ambiguous direction concerning use of shrouds. The "MTDC Tech Tip" in Appendix B contains essentially the only national advice on the use of shrouds, stating: ***"Do not proceed with assignments that are too risky just because you are wearing or carrying personal protective equipment such as the face and neck shroud."***

Clearly lacking is a consistent national awareness of the risks and benefits of shrouds and clear national counsel to firefighters giving them recommendations on when shroud use might amplify risk versus amplify safety. **The APA team recommends that the agency put forth an updated briefing paper on the risks and benefits of shroud use so that firefighters can make better informed risk management decisions.**

Background: The APA team noted that several firefighters involved in the Woody Ridge Burn were furnished neoprene-framed, tightly fitting, "Hepa-Type" filtration respirators. These respirators reduce some of the particulates in smoke and can make working in very heavy smoke concentrations more comfortable. These respirators do not, however, filter or reduce carbon monoxide. The obvious concern is that use of these respirators may provide enough comfort in high smoke concentrations to permit our employees to remain in these environments longer with consequent greater exposure to carbon monoxide. **The APA team recommends the agency put forth an updated briefing paper on the risks and benefits of tightly fitting "Hepa-Type" respirator use so that firefighters can make better informed risk management decisions.**

4. – Establish policy on the role, purpose, need and expectation of agency emergency medical technicians.

Background: It is common throughout the agency in both wildland fire and prescribed fire operations to identify agency employees who are emergency medical technicians and list them on medical plans or otherwise use them as contingencies in the event of an injury. On the Woody Ridge Burn, an EMT was called upon to assess, treat, and assist in transporting the injured employees. This EMT was assigned a leadership role on the burn that had nothing to do with and conflicted with serving as an EMT. The individual's EMT "role" was never identified nor even expected until the accident happened.

While the agency has hundreds of EMTs throughout the organization, there is no defined purpose, role, need, or competency standard for an agency EMT. The function and leadership expectation of an agency EMT varies from unit to unit across the agency. On some units, there is a strong incentive to attain EMT certification as it can benefit career advancement and even job selection opportunities. Some units fund employees to obtain EMT training and certification and some do not. Some fund extensive medical equipment and some do not.

EMTs who routinely respond to civilian accidents either as a recognized component of their duties or as sideline work with ambulance services have a profoundly different skill level than do EMTs who rarely become involved in any medical response. Yet we do not recognize this difference and, in fact, have no standard for skill levels or even medical response equipment. Lacking agency support, some of our agency EMTs even provide medical supplies from their personal resources.

As an agency, we are conflicted and provide inconsistent messages to agency EMTs. This has resulted in a clear lack of leadership and doctrine on the issue. The consequence is that we put our agency EMTs in situations of ambiguous risk without the agency structure or policy to support them. Leadership at many levels throughout the agency presumes (sometimes stated, sometimes unstated) that the presence of EMTs is risk mitigation. Yet this mitigation is neither defined nor quantified in policy or practice. **The APA team recommends the agency provide clear doctrine and policy on the purpose, role, and function of an agency EMT. Lacking national direction, the Region can locally ameliorate many assumed risks by defining EMT roles and expectations and providing EMTs with a support structure that quantifies competency.**

Chronology of Events, Appendix A

(All times are approximate.)

Date	Time	Event
09/21/09	1400	Overhead requests ADEQ smoke permit.
09/22/09	0717	Holding engine leaves en route to burn site.
	0720	Agency administrator pre-ignition checklist completed and signed.
	0749	Additional engines and lighting crew leave for burn site.
	0757	Additional overhead leave for burn site.
	0800	District Ranger notified by phone of decision to burn. On-site weather observations recorded as: NE winds @ 8-10 mph, gusts to 15 m.p.h.; 50° F., relative humidity: 60%.
	0808	Additional holding forces dispatched.
	0812	Personnel on site request spot forecast.
	0820-0855	Holding, firing, and additional overhead arrive on site.
	0830	Burn Boss, Firing, Boss, Holding Boss hold a pre-briefing on site.
	0850	Wind update from NWS: 25 m.p.h. gusts, not 30. Relayed to burn site: 20' winds NE @ 10-15 m.p.h.
	0906	Flagstaff RAWS: 55° F., 22% relative humidity, NE winds @ 14 m.p.h. with gusts to 28 m.p.h.
	0909	Burn briefing and test firing begin.
	0920	Pie ball launched. Ignitions begin (east).

	0920-0925	Ignitions begin (west).
	0925-0945	Spots reported on west side near Point A. Next call: firefighter reports in, saying unable to catch the spot. Numerous lighters and engines respond to spot. Two firefighters sustain airway injuries at approximately 0930. By 0945, spots contained.
	1000	Injured firefighters directed to return to trucks for attention. They leave spot and begin walking to their truck near the briefing spot.
	1006	Flagstaff RAWS: winds NE at 15 m.p.h. with gusts to 26 m.p.h., 58° F., relative humidity 18%.
	1015	First overhead depart fire for station.
	1030	Firefighter sees the injured firefighters walking toward the briefing spot along the west road.
	1045	Injured firefighters arrive at truck.
	1100	Burn Boss observes injured firefighters at truck, calls for EMT.
	1106	Overhead personnel, EMT, and 2 injured firefighters en route to hospital.
	1131	2 injured firefighters arrive at emergency room.
	1200	Operation resumed on burn unit.
	1600	Injured firefighters released from hospital.
	1642-1800	Resources released.
	1900	Burn Boss reports that all resources have returned to station.

Fire
Tech Tips

United States Department of Agriculture
Forest Service
Technology & Development Program
June 2004
5100 0451-2323–MTDC

Improved Face and Neck Shroud for Wildland Firefighters

Lori Messenger, Project Assistant, and Tony Petrilli, Project Leader

The Missoula Technology and Development Center (MTDC) developed a detachable face and neck shroud to protect wildland firefighters from radiant heat without compromising work performance or comfort. The shroud was developed after face and neck shrouds and balaclava-style hoods were tested at the University of Montana Human Performance Laboratory in Missoula, MT.

Firefighters should not use the face and neck shroud to work in areas that are more dangerous than those they would work in without the shroud. ***Do not proceed with assignments that are too risky just because you are wearing or carrying personal protective equipment such as the face and neck shroud.***

The new face and neck shroud was designed with the same Nomex material as the yellow Nomex shirt worn by wildland firefighters. It attaches to a hardhat easily with its hook and pile (Velcro) fastener (figure 1). When the shroud is not needed, it can be removed or rolled outside of the hardhat and fastened to itself above the bill (figure 2). When the shroud is being used, firefighters can secure it around their throat and face using the hook and pile fastener sewn to the front of the shroud (figure 3). For maximum protection, firefighters should adjust the shroud to fit comfortably loose. The face and neck shroud meets requirements set by the National Fire Protection Association (NFPA) Standard 1977, *Protective Clothing and Equipment for Wildland Firefighters*.

Because firefighters are statistically more likely to suffer from heat stress than to be injured by radiant heat, MTDC has designed personal protective clothing primarily to let body heat escape, rather than to shield workers from the heat of a fire. The face and neck shroud is not intended to be worn continuously, because it would interfere with the body's ability to cool itself efficiently. The shroud is not an airway filter, and has only a limited ability to protect firefighters from smoke, ash, or other small particles.

Figure 1—Attaching the shroud to the helmet using the hook and pile fastener.

Figure 2—Shroud rolled over the helmet brim.

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Figure 3—Shroud unrolled to protect the face and neck.

You should wear your shroud during entrapments, when moving past areas of intense heat, or when leaving other situations that occur suddenly (such as when a fire flares up). Do not use your face and neck shroud to remain in places that are hotter than you could tolerate otherwise.

Exposed skin is your best indicator of extreme temperatures. Do not cover your most reliable thermometer—the exposed skin on your face and neck—unless you must.

About the Authors—Lori Messenger joined her first fire crew at the Boise National Forest in 1997, then moved to the Union Hotshots. She became a Missoula smokejumper in 2000, after receiving her master of fine arts degree in creative writing from the University of Pittsburgh. Lori has spent many winters coaching cross-country skiing and teaching creative writing to young people. During the spring of 2003, she began teaching basic firefighting classes in Missoula. She completed a part-time detail at MTDC that summer.

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Library Card—Messenger, Lori; Petrilli, Tony. 2004. Improved face and neck shroud for wildland firefighters. Tech Tip 0451-2323-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 2 p.

Describes a new face and neck shroud the Missoula Technology and Development Center developed to protect wildland firefighters from radiant heat. Hook and loop fasteners attach the shroud to the firefighters' hardhat. The shroud is intended only for temporary protection during entrapments or when leaving areas after the fire has flared up suddenly. The shroud should not be used at other times because it prevents the body from cooling and also prevents firefighters from feeling just how hot the fire really is.

Keywords: clothing, fire fighting, firefighting, helmets, personal protective equipment, safety at work

Single copies of this document may be ordered from:
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Electronic copies of MTDC's documents are available on the Internet at:
http://www.fs.fed.us/eng/t-d.php?link=pubs

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