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Toolbox Complex Fire Shelter Deployment Accident Investigation

Factual Report and Management Evaluation Report, September 6, 2002

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USDA Forest Service

USDI Bureau of Land Management

September 2002

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Factual Report

Executive Summary

On July 24, 2002, three crews (Ferguson 53, a Pacific Northwest Region type 2 contract crew; Chugach 1, a type 2 crew; and Gila Hotshots, a type 1 crew) were assigned to Division T of the Toolbox Complex Fire near Picture Rock Pass on the Fremont National Forest in Oregon. Ferguson 53 had been working on the fire since July 18 and in this division since July 20. On the morning of July 24, the Ferguson 53 crew arrived late at Division T, due to a contract inspection and difficulties with its bus. Chugach 1 and the Gila Hotshots had worked together during the morning prior to the arrival of Ferguson 53. Upon the arrival of Ferguson 53, the division supervisor briefed all three crews before the crews began firing the ridgeline. Approximately one-and-one-half hours later, the division supervisor disengaged that operation due to numerous spot fires. He moved the three crews to the upper safety zone so the crews could rest and have lunch. He then departed with the Gila Hotshots superintendent and the Gila Hotshots assistant superintendent to scout and determine the possibility of another firing operation. The Chugach 1 crew boss followed them and marked escape routes. All three crews were then told to report to the lower safety zone to receive further instructions.

The division supervisor and the Gila Hotshots superintendent determined the next course of action, then the division supervisor headed north along the lower dozer line to return to road 2901. When the three crews arrived at the lower safety zone, the superintendent from the Gila Hotshots radioed for his crew to move north along the lower dozer line to begin the next firing operation. The Chugach 1 crew also departed the safety zone to assist and the Ferguson 53 crew was told to stay behind in the lower safety zone until needed.

Shortly after the two crews departed from the lower safety zone, Gila radioed to the Ferguson 53 crew boss to watch Gila's backs. The Ferguson 53 crew boss briefly left his crew to walk a short distance north along the lower dozer line. Heavy smoke and a roaring sound drew his attention, so he returned to his crew back at the lower safety zone. Upon his arrival, he noted a spot fire adjacent to the lower safety zone on the southeast side. At the same time, wind direction changed and pushed the main fire down the ridge from the west. All escape routes leading away from the lower safety zone were quickly compromised. Ferguson 53 crewmembers moved to different sides of the lower safety zone to escape the heat. They became nervous as the fire spread quickly around the lower safety zone and embers were falling on them. To calm their fears and to provide protection from the heat and smoke, the Ferguson 53 crew boss ordered his crew to deploy their shelters.

The shelter deployment lasted about 15 minutes. Simultaneously, two other events occurred:

- The Gila and Chugach crews began firing operations and almost immediately disengaged due to the advancing fire from the west.

- The division supervisor was contacted by the deputy incident commander to disengage operations in that area because of a spot fire which compromised the Division T operations. The division supervisor radioed the three crews to disengage, but received no response from Ferguson 53. The sequence of events indicates that the Ferguson 53 crew was in their shelters at this time and their crew boss had switched back to their company radio frequency to communicate with his crewmembers.

After the deployment ended, Ferguson 53 crewmembers walked out of the deployment area carrying their shelters and met overhead personnel who treated two crewmembers for minor burns. All crewmembers returned to camp. Later that evening, crewmembers were treated by medical personnel in camp for burns and complaints associated with smoke inhalation. Eleven crewmembers were transported to St. Charles Hospital in Bend, OR, where they were treated and released.

Investigation Process

An accident investigation team was assembled to gather facts and evidence related to fire shelter deployments that occurred on the Toolbox Complex Fire on July 24. The investigation was initiated by the Forest Service, Pacific Northwest Region, and the Bureau of Land Management (BLM) Oregon/Washington State Office, through the BLM National Office of Fire and Aviation. At the time that the investigation team was ordered, there was uncertainty regarding the specific location of the deployment and uncertainty regarding agency jurisdiction. The incident was later determined to have occurred on National Forest system land.

The team assembled in Lakeview, OR, for a briefing with agency administrators and area command (Rex Mann, incident commander) on July 25, at which time the team received a delegation of authority from the Fremont National Forest supervisor. The acting regional forester provided a second delegation of authority on July 29.

The investigation team members were:

- Susan Giannettino, team leader, (deputy State director for resources, Bureau of Land Management, Idaho)

- Kathy Greer, lead investigator, (safety manager, Bureau of Land Management, Utah)
- Tom Chavez, safety officer, (Bureau of Land Management, New Mexico, Albuquerque Field Office)
- Gene Rogers, technical expert, fire operations and fire behavior, (assistant fire staff officer, Winema National Forest)
- Leslie Anderson, technical expert, fire shelters and protective clothing, (equipment specialist, Forest Service, Missoula Technology and Development Center)
- Tony Petrilli, technical expert, fire shelters and protective clothing, (equipment specialist, Forest Service, Missoula Technology and Development Center)

Gene Rogers joined the team on July 27. In addition, Ben Croft of MTDC took aerial photographs of the deployment site.

The investigation team reviewed procedures and began assembling information while in Lakeview on July 26, but moved north that morning to the Toolbox Complex Fire incident command post (ICP) at the North Lake School in Christmas Valley, OR. Team members visited the deployment site in the afternoon of July 26 and again on July 27. The incident site had been flagged and roped off to protect evidence. However, the Ferguson 53 crew, as a precautionary measure, had carried the fire shelters off the deployment site when they hiked out to the road. The fire shelters were stored at the ICP. The crewmembers' flame-resistant clothing had been bagged and labeled with crewmembers' names.

The team provided a 24-hour briefing and report to local agency administrators or their representatives, area command, and incident command by teleconference on July 26.

Aerial photographs were taken of the deployment site and surrounding area. In addition, the Ferguson 53 crew boss provided pictures taken during and immediately after the deployment.

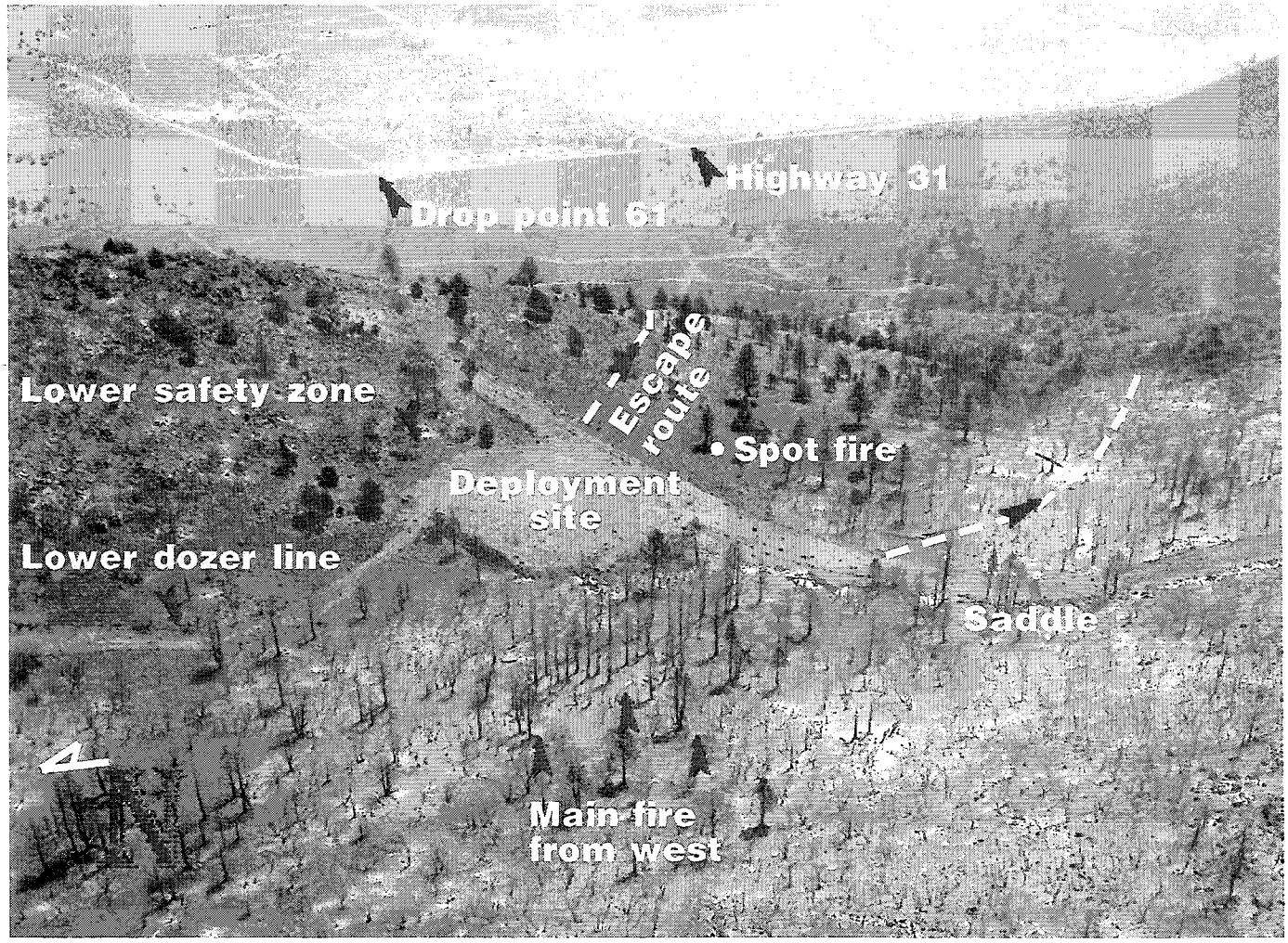
The team interviewed and/or reviewed witness statements provided by approximately 15 individuals assigned to the fire who were directly or indirectly involved with the shelter deployment. This included individuals within the incident command hierarchy, the other crew bosses and engine strike team leader working in Division T on July 24, the Ferguson 53 crew boss and squad bosses, several members of the medical staff, and the contract inspector who had inspected the Ferguson 53 crew on the morning of the deployment. The investigation team did not talk to members of the Ferguson 53 crew because they had been officially demobilized at 6 a.m. on July 26 as scheduled. Ferguson Management Co. was contacted July 27 and 28 in an attempt to set up telephone interviews with the crew boss and squad bosses but the latter were not available. As noted above, the Ferguson 53 crew boss was interviewed on July 28. In addition, the investigation team provided written questions to Ferguson Management Co. on July 29 so they could convey those questions to the two crewmembers who were injured. Written answers were provided to the investigation team on July 31. Information gleaned from these interviews, witness statements, and unit logs were used to develop findings for this report.

The equipment specialists inspected eighteen available sets of flame-resistant clothing and all twenty fire shelters. They also inspected the shelter bags found on the deployment site. The fire behavior/fire operations specialist gathered appropriate data as well as the forecasts and briefing material provided to the crews on July 24.

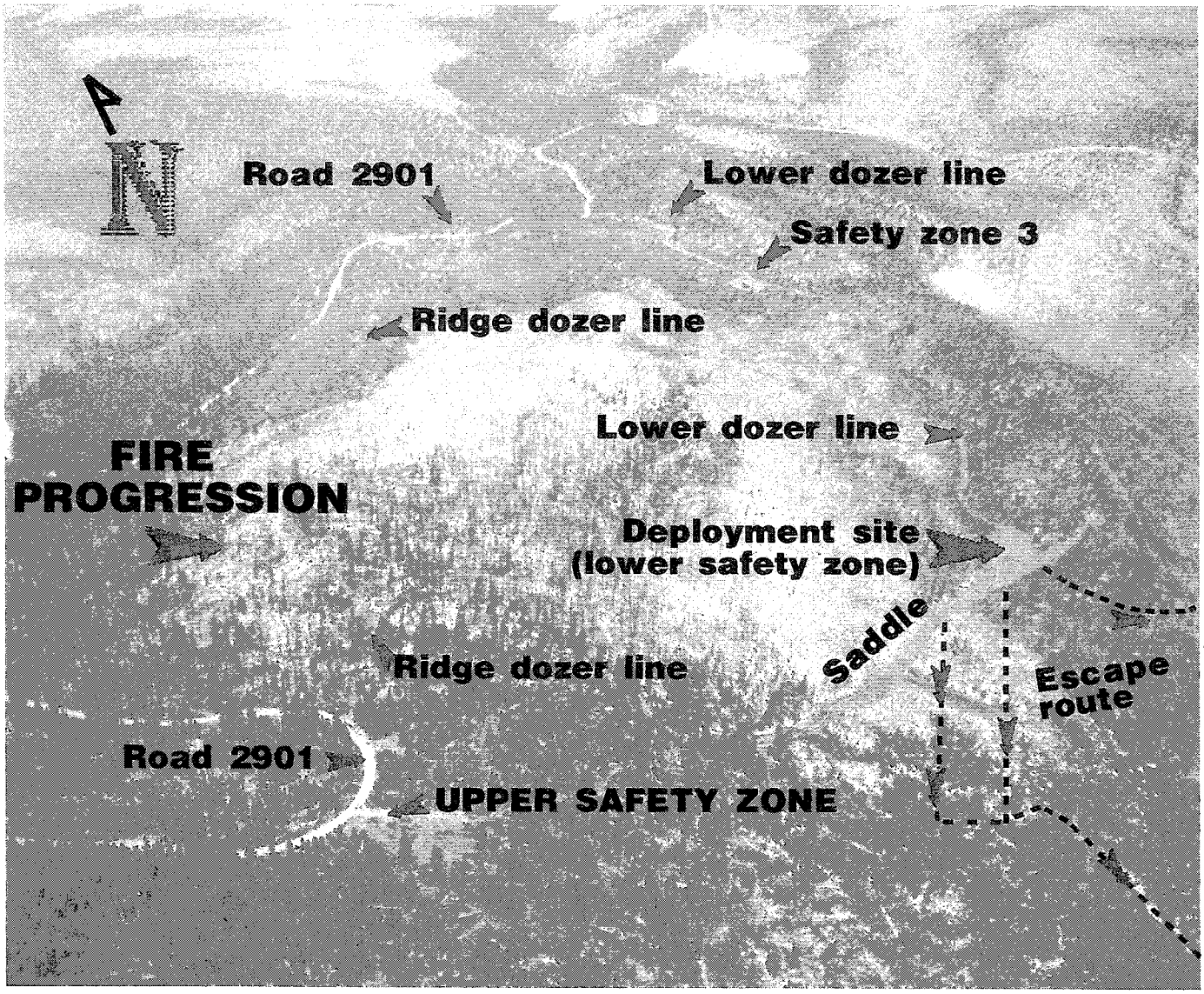
A draft 72-hour report was discussed by teleconference with local agency administrators' representatives, area command, and incident command on July 28. The 72-hour report was finalized following the conference call. The 72-hour report included preliminary and incomplete findings, which were also discussed.

The investigation team moved to Bend, OR, on the evening of July 30. On July 31, the team briefed the acting regional forester, acting deputy regional forester, acting State director, and deputy director for Oregon Department of Natural Resources at the Prineville BLM district office. The briefing reviewed the 72-hour report, preliminary findings, and strategy for completing the final report. Guidance provided by agency administrators was to stay focused on the incident itself and provide the report within 45 days. Following the briefing, the team members dispersed to their home units with their assignments.

On August 13–15, the investigation team assembled in Boise, ID, to complete the team interaction needed for the final report. At that time, the team reviewed the Pacific Northwest Region's plan to abate the hazards documented in the Occupational Safety and Health Administration (OHSA) citations regarding the Thirtymile Fire accident. The plan's actions were assessed relative to its application to the Toolbox Complex Fire shelter deployment. No repeat violations were noted.



Toolbox Fire Division T.



Toolbox Fire fire shelter deployment site.

Incident Chronology

All times are approximate and based on witness interviews and daily logs.

July 24, 2002:

0630—Morning briefing.

0700—Crew preparation.

0800—Bus problems; delay for Ferguson 53 crew.

0845—Contract inspection of Ferguson 53 crew.

0915—Ferguson 53 crew enroute to assignment (Division T).

1000—Ferguson 53 crew delayed at intersection of Highway 31 and road 2901 while trying to contact Division T.

1030—Ferguson 53 crew enroute to Division T.

1130—Ferguson 53 crew arrives on the line; meets with division supervisor (DIVS).

1130—DIVS briefs all crews on operations and safety.

1200 to 1330—Division T crews (Ferguson 53 type 2 crew, Gila Hotshots type 1 crew, and Chugach 1 type 2 crew) conduct firing operation at ridge dozer line.

1330—Multiple spot fires causes DIVS to disengage and Division T crews move to upper safety zone and have lunch.

1400—DIVS scouting existing lower dozer line with Chugach 1 crew boss and Gila Hotshots superintendent for additional firing operations. Chugach 1 crew boss begins flagging escape routes.

1445—Gila Hotshots superintendent relays message for crews to move to lower safety zone (eventual deployment site) per DIVS instructions.

1500—Crews depart for lower safety zone. DIVS continues north on lower dozer line toward road 2901.

1530—Ferguson 53, Gila Hotshots, and Chugach 1 crews arrive at lower safety zone.

1535—The following events occurred during a period of about 10 minutes:

» Gila Hotshots superintendent notifies Gila Hotshots assistant superintendent to bring Hotshot crew.
» Gila Hotshots assistant superintendent asks if all three crews are needed.
» Gila Hotshots superintendent responds to bring Chugach 1 crew and leave Ferguson 53 crew in safety zone.
» Gila Hotshot and Chugach 1 crews depart lower safety zone and proceed north on lower dozer line to conduct next firing operation.
» Ferguson 53 crew boss asks Chugach 1 crew boss if Ferguson 53 is also going.
» Ferguson 53 crew boss told by Chugach 1 crew boss to remain in lower safety zone.
» Chugach 1 crew boss tells Ferguson 53 crew boss that he had flagged an escape route over to the dozer line leading to Highway 31.
» Gila Hotshots contact Ferguson 53 crew boss by radio to "watch our backs."
» Ferguson 53 crew boss tells his crew to remain at lower safety zone, and that he'll be back in a minute.
» Ferguson 53 crew boss departs lower safety zone and walks north along lower dozer line about 200 yards to serve as lookout for the Gila and Chugach crews.
» Ferguson 53 crew boss sees smoke haze from south and a large dark cloud over the ridge to the west; hears a "747-type noise" from the lower safety zone and returns to his crew.
» Ferguson 53 crew boss reaches his crew in safety zone and crew points out spot fire near the flagged escape route.
» Spot fire torches a juniper; fire spread compromises escape routes.
» Gila Hotshot and Chugach 1 crews attempt to start firing operation near safety zone 3.
» Wind shifts and changes fire behavior and direction.
» Gila Hotshots superintendent aborts firing operation.
» Gila Hotshot and Chugach 1 crews gather in third safety zone.
» Ferguson 53 crew boss radios Gila Hotshots superintendent to notify him of the spot fire at the lower safety zone.
» DIVS overhears radio conversation and asks Ferguson 53 crew boss if spot fire is inside or outside the line.
» Ferguson 53 crew boss responds that it is inside the line.
» While out conducting fireline safety inspections and reviewing operations with the incident commander and planning section chief from drop point 61, deputy IC observes and reports a new spot fire to DIVS that makes its second control line obsolete and advises DIVS to disengage.
» DIVS orders crews to disengage; can't reach Ferguson 53 crew boss by radio after multiple attempts.

» Ferguson 53 crewmembers move to the northwest side of the lower safety zone as the spot fire on the southeast side grows quickly.
» The crew moves to the southwest side of the safety zone as the fire spreads to the northeast side of the safety zone.
» The main fire approaches the lower safety zone from the west.
» Ferguson 53 crewmembers become nervous as embers blow across the lower safety zone so they move to the east corner of the safety zone.
» Ferguson 53 crew boss orders his crew to deploy shelters to keep them from leaving the safety zone and to give relief from smoke and heat.
» Ferguson 53 crew boss notifies Gila Hotshots superintendent that the two crews (Gila Hotshots and Chugach1) could not come back toward the lower safety zone and that Ferguson 53 crew had deployed shelters.
» Division S is also disengaging, creating radio congestion on Tac 10.

1545—DIVS meets strike team engine leader (STEN) 3645C on road 2901; STEN tells him that they heard Ferguson 53 crew boss on the radio reporting that shelters had been deployed by Ferguson 53 crew.

» IC hears on radio that Ferguson 53 had deployed shelters.
» Ferguson 53 crew receives okay to exit shelters from Ferguson 53 crew boss.
» DIVS contacts Ferguson 53 crew boss and learns that they are okay.

1550—DIVS contacts operations section chief (OSC1) to report that shelter deployment has occurred and asks him to meet him at road 2901 near the upper safety zone.

1620—Operations section chief and branch III director arrive at road 2901 and meet DIVS at upper safety zone.

» DIVS and branch III director walk toward lower safety zone to assist crew.
» Operations section chief contacts Ferguson 53 crew boss by radio to confirm that they are okay and all accounted for
» Operations section chief asks safety officer to report to road 2901.

1640—Safety officers arrive at upper safety zone and meet with operations section chief.

» Safety officers walk toward lower safety zone.
» DIVS and branch III approaches lower safety zone, but can't continue due to heavy smoke and heat.

1645—DIVS brings Ferguson 53 crew out to upper safety zone. Initial report is that there are no injuries.

1700—Ferguson 53 crew arrives at upper safety zone. Two crewmembers treated for minor burns by ops chief and safety officer; all others deny injury.

1715—Safety officer advises crew that critical-incident stress debriefing will take place and interviews will take place at a later time. Emergency medical technician (EMT) and medic go to drop point to offer assistance for possible injuries.

1750—Ferguson 53 departs for base camp.

1830—EMT and medic released from scene.

1900—EMT and medic return to base camp from Division T and report no injuries.

1910—Two members of Ferguson 53 arrive at medical unit with human resource specialist.

1930—Deputy IC requests all flame-resistant clothing be collected.

1945—Ambulance transports two Ferguson 53 crewmembers to St. Charles Hospital in Bend, OR.

1950—Medical assessment of remaining 18 crewmembers begins at medical unit.

2030–2130—Nine additional Ferguson 53 crewmembers transported to St. Charles Hospital.

July 25, 2002:

0345—All Ferguson 53 crewmembers return from St. Charles Hospital where they were treated and released.

Photo (looking east) taken during fire shelter deployment (photo by Ferguson 53 crew boss).

Photo (looking north) taken during fire shelter deployment (photo by Ferguson 53 crew boss).

Entrapment Investigation Elements

	Did not contribute	Influenced	Significant contribution
Fire Behavior			
Fuels	X		
Weather	X		
Topography	X		
Predicted v. observed	X		
Other		X	
Environmental Factors			
Smoke, temperature, embers		X	
Slope	X		
Visibility	X		
Incident Management			
Incident objectives	X		
Strategy	X		
Tactics		X	
Safety briefings/major concerns	X		
Instructions given	X		
Control Mechanisms			
Span of control	X		
Communications	X		
Ongoing evaluations (NA.)			
10 Standard Fire Orders/18 Watchout Situations, and LCES (appendix A)		X (safety zone)	
Personnel Profiles of Those Involved			
Training/qualifications/physical fitness	X		
Length of operational period/fatigue	X		
Attitudes			X
Leadership			X
Experience levels		X	
Equipment			
Availability	X		
Performance/nonperformance	X		
Use for intended purpose	X		
Other	X		

Findings

Fire Behavior—

A thorough discussion of the factors affecting fire behavior before and during the shelter deployment can be found in appendix B. The following findings are based on the appendix.

- Fuels: There is no indication that anyone underestimated the fuel conditions that existed. Fuels in and of themselves did not contribute to the shelter deployment. See 'Other' below.

- Weather: Crews and overhead were briefed on anticipated weather conditions for the day. Weather in and of itself did not contribute to the deployment. See 'Other' below.

- Topography: The fire behavior analyst addressed topography in the day shift briefing. Topography in and of itself did not contribute to the deployment. See 'Other' below.

- Predicted versus observed: The fire weather forecast was accurate for the shift conditions experienced. The fire behavior forecasts gave an accurate prediction of fire behavior potential for the shift. This factor did not contribute to the deployment.

- Other: The shifting winds and influence of eddy rolls along the topographic break dropped fire brands adjacent to the safety zone, according to the Ferguson 53 crew boss. The phenomenon of eddy rolls combined with active spotting, torching and crowning fire behavior influenced the deployment.

Environmental Factors (smoke, temperature, embers)—

The Ferguson crew boss reported the presence of "dust, embers and heavy smoke" at the time of the deployment. He reported that he ordered the deployment to "calm the crew and to provide protection from the heat, smoke, and embers." He did not believe they were in danger of serious injury or death. He reported that if they had not deployed there may have been more minor burns from embers and more lung problems from smoke inhalation, or that someone might have panicked and run. The combination of smoke, heat and embers influenced the decision to deploy shelters.

- Visibility: Did not contribute.

- Slope: Did not contribute.

Incident Management—

A thorough discussion of the incident management issues related to the deployment can be found in appendix C. The following findings are based on this appendix unless otherwise indicated.

- Incident Objectives: The overall incident objectives as described in the incident action plan (IAP) for July 24 did not contribute to the shelter deployment.

- Strategy: The Division T assignment (construct and hold line) for July 24 did not contribute to the shelter deployment (see IAP).

- Tactics: The tactical deployment of personnel for the second firing operation (that is, the Gila Hotshots superintendent decision to leave the least experienced crew, Ferguson 53, in the safety zone), influenced the deployment in that Ferguson 53 was left in the location that was cut off by the spot fire and the advancing fire from the west. The decision to leave the crew in the safety zone positively affected the outcome in that the crew was in a survivable location when the deployment occurred.

- Safety briefings/major concerns: While safety briefings were informal and indirect during the second burning operation, critical safety messages were shared according to those interviewed. Safety briefings were not an issue that contributed to the deployment.

- Instructions given: Instructions given were followed, per interviews; instructions—or lack of—did not contribute to the deployment.

Control Mechanisms—

- Span of Control: Did not contribute.

- Communications: Division communication with the Ferguson 53 crew boss, according to interviews, was often indirect and relayed through the other crew bosses. Indirect communication did not contribute to the deployment.

  In his interview, the Ferguson 53 crew boss estimates that about one half of the crew spoke English, including all squad bosses. He also stated that orders were given in English and Spanish prior to and during the deployment. When commands were given in English, the squad bosses immediately translated them. No interviews (three squad bosses and crew boss) mentioned any hindrances due to language. Overall communication did not contribute to the deployment.

- Ongoing evaluations: Not applicable.

- 10 Standard Fire Orders, 18 Watchout Situations, and LCES: None of the 10 Standard Fire Orders were violated such that they contributed to the deployment of shelters by the Ferguson 53 crew. Facts and findings for all 10 Standard Fire Orders are discussed more thoroughly in appendix A. The facts indicate that the 18 Watchout Situations were recognized by the personnel working in Division T. None were determined to be direct contributing factors to the shelter deployment. Discussion of all 18 Watchout Situations is presented in appendix A. Finally, compliance with guidance relative to Lookouts, Communication, Escape Routes and Safety Zones (LCES) was evaluated. Safety zone location and size was determined to be an element that influenced the shelter deployment and is discussed in the following two paragraphs. Additional LCES facts and findings, including additional discussion of safety zones, are presented in appendix A.

The Ferguson 53 crew was in an area that had been constructed as a safety zone by a bulldozer. The lower safety zone had been located and constructed by the previous fire management team. It measured approximately 195 by 210 feet and was located on the east slope of the saddle approximately one half way up the slope from the bottom of the saddle (see photos on pages 3 and 4).

The safety zone was adequate to prevent any serious injury but discomfort and minor burns may not have been prevented without the deployment of fire shelters. Minor burns and smoke inhalation was experienced by Ferguson 53 crewmembers. One individual had first- and second-degree burns to an ear and hand, and another individual had a small second-degree burn on an elbow. Responses to written questions indicate the injuries occurred prior to shelter deployment.

Personnel Profiles of Those Involved—

- Training/qualifications/physical fitness: The division supervisor and Ferguson 53 crew had the appropriate red card qualifications, including fire shelter training. The crew's qualifications were confirmed during the morning contract inspection of the Ferguson 53 crew on July 24th (per contract inspection documentation). The contract inspector found the crew to be well organized and the crew boss well prepared for inspection. Her inspection found no issues with the crew. On July 23, the Ferguson 53 crew received an acceptable performance rating from the outgoing division supervisor. Training, qualifications, and physical fitness did not contribute to the deployment.

- Length of operational period/fatigue: The division supervisor and Ferguson 53 crew were operating within the required work/rest guidelines, based on a review of their time sheets, and this factor did not contribute to the shelter deployment.

- Attitudes: Some of the Ferguson 53 crewmembers' displays of anxiety significantly contributed to the crew boss's decision to order shelter deployment.

- Leadership: The crew boss's leadership skills in a challenging situation led him to the decision to order the deployment that maintained control of his crew. His leadership significantly contributed to a positive outcome.

- Experience levels: This was the first fire for four members of the Ferguson 53 crew. It was the first fire season for ten members of the crew, according to the crew boss and squad bosses. The crew boss had fought fire since 1984 with 1 year off. Ferguson 53 is a type 2 crew. The Gila Hotshots superintendent staged the Ferguson 53 crew in the safety zone during the second firing operation because he did not know the experience level of the Ferguson 53 crew. Experience levels influenced the shelter deployment.

Equipment—

A thorough discussion of equipment issues affecting the shelter deployment can be found in appendix D. The following findings are based on this appendix unless otherwise indicated.

- Availability: The contract inspection conducted on the morning of the shelter deployment indicated the crew was appropriately equipped with personal protective equipment. Equipment availability did not contribute to the deployment. Radio equipment was available and, although availability of or access to frequencies might have been an issue, this did not contribute to the deployment.

- Performance/nonperformance:

  - Flame-Resistant Clothing: Examination of the flame-resistant clothing worn by the crew during the deployment indicated that the clothing performed as designed and offered protection to the entrapped firefighters. Heat damage was limited to a small number of tiny marks, predominantly smaller than $^1/_4$ inch in diameter where embers came in contact with the clothing.

  - Fire Shelters: A review of the fire shelters used in the deployment indicate that all of the shelters performed as designed and offered the firefighters protection from smoke and minor burns. Two shelters did have flaws (one hole, one seam separation) that potentially could

have resulted in reduced protection. However, since the two people who received minor burns during the incident both reported that their injuries occurred prior to the deployment, there is no evidence these flaws led to further injury of any firefighter.

- ♦ Radio Equipment: Radio equipment performance was not an issue.

- Used for Intended Purpose: Equipment was used as intended and so did not contribute to the deployment.

- Other:

  - ♦ Maintenance: Black marks on the inside of the shelter bag indicate abrasion. Inspection procedures outlined in the training materials explain that shelters with evidence of abrasion should be withdrawn from service. There is evidence that proper inspection and maintenance were not properly performed. The fire shelters still performed as designed.

  - ♦Procedures: All firefighters involved in the deployment were reportedly able to deploy their shelters without delay. However, some crewmembers did not follow the deployment procedures recommended by the National Wildfire Coordinating Group (NWCG).

-It was clear after examining the fire shelter bags after the deployment that the tear strips of several of the bags had not been torn prior to the deployment as required by a May 2001 Fire Shelter Safety Alert.

-Examination of the fire shelter bags after the deployment indicated that several of the fire shelters were deployed by opening the top of the PVC bag instead of using the tear strips provided.

-Interviews and pictures taken as the crewmembers were exiting their shelters indicate that several firefighters were not wearing gloves during deployment or took them off just as they were exiting their shelters.

-Pictures taken during the deployment show that some shelters were deployed next to line gear packs.

-Pictures taken during the deployment show that the hardhat of at least one firefighter was left outside the firefighter's fire shelter.

Management Evaluation Report

Executive Summary

On July 24, three crews (Ferguson 53, a Pacific Northwest Region type 2 contract crew; Chugach 1, a type 2 crew; and Gila Hotshots, a type 1 crew) were assigned to Division T of the Toolbox Complex Fire near Picture Rock Pass on the Fremont National Forest in Oregon. Ferguson 53 had been working on the fire since July 18. On the morning of July 24, the Ferguson 53 crew arrived late at Division T, due to a contract inspection and bus difficulties. Chugach 1 and the Gila Hotshots had worked together during the morning, prior to the arrival of Ferguson 53. Upon the arrival of Ferguson 53, the division supervisor briefed all three crews before the crews began firing the ridgeline. Approximately one-and-half hours later, the division supervisor disengaged that operation due to numerous spot fires. He moved the three crews to the upper safety zone so the crews could rest and have lunch. He then departed the area with the Gila Hotshots superintendent and the Gila Hotshots assistant superintendent to scout and determine the possibility of another firing operation. The Chugach 1 crew boss followed them and marked escape routes. All three crews were then told to report to the lower safety zone to receive further instructions.

The division supervisor and the Gila Hotshots superintendent determined the next course of action, then the division supervisor headed north along the lower dozer line to return to the road 2901. When the three crews arrived at the lower safety zone, the superintendent from the Gila Hotshots radioed for his crew to move north along the lower dozer line to begin the next firing operation. The Chugach 1 crew also departed the safety zone to assist and the Ferguson 53 crew was told to stay behind in the lower safety zone until needed.

Shortly after the two crews departed from the lower safety zone, Gila radioed to the Ferguson 53 crew boss to watch their backs. The Ferguson 53 crew boss briefly left his crew to walk a short distance north along the lower dozer line. Heavy smoke and a roaring sound drew his attention, so he returned to his crew back at the lower safety zone. Upon his arrival, he noted a spot fire adjacent to the lower safety zone on the southeast side. Wind direction changed and pushed the main fire down the ridge from the west. All escape routes leading away from the lower safety zone were quickly compromised. Ferguson 53 crewmembers moved to different sides of the lower safety zone to escape the heat. They became nervous as the fire spread quickly around the lower safety zone and embers were blown on them. In order to calm their fears and to provide protection from the heat and smoke, the Ferguson 53 crew boss ordered his crew to deploy their shelters.

The shelter deployment lasted approximately 15 minutes. Simultaneously, two other events occurred:

- The Gila and Chugach crews began firing operations and almost immediately disengaged due to the advancing fire from the west.

- The division supervisor was contacted by the deputy incident commander to disengage operations in that area, due to a spot fire which compromised the Division T operations. The division supervisor radioed the three crews to disengage, but received no response from Ferguson 53. The sequence of events indicates that the Ferguson 53 crew was in their shelters at this time and their crew boss had switched back to their company radio frequency to communicate with his crewmembers.

After the deployment ended, Ferguson 53 crewmembers walked out of the deployment area carrying their shelters, and met overhead personnel who treated two crewmembers for minor burns. All crewmembers returned to camp. Later that evening, crewmembers were treated by medical personnel in camp for the burns and for complaints associated with smoke inhalation. Eleven crewmembers were transported to St. Charles Hospital in Bend, OR, where they were treated and released.

Causes and Contributing Factors

The primary cause of the incident (in this investigation, the Ferguson 53 crew's shelter deployment) is the direct agent that starts or sustains an incident. A contributing factor influences or contributes to the cause of the shelter deployment. These have been built from the findings presented in the factual report.

- The probable cause of the shelter deployment: The crew boss's leadership skills in a challenging situation led him to the decision to order the deployment that maintained control of his crew. His leadership significantly contributed to a positive outcome.

- Contributing factors: Some of the Ferguson 53 crewmembers' open display of anxiety significantly contributed to the crew boss decision to order shelter deployment.

- Ferguson 53, according to interviews of the crew boss and squad bosses, had four members for whom this was their first fire and for a total of ten members, this was their first year of experience. The crew boss had fought fire since

1984 with 1 year off. Ferguson 53 is a type 2 crew. The Gila Hotshots superintendent staged the Ferguson crew in the safety zone during the second firing operation because he did not know the experience level of the Ferguson 53 crew. Experience levels influenced the shelter deployment.

- The shifting winds and influence of eddy rolls along the topographic break dropped fire brands adjacent to the safety zone. The phenomenon of eddy rolls combined with active spotting, torching, and crowning fire behavior influenced the deployment.

- The Ferguson 53 crew boss reported the presence of "dust, embers and heavy smoke" at the time of the deployment. He reported that he ordered the deployment to "calm the crew and to provide protection from the heat, smoke, and embers." He did not believe they were in danger of serious injury or death. He reported that if they had not deployed there may have been more minor burns from embers and more lung problems from smoke inhalation, or that someone might have panicked and run. The combination of smoke, heat and embers influenced the decision to deploy shelters.

- Safety zone location and size was determined to be an element that influenced the shelter deployment. Ferguson 53 crew was in an area that had been constructed as a safety zone by a bulldozer. It measured approximately 195 by 210 feet and was located on the east slope of the saddle approximately one half way up the slope from the bottom of the saddle. The safety zone was adequate to prevent any serious injury but discomfort and minor burns may not have been prevented without the deployment of fire shelters. Minor burns and smoke inhalation were experienced by Ferguson 53 crewmembers.

Recommendations

- Management needs to make it clear that, although escape is always a preferred alternative, it may be necessary and appropriate to deploy shelters as a means of controlling panic and as a precautionary measure against minor injuries.

- The current type 2 crew category is too broad to allow management to be able to ensure assignments match crew capabilities. The crew typing system needs be able to recognize crew experience beyond the type 1 or type 2 classification.

- Align the conflicting guidance regarding safety zone size (Red Book, IRPG) including conducting the necessary additional research needed to provide guidance.

- Reemphasize that crews need to evaluate the adequacy of safety zones, as if they were going to use them, in planning operations.

Appendix A—10 Standard Fire Orders, 18 Watchout Situations, and LCES

10 Standard Fire Orders

F: Fight fire aggressively but provide for safety first.
Fire was being aggressively fought. The firing operations conducted by the crews in Division T on July 24th evidence the difficulty the crews were having in accomplishing objectives due to predicted and experienced fire behavior. At the same time, safety was provided for through day-shift briefings, contract inspections, identification of safety zones and escape routes, and the fact that the less-experienced Ferguson 53 crew was told to remain in the lower safety zone until needed. The facts that support this finding are in the investigation file (see the July 24th IAP), and interviews with the contract inspector and crew bosses.

I: Initiate all action based on current and expected fire behavior.
All actions were consistent with forecasted weather and forecasted fire behavior (see appendix B). The disengagement of the first firing operation reflected recognition of the current and expected fire behavior.

R: Recognize current weather conditions and obtain forecasts.
Weather conditions were recognized and forecasts were provided at briefings (see appendixes B and E).

E: Ensure that instructions are given and understood.
Division supervisor (DIVS) communication with the Ferguson 53 crew boss was often indirect and relayed through the other crew bosses. The Ferguson 53 crew boss did not prompt the DIVS for direct instruction. Neither the DIVS nor Ferguson 53 crew boss followed up on indirect communications to make sure instructions were understood.

O: Obtain current information on fire status.
The fire edge was clear to personnel on Division T and operations and command functions had focused attention on the active portions of the fire (Divisions S and T). This finding is supported by the interviews conducted with Division T personnel. The operations section chief and branch director were in the process of arranging for overflight of this branch just prior to deployment.

R: Remain in communication with crew members, your supervisor, and adjoining forces.
According to interviews, there were some periods of inability to communicate directly on Tac 10 due to radio traffic (including two adjacent divisions, Divisions S and T, on the same radio frequency), terrain features and intra crew radio frequency communication. The cloning process set by the communications unit at the ICP deprogrammed priority setting capability.

D: Determine safety zones and escape routes.
Safety zones and escape routes were established and known to Division T personnel.

E: Establish lookouts in potentially hazardous situations.
The Ferguson 53 crew was in a safety zone with the crew boss serving as a lookout for his crew.

R: Retain control at all times.
According to interviews, the Ferguson 53 crew boss ordered his crew to remain in the lower safety zone and moved them, as a group, from one side of the safety zone to another several times before ordering them to deploy shelters as a strategy to ensure he retained control of their actions. The decision to not bring the Ferguson 53 crew into the second firing operation helped maintain control of that action.

S: Stay alert, keep calm, think clearly, and act decisively.
Ferguson 53 crew boss acted decisively when he told crew to stay calm, stay in the safety zone, and he gave the crew members the order to deploy shelters as he observed they were displaying significant uneasiness.

18 Watchout Situations

1: The fire is not scouted and sized up.
Fire was scouted and sized up and the limited chance of success for the second firing operation was understood according to crew boss interviews.

2: You're in country not seen in daylight.
Ferguson 53 crew had been working Division T day shift for 4 days.

3: Your safety zones and escape routes aren't identified.
Safety zones and escape routes were identified.

4: You're unfamiliar with weather and local factors influencing fire behavior.
According to interviews, briefings were provided by the meteorologist and the fire behavior analyst and were attended by Ferguson 53 crew boss.

5: You're uninformed on strategy, tactics and hazards.
Ferguson 53 crew boss was not clear on overall plan for operations on Division T and somewhat out of the direct line of communication. But he understood the second firing operation was occurring (and had concerns about the wind) and he understood his crew was to stay in the safety zone until needed.

6: Instructions and assignments are not clear.
Division supervisor communication with the Ferguson 53 crew boss was often indirect and relayed through the other crew bosses. The Ferguson 53 crew boss did not prompt the division supervisor for direct instruction. Neither the division supervisor nor Ferguson 53 crew boss followed up on indirect communications to make sure instructions were understood.

7: No communication link with crewmembers/ supervisor. The communication link was there. However, there were some periods of inability to communicate directly on Tac 10 due to radio traffic (including two adjacent divisions, Divisions S and T on the same radio frequency), terrain features and intra crew radio frequency communication. The cloning process set by the Communications Unit at the ICP deprogrammed priority setting capability.

8: You're constructing a line without a safe anchor point.
Not applicable.

9: You're building a fireline downhill with fire below.
Not applicable.

10: You're attempting a frontal assault on the fire.
The Division T crews were making a frontal assault using a firing operation as a tactic. They had identified safety zones and escape routes to mitigate the risks.

11: There is unburned fuel between you and the fire.
This watchout situation existed but was mitigated by the identification of safety zones and escape routes.

12: You cannot see the main fire and you're not in contact with anyone who can.
Ferguson 53 crew could see the main fire and were in contact with others who could see it also.

13: You're on a hillside where rolling material can ignite fuel below.
Not applicable.

14: The weather is getting hotter and drier.
Conditions were getting hotter and drier. The tactics used for the second burning operation recognized a limited chance of success and relied on mitigation provided by established safety zones and escape routes.

15: Wind increases and/or changes direction.
Wind direction and speed were changing. The tactics used for the second burning operation recognized a limited chance of success and relied on the mitigation provided by established safety zones and escape routes.

16: You're getting frequent spot fires across the fire line.
Spot fires contributed to the fire activity around the lower safety zone that caused the crew to deploy shelters but the crew was already in a safety zone.

17: Terrain and fuels make escape to safety zones difficult. All Division T crews had easy access to safety zones and Ferguson 53 crew was already in the lower safety zone.

18: You feel like taking a nap near the fireline.
Not applicable.

LCES

Lookouts: Formal lookouts were not posted. The Ferguson 53 crew was in a safety zone with the crew boss serving as a lookout for his crew.

Communication: Division communication with the Ferguson 53 crew boss was often indirect and relayed through the other crew bosses. A more direct and complete briefing may have improved the Ferguson 53 crew boss understanding of the situation but the absence of such a briefing probably did not contribute to the deployment.

Not all the Ferguson 53 crewmembers spoke English. The Ferguson 53 crew boss said about one-half his crew spoke English and he speaks Spanish and English. Interviews with the squad bosses did not specifically address their ability to speak English but their statements about conversations they overheard indicate they understood English. The contract requirement is that the "crew boss and two squad bosses of every crew shall be able to communicate fluently in English and in any language that crewmembers use to communicate." This requirement appears to have been met. In any case, all instructions

given to the crewmembers on July 24th were followed including the crew boss's instructions to his crew to deploy shelters. The facts do not indicate communication was a factor contributing to the deployment of shelters.

Escape Routes: Multiple escape routes were identified and flagged. A lack of identified escape routes did not contribute to the shelter deployment. However, the rapid spread of the spot fire adjacent to the lower safety zone and the approaching main fire quickly compromised all the escape routes and led Ferguson 53 to have no option but to stay in the safety zone where they deployed shelters.

Safety Zones: Ferguson 53 crew was in an area that had been constructed as a safety zone by a bulldozer. The lower safety zone had been located and constructed by the previous fire management team. Per interviews, the lower safety zone was considered acceptable. It measured approximately 195 by 210 feet and was located on the east slope of the saddle approximately half way up the slope from the bottom of the saddle (see aerial photos).

The safety zone was adequate to prevent any serious injury but discomfort and minor burns may not have been prevented without the deployment of fire shelters. The safety zone was not quite adequate to endure the fire without fire shelters. Minor burns and smoke inhalation were experienced by Ferguson 53 crewmembers. One individual had first- and second-degree burns to an ear and hand and another individual had a small second-degree burn on an elbow. These individuals indicated these injuries occurred prior to shelter deployment.

It is difficult to determine what constitutes an adequate safety zone because of the variables that can not easily be determined prior to the event that might cause a safety zone to be used. For example, weather, topography, and fuels are significant factors influencing flame length, presence of gases, heat, smoke, and blowing embers. On site guidance available for selection and development of safety zones is contained in "Standards for Fire and Aviation Operations 2002" (the Red Book) and the Incident Response Pocket Guide, NFES No. 1077 (IRPG). The guidance contained in these two documents differs in that the Red Book uses flame length and the IRPG uses flame height. Both guides address only radiant heat. The guidance says to consider factors such as topographic features and wind but doesn't provide details.

The Red Book describes a safety zone as "a preplanned area of sufficient size and suitable location that is expected to protect fire personnel from known hazards without using fire shelters." The formula provided for calculating the size of a safety zone is "four times the expected flame length plus an extra four feet per firefighter." The formula provides a recommended distance in feet completely around personnel, and addresses protection from radiant heat only. In addition to the size of the safety zone, guidance is provided for the location of the safety zone, in other words, avoid locations down wind from the fire. Avoid locations that are in chimneys, saddles, or narrow canyons. Avoid locations that require a steep uphill escape route (steeper than 50 percent). Using the recommended formula in the Red Book for calculating the size of a safety zone, an adequate safety zone to protect personnel would have been 192 by 192 feet for an expected four-foot flame length.

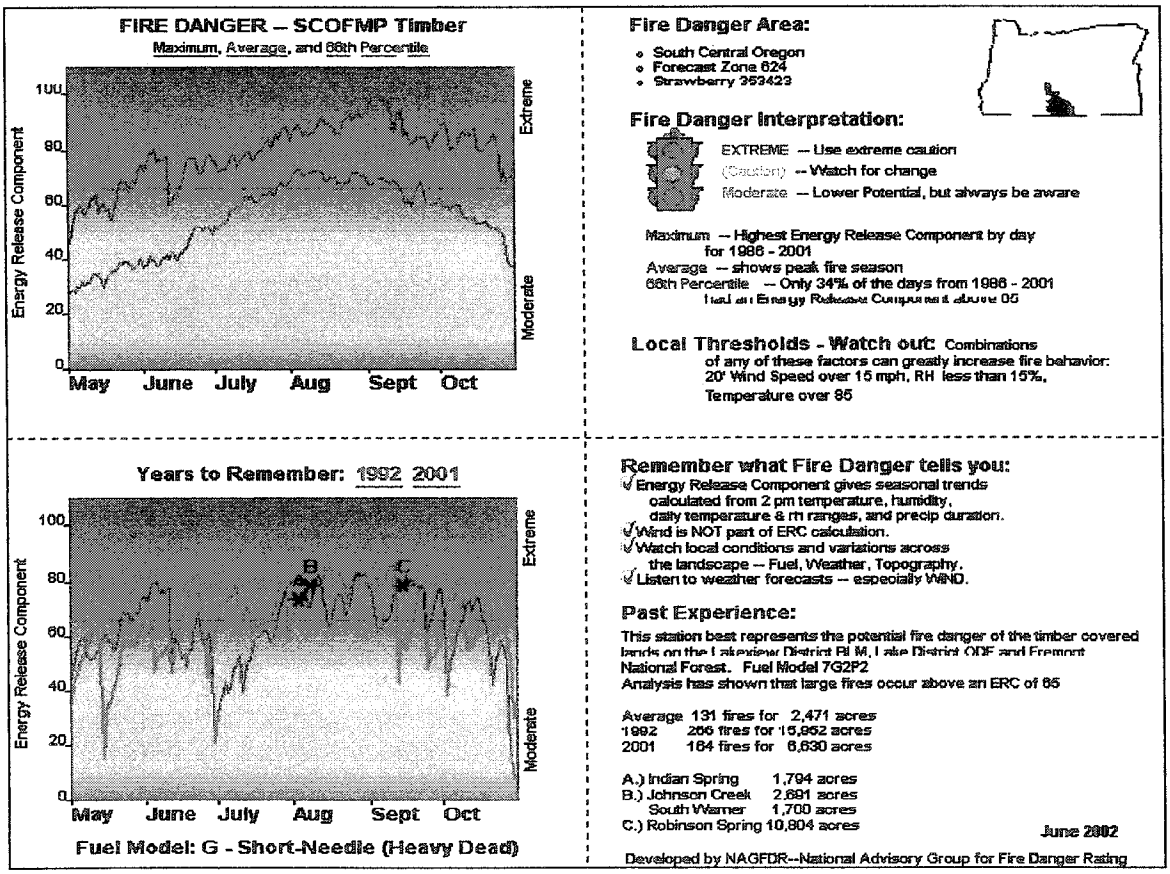
The IRPG provides qualitative guidance regarding location of safety zones and a table that relates flame height to the separation distance between firefighters and flame to calculate appropriate size of a safety zone. Using the table in the IRPG, an adequate zone to protect personnel in a situation with a 20-foot flame height (considering radiant heat only) would have been one half acre (104 by 104 feet). The flame height at the time of the shelter deployment is unknown but just prior to shelter deployment on the east side of the lower safety zone the flame length was observed to be two to four feet. Fuels, though, were different on other sides of the lower safety zone.

Fire Weather and Fire Behavior

The fire weather forecast was accurate for the shift weather conditions experienced (see appendix E.) Data compiled by the incident meteorologist (IMET) was also consulted.
A narrative synopsis of the atmospheric conditions over south-central Oregon has been prepared by a Fire Weather Meteorologist from the Medford Office of the National Weather Service and is enclosed.

The fire behavior forecast gave an accurate forecast of fire behavior potentials for the shift. Key fire behavior characteristics predicted included: torching, crowning, spotting with a high probability of fire brands starting spots fires (80 to 90 percent). Specific fire behavior forecast comments about Branch II, III and IV were: "Expect all unsecured lines within these branches to become active today. Branch III will likely be most active in the area that blew out on July 23rd. Southwest winds will continue to push the fire towards Highway 31. Expect the heavier fuels to produce the most heat and flame lengths, but expect other fuel types to be more active as well" (see appendix E.)

Personnel were made aware of the energy release component (ERC) during shift briefings. A copy of the local unit fire danger pocketcard was included in each incident action plan (IAP). This pocketcard posted the observed ERC for the previous shift and the forecasted ERC for the current shift. Additionally, the average ERC for the date was posted for relative comparison. ERC for fuel model G (heavy dead) was forecasted to be 82 on July 24, compared to an average for that date of 60. The local pocketcard further stated that large fires (more extreme fire behavior events) occur at ERC values above 65. (Pocketcard displayed below)



Appendix B—Fire Weather and Fire Behavior

Fire weather conditions on the Toolbox Complex Fire had become more severe by the July 24 shift compared to the previous 5 days. The air mass over the fire area had become significantly more dry as evidenced by the following relative humidity traces from area remote automatic weather stations (RAWS). Chart 1, below, shows a trace of the relative humidity for the Coffee Pot RAWS from June 1 through July 24, compared to historical values since 1982. Note that the recorded value on July 24, is at the 97th percentile low value since 1982.

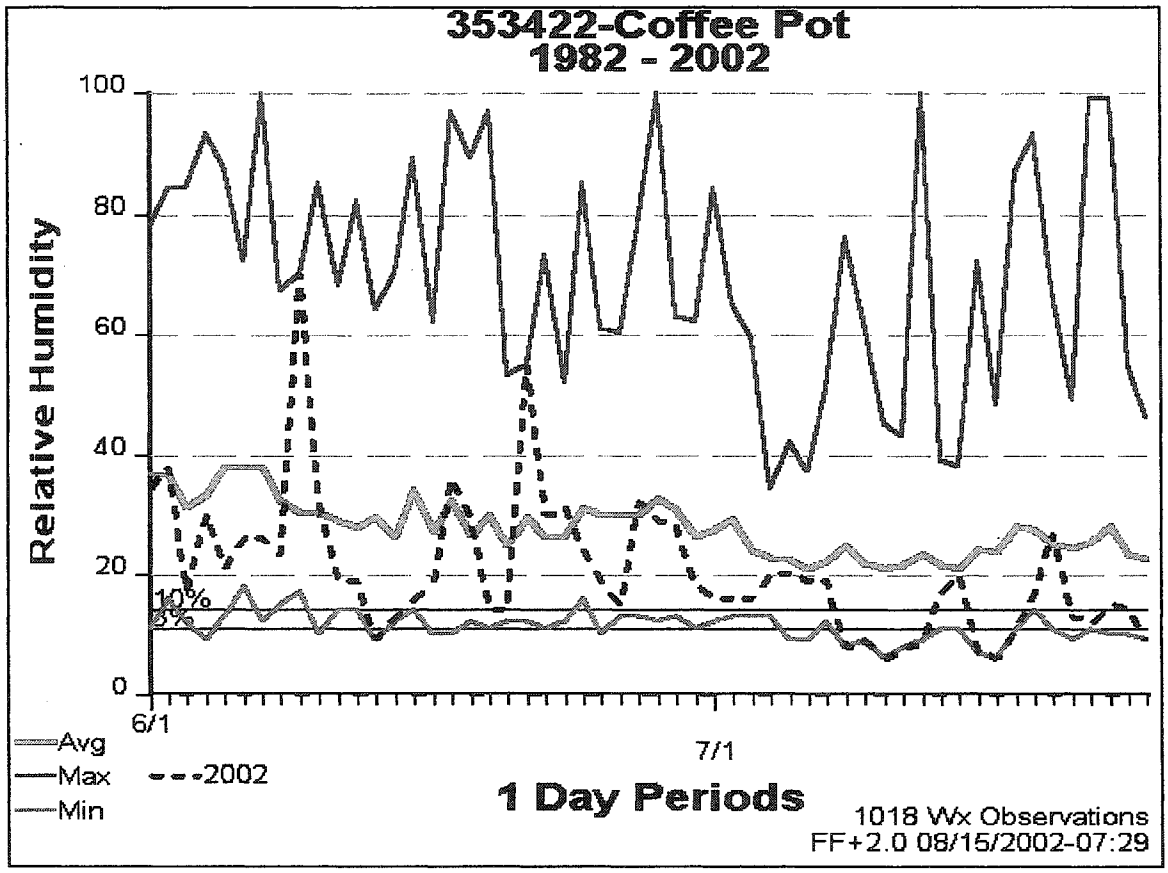


Chart 1

Obviously, the fuels in the Toolbox Complex Fire were at volatile moisture content levels. Chart 2 displays the 2002 trace for woody fuel moisture content for the Coffee Pot RAWS. The live woody fuel moisture value for July 24 is at the 97th percentile low value since 1982. This displayed woody fuel moisture value was confirmed by fire behavior observed in Division T, which included crown fire in mountain mahogany stands.

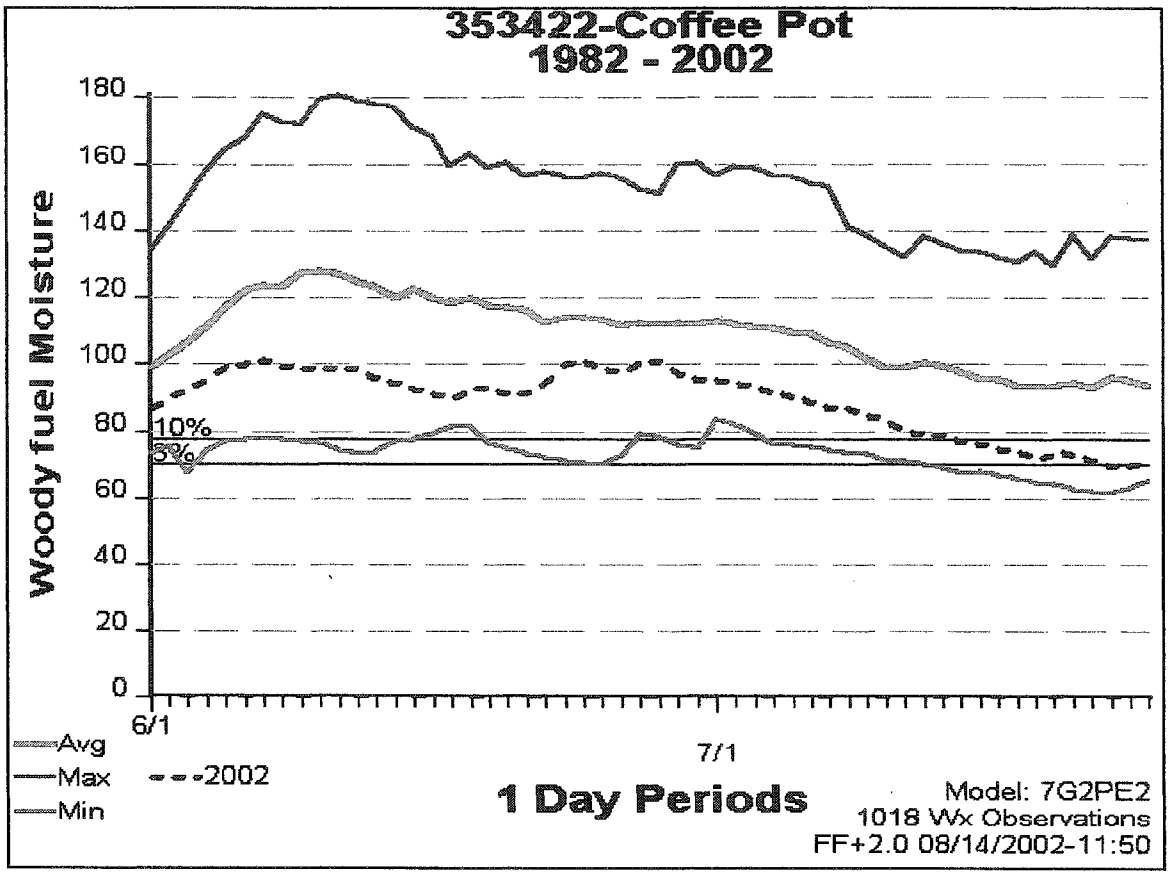


Chart 2

Fire spread direction in Division T was driven predominantly by wind and topography. A southwest wind aloft until late afternoon continued to push the fire, generally, to the northeast. During the late afternoon, preceding and during the deployment, the winds switched several times. This was caused by two heat "lows", one to the northeast and one to the southeast of the fire, competing for controlling influence of the wind. As the wind made contact with the terrain features in Division T eddy rolls became visible and the column was observed to "roll over" and lay down over the terrain, then lift again. This phenomenon is common where winds contact terrain features such as passes, saddles, ridges and benches. (The Winter Rim area is infamous to local fire managers for it's effect on winds. Fires in the past have been observed to push downslope during the afternoon.)

Spotting potential was recognized by the fire behavior analyst and noted in his forecast for the shift. This potential is confirmed by the ignition component trace in chart 3 for the Coffee Pot RAWS. Ignition Component displays the probability of a firebrand causing an ignition requiring a suppression action.

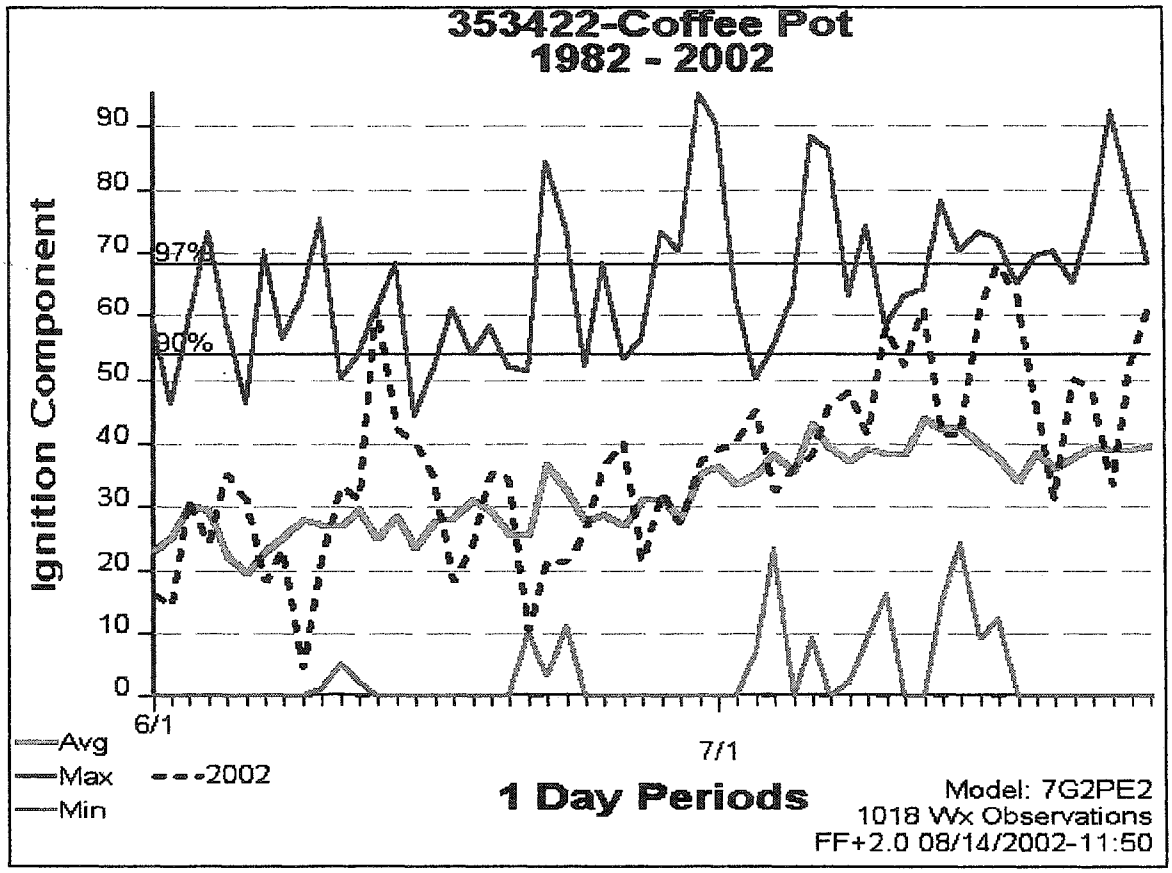


Chart 3

The main fire edge worked down the gentle slope of the ridge west of the lower dozer line. As the fire entered the continuous stand of mountain mahogany in the base of the draw the fire intensity increased dramatically. This was due to hardwood surface litter to feed a more intense surface fire, resulting in crowning of the mahogany canopy (see photo B-1 for area of mahogany stands labeled MM), which drew more air as the convection increased. This resulted in the roaring sound "like a 747" heard by the Ferguson 53 crew boss when he left his lookout location to return to the lower safety zone. (Mahogany stands will support crowning fire behavior only under moderate winds, eye-level 5 to 10+ mph, as experienced in the afternoon of July 24. Lighter winds result in an underburn with a surface fire in litter fuels. The winds would have increased in speed and turbulence in response to the increasing fire behavior.)

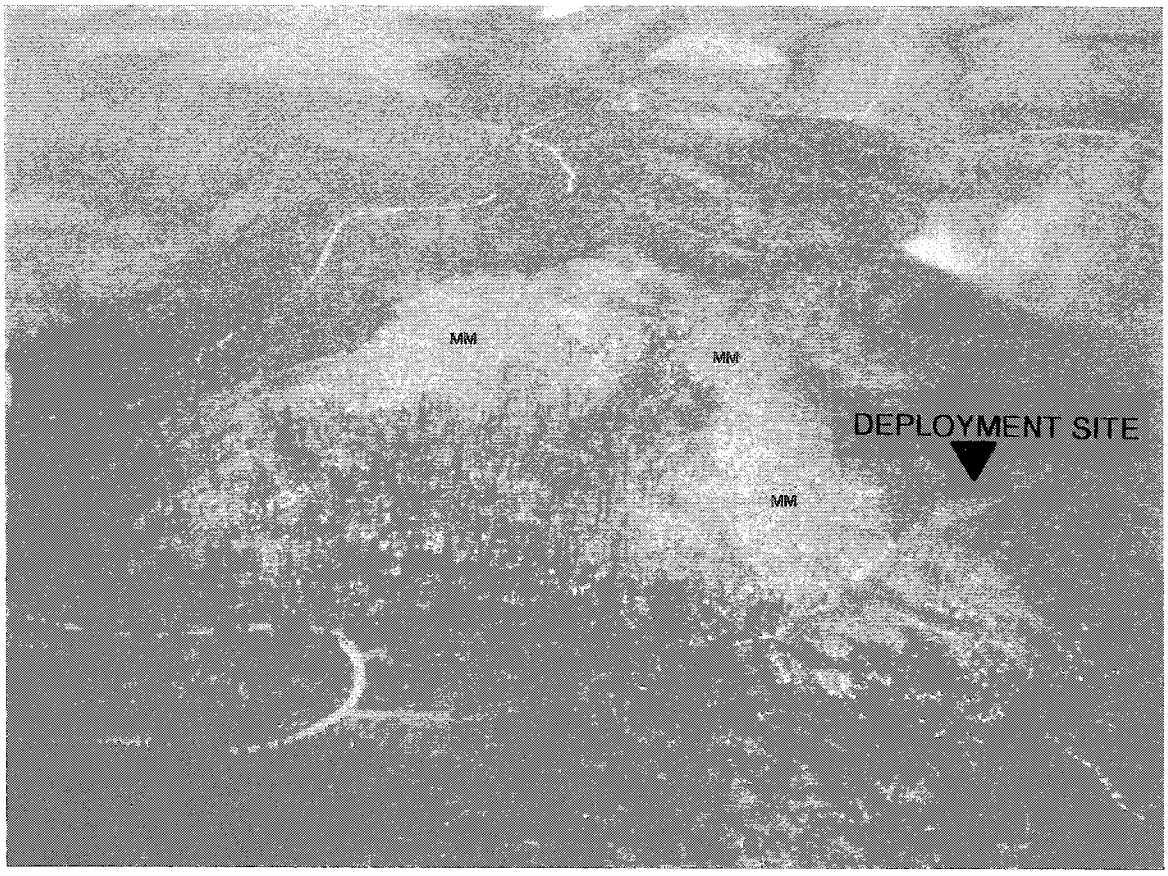


Photo B-1 Large areas of white ash in mountain mahogany stands.

As the fire behavior began to pickup in the afternoon, torching and crowning behavior was evident in Division T. The shifting of the winds and influence of eddy rolls along the topographic break dropped firebrands into the unburned fuel inside the lower dozer line and beyond it. Spot fire activity was observed by the Ferguson 53 crew adjacent to their safety zone. Spot fires were observed by the incident commander, deputy incident commander and plans section chief on the face of the slope below the Division T lower safety zone. See photo B-2.

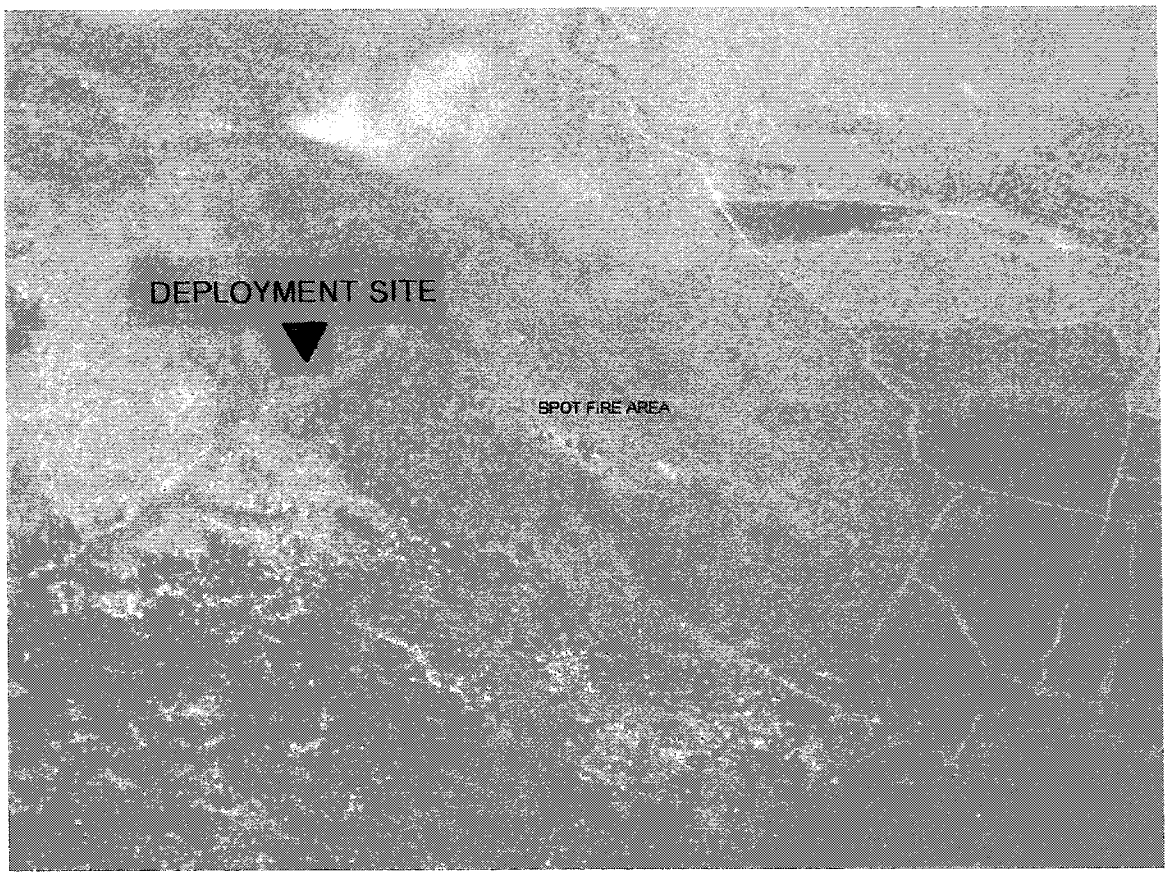


Photo B-2

As noted by the Ferguson 53 crew boss, the first spot fire near the lower safety zone appeared near the southeast side of the safety zone. This spot grew rapidly in light grass and generated its own spotting when scattered juniper trees began to torch. Spot fires formed on the west side of the short ridge above the safety zone. This slope burned rapidly in the fine grass fuels. By this time there had to be prolific spotting from the mahogany stand as leaves were lofted by crown fire behavior. (It was about this phase in the fire spread that the mid-slope spot fires were observed by the incident commander, deputy incident commander and plans section chief on the road. The same group observed the column of the fire "roll over" the slope prior to the mid-slope spots being observed, see Photo B-2.)

The pocket of ponderosa pine adjacent to the west corner of the safety zone torched, probably as the mahogany stand west of it crowned. It is likely that flames from the torching pine were drawn toward the convection column of the mahogany stand, which was a larger, more homogenous fuel bed. (Note large areas of white ash in the mahogany stand area, labeled MM in photo 1.) The mahogany stand that crowned is distinctive in the photo, as compared to the mahogany that only underburned, where only surface litter fuel was consumed.

Gene Rogers
Fire Behavior Analyst

The following weather synopsis was requested from the Medford office of the National Weather Service. The synopsis was prepared by Dennis Gettman of that office.

Weather synopsis for July 24-25, 2002

An upper level ridge was centered over the southwest U.S. with an upper level low pressure slightly offshore. During the afternoon of July 24th, the low pressure started to move NE across northern California into Klamath county, and acted to destabilize the air mass by cooling the atmosphere aloft. Upper level temperatures at 500 mb decreased by 2° F, which helped to steepen the lapse rate. Surface high temperatures were in the middle 80s in Klamath County. Afternoon relative humidity was between 10-15% with some RAWS stations showing minimum relative humidity in the single digits. RAWS at Chiloquin dropped to 3 percent and Gerber Reservoir at 9 percent. Observed High Level Haines Index from Medford was 5 on afternoon of July 24 while further east the High Level Haines Index reading at Boise was 6. The low-level pressure gradients were not unusual for the time of year and the winds aloft were southwest 10-15 mph which is near normal as well. Thus nothing distinguishes itself to make this day unusual other than the instability. Judging from the plume development seen on satellite pictures the afternoon of July 24, deep dry instability as indicated by the Haines 6 at Boise combined with single digit humidities and rather normal afternoon breezes to cause existing fires to experience very rapid growth and likely erratic fire behavior.

Dennis

Appendix C—Fire Operations

Fire Operations

The division supervisor (DIVS) was on his first shift on the division. The Gila Hotshots were added to the Division on this shift. The Chugach and Ferguson 53 crew had worked this division previously. Firing operations were implemented that generated too many spots, so that line location was abandoned. A second firing plan was quickly formulated after scouting the lower dozer line. The hand crews (Gila, Chugach, and Ferguson 53) were moved to the lower safety zone while the Division Supervisor and Gila Superintendent scouted the secondary dozer line.

This line was not ideal in location. After leaving the safety zone the line ran slightly uphill on a side-slope before turning slightly downhill maintaining the side-slope location until flattening out in a shallow saddle between two short ridges. (See photos on pages 3, 4 and photo B-1 on page 22) The main fire was moving toward and obviously going to bump the lower dozer line. The line was not expected to hold without firing so an attempt to fire the line was made, but quickly abandoned. This effort was coordinated by the Gila superintendent. The Gila crew and the Chugach crew were committed to the operation. The Ferguson 53 crew remained in the safety zone, as instructed, awaiting further instruction.

The main fire bumped the lower dozer line between the lower safety zone and safety zone 3. Gila and Chugach retreated to safety zone 3, Ferguson 53 remained in the lower safety zone.

Communications were typical for an active division with tactical and command frequencies experiencing a high level of traffic. Radios cloned by the Communications Unit for the July 24 shift were not able to set a priority frequency. Radios used by the Ferguson 53 crew were able to set a priority frequency, and had that function activated to prioritize the intra-crew frequency. The tactical frequency, TAC 10 - 166.775, was being utilized by resources assigned to both Division T and S. Use of the same tactical frequency on adjacent divisions complicated the communication situation.

Command of Division T was assumed and maintained by the division supervisor. Supervision of the firing attempt near safety zone 3 was delegated to the Gila superintendent. Supervision of all assigned line resources was maintained through the shift by single resource bosses (crews), strike team leader (engines) and the division supervisor. The directions given by the division supervisor were made directly or indirectly to crews on the line. The directions given to Ferguson 53, after the division supervisor gave the Gila superintendent responsibility for the firing attempt near safety zone 3, were primarily from the Gila superintendent. The division supervisor was monitoring Division T radio traffic.

The placement of the Ferguson 53 crew in the lower safety zone was following a division supervisor decision to bring all three crews to that safety zone. The holding/staging of the Ferguson 53 crew in the lower safety zone was made pending a specific assignment of the crew to the tactical operations on the lower dozer line. When the division supervisor was giving the order for Division T resources to disengage the Ferguson 53 crew boss did not acknowledge. At this time the Ferguson 53 crew boss was using the intra-crew frequency to communicate with his personnel during the deployment and was not able to hear transmissions on other frequencies.

Gene Rogers
Operations Technical Specialist

Appendix D—Equipment Report

Since the Ferguson 53 crew was demobilized before the investigation team arrived, the team was unable to speak to most of the crewmembers. Information in this equipment report is therefore based on examination of the fire shelters, fire shelter bags, and flame-resistant clothing used by the crew; interviews with the Ferguson 53 crew boss; notes from interviews of the three squad leaders done by Forest Service law-enforcement personnel before the crew left the incident; contract inspection reports; examination of photos taken during the deployment; and brief written answers to questions posed by the investigation team from the two individuals who suffered burns during the incident. It was not possible to review personal protective equipment other than that directly examined.

Personal Protective Equipment—Based on the records from the contract inspection done on the morning of the day of the incident, the crew was appropriately equipped with personal protective equipment. Crews should have flame-resistant clothing, 8-inch-high leather boots with lug soles, leather gloves, a hardhat, and eye protection. The contract inspection found no issues with the crew's equipment.

Fire-Resistant Clothing—Eighteen of the 20 sets of fire-resistant clothing worn by the crew were collected and bagged after the incident. The clothing was reviewed at the ICP on Saturday, July 27.

- –All of the flame-resistant pants and shirts were made of aramid cloth and appeared to be in good condition.
- –Tiny (predominantly less than 1/4 inch in diameter) spots of dye sublimation or char were present on 14 pairs of pants and on 11 shirts, indicating that embers had at some point been present. It is not possible to distinguish between marks that occurred on this incident and those that occurred at some earlier date. However, since several of the pants appeared to be brand new, it is likely that many of the marks occurred during this incident.
- –The shirt worn by the firefighter who suffered a second-degree burn to the elbow had a dye sublimation mark $2^1/_2$ by $^1/_2$ inches, the largest mark of any kind on the firefighter's clothing. This mark indicates a material temperature 205 °C.

Fire Shelters and Fire Shelter Bags—The 20 fire shelters used by the crew in the deployment were reviewed at the ICP on July 27. They were examined for heat damage and other structural damage.

- –None of the shelters showed any heat damage indicating that they were exposed only to radiant heat and to limited levels of convective heat.
- –Eighteen of the shelters showed minor structural damage as would be expected in a deployment of this type; small holes caused from abrasion against the ground, and from wadding and crushing the shelters during and after the deployment.
- -Several of the shelters showed holes, dime-sized or smaller at the location of the corner folds (the location on the shelter corresponding to the corners of the folded shelter). These occur over time from repeated compression and abrasion of the folded fire shelter when carried by firefighters.

Two of the fire shelters had damage worth noting separately.

- –One shelter (Anchor, 1993) had an approximately 3-inch slit near one end of the shelter (7 inches from the end, vertically midway on the main panel). The slit was on a fold mark from an inside fold, a fold that would not have been exposed prior to deployment. Without interviewing each crewmember, it is not possible to know who used this shelter, whether the slit was present prior to the deployment, how it might have occurred, or what the impact of the slit was on the user.
- –A second shelter (Weckworth, 1998) had an approximately 10-inch opening in the seam at the ridge of the shelter. This opening was the result of a poorly stitched seam in which the shelter material was not caught in the stitch line. Also found on this shelter was a missed box-X stitch where the fiberglass tape is sewn to the sod cloth of the shelter. Again, without interviewing the crewmembers it is not possible to determine which crewmember used this shelter, or how it might have affected the occupant. It is likely that the missed box-X stitch had little affect since the purpose of the stitch is to add strength to the attachment of the glass tape, and no tears or separations were noted. The open seam at the peak of the shelter may have affected the amount of protection offered the occupant.

The fire shelter bags were gathered at the site of the deployment and were examined at MTDC on Aug. 1. Nineteen of the bags were collected. The following observations are noted:

- –Five shelter bags were opened from the heat-sealed top of the bag instead of, or in addition to, using the pull strips. One shelter bag was inside out when found, potentially indicating that the user had difficulty extracting the shelter from its bag.
- –Every shelter bag showed minor to significant evidence of abrasion of the aluminum from the shelter. Even the newest shelter bags that are less than 1 year old had significant black and silver marks indicating abrasion of the aluminum surface of the shelter.
- –An MTDC Safety Alert, issued spring 2001, requires that the tear strips on all fire shelter bags be pulled halfway down prior to being carried on the fire line. The only exception to this rule is for the new bag that has a single red strip that extends around the entire bag. Some tear strips on the older style bags were breaking when pulled and having firefighters pull them in advance was meant to prevent any delays in shelter deployment. Three of the

shelter bags used in this incident had evidence that the pull strips had either broken or otherwise did not have a clean opening. Two shelter bags were of the new style and would not have required having the strips pulled halfway prior to carrying them on the fireline. The strips on six more bags had clearly not been pulled prior to the deployment. Without interviewing the crewmembers themselves, it is impossible to know if the remaining ten had been pulled prior to the deployment.

–Melted holes or marks that were likely caused by falling embers were present on six of the shelter bags. In some cases, the sides of the bags were fused together indicating that embers were still falling after the shelters were deployed.

Training—According to the crewmembers' red cards, all firefighters had fire shelter training.

Additional Information About the Deployment—

–According to interviews with the Ferguson 53 crew boss, the conditions during the deployment were not life-threatening. He indicated that he was never completely deployed, but instead used the shelter as a shield so that he could watch his crew. He indicated that the discomfort came primarily from smoke and embers, rather than heat. He said that while the smoke and embers were thick, hot gases were not present.

–The two crewmembers who suffered minor burns said that their injuries occurred prior to the deployment of shelters.

–Two gloves were found on the safety zone after the deployment. It is not known when or by whom the gloves were discarded.

–Interviews and pictures taken as the crewmembers were exiting their fire shelters indicate that several firefighters were not wearing gloves during or immediately after the deployment.

–According to the Ferguson 53 crew boss, the deployment went smoothly with people getting into the shelters with little delay. One person had momentary trouble, but soon had her shelter out and deployed.

–Examination of photos taken during the deployment show that some shelters were deployed next to line gear packs.

–Examination of photos taken during the deployment show that the hardhat of at least one firefighter was left outside his or her shelter.

Discussion

Shelters—MTDC carefully inspects the first article of each fire shelter contract. The contractor is allowed to proceed with manufacture only when the first article fire shelter has been accepted. After the initial inspection, the General Services Administration (GSA) maintains a stringent quality-assurance inspection program. The fire shelter with the incomplete seam will be reported to GSA and to the manufacturer. Since the two burn injuries occurred prior to the deployment, it does not appear that the flaw led to any burn injuries in this situation.

Shelter bags—Review of the shelter bags raises questions about the level of fire shelter training or practice by the crew. Five of the shelter bags were opened from the top. One was inside out, indicating a potential struggle to get the shelter out of the bag. Training materials including the videos "Your Fire Shelter" (1985) and "Using Your Fire Shelter" (2001), and the booklet "Your Fire Shelter, 2001 Edition" all show proper opening procedures using the red rings to pull the tear strips to open the shelter bag. The practice fire shelter has a similar opening procedure. Opening the shelter from the top can slow deployment. Under more severe conditions such a delay could lead to firefighters being exposed to dangerous hot gases and high temperatures.

–Pulling the tear strips in advance as outlined in the MTDC Safety Alert is an important measure aimed at avoiding delays in shelter deployment. It is critical that all firefighters, including contract crews be informed of and follow Safety Alerts.

–Black marks on the inside of the shelter bag indicate abrasion. Inspection procedures outlined in the training materials explain that shelters with evidence of abrasion should be withdrawn from service. The extent of the black marks, even on new shelter bags raises questions about whether regular inspection was accomplished and/or if the crewmembers' shelters were carried in hard plastic

liners. These liners are provided to reduce damage from abrasion and repeated compression of the folded fire shelters.

–The polyvinyl chloride material from which the shelter bags are made melts at 140 °C. Human skin can suffer second-degree burns at about 55 °C. The presence of these melt holes in the shelter bags indicates that further minor burns may have occurred had the crewmembers not deployed their shelters.

Procedures—The use of hardhats and gloves during a fire shelter deployment is stressed in fire shelter training materials. The lack of gloves has led to severe burns and even death in other fire shelter deployments.

–The importance of deploying shelters away from packs is stressed in fire shelter training materials. Packs left outside of shelters have burned and caused injuries in past deployments. Some shelters were deployed too close to line gear packs.

Conclusions

–The Ferguson 53 crew was properly equipped with personal protective equipment.

–The crewmembers were able to adequately deploy their fire shelters. However, some fire shelter deployment procedures were not followed by some members of the crew including:

- Some crewmembers did not pull the tear strips on the older model shelter bags down half way prior to carrying the shelters on the fireline,
- Some crewmembers opened their shelters from the top of the PVC bag instead of by using the tear strips provided.
- At least one firefighter apparently deployed his shelter without gloves.
- The hardhat of at least one firefighter was left outside his or her shelter.

The fire-resistant clothing appears to have performed as designed and offered protection to the entrapped firefighters.

The fire shelters appear to have performed as designed and offered the entrapped firefighters protection from smoke and minor burns. Regular inspection of fire shelters helps ensure that damaged shelters are not carried on the fireline.

–Having the crew deploy, even though the conditions were not immediately life- threatening made the crewmembers more comfortable, helped control the crew and probably limited further injury.

Suggestions

–Proper deployment techniques can save lives. Training and regular practice in fire shelter deployment is critical. Time should be made for such activity by all fire going personnel, including contract crews.

–It is critical that all fire going personnel, including contract crews be made aware of and follow the instructions in safety alerts.

–All crews should be reminded to follow the fire shelter inspection recommendations detailed in the booklet, "Your Fire Shelter, 2001 Edition."

–All fire shelters should be carried inside hard plastic liners.

–Firefighters should be reminded of the importance of wearing gloves and hardhats during fire shelter deployments.

–Firefighters should be reminded of the importance of not deploying shelters next to packs or other equipment.

–Management needs to make it clear that, although escape is always the preferred alternative, it may be necessary and appropriate to deploy shelters as a means of controlling panic and as a precautionary measure against injuries.

Appendix E—IAP for July 24, 2002