Upper Lyons Prescribed Fire Entrapment and Fire Shelter Deployment
Facilitated Learning Analysis

"This firefighter did just what managers and supervisors expect all personnel to do when entrapped: 'Follow your training and use your fire shelter without hesitation.' This firefighter is alive today because the firefighter did not delay in deciding to deploy the fire shelter."

The FLA Team

Incident Date

October 13, 2014

"It all happened pretty quickly."

Burn Boss Trainee referring to the entrapment and fire shelter deployment that occurred on the Upper Lyons Prescribed Fire in Redwood National Park on Oct. 13, 2014.

Contents

1. Summary

Number and Type of Injuries

One individual with second degree burns to the left hand and first degree burns to the right hand and face.

Narrative Summary

On October 13, 2014, firefighters were conducting a prescribed fire in the Bald Hills Area of Redwood National Park.

Crews were burning off of a handline when a combination of factors aligned to cause several spot fires in heavy fuels outside the unit. These spot fires burned together to form multiple slopovers.

A decision was made to suspend ignition until an assessment of the slopovers could be completed. At approximately that same time, a firefighter who was hiking up the fireline became entrapped due to intense heat and dense smoke. As a result, this firefighter deployed their fire shelter on the handline.

The firefighter was quickly located and escorted a short distance out of the smoke and heat. The firefighter, immediately assessed by an onsite paramedic, was able to walk—with some assistance by others—to an area where a vehicle was waiting to transport them to a landing zone.

The firefighter, accompanied by a flight nurse, was airlifted to Shasta Regional Hospital for treatment. The firefighter was released a short time later and referred to the University of California Davis Burn Center for follow-up the next day.

The diagnosis from the specialist at the burn center was second degree burns to the left hand and first degree burns to the right hand and face. Over the next several weeks, the firefighter received follow-up treatment at the burn center.

Significant Note

During the Facilitated Learning Analysis (FLA) process, the firefighter continued to emphasize the profound role that previous fire shelter training played in the successful deployment of the firefighter's shelter during this event.

2. Incident Narrative

Monday, Oct. 13, 2014
0800 Hours

A Mix of Resources
At 0800, prescribed fire personnel and equipment (resources) met at Redwood National Park's South Operations Center in Orick, Calif.

The mix of resources included:

- The local unit federal Service First[1] Interagency National Park Service and U.S. Forest Service personnel;
- Local government and non-governmental personnel, including The Nature Conservancy (TNC) Training Exchange (TREX) representing fire-qualified participants hosted by Redwood National Park. (The TREX program is a collaborative training effort provided through cooperative agreements between The Nature Conservancy, Department of the Interior agencies, and U.S. Forest Service. TREX burn teams are built to be fully qualified and fully functional. They include a range of experience and skills expected to be on an organized prescribed fire module. TNC's Fire Learning Network spearheads TREX events and provides funding and other support across the country. Part of the TREX mission is to serve federal agencies and provide training to federal agency staff.)

Redwood National Park has a successful history of encouraging participation in its prescribed burning program. The TREX program provides participants from both non-governmental agencies (NGOs) and governmental agencies training and experience in planning and implementing prescribed burns. During 2013, TREX was used on multiple prescribed fires in the Park.

Prior to traveling to the burn unit, an organizational briefing for the TREX participants was held at the South Operations Center.

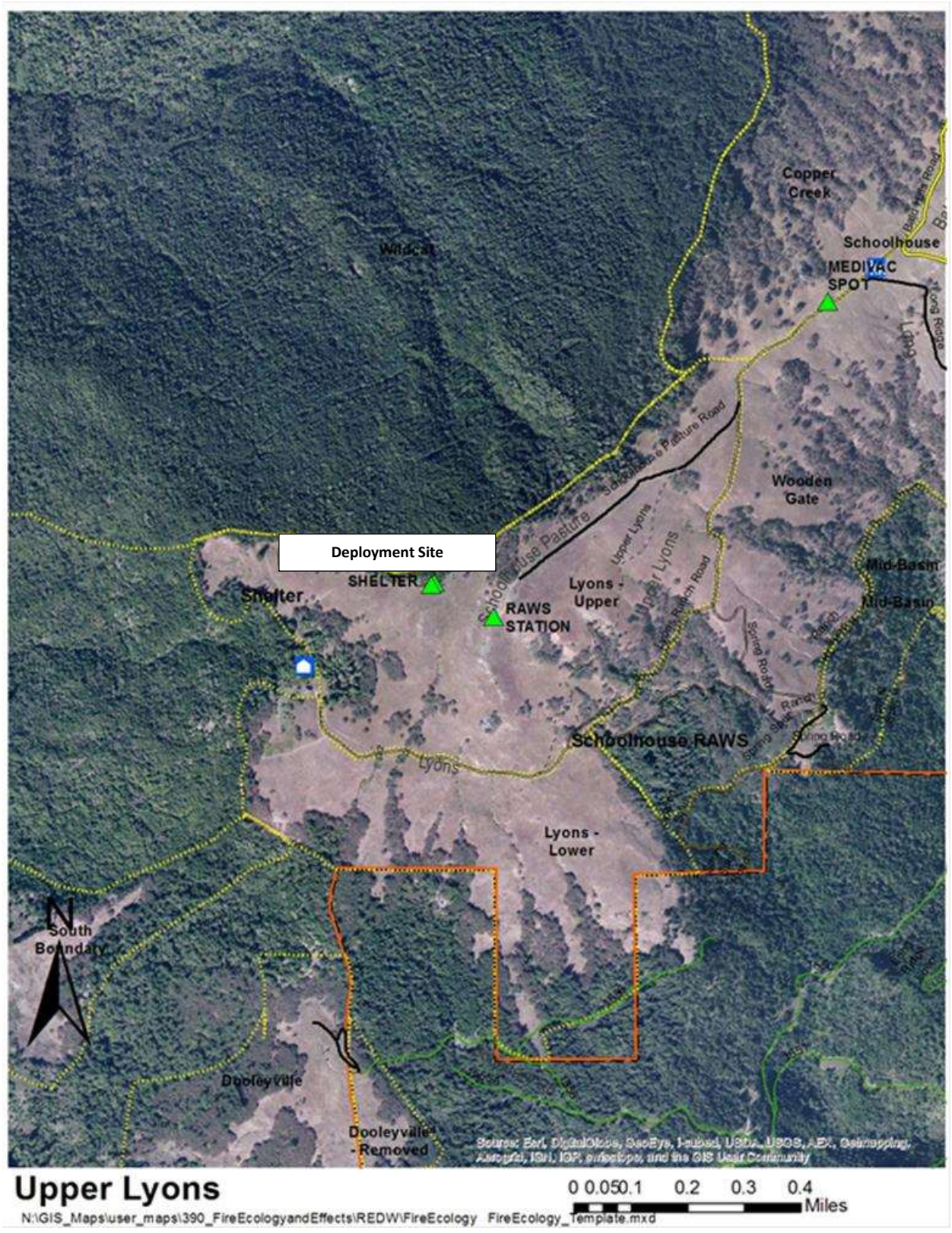
1000 Hours

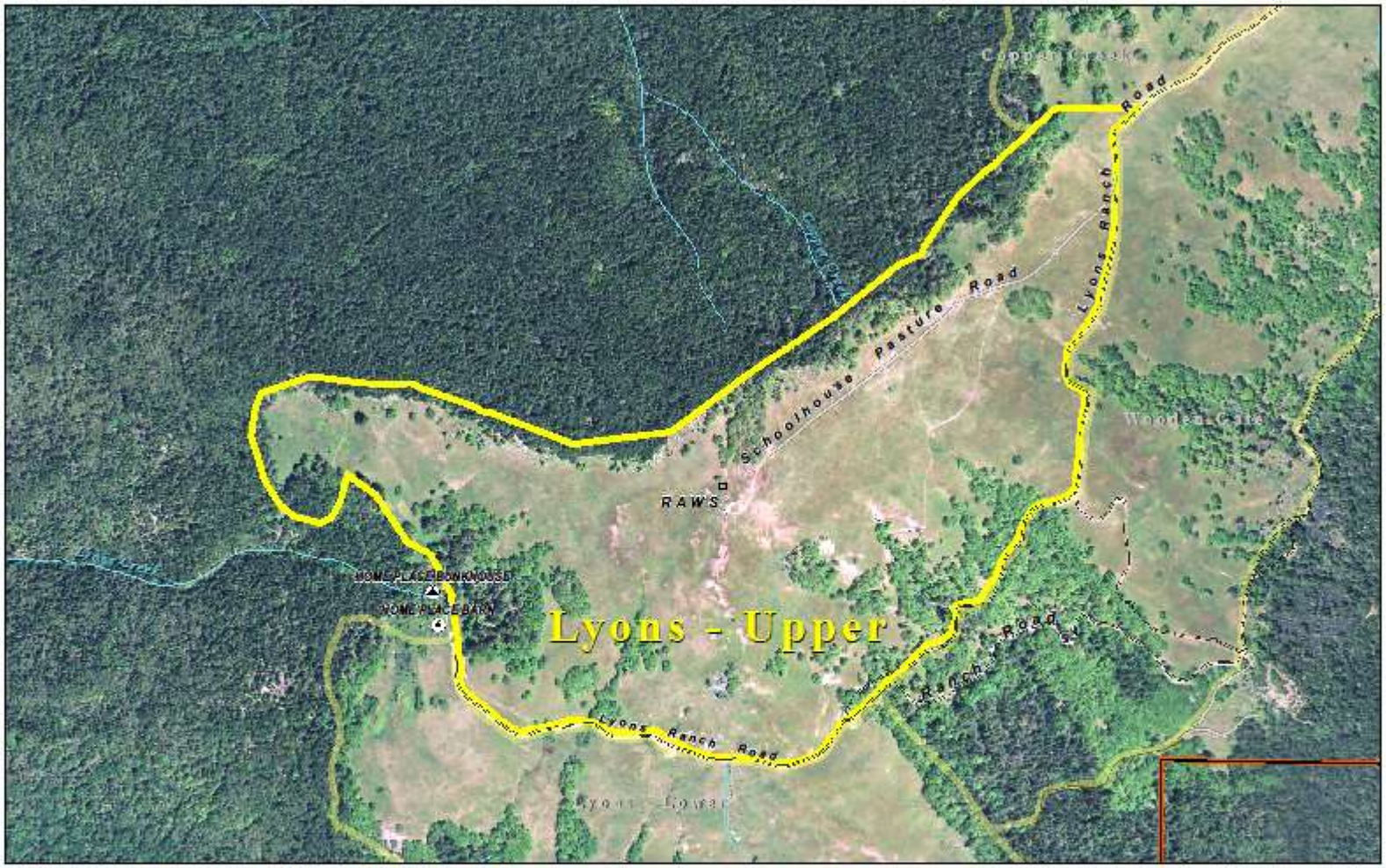
Decision Made to Burn Another Unit
Resources arrived in the Bald Hills area of the Park at approximately 1000 hours. Dispatch logs recorded that at 1025 the Childs Hill "test fire was not successful". The Burn Boss Trainee noted that 100-hour fuels were "consuming just fine". This consumption would not meet the natural resource and control objectives for the burn. Therefore, Childs Hill was too dry to burn.

The Burn Boss and Burn Boss Trainee made the decision to move to the Upper Lyons Unit, located approximately one mile up the road. The Upper Lyons Unit met burn plan specifications, was in prescription, and had established fire line. Thus, it was considered available to burn. Additional time was needed to adjust the Incident Action Plan (IAP) and print maps. This resulted in some of the prescribed fire resources having some downtime while they waited.

[Maps of the Upper Lyons Unit are provided on the next two pages.]

[1] "Service First" authorizes four agencies (the Bureau of Land Management, U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service) to conduct shared or joint management activities to achieve mutually beneficial resource management goals. The three goals of Service First: (1) improve customer service to the public; (2) increase operational efficiencies among the agencies; and (3) improve land management across the agencies' jurisdictional boundaries. The Service First statute is outlined under Section 422 of the Consolidated Appropriations Act of 2012, Public Law No. 112-74.


Copper Creek
Schoolhouse
MEDIVAC SPOT
Wildcat
Schoolhouse Pasture Road
Wooden Gate
Deployment Site
SHELTER
Shelter
Lyons - Upper
RAWS STATION
Upper Lyons
Lower Lyons
Mid-Basin
Schoolhouse RAWS
Lyons
Lyons - Lower
N
South Boundary
Dooleyville
Dooleyville - Removed
Upper Lyons
0 0.050.1 0.2 0.3 0.4
Miles
N:\GIS_Maps\user_maps\390_FireEcologyandEffects\REDW\FireEcology FireEcology_Template.mxd


Lyons - Upper
Schoolhouse Pasture Road
Lyons Ranch Road
RAWS
HOME PLACE BARN
Redwood National and State Parks
Lyons - Upper
0 0.1 0.2 0.3 Miles
0 0.1 0.2 0.3 0.4 Kilometers
NAD 1983 UTM Zone 10N
Burn Unit Boundary
Park Boundary
Legal Description
Latitude: N41° 8.336'
Longitude: W123° 54.385'
Township/Range: T9N R2E
Section(s): 25,26,35,36
Acres: Upper 207.5, Lower 143

1130 Hours

Prescribed fire resources assembled for the Upper Lyons Prescribed Fire at approximately 1130 hours. Maximizing broad interagency training via prescribed fire opportunities has been an ongoing, well-received and productive practice of the Park. At the briefing, everyone could see how many resources were on site, approximately 80 personnel. The Burn Boss Trainee reflected: *"A lot of folks for a briefing. More than you need for 200 acres."*

Operational Briefing

In the briefing, because so many people were on site, the Burn Boss stressed the importance of everyone knowing who they worked for that day. The operational briefing covered burn organization and assignments—which was challenging due the large number of personnel.

At the Operational Briefing, the breakout groups for briefing small groups was initially described as "not going well" and "busy". This resulted in the Burn Boss shifting some people around, which resolved the confusion.

All personnel attended the briefing. From previous experience on prescribed fires on this same unit, "known problem areas" were covered in the briefing, including the challenge of holding a particular dogleg section of line. (This problem area ended up being where the shelter deployment occurred.)

The operational briefing was comprehensive. It highlighted areas of concern throughout the unit, including the potential for increased fire behavior at the dogleg on the unit's north flank. "We could have problems here," the Firing Boss informed. At the briefing the Burn Boss clarified: "I wanted no one ahead of the firing on that part of line." In addition, the Burn Boss said: "No one works on that line unless they go through the chain of command all the way to me."

The firefighter who later deployed felt that the briefing was adequate.

Important Information Not Received in Briefing

Regardless, and for reasons unknown, later that afternoon a TREX squad member would reflect in their unit log: "Module never given a squad briefing".

Furthermore, a Module Leader would later explain: "Listened to the brief of who was doing what . . . I had never seen the area before. I had no idea what it looked like . . ." "After [the shelter deployment], they said they always have problems around this corner and have lost it here before and had holding issues here before. That would have been really helpful to know [before the lighting started].

Communications and other Concerns

Reflecting back on the number of people in the burn organization, the Type 2 Initial Attack Crew Superintendent thought: "If anything, there were too many people."

Communications was an area of concern. The idea of using two tactical (TAC) channels was discussed. However, it was decided that one tactical channel would be used to ensure that **everyone** was hearing and benefiting from the situational awareness that radio traffic provides.

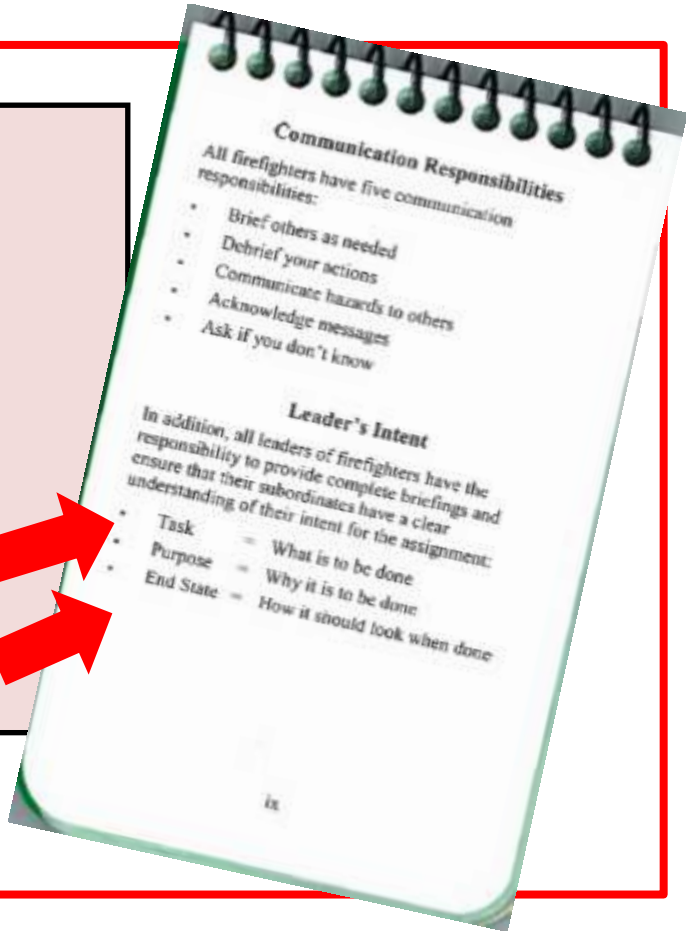
Following the briefing, various informal conversations floated around the briefing area including discussions about the leadership of the TREX participants and their assignment. The TREX Module C Leader noted: "The module had only worked together for two hours . . . I've had this work well before . . . it's been fine."

Lessons Learned

Further reflection by those involved with the Upper Lyons Prescribed Fire yielded this question:

"Was sending and receiving information actually occurring during the operational briefing?"

[Refer to your Incident Response Pocket Guide (IRPG), Page ix: "Communication Responsibilities" and "Leader's Intent"]



On past prescribed fires within the Park, the TREX group members spent a "couple of days" together team building and training, prior to engaging in a training burn. The Burn Boss Trainee on this incident, recognizing that additional time was needed to organize the large number of resources, allowed the Holding Boss (HB) the necessary time to assess needs, coordinate resources, and establish leadership.

Contingency Plan if Squad Boss is Called Away

The TREX Module C Leader, Squad Boss, and Firefighter (a TREX member and U.S. Forest Service employee, who was also qualified to serve as a Squad Boss) had discussed that if the Squad Boss was called away, this Firefighter would assume the role of Squad Boss.

1214 Hours

At 1214 hours, a test fire for the Upper Lyons Prescribed Fire was conducted on the burn's north flank. Criteria for a successful test fire were: "If smoke was pulling back off the line". It was.

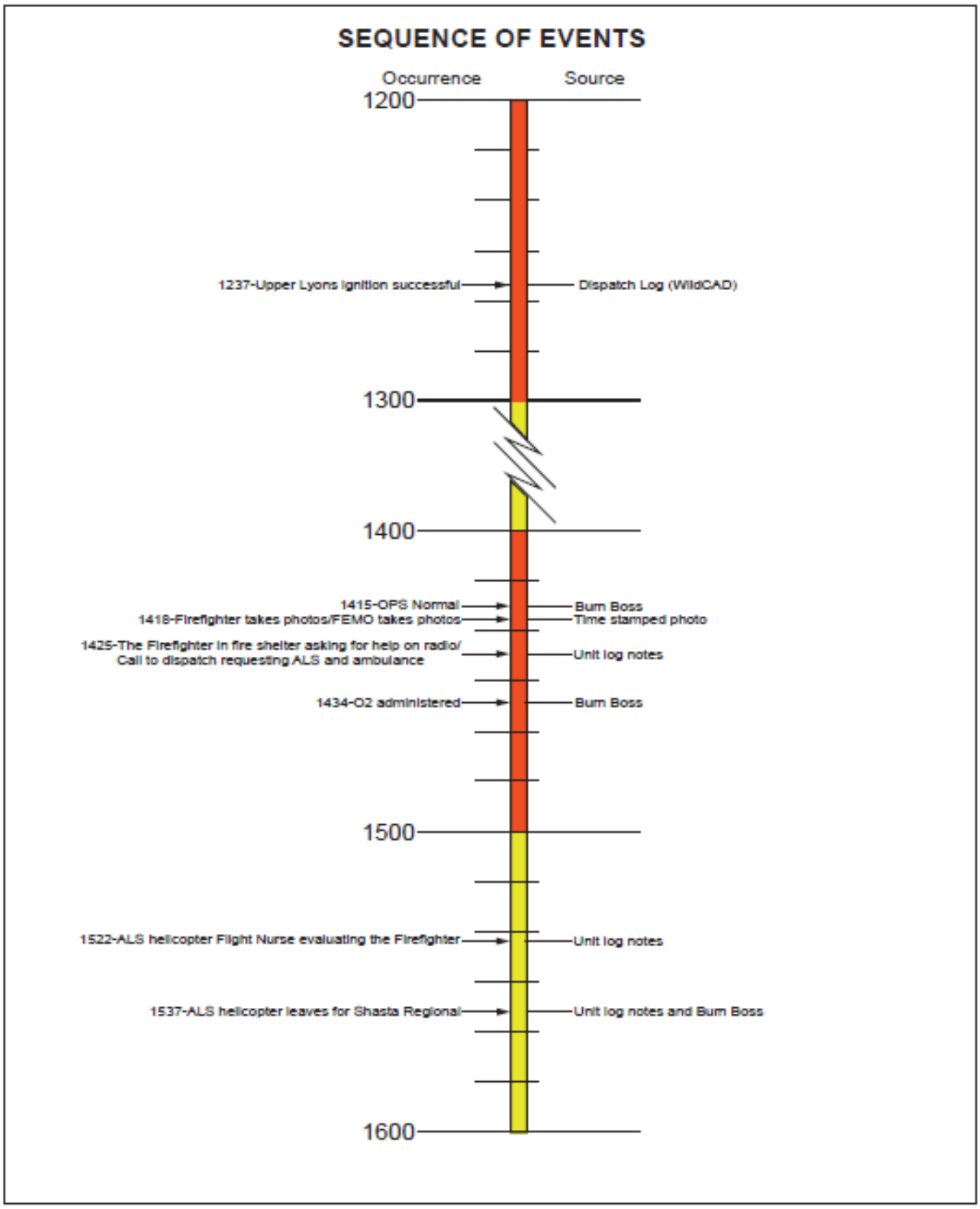
1237 Hours

At 1237 hours, Dispatch was notified that ignitions were successful and that a half-acre test fire had been completed. The objective was to complete a prescribed fire of just over 200 acres.

The Burn Boss Trainee noted that the area had not experienced rain in more than three weeks. "A lot of slash was prepped at the edge of the line. Slash piles were cured and red." The amount of slash along the north flank was a concern.

Slash Accumulations Delay Firing Operation

As firing progressed along the timbered north flank and down the ridge to the Remote Automated Weather Station (RAWS), the Firing Boss started to express concern that the slash was not pulled back far enough from the line. The Burn Boss Trainee said the Firing Boss "was concerned how slash was consuming. For the Park, it was a concern in terms of meeting objectives to retain oaks."


SEQUENCE OF EVENTS
Occurrence
Source
1200
1237-Upper Lyons ignition successful
Dispatch Log (WildCAD)
1300
1400
1415-OPS Normal
Burn Boss
1418-Firefighter takes photos/FEMO takes photos
Time stamped photo
1425-The Firefighter in fire shelter asking for help on radio/ Call to dispatch requesting ALS and ambulance
Unit log notes
1434-O2 administered
Burn Boss
1500
1522-ALS helicopter Flight Nurse evaluating the Firefighter
Unit log notes
1537-ALS helicopter leaves for Shasta Regional
Unit log notes and Burn Boss
1600

"Your pucker factor is going to get high around this corner."

What the Firing Boss told the Firing Boss Trainee as the firing approached the top of the hill near the RAWS station—referring to the burn conditions in the area where the entrapment would eventually occur.

Ahead of the lighters, a squad from TREX Module C was assigned to walk along the north handline and pull apart old piles and jackpots ahead of the firing team. This process of pulling back the slash caused a delay in the firing operation, resulting in the Firing Boss requesting more people to assist with pulling back the slash.

The firing team consisted of three firefighters from a Type 2 IA crew and one TREX participant. The remaining Type 2 IA crew members were assigned to holding along the north flank.

Firefighter Takes on Squad Boss Responsibilities

When the TREX Squad Boss was called back to shuttle water for an engine that was pumping a hose lay on the north flank, the Squad Boss told the Firefighter: "They are all yours." As previously arranged, at this time, the Firefighter began serving as Squad Boss. (For the purposes of this FLA, this person will continue to be referred to as "the Firefighter" in this narrative.)

The Firefighter (now acting Squad Boss) began scouting the north flank looking for more slash piles while the rest of the squad (with the TREX Module C Leader embedded in the squad) continued breaking up these piles and monitoring the north line.

While scouting the north flank looking for more slash piles, the Firefighter began working ahead of the firing operation. Later, during the FLA process, when asked why the Firefighter was not wearing gloves, the Firefighter stated: "I was way ahead of the fire and did not feel that I needed gloves at that time."

Did You Know that THREE Different Glove Options are Available?

Check out "Firefighters' Leather Gloves Redesigned to be More Comfortable" at:

http://www.fs.fed.us/t-d/pubs/htmlpubs/htm09512312/

For more information, see the "Lessons Learned by the FLA Team" section in this FLA.

The Firefighter received a radio call from the Squad Boss instructing him to bring the squad back for assignment to another mission. The Firefighter attempted to relay the message to the TREX Module C Leader to inform him to go ahead and start hiking the squad out and that he would meet them at the engine. However, the Firefighter was apparently unable to make contact.

Photo taken at 1418 hours by the Firefighter who would (eventually) deploy shelter near this area.

As the Firefighter started up the line (up the hill) he passed the burners (lighters). About 50 feet from the closest lighter, the Firefighter noticed an increase in fire behavior and paused to take "a couple of pictures" for documentation (see photo above).

A Change Occurs

The Firefighter recalled: "The smoke was bending across the line." Therefore, the Firefighter "walked about 30 feet into the green and was able to breathe fresh air."

At this time, the Firefighter saw a slopover and called it in. Following this transmission, radio traffic became congested.

TREX Module C Leader recalled: "Communications sucked. You couldn't hear people at the RAWS. And people at the RAWS said they didn't hear the Firefighter."

1419 Hours

Dense Smoke and Multiple Spots Pull Crews Back into Black as a Precaution

By 1419 hours, a combination of factors contributed to dense smoke pushing over the line. Multiple spot fires were being reported on the north flank. At the same time, as fire was being brought down the north flank, the Burn Boss and others near the RAWS noticed it was getting very smoky (see photo on right).

Photo taken at 1418 hours looking toward what would become the entrapment area—located left of center in this photo. (Photo taken by the Fire Effects Monitor.)

The Firing Boss Trainee had the lighters stop ignitions and "cork their torches". The Type 2 IA Crew Superintendent informed the Burn Boss Trainee that the "crew had to pull back" because some of the spots had burned together. Responsible for the safety oversight of the Type 2 IA crew, the Crew Superintendent said: "I grabbed everybody—including my lighters—and moved them into the black."

On the radio, the Burn Boss told "folks to come on out until spots calmed down" and directed workers in the area "to get out". Spot fires became established that created several slopovers.

Likewise, the Type 2 IA Crew Superintendent was not in favor of committing resources to aggressively suppress the slopovers and spots. To do so would not be prudent risk management, the Type 2 IA Superintendent said. "I've been burning in this Park since 2004 . . . I knew we could get them [the slopover and spots] later. There was no sense of urgency to catch them."

The past experience stated by several individuals involved in the Upper Lyons Prescribed Fire was that when burning in this area in the past, grass fire can be run into the hardwoods and conifers to "hold" the fire edge from further progressing.

The Crew Superintendent, overseeing the portion of the crew assigned with holding the fireline stated: "there was intense fire behavior and really thick smoke." The Burn Boss said: "The smoke was mostly from tan oak fuel: heavy, acrid type smoke." Another burn participant observed: "Dudes were really eating smoke on the line, that's for sure." (See photo below.)

Slopovers Force Firefighter to Utilize Escape Route

As previously mentioned, due to the dense smoke blowing across the fireline, the Firefighter walked about 30 feet into the green in an attempt to breathe clean air.

The Burn Boss Trainee stated: "Being caught in smoke like that is like being under water."

The Firefighter saw a slopover above and attempted to notify the Firing Boss Trainee that this slopover was making a push toward the resources above. However, there was too much radio traffic congestion to get through.

The Firefighter stated: "I tried time and time again to get out on the radio but traffic never cleared."

The Firefighter decided to utilize the escape route along the fireline, heading downhill.

When withdrawing, the Firefighter observed another slopover below that was torching trees and making a hard push uphill toward the Firefighter's location.

Photo looking downhill from RAWS station.
(Photo taken by the Fire Effects Monitor.)

Decision Made to Deploy Shelter

The Firefighter ran up the fireline, hoping to get past the tree line, where the Firefighter could make a right-hand turn toward what should have been the black. Instead, the Firefighter encountered heavies burning that resembled a "wall of fire". Next, the Firefighter decided to run down the fireline, but the fire was too intense. The Firefighter recalls: "At that point, I felt like I was being burned alive from all directions—so I decided to deploy my fire shelter." The Firefighter deployed on the four- to five-foot-wide fireline.

The Firefighter experienced some difficulty in getting the shelter to unfold. The Firefighter used the left and right handles to pull apart the accordion folds and shook the shelter four times, but was still unable to shake out the rest of the "long-folds".

The Firefighter then got on the ground, put one knee on the shelter and pried it open the rest of the way, then entered the shelter from a kneeling position and got into a prone position. Once inside the fire shelter, the Firefighter attempted to retrieve the Firefighter's gloves from the left cargo pants pocket, but the Firefighter's left hand felt as if it were on fire (from burns received prior to entering the shelter). The Firefighter decided to cross their arms in front of their chest and tuck their hands into their arm pits.

Equipment recovered from the deployment site indicates that air temperatures outside of the fire shelter were at the upper limits of human survivability. (For more information, see Appendix A.)

Lessons Learned

It can be determined that this fire shelter deployment prevented more serious injuries and saved a life.

[For complete information, see Appendix A: "Upper Lyons Prescribed Fire Entrapment and Fire Shelter Deployment Site and Equipment Analysis".]

What Other Firefighters Experienced

One TREX squad member recorded in their unit log that afternoon that: "Firefighter went down the handline separating from the group . . . Everything seemed calm . . . Wind shifted and it got very smoky. The winds were blowing pretty hard out of the unit into the green. We were getting hit by embers . . . Then we saw fire with high flame lengths below us, 10-feet high."

At this same point in time, another TREX squad member wrote in their unit log: "Firefighter walked ahead of the group to check for remaining burn piles. Winds changed direction and were blowing smoke north over the line . . . Winds picked up even more and blew thicker smoke at us. As we headed downhill in the black we saw the trees in the green ahead of us torch to a canopy fire [individual and perhaps group torching].

A third TREX squad member recorded in their notes: "We reached the edge of the oak stand and did not see any piles nearby. The Firefighter was our lead and

Photo shows the trees torching when the wind shift increased. (Photo taken by the Fire Effects Monitor.)

" . . . The fire behavior downslope of us became extreme and the trees started to torch near the line . . . TREX Module C Leader ordered us into the black . . . Two squad members noted embers hitting their necks . . . As trees continued to torch, he ordered us farther into the black. It was incredibly hot, smoky, and the wind pushed smoke into the green."

TREX Squad Member

TREX Module C Leader was behind us. The Firefighter continued downhill [down the line] to scout for other piles . . . Fire behavior hot, torching, and creating a lot of smoke . . . It was difficult to breath and my eyes were crying . . . We went back uphill toward the oaks at this point to escape the thick smoke . . . We were taking a lot of smoke and moved into the green to avoid the smoke. The fire behavior downslope of us became extreme and the trees started to torch near the line . . . TREX Module C Leader ordered us into the black . . . Two squad members noted embers hitting their necks . . . As trees continued to torch, he ordered us farther into the black. It was incredibly hot, smoky, and the wind pushed smoke into the green." (They would later discover that the Firefighter had deployed just downslope from these torching trees.)

1425 Hours

Radio Distress Call: Someone is Surrounded by Fire

On the radio shortly before 1425 hours, several participants heard a distress message on the radio. Someone was saying that they were surrounded by fire—and to stop firing!

At 1425, the distressed voice of the Firefighter was heard by other participants on the radio—when the Firefighter said they were deploying their fire shelter.

Shortly after 1425, the Burn Boss Trainee directed everyone on the radio to stop talking. Over the radio, the Burn Boss Trainee asked if there was an emergency. In a radio transmission, the Firefighter replied: "This is 'the Firefighter'. I'm in my shelter."

The Firing Boss Trainee was momentarily in disbelief at what was just heard on the radio. The Firing Boss Trainee thought: "Someone is really in there and they are melting."

The Burn Boss Trainee remained in radio communication with the Firefighter. At this point, a search for the Firefighter was initiated.

Just after 1425 hours, a search is underway for the Firefighter who has deployed a fire shelter.

For more insights and information on the entrapment and deployment, including photos of the deployment site, see Appendix A.

(Photo taken by TREX participant.)

Even though the smoke was extremely thick—with visibility less than a few feet in some areas—the following nearby resources simultaneously ran to the Firefighter's vicinity: Burn Boss, Firing Boss, Firing Boss Trainee, Fire Effects Monitor (FEMO), and the TREX Module C Leader.

At some point, for approximately one minute, the Firefighter was not responding on the radio. As several others later recalled: "I couldn't hear [the Firefighter]. I thought [the Firefighter] was dead."

The searchers tried yelling. The Burn Boss Trainee asked the Firefighter to yell out so that the searchers could locate the Firefighter. The Firing Boss Trainee stated: "I thought I could hear [the Firefighter]; but I couldn't see through the smoke." The trapped Firefighter stated: "I yelled three times. Thankfully, that was enough to help them locate me."

Photo shows entrapment site. Notice ash on pack, but not on helmet. The Firefighter's helmet fell off as the Firefighter was exiting the fire shelter. (Photo taken by TREX participant.)

The Fire Effects Monitor and Firing Boss were approximately 100 feet uphill from the rest of the searchers when a shift in smoke allowed just enough visibility for them to see the Firefighter's deployed fire shelter.

'We Gotta Go. We Gotta Get Out of Here'

At approximately 1429, the Firing Boss and the Fire Effects Monitor located, lifted up the fire shelter, and confirmed that the Firefighter was inside.

Just prior to arriving at the deployment site, the Firing Boss overheard the Firefighter say: "I am burning."

The Firing Boss now requested that the Firefighter get up, saying: "We gotta go. We gotta get out of here." Once the Firefighter stood up, the Firing Boss attempted to lead the Firefighter from the line to the lighter fuels in the cool black.

However, once again—just as the Firefighter had experienced earlier—after a few steps, this direct route into the black was blocked by overwhelming heat. They backtracked to the fire shelter and picked it up to shield themselves from the heat—and to protect the Firefighter's burned left hand.

The Fire Effects Monitor, who had scouted ahead, motioned to them through a break in the smoke toward a safe route into the cooler black. The Firing Boss was able to lead the Firefighter out to this cool black and out of the smoke. The Firing Boss described the conditions as: "Heavy smoke . . . Hard to see the way out myself. I found myself getting into fight or flight."

One of the TREX squad members described the search scene: "When we arrived [in the search area] the flames were up to 12-feet tall. The fire looked incredibly hot and persisted throughout the search process."

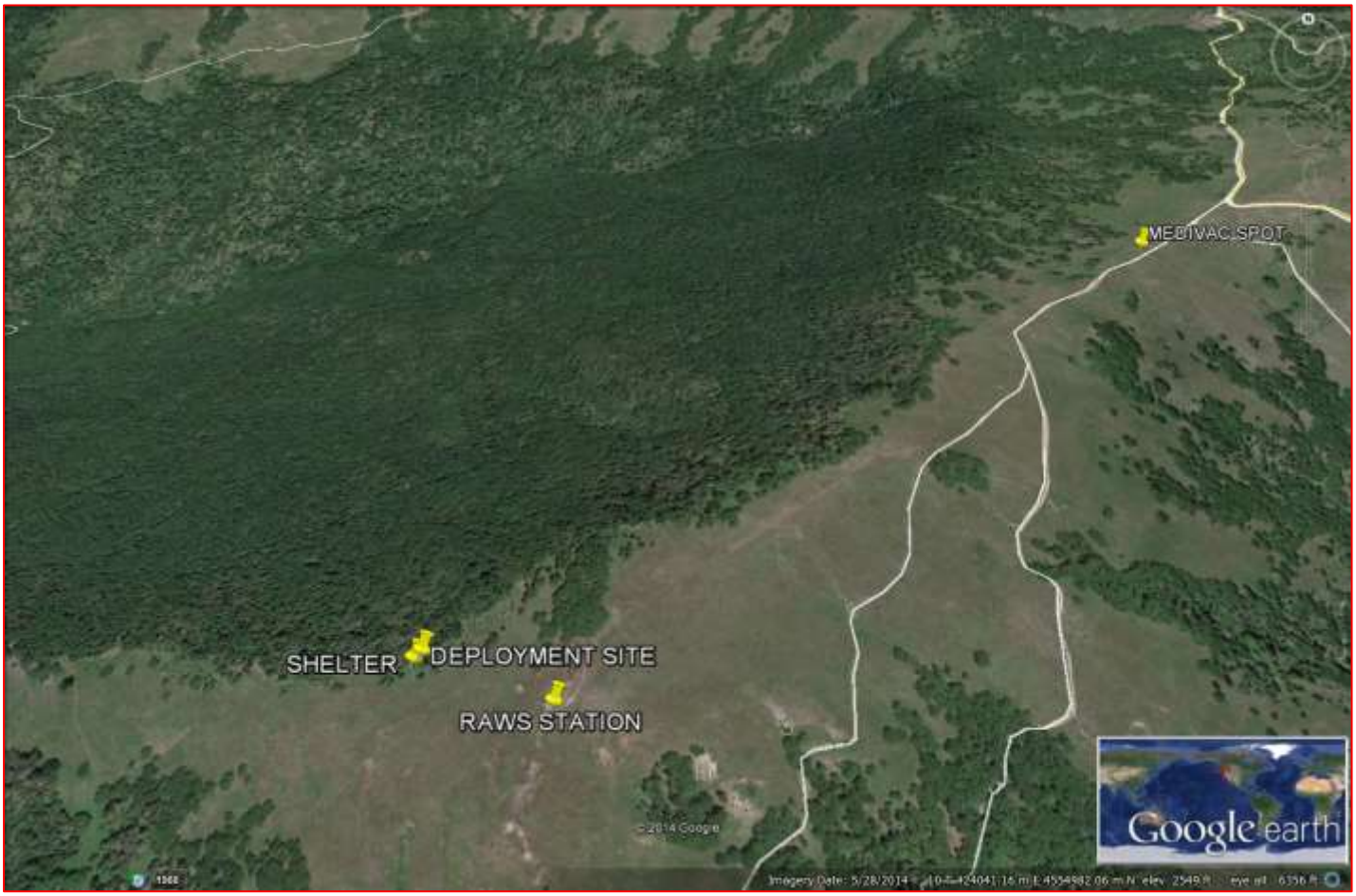
1432 Hours

Medical Plan Well Thought Out, Planned, and Implemented

At this time, the Burn Boss Trainee requested a Ground Ambulance with Advanced Life Support and medivac. The Burn Boss Trainee also provided the coordinates for the Landing Zone. (See image below.)

Once into the cool black, the Firefighter knelt down onto the ground. At approximately 1432, the Firing Boss reported that the Firefighter was outside the shelter and was in stable condition. Shortly thereafter, the Firing Boss Trainee and the Module Leader, who was also a Paramedic, arrived to begin assessing the patient. The Paramedic stated: "I saw main burn on left hand." The patient also indicated to the Paramedic that they had tingling on their right hand and cheek. The Paramedic also stated that "there was coughing and wheezing in [the patient's] lungs." In addition, the Paramedic also described the Firing Boss as "having red cheeks and hands".

The medical plan was well thought out, planned, and implemented. The Firefighter was transported to a medical facility within approximately 30 minutes from being assessed by a Paramedic and received definitive care within 55 minutes (as estimated by the Burn Boss Trainee).



3. Lessons Learned by the Incident Participants

Burn Unit Preparation

"Speaking specifically to preparing a unit, I would pull piles farther into the unit and away from the fire line, or bone pile and burn."

Park Fuels Specialist

Briefings

Always consider: Was sending and receiving of information actually occurring?

From the FLA's Facilitated Dialogue Session

Potential Contributing Factors that Could Impact Your Burn

Take a critical look at the prescription for the unit to be burned. Consider long-term contributing factors such as drought and conditions that can easily change—despite the predicted weather forecast (such as wind).

From the FLA's Facilitated Dialogue Session

Importance of Fire Shelter Training

Fire shelter training played a profound role in the successful deployment on this incident.

Input from the Firefighter who was entrapped and deployed

Medical Plan

"The Medical plan went great. (Unfortunately, we had to use it.)"

Burn Boss Trainee

Personal Protective Equipment

Have and use your PPE. "The Firefighter used the tool that the Firefighter had: Fire Shelter."

Burn Boss Trainee

4. Lessons Learned by the FLA Team

Gloves

In addition to the Firefighter who was not wearing gloves when entrapped, a number of other gloveless individuals appear in various photographs and videos taken during the Upper Lyons Prescribed Fire.

From "Chapter 7: Safety and Risk Management" in the "2014 Interagency Standards for Fire and Aviation Operations (Redbook)": *The goal of the fire safety program is to provide direction and guidance for safe and effective management in all activities."* Under "Personal Protective Equipment": *All personnel are required to use Personal Protective Equipment (PPE) appropriate for their duties and/or as identified in JHAs/RAs. Employees must be trained to use safety equipment effectively. Required Fireline PPE includes: Leather or leather/flame resistant* combination gloves.

It should be noted that a Job Hazard Analysis (JHA) was signed prior to ignition of the Upper Lyons Prescribed burn. The JHA had two sections that referenced wearing gloves, specifically the "protective clothing and equipment" and "holding and mop-up/patrol crews" sections.

From the "*Facilitated Learning Analysis Implementation Guide": "Many risks are ephemeral and emerge from the complex interactions of random or sporadic events. These irregular threats are managed though employee ingenuity with adaption. Essentially, <u>every</u> risk mitigation (every safety precaution) carries some level of "cost" to production or compromise of efficiency. Employees at all levels are continuously—and often subconsciously—estimating, balancing, managing, and accepting these subtle and nuanced tradeoffs between safety and production."*

Wildland firefighter leather work gloves supplied by GSA/Defense Logistics Agency (DLA) (replaced GSA as the provider for many types of wildland fire equipment) and the caches are certified to the National Fire Protection Association (NFPA) 1977 Standard on Protective Clothing and Equipment for Wildland Firefighting. This standard has tests that measure flame resistance, conductive heat resistance, thermal protective performance, cut resistance, puncture resistance, dexterity and grip. Gloves made to this standard attempt to provide a balance among all these requirements. In all likelihood, increasing one characteristic would adversely affect others. For instance, thinner leather would most likely increase comfort, but it would not provide sufficient protection for many of the other aspects of the gloves.

The following are routinely mentioned by firefighters (including members of this FLA Team) as reasons why safety conscious firefighters, at times, remove their gloves in the work environment: comfort, fit, blisters to the hands caused by thick interior folds in flexed gloves, fine motor skill dexterity, avoidance of embers becoming lodged in the cuffs of gloves, as well as other general work considerations.

While gloves can obviously provide protection of skin from exposure to heat, it is a commonly accepted practice for wildland firefighters during mop-up to remove their gloves and "feel" for heat with the backs of their hands. For various other reasons, experienced and well-trained firefighters, at times, also make reasoned decisions to not wear their gloves.

<u>Discussion</u>

The FLA team suggests the evaluation of use of different types of gloves or hand protection systems/processes to address the variable work environment firefighters face in a manner that concurrently provides for worst case protection, and for more common work realities.

Encouragement of having a wildland fire "learning culture" has tangible positive outcomes on safety and work productivity. For example, past lessons learned resulted in changing vehicle seatbelt types in some

type of vehicles to address reasons that firefighters were making reasoned decisions not to wear automatically tightening seatbelts. That change resulted in increased seatbelt use and potentially reduced severity of injuries when unexpected accidents occur.

In 2009, the Missoula Technology and Development Center (MTDC) published the results of a nationwide product review (Smith, John R. 2009. *Firefighters' Leather Gloves Redesigned To Be More Comfortable*. 0951 2312P. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 4 p. Available at: http://www.fs.fed.us/t-d/pubs/htmlpubs/htm09512312/). This review evaluated the fit, comfort, and utility of the standard heavy-duty gloves available through the General Services Administration's (GSA) Wildland Fire Equipment Catalog.

As part of that 2009 effort, comments from almost 2,000 wildland firefighters indicated that the existing gloves needed to be more comfortable, although the firefighters said the gloves provided acceptable levels of protection and durability.

Feedback from Firefighters

Based on this feedback from firefighters, MTDC worked with the manufacturer of the existing gloves to increase comfort while maintaining protection and durability.

Three modifications of the existing gloves were developed and field tested. As a result, more glove options became available for wildland firefighters.

These glove options are now available from the Defense Logistics Agency (DLA) (replaced GSA as the provider for many types of wildland fire equipment) at: https://dod.emall.dla.mil/acct/. (For further reference, see GSA Advantage at: https://www.gsaadvantage.gov/advantage/s/search.do?db=0&q=0:2firefighting+gloves&searchType=0&p=2.)

Glove Options

In 2014 these glove options include:

The now standard "Firefighter Work Gloves" are stocked in all of the National Interagency Support Caches and are also available from DLA. The national stock numbers (NSNs) (NFES numbers also provided) for these gloves:

'Firefighter Work Gloves (rough out)'

X-small, NSN 8415-01-394-0208, NFES 1293

Small, NSN 8415-01-394-0209, NFES 1294

Medium, NSN 8415-01-394-0210, NFES 1295

Large, NSN 8415-01-394-0215, NFES 1296

X-large, NSN 8415-01-397-3937, NFES 1297

(2014 prices for all $14.18 per pair)

[More glove options on next page.]

Other NFPA compliant gloves available from DLA (although not stocked by all of the National Interagency Support Caches). Their national stock numbers (NSNs) (NFES numbers also provided):

'Brushed pigskin with elastic wrist shirring'

(Also stocked in 2014 by the Coeur D'Alene (CDK) and Southern California (LSK) Incident Support Caches)

X-small, NSN 8415-01-565-0623, NFES 1639

Small, NSN 8415-01-565-0620, NFES 1640

Medium, NSN 8415-01-565-0618, NFES 1641

Large, NSN 8415-01-565-0624, NFES 1642

X-large, NSN 8415-01-565-0625, NFES 1643

(2014 prices for all $19.08 per pair)

'Split cowhide with elastic Kevlar knit wristlet'

(Also stocked in 2014 by the Coeur D'Alene Incident Support Cache (CDK))

X-small, NSN 8415-01-568-0011, NFES 1474

Small, NSN 8415-01-568-0006, NFES 1475

Medium, NSN 8415-01-568-0013, NFES 1476

Large, NSN 8415-01-568-0008, NFES 1477

X-large, NSN 8415-01-568-0012, NFES 1478

(2014 prices vary and are just over $26 per pair)

Whether firefighters and managers are widely aware of all of these glove options to address fit and comfort issues is unknown.

5. Recommendations

1. Gloves

Based on the Lessons Learned by the FLA Team, the following recommendations are suggested regarding gloves:

A. **Further action should be taken nationally to ensure broader awareness of alternative glove options by wildland firefighters and managers. In addition, supervisors need to lead by example and ensure that firefighters are wearing gloves at the appropriate times.**

B. **The National Fire Equipment System (NFES) Committee and the NFES National Interagency Support Caches (NISC) should consider expanding the stocking of all three glove types by all of the Interagency Support Caches.**

C. **Further evaluation should be done to assess the different types of gloves or hand protection systems/processes to address the variable work environments that firefighters face in a manner that concurrently provides for worst case protection and more common work realities.**

2. Minimizing Fire Shelter Surprises

It is important for firefighters to remember their training and to try to remain as calm as possible during an entrapment situation. Training which maximizes realistic conditions and draws upon actual emergency fire shelter deployment scenarios can reduce "surprises", help firefighters remain focused on implementing their training rather than becoming distracted by unexpected developments, and, thereby, help firefighters remain as calm as possible in the otherwise severely adverse conditions.

During this incident, the Firefighter experienced that the long-folds in the fire shelter did not "shake out" as they do with practice shelters. In turn, the Firefighter immediately developed a manner to successfully address this situation. At the same time, there were specific aspects of fire shelter training that the Firefighter recalled that helped the Firefighter remain calm by recognizing "normal" conditions—such as light entering the fire shelter. (For more specific details, see Appendix A.)

Recommendations

Based on the Lessons Learned by the FLA Team on this incident, as well as descriptions in several recent FLAs regarding firefighters being surprised by circumstances that occurred when they deployed their fire shelters in actual entrapment incidents, this FLA Team recommends:

> **As fire shelter training curricula is updated, it should reflect lessons learned relative to equipment as documented in the many FLAs available at this time.**

Incorporating actual unanticipated experiences with fire shelters encountered on actual emergency fire shelter deployments—as well as the ways in which firefighters overcame these "surprises"—can benefit firefighters who may encounter similar situations.

In addition, as described in Appendix A, this FLA Team recommends:

> **When training for fire shelter deployments, a variety of training scenarios can be used to make training more realistic; for example, using actual fire shelters that are taken out of service for training purposes.**

6. FLA Team

Rob Griffith, FLA Team Leader
Assistant Director
Pacific Southwest Region, Fire and Aviation Management Staff
U.S. Forest Service

Godot Apuzzo
Equipment Specialist
National Technology and Development Program,
Missoula Technology and Development Center
U.S. Forest Service

Deron Mills
Deputy Fire Chief – Operations
Yosemite National Park
National Park Service

Jamie Tripp-Kralman
Regional Fuels Operations Specialist
Pacific Southwest Region, Fire and Aviation Management Staff
U.S. Forest Service

Paul Keller
Writer Editor
Wildland Fire Lessons Learned Center

The FLA Team would like to thank George Toyama, Visual Information Specialist at the San Dimas Technology and Development Center, for his assistance in developing this Facilitated Learning Analysis report.

7. Appendix A – Upper Lyons Prescribed Fire Entrapment and Fire Shelter Deployment Site Analysis and Equipment Report

The following discussion is derived from a site visit, inspection of personal protective equipment (PPE), and interviews with the Firefighter who deployed the fire shelter. The site visit was conducted on October 17, 2014; four days after the fire shelter deployment. In the time between the shelter deployment and site visit, the area received rain and wind.

The Firefighter received second-degree burns on the back of the left hand and first-degree burns on the left side of the face, and on the knuckles and fingertips of the right hand. The Firefighter did not wear gloves during fire operations and received these burns while attempting to escape the fire. The Firefighter stated that once inside the shelter, the burns were too painful to put on gloves.

The Firefighter stated that several attempts were made to use escape routes. The first attempt to escape entailed going down the fireline and out to the "black," but the fire behavior was too intense. The Firefighter also tried to escape by going up the fireline, but was prevented by a "wall of fire" from a heavy fuel concentration. The Firefighter started to "feel pain on the left, right, and all around" and tried to escape into the "green," but the smoke and vegetation were too thick (Figure 1). The Firefighter became entrapped and chose to deploy the fire shelter on the four- to five-foot fireline on the north-northwest flank of the Upper Lyons Prescribed Burn.

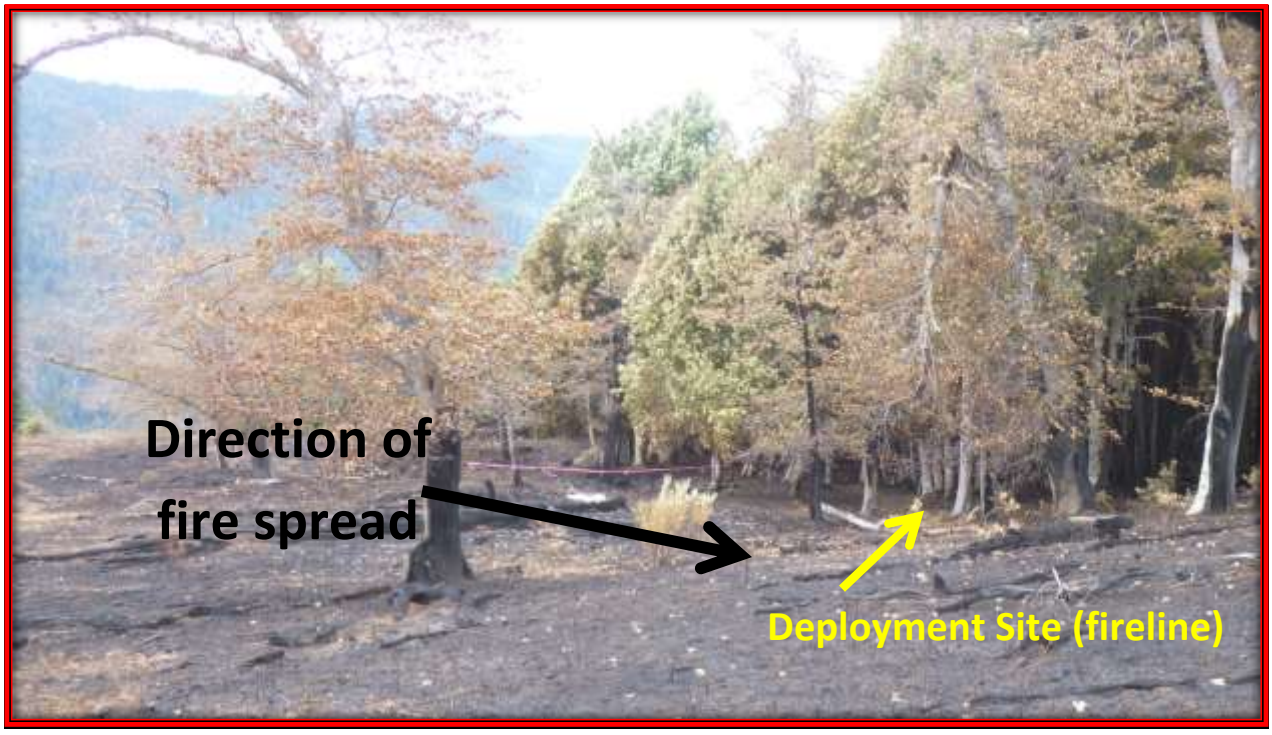


Figure 1 – Fire shelter deployment site.

Site Description – The deployment site was located on the edge of mixed conifer/oak canopy and prairie/grassland. The site was adjacent to jackpots of slash containing heavier 100- and 1000-hour fuels.

The summary of fire behavior compiled by the Fire Effects Monitor (FEMO) estimated consistent flame lengths of two to three feet in the oak understory and two to six feet in the open grass. FEMO estimated flame lengths at five to 15 feet in areas of red slash, resulting in tree torching and canopy scorch.

Figure 2 – The deployment site along the fireline. The "X" indicates the location at which the Firefighter deployed the fire shelter. (Note: The log fell across the line after the fire.)

Deployment Sequence – The deployment sequence is listed below in the chronological order of events.

Deployment Site Preparation – The Firefighter remembered "dig to dirt" from fire shelter training. The fireline was four to five feet wide and had previously been scraped to mineral soil (Figure 2). The Firefighter determined that this site required minimal preparation and deployed the fire shelter on the fireline.

Removal of the Fire Shelter from the Fireline Pack – The fire shelter was stowed in the sleeve on the bottom of the Firefighter's fireline pack. The Firefighter removed the shelter while wearing the fireline pack. The Firefighter took off the fireline pack, dropped the pack to the ground, and took a few steps uphill to deploy the fire shelter. The Firefighter mentioned no problems with the removal of the shelter from the fireline pack.

Opening the Fire Shelter Polyvinyl Chloride (PVC) Bag – The Firefighter stated that the red pull-ring and PVC bag opened and performed as designed.

Fire Shelter Deployment – The Firefighter grabbed the left and right fire shelter handles and pulled apart the accordion folds, then shook the shelter four times to unfold the long-folds. However, these folds felt "stuck together". The Firefighter dropped to the ground and put one knee on the partially deployed shelter and pried open the long-folds of the shelter by hand. The Firefighter maneuvered from one knee to a sitting position before rolling into the fire shelter, got into a prone position, and stuffed each hand into the opposite armpit to protect them (Figure 3).

Inside the Fire Shelter – The Firefighter stated that the inside of the shelter became smoky, apparently from firebrands trapped under the shelter during deployment. The Firefighter "thought I was going to suffocate." The Firefighter therefore dug a two-inch deep breathing hole by hand which "made a big difference for air quality." The Firefighter noticed "light holes" along the fire shelter's sewn seams and thought they were normal from a fire shelter training video that the Firefighter remembered watching. The firefighter, even without gloves, held down the shelter with body, elbows, and feet.

Fire Shelter and PPE Inspections – The used fire shelter and PPE worn during the deployment were collected and their conditions were analyzed.

Summary of the Firefighter's equipment:

Materials—Conditions and Corresponding Temperatures

Material and Characteristic	Temperature (°F)
Skin: Second-degree blister	131
Human survivability: Air temperature	300
Nylon: Melt	500
Fire shelter PVC bag: Melt	280
Fire shelter HDPE plastic liner: Melt	270

Figure 3 – The Firefighter's position inside the fire shelter.

Equipment Recovered – Items recovered were: a fire shelter, fireline pack and steel water bottles, high-density polyethylene (HDPE) fire shelter plastic liner, handtool (Rogue Hoe) with fiberglass handle, fire shelter polyvinyl chloride (PVC) bag, fire shelter PVC bag red pull ring, and firefighter helmet.

The outside of the fire shelter had areas of brown residue, most likely from firebrands. The red pull ring was partially consumed and appears to have contacted burning surface fuels. The fireline (nylon) pack had a one-inch melt hole from a hot ember. The fire shelter PVC bag had two one-inch melt holes and a two-inch long melt along the edge of the bag. The HDPE plastic liner was partially melted and deformed from radiant heat.

Figure 4 – Fire shelter from the Upper Lyons Prescribed Fire deployment.

Fire Shelter Analysis – New Generation Fire Shelter, M-2002, Forest Service Specification 5100-606 (Figure 4).

PPE Items

Fire shelter manufacture date and size: 12/2009, large size.

- **Condition:** No visual indications of exposure to high temperatures.
- **Outer shell:** Minimal (less than one percent) physical abrasion and delamination from wear and tear along fold lines.
- **Inner shell:** Nothing to note.
- **Floor:** Six-inch tear on end-cap; one-inch hole on opposite end-cap.
- **Seams:** Nothing to note.
- **Hold-down straps:** Nothing to note.

Figure 5 – Fire shelter pull-strip and PVC bag.

Fire shelter pull-strip and PVC bag: The PVC bag had two burn holes. These were most likely from firebrands. The pull-strip was partially consumed by the fire (Figure 5).

Fire shelter HDPE plastic liner: The liner was partially melted on the exposed edges (Figure 6).

Helmet: Bullard Wildfire Series, FH911H, certified to National Fire Protection Association (NFPA) 1977, manufactured 03/2012. No visual indications of exposure to high temperatures.

Flame-resistant shirt: Forest Service Specification 5100-91H, manufactured 04/2010. No visual indications of exposure to high temperatures.

Flame-resistant pants: Forest Service Specification 5100-92M, manufactured 02/2013. No visual indications of exposure to high temperatures.

Figure 6 – Fire shelter high-density polyethylene plastic liner.

Summary of Upper Lyons Prescribed Fire Entrapment/Fire Shelter Deployment

The Firefighter received burns to the hands and face that required hospitalization. The Firefighter received these burns while trying to escape.

The Firefighter deployed the fire shelter after entrapment when escape was no longer an option. The Firefighter remained inside the shelter from four to five minutes. The Firefighter stated that it was hot inside the shelter, but "it provided a lot of protection" and "I was glad I had it." The Firefighter (6'4", 310 lbs.) stated that the shelter was "roomy". The Firefighter also stated that once the shelter was opened, "it was easier to get into than a practice shelter, not as loose."

Analysis of the equipment in and around the deployment site indicates radiant heat exposure high enough to melt plastic and nylon materials. These temperatures are at the upper limits of human survivability. It can be determined that this fire shelter deployment prevented more serious injuries and saved a life.

Important Reminders

It is important for firefighters to remember their training and to try to remain as calm as possible during an entrapment situation. This Firefighter experienced issues with the shelter not encountered during training—the folds didn't shake out as they do with the practice shelter.

When training for fire shelter deployments, try different training scenarios to make training more realistic. Fire shelters that are taken out of service should be used for training purposes. Firefighters should practice shelter deployments while wearing PPE in a high-stress environment with time constraints and in different positions (standing, kneeling, and lying). Adding high ventilation fans for wind also helps create more realistic training.

Even though it is more comfortable to not wear gloves during fire operations, the need for hand protection can suddenly and unexpectedly arise. Gloves should be worn during fire operations except when fine motor skills are needed.