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THIRTYMILE FIRE



United States Department of Agriculture
Forest Service

CORRECTION: BEAR RIVER FIRE

The cover of the Summer 2001 issue of *Fire Management Today* (volume 61, number 3) shows a silhouetted firefighter identified as a member of the Payson Hotshots. A reader notified *Fire Management Today* that the firefighter in the photo was actually a member of his crew, the Flagstaff Hotshots.

The photo shows the 1994 Bear River Fire (not “Bear Creek Fire,” as the caption states) on Idaho’s Boise National Forest. The caption states that the fire had a low suppression cost, which is true but misleading. The fire was overrun by the Rabbit Creek Fire shortly after containment. Suppression costs were low in part because mopup costs were minimal.

Thanks for the correction go to Paul F. Musser, Superintendent, Flagstaff Interagency Hotshot Crew, Flagstaff, AZ.

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On the Cover:



Canyon of the Chewuch River on the Okanogan National Forest near Winthrop, WA. On July 10, 2001, the Thirtymile Fire entrapped 16 people in the canyon. Firefighters deployed their fire shelters on the road and scree slope above the widening of the river visible at bottom center; four perished in the subsequent burnover. Photo: Ben Croft, USDA Forest Service, Missoula Technology Development Center, Missoula, MT, 2001.

The FIRE 21 symbol (shown below and on the cover) stands for the safe and effective use of wildland fire, now and throughout the 21st century. Its shape represents the fire triangle (oxygen, heat, and fuel). The three outer red triangles represent the basic functions of wildland fire organizations (planning, operations, and aviation management), and the three critical aspects of wildland fire management (prevention, suppression, and prescription). The black interior represents land affected by fire; the emerging green points symbolize the growth, restoration, and sustainability associated with fire-adapted ecosystems. The flame represents fire itself as an ever-present force in nature. For more information on FIRE 21 and the science, research, and innovative thinking behind it, contact Mike Apicello, National Interagency Fire Center, 208-387-5460.



Firefighter and public safety is our first priority.

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REVISITING THE LOSS OF OUR OWN

Dale Bosworth



Before we get to the primary reason why we are all here,* I would like to share a personal thought or two with you. Two weeks ago, the United States suffered a terrible attack upon its homeland.** As you all know, the projected loss of life from those terrorist acts is inconceivable. While we mourn the loss of lives on September 11, we also grieve the tragic loss of four of our young firefighters here on the Okanogan–Wenatchee National Forest on July 10.

Sense of Loss

The tremendous sense of loss I personally feel for these firefighters' families compelled me to be here—in your community—to receive the investigation team's final report. The loss of any firefighter is tragic; and now, today, we must, for good reasons, revisit the loss of four of our own.

I am here today to personally receive the findings and recommendations presented to me by the Thirtymile Fire Accident Investigation Team. Before that could happen, a formal Thirtymile Fire Accident Review Board was con-

vened to ensure the adequacy of the investigation team's findings. After careful review and analysis, and with their input included, the board has recommended the report and I have accepted it.

I wish to thank Jim Furnish and his dedicated team for their diligence and professionalism in completing this most difficult investigation assignment.*** Jim has assembled a team of highly experienced members with expertise in many areas, including wildland fire and weather behavior, suppression tactics, safety, fire crew skills, training, and equipment, just to name a few. The investigation report reflects the fact that five members of the investigation team, including Jim, have more than 30 years of agency experience, and that several have prior experience in serious accident investigations, including fire fatalities.

Jim, I am especially appreciative of your bringing in the expertise of a widely respected chief investigator from the private sector, one who has some 20 years of investigative experience, including experience in fatality accident investigation, safety management, and human error analysis.

I would like to remind everyone once again that firefighting is a dangerous vocation—whether you are engaged in fighting wildland fires or are called upon to respond to the worst urban tragedy imagin-

able, such as the recent terrorist attacks.

Let us do our brave wildland firefighters a great service by remembering the things they have accomplished. This summer, these courageous men and women have succeeded in saving thousands of homes. They successfully fought thousands of lightning- and human-caused fires, controlling them at sizes smaller than this room. Overall, they have accomplished many millions of hours of dangerous, back-breaking work accident free.

Never Again

But sometimes, no matter how much safety is stressed, accidents do occur. And they can occur with tragic results, such as serious injury or death. I promise you that the recommendations of this investigation team will not be forgotten. I am charging my leadership team with ensuring—and I am accepting responsibility for the Forest Service to do everything within its power to ensure—that what happened on the Thirtymile Fire does not happen again.

Although the investigation team's job might be done, the board of review's job will continue. The board is now developing an action plan that addresses the findings and recommendations of the report, with the intent of improving wildland firefighter safety for all agencies.****

**** The action plan is completed and being implemented. It is reprinted on pages 14–18. The board's findings and recommendations are reprinted on pages 9–13.

Dale Bosworth is the Chief of the USDA Forest Service, Washington, DC.

* On July 10, 2001, four firefighters died in a burnover on the Thirtymile Fire on the Okanogan National Forest near Winthrop, WA. The USDA Forest Service immediately formed a team to investigate the accident. This article is based on opening remarks by Chief Bosworth at a press conference in Yakima, WA, on September 26, 2001, to announce release of the Thirtymile Fire Investigation Report.

** On September 11, 2001, terrorists flew two hijacked airliners into the World Trade Center in New York City, collapsing its twin towers. They flew a third airliner into the Pentagon outside Washington, DC; a fourth hijacked airliner crashed in the Pennsylvania countryside. In all, many thousands of people were killed and injured.

*** Jim Furnish, the Deputy Chief for the National Forest System (retired), led the Thirtymile Fire Accident Investigation Team. He was present with Chief Bosworth in Yakima to release the investigation report.

Let me close by saying this: I continue to search for words to express how deeply sorry I feel for the loss of the four firefighters on

the Thirtymile Fire and the loss of other fire personnel across the Nation this summer. Let us keep our thoughts and prayers with the

families, friends, and colleagues of those who have suffered—those who have perished—and, finally, with those who have survived. ■



Firefighter gear. Photo: Josh Shroyer, Missouri Department of Conservation, Clinton, MO, 1998.

LESSONS FROM THIRTYMILE: TRANSITION FIRES AND FIRE ORDERS*



Jerry Williams

In November 2001, I was flying over Helena, MT, when I looked out the window and saw Mann Gulch. As a wildland firefighter, you cannot see Mann Gulch without being deeply moved.** More than most places, Mann Gulch speaks to our past and our future. The story of Mann Gulch reminds us of how far we have come and what challenges we still face in improving fireline safety.

Mann Gulch reminds us of other fires in other places as well, fires with names like Dude, South Canyon, Island Fork, and now Thirtymile.*** Like Mann Gulch, these were all tragedy fires—fires where lives were lost. They invite us to see a connection to Mann Gulch. Especially after the Thirtymile Fire, they call on us to act on that connection.

Transition to Tragedy

These fires were all transition incidents—fires in transition from

Jerry Williams is the Director of Fire and Aviation Management, USDA Forest Service, Washington Office, Washington, DC.

* Based on remarks made by the author on November 6, 2001, at a meeting of wildland fire safety managers in Missoula, MT.

** On August 5, 1949, 13 firefighters lost their lives on the Mann Gulch Fire on the Helena National Forest, MT (see Richard C. Rothermel and Hutch Brown, "A Race That Couldn't Be Won," *Fire Management Today* 60(2): 8–10). The accident shocked the wildland fire community, precipitating safety reforms that laid the basis for today's methods of wildland firefighting.

*** On June 26, 1990, six firefighters were killed on the Dude Fire on the Tonto National Forest, AZ; on July 6, 1994, 14 firefighters died on the South Canyon Fire near Glenwood Springs, CO; and on April 6, 1999, two firefighters perished on the Island Fork Fire near Cranston, KY.

With few exceptions, transition fires are our tragedy fires, the fires where most of our entrapments and deployments occur.

small to large (see sidebar). They became tragedy fires as they grew from something we thought was under control into something that suddenly overwhelmed us. Sometimes, such as at Mann Gulch, transition fires involve blowup conditions; at other times, such as at Thirtymile, they do not. In most cases, we did not recognize the full gravity of the situation until it was too late and there was nowhere to escape.

For most of the fires we manage, our policy is sound. We have strong strategies for initial attack through our preparedness planning—our

National Fire Management Analysis System for deriving the most efficient level of resources. We also have flexible options for managing large fires through our Wildland Fire Situation Analysis.

However, we remain vulnerable in managing the fires in between. Transition fires are relatively few, but their small number belies their significance. Probably because they occur so infrequently, we are sometimes unprepared for their potential consequences. We get into trouble when we continue offensive tactics in a situation that puts us on the defensive. People sometimes get

WHAT ARE TRANSITION FIRES?

On average, the USDA Forest Service suppresses about 10,000 wildfires per year on the national forests and grasslands. Of these, about 92 to 93 percent are controlled quickly, at little cost, with relatively little effort, and with scant loss or damage.

At the other end of the spectrum, about 2 to 3 percent of our fires are large almost from the outset. Factors such as volatile fuels, drought, and wind combine to produce a fire that quickly leads to a dispatch call for a type 1 incident command team. Though rare, such fires account for nearly 70 percent of our total suppression expenditures.

The remaining 5 percent of our fires—about 500 per year—are between rapid, successful initial attack and quickly recognized, almost immediate large-fire mobilizations. They are fires in transition from small to large.

It is time to develop and adopt a more formal approach to transition fires, one that makes us less vulnerable.

hurt or even killed. With few exceptions, our tragedy fires—the fires where most of our entrapments and deployments occur—are transition fires.

Special Challenges

Transition fires raise special questions:

- What is our strategy for dealing with a fire specifically while it is in transition?
- What predictive models do we use to see a transition coming, and how do we use them?
- Operationally, how do we adjust to mitigate the risks of a rapidly expanding incident?
- In terms of management oversight, supervisory control, and crew leadership, what do we do differently on transition fires? How do we obtain the astute situational assessments and fluid operational control required under rapidly changing conditions?

I believe that we do not have a coherent strategy for what are arguably the most important fires we face. We find ourselves doing the best we can with that we have, hoping that it will suffice. Usually, it does suffice; faced with a transition fire, experienced leaders will disengage and regroup. But as long as good judgment during transition fires is more a matter of chance than design, another tragedy seems inevitable sooner or later.

It is time to develop and adopt a more formal approach to transition fires, one that makes us less vulner-

able. Many of the items in the Thirtymile Fire Prevention Action Plan are specifically designed to improve our approach to managing transition fires (see the action plan items beginning on page 14). At the fall 2001 meeting of the National Wildfire Coordinating Group, the interagency leadership committed itself to such an approach. Support is needed from the entire interagency wildland fire community.

“Can-Do” Attitude

Beginning with Mann Gulch, transition fires have shocked the wildland fire community and precipitated safety reforms. A key reform was the introduction of the Ten Standard Firefighting Orders.* The Fire Orders and other safety measures complement our fundamental beliefs, behaviors, and values as wildland firefighters. They are a vital counterweight to a remarkable strength in our culture that, if left unattenuated, can jeopardize our safety on the fireline: our “can-do” attitude.

Our “can-do” attitude is written across the face of every firefighter on every incident. The attack on the World Trade Center on September 11, 2001, produced some remarkable examples. One photograph shows people in a stairwell streaming downstairs past a New York City fireman on his way up. His expression is typically “can-do”: bright-eyed, eager, and ready for a firefight.

That look, that attitude, and that spirit define the firefighter. I see

* For more on the Ten Standard Fire Orders, see Karl Brauneis, “Fire Orders: Do You Know Their Original Intent?”, *Fire Management Today* 62(2): 27–29.

that look during every fire season. The shine comes off a little as the season wears on, but it is always there. It projects our “can-do” strength of character. But it is a strength that can defeat us; if untempered by sound judgment, “can-do” can devolve into “make-do,” which can lead to tragedy. The role of management supervisors and crew leaders is to instill the sense that the biggest part of our job is doing the job right. Doing the job right by following the rules is what keeps “can-do” from slipping toward tragedy.

Our rules of engagement are the Ten Standard Firefighting Orders. Though simple, they are sometimes overlooked or ignored. Our “can-do” orientation can impel us to put operations ahead of safety. The Fire Orders remind us that there is a right way to do things before we engage, while on the fireline, and in our after-action reviews. The Fire Orders are not an obstacle to getting the job done; instead, they are the way to get the job done right.

Discipline Needed

We especially need to follow the Fire Orders at times when we might be tempted not to:

- When the challenge is great because the consequence greatly matters;
- When we are tired, fooled by a deceptive fire, preoccupied, or complacent; or
- When managers and supervisors show that they are human by missing or forgetting something that they should have noticed or remembered.

The Fire Orders have less value in a controlled environment than in an environment that is uncertain:

The Ten Standard Fire Orders are not an obstacle to getting the job done; instead, they are the way to get the job done right.

when equipment fails, when the weather changes, when we get tired and our thoughts drift, or when somebody lets us down. Such things happen in the world of firefighters, though infrequently. When they do happen, especially during a transition fire, their consequences can be fatal. When the unexpected happens, the Fire Orders assume their real value. And because the unexpected does happen, we must be disciplined in observing the Fire Orders day in, day out.

In our business, especially on transition fires, the unexpected can happen without warning. That's why:

- Safety comes first on every fire, every time.
- The Ten Standard Firefighting Orders are firm. We don't break them, and we don't bend them.
- We don't just do the job; we do it right.

The Thirtymile Fire, like other tragedy fires, reminds us that we are accountable at all times for our performance as fire managers, crew supervisors, and firefighters. The Ten Standard Firefighting Orders are the measure against which our performance as professionals should be judged. It is time we used the Fire Orders not only as guidelines for safe firefighting, but also as criteria for measuring our firefighting performance. ■



WEBSITES ON FIRE*

Wildland Fire Training

If wildland fire training is on your to-do list, then this Website is the place for you. The site provides access to workshops, meetings, and training courses by geographic area. Users can access a multiagency training schedule and then complete a training nomination form electronically. Links to seven different national training centers are available, including the National Interagency Fire Center's National Fire and Aviation Training Group/Course Development, Office of Aircraft Services, Southwest Fire Use Training Academy, National Advanced Resource Technology Center, National Fire Academy, National Interagency Rx Fire Training Center, and Technical Fire Management. The site offers a field manager's course guide containing the National Wildfire Coordinating Group's course descriptions, prerequisites, and target audience, along with news and other information of interest to the wildland fire community.

Found at <<http://www.fire.nps.gov/firetraining>>

* Occasionally, *Fire Management Today* briefly describes Websites brought to our attention by the wildland fire community. Readers should not construe the description of these sites as in any way exhaustive or as an official endorsement by the USDA Forest Service. To have a Website described, contact the managing editor, Hutch Brown, at USDA Forest Service, Office of Communication, Mail Stop 1111, 1400 Independence Avenue, SW, Washington, DC 20250-1111, 202-205-1028 (tel.), 202-205-0885 (fax), hutchbrown/wo@fs.fed.us (e-mail).

Interagency Aviation Training

The Interagency Aviation Training Education, Qualification, and Currency System was developed under the direction of the Aviation Management Council to establish aviation training standards for natural resource agency personnel. Personnel meeting these standards are qualified to perform a variety of aviation-related tasks. The system is training based. The primary criterion for qualification is completion of the training modules with a passing score. The aviation training subject matter is designed to be progressive and to build on past training experience. Training is offered online, in the classroom, through aviation conferences and education, and through a combined airplane/helicopter safety course.

Found at <<http://iat.nifc.gov>>

CAUSAL FACTORS IN THE THIRTYMILE FIRE ACCIDENT



Thirtymile Fire Accident Review Board*

Editor's note: On July 10, 2001, four firefighters died in a burnover on the Thirtymile Fire on the Okanogan National Forest near Winthrop, WA. The USDA Forest Service formed a team to investigate the accident and a board to review the team's findings and determine causal factors for the accident. In its Management Evaluation Report, part of the Thirtymile Fire Investigation Report of September 26, 2001, as amended on October 16, 2001, the board established 14 significant causal factors and 5 influencing factors. The section of the report describing these factors is reprinted here, lightly edited.

A causal factor is any behavior or omission that starts or sustains an accident occurrence. For this investigation, the causal factors were classified as either significant or influencing. They were identified from the four categories of findings by the Thirtymile Fire Accident Investigation Team (see the sidebar on page 10).

The causal factors on the Thirtymile incident are interrelated, and it is difficult to point to one causal factor or one finding as the most important. Additionally, several causal factors were identified from more than one phase of the incident. The five phases of the incident were preparedness, initial attack, transition, entrapment, and fire shelter deployment (see sidebar).

Significant Causal Factors

The causal factors determined to be significant are listed below, in relative order, together with the

* Board members were Tom L. Thompson, Regional Forester, Rocky Mountain Region, USDA Forest Service, Denver, CO (chairperson); Mark Boche, Director of Fire and Aviation Management, Eastern Region, Forest Service, Milwaukee, WI; Paul Broyles, National Fire Operations Specialist, USDI National Park Service, Boise, ID; Ron Hooper, Business Operations Specialist, Washington Office, Forest Service, Washington, DC; Jim Golden, Supervisor, Coconino National Forest, Forest Service, Flagstaff, AZ; Paul Orozco, Fire Operations Specialist, Santa Fe National Forest, Santa Fe, NM; and Marc Rounsaville, Emergency Operations Specialist, Southern Region, Forest Service, Atlanta, GA.

All 10 Standard Fire Orders
and 10 of the 18 Watch Out Situations were
violated or disregarded during the incident.

associated subject category and incident phase(s).

Inadequate safety consideration

Category: Management

Phases: Preparedness, initial attack, transition, entrapment, deployment

The safety considerations were not appropriate to respond to the current, potential, and subsequent fire conditions on this incident. All 10 Standard Firefighting Orders and 10 of the 18 Watch Out Situations were violated or disregarded during the incident.

Lack of situational awareness/ inaccurate assessment

Category: Management

Phases: Preparedness, initial attack, transition, entrapment, deployment

At critical points throughout the incident, the lack of situational awareness by key incident, district, and forest personnel led to inaccurate assessments of fuels, fire behavior, and fire potential.

Fatigue

Category: Management

Phases: Preparedness, initial attack, transition, entrapment, deployment

Work/rest cycles for incident and fire program management personnel, both at the forest and district levels, were disregarded, resulting in mental fatigue. This significantly degraded the vigilance and decision-making ability of those involved.

Command and control

Category: Management

Phases: Preparedness, initial attack, transition, entrapment, deployment

Failure to maintain clear command and control resulted in poor risk management and inhibited decisive actions, which contributed to the entrapment and deployment of fire shelters.

Strategy, tactics, and transition

Category: Management

Phases: Initial attack, transition

The suppression strategy failed to

adequately consider objectives, fuels, fire behavior, and fire potential, as well as the capability, availability, and condition of the suppression resources. This led to the selection of tactics that could not succeed. As the fire complexity changed significantly and initial attack was unsuccessful, there was

not a corresponding change in strategy or tactics.

Fire behavior

Category: Environment

Phases: Preparedness, entrapment, deployment

A variety of environment factors supported the development of a

crown fire growing from a few acres to several thousand acres on the day of the accident:

- Valley bottom and slope fuels were dense, with abundant ladder fuels.
- The moisture content of the fuels was at historically low levels.

DEFINITIONS

Subject Categories

As directed in the USDA Forest Service's Accident Investigation Guide (2001), the Thirtymile Fire Accident Investigation Team placed its findings in four subject categories:

- Environment of the location of the incident;
- Equipment involved in or contributing to the incident;
- People involved in or contributing to the incident; and
- Management issues or principles associated with the incident.

Incident Phases

The Thirtymile Fire Review Board identified five phases of the incident.

Preparedness. The Wildland and Prescribed Fire Management Policy Guide (1998) defines preparedness as: "Activities that lead to a safe, efficient, and cost-effective fire management program in support of land and resource management objectives through appropriate planning and coordination." Examples include activities in preparation for the fire season, such as annual refresher training, work capacity testing, review of plans and guides, and fire equipment and personnel readiness checks.

Initial Attack. The Wildland and Prescribed Fire Management Policy Guide (1998) defines initial attack as: "An aggressive suppression action consistent with firefighter and public safety and values to be protected." Initial attack is made by the first resources to arrive on a fire. It is designed to protect lives and property and prevent further extension of the fire.

Transition. Based on the Fireline Handbook (1998), transition can be defined as the next level of management that is expected and required when it becomes apparent that the assigned resources will not meet containment objectives within the expected timeframes and/or the fire escalates to another level of complexity.

Entrapment. The Glossary of Wildland Fire Terminology (1996) defines entrapment as: "A situation where personnel are unexpectedly caught in a fire-behavior-related, life-threatening position where planned escape routes or safety zones are absent, inadequate, or compromised. An entrapment may or may not include deployment of a fire shelter for its intended purpose."

Fire shelter deployment. The Glossary of Wildland Fire Terminology (1996) defines fire shelter deployment as: "The removing of a fire shelter from its case and the using of it as protection against fire."

References

- Accident Investigation Guide. 2001. Missoula, MT: USDA Forest Service, Missoula Technology and Development Center.
- Fireline Handbook. 1998. National Wildfire Coordinating Group, Incident Operations Standards Working Team. PMS 410-1; NFES 0065. Boise, ID: National Interagency Fire Center.
- Glossary of Wildland Fire Terminology. 1996. National Wildfire Coordinating Group, Incident Operations Standards Working Team. NFES 1832. Boise, ID: National Interagency Fire Center.
- Wildland and Prescribed Fire Management Policy: Implementation Procedures and Reference Guide. 1998. Boise, ID: National Interagency Fire Center.

- The combination of extremely low relative humidity, high temperature, and atmospheric instability created weather conditions conducive to the rapid movement, growth, and intensity of the fire at the times of entrapment and deployment.

Failure in road closure and area evacuation

Category: Management

Phase: Initial attack

The entrapment of two civilians was due to the failure to close the road and to subsequently evacuate the upper valley in a timely fashion.

Management intervention

Category: People

Phase: Transition

There were missed opportunities for intervention by management personnel on this incident. Leadership's failure to respond to concerns and observations by key individuals exacerbated circumstances that led to the entrapment.

Lack of escape routes and safety zones

Category: People

Phase: Entrapment

Given the rapidly increasing fire intensity and changing fire situation, adequate consideration was not given to identifying escape routes and safety zones.

Failure to prepare for deployment

Category: People

Phase: Deployment

Leadership of the entrapped firefighters failed to utilize available time and resources to coordinate and prepare crewmembers and civilians for fire shelter deployment.

Deployment site selection

Category: Equipment/people

Phase: Deployment

Site selection for the deployment of the shelters above the road contributed to the four fatalities. The rocky nature of the deployment site made it difficult to seal out the superheated air. The large size and the arrangement of the rocks made it difficult to fully deploy the shelters.

Personal protective equipment

Category: Equipment/people

Phase: Deployment

The improper use of personal protective equipment contributed to injuries. Three people occupied one shelter. This exceeded the design capacity (although providing shelter protection of the two civilians was appropriate and justified by the emergency). One crewmember and the two civilians did not have gloves; other



Tree torching at night. On the Thirtymile Fire, nighttime torching contributed to initial fire spread. Photo: Paul S. Fieldhouse, USDA Forest Service, Missoula Smokejumper Base, Missoula, MT.

crewmembers did not wear their gloves. Some of the line gear that was left close to the shelters ignited, and there was burning vegetation close to and under the shelters.

Sudden upcanyon extreme fire behavior

Category: Environment

Phase: Deployment

The dense forest and the strong fire-induced winds on the southern canyon wall contributed to intense spotting, causing the fire on the canyon floor to intensify suddenly and surge over the deployment area.

Heat from fire

Category: Environment

Phase: Deployment

The fatalities were caused by inhalation of superheated air and exposure to high levels of radiant and convective heat. The presence of burnable fuels around and under the chosen deployment sites also contributed to the fatalities and injuries. The higher temperatures of the rock scree slope made conditions worse for deployment than conditions on the road.

Influencing Factors

The causal factors determined to be influencing are listed below.

Overextension of fire personnel

Category: Management

Phase: Preparedness

Unit fire personnel were overextended. Although weather and fuel conditions were near historic highs and there was significant fire activity on the forest, additional fire program management personnel and additional initial- and extended-attack resources were not readily available.

Development of crew cohesion

Category: Management

Phase: Preparedness, deployment

A number of issues limited the development of crew cohesion for the Northwest Regular #6 crew, including collateral duties of command, fatigue, incident complexity, lack of previous opportunity to work together, and management effectiveness.

Ineffective water operations

Category: Equipment/people

Phase: Preparedness, initial attack
Water operations, both aerial and ground-based, were ineffective or delayed during the initial suppression actions.

Helicopter delay

Category: Management

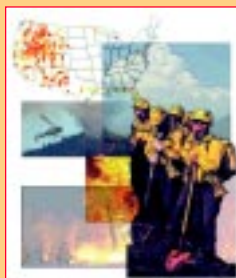
Phase: Preparedness, initial attack
Assignment of a helicopter to the incident was delayed. This may have reduced the effectiveness of suppression actions. The lack of a clear process and determination of responsibilities to deal with Endangered Species Act issues contributed in part to this delay, as did dispatch actions and confusion associated with availability.

Organizational relationships

Category: Management

Phases: Initial attack, transition, entrapment, deployment
Unclear organizational relationships among forest, district, and incident personnel reduced management effectiveness on the incident. ■

NATIONAL FIRE PLAN AT WORK*



Watershed Restoration in California

Streams are ecological ribbons that tie together the land through watersheds. Watersheds are key to healthy, resilient ecosystems. Fire

damage to watersheds can impair ecological health across entire landscapes. That's why Congress authorized funding for watershed restoration through the National Fire Plan.

Lassen Creek is a tributary of the Upper Pit River on the Modoc National Forest in northern California. The National Fire Plan is funding the Upper Pit River Watershed Restoration Project, one of more than a dozen large watershed projects across the Nation. The Lassen Creek component of the project is designed to restore historical ecosystem structure, function, diversity, and dynamics along Lassen Creek. Goals include the conservation of basic soils, the restoration of historical waterflows, and the prevention of invasion by nonnative species. Specific projects include the planting of native grasses, forbs, shrubs, and trees to restore flourishing biological communities. ■

* Occasionally, *Fire Management Today* tells a success story or describes an exemplary project under the National Fire Plan. Readers can find many more such accounts on the Website for the National Fire Plan at <<http://www.fireplan.gov>>.

RECOMMENDED CHANGES IN WILDLAND FIRE MANAGEMENT



Thirtymile Fire Accident Review Board*

Editor's note: On July 10, 2001, four firefighters died in a burnover on the Thirtymile Fire on the Okanogan National Forest near Winthrop, WA. The USDA Forest Service formed a team to investigate the accident and a board to review the team's findings and make appropriate recommendations. In its Management Evaluation Report, part of the Thirtymile Fire Investigation Report of September 26, 2001, as amended on October 16, 2001, the board made 10 recommendations. They are reprinted here, lightly edited.

The following recommended changes to avoid incidents similar to what happened on the Thirtymile Fire are proposed for agency consideration and action. As appropriate, it is recommended that they be responded to with the involvement, understanding, and support of the interagency wildland fire community (National Wildfire Coordinating Group). These recommended changes should be considered in the context of this larger interagency perspective.

Situational Awareness, Assessment, and Transition

- Ensure that fire program managers, fireline supervisors, and firefighters have situational awareness, assessment, and decisionmaking abilities necessary to successfully and safely transition command from initial attack to extended attack on incidents.
- Ensure that fire program managers and incident commanders have situational awareness, assessment, and decisionmaking abilities necessary to react to significant changes in fire danger thresholds.

Develop and fully implement
a fatigue countermeasures program.

Fatigue

- Develop and fully implement a fatigue countermeasures program.

Incident Operations

- Strengthen command-and-control performance by agency administrators, fire program managers, and type 3–5 incident commanders.
- Strengthen operating procedures to ensure accurate determination of complexity, with proper alignment of resources to match the incident complexity and potential, and requisite command and control.

Leadership

- Critically review the fire management leadership program on a national basis to ensure that all individuals in leadership positions, at all levels of organizations, have the skills and capabilities to unquestionably lead in a responsible way.

- Develop and strengthen the annual preparation of firefighters for personal responsibilities and leadership.

Safety Management and Accountability

- Improve fire program safety management by adopting and aggressively implementing proven components of a comprehensive safety program.

Equipment

- Continue improvements in personal protective equipment to provide for firefighter safety.

Endangered Species Act Protocols

- Clarify the relationship between the Endangered Species Act (ESA) and fire suppression actions to establish a coherent process that accounts for ESA requirements with respect to the full range of fire suppression activities. ■

* For a list of board members, see the footnote on page 9.

THIRTYMILE FIRE PREVENTION ACTION PLAN



Thirtymile Fire Accident Review Board*

Editor's note: On July 10, 2001, four firefighters died in a burnover on the Thirtymile Fire on the Okanogan National Forest near Winthrop, WA. The USDA Forest Service formed a team to investigate the accident and a board to review the team's findings and formulate an action plan for preventing similar future accidents. The action plan, released on October 22 and updated on December 3, 2001, is reprinted here, with condensed preface and lightly edited action items. For timelines and progress updates, see the Fire and Aviation Management Website at <http://www.fs.fed.us/fire/fire_new/safety/investigations/30mile/index.html>.

Preface

The Thirtymile Fire Prevention Action Plan was developed from the recommendations made by the Thirtymile Fire Accident Review Board (see page 13). The plan seeks to prevent future accidents of the type that occurred on the Thirtymile Fire. Although all firefighters involved in the Thirtymile Fire were Forest Service employees, the corrective actions in this plan will affect wildland fire management and policy in all jurisdictions and should be addressed by the National Wildfire Coordinating Group (NWCG). The Accident Investigation Team and the Accident Review Board were both made up of inter-agency representatives.

There are 31 action items in this plan; 26 items address issues that affect all agencies involved in wildland fire management. Many action items are assigned to the Forest Service's Director of Fire and Aviation Management (F&AM), who is the agency's representative to the NWCG. The NWCG, through its interagency working teams, will address and reconcile the action items.

The Director of F&AM will bring these items to the NWCG. This does not relieve senior agency line

Ensure that there is adequate direction in fire management plans to trigger fire danger awareness with escalating fire potential.

officers of their responsibility to be engaged and involved in the development of these policies and procedures, nor does it relieve agency representatives to the NWCG of their responsibility to keep senior management of the agencies informed and engaged.

Action Items

A-1 The Director of F&AM will initiate changes in the Federal Wildland Fire Management Policy to include recommendations for fire suppression and for firefighter safety, in preparation for and in the transition phase between initial-attack and extended-attack fires.

A-2 The Director of F&AM will work with the NWCG to review current policy on preparation and direction for fire management plan development, and amend the direction to ensure that these plans specifically address staffing modifications (firefighters, crew, and supervisory span of control); management coordination; and allocation of resources as fire danger and occurrence escalate.

A-3 The Director of F&AM will ensure that there is adequate direction in fire management plans to trigger fire danger awareness with escalating fire potential. More specifically:

- A-3-a Notification from forest to districts (with regional assistance) of key increases in fire danger thresholds that typically affect safety and control. At regional, forest, and district levels, identify departures from historical weather patterns that will significantly influence increased fire potential or fire behavior thresholds for safety and control in the operational area.
- A-3-b District fire program managers will review fire danger indices and convey their meaning and significance to crews and incident management teams (e.g., use pocket cards to ensure availability to firefighters).
- A-3-c Identify the thresholds at which large fires typically occur. These thresholds indicate fire danger levels that significantly compromise safety and control. When thresholds are approached, fire program managers will

* For a list of board members, see the footnote on page XX.

request additional supervisory and suppression support.

A-4 The Director of F&AM will initiate changes to the Federal Wildland Fire Management Policy to ensure that there are defined indicators for the need to transition from initial attack to extended attack. An example that might be considered is establishing a fire-specific perimeter limit trigger point.

A-5 The Directors of Human Resources and F&AM should review policy, procedures, and performance expectations to reduce firefighter fatigue, working with NWCG to coordinate the effort. Consider:

- A-5-a Requiring agency administrators to periodically review time-and-attendance records for compliance with work/rest guidelines (including local agency administrators, fire program managers, fire support personnel, and firefighters).
- A-5-b Working to build electronic review options in the existing automated payroll systems.
- A-5-c Setting a daily duty hour limitation.
- A-5-d Reviewing S-200 and S-300 courses to ensure that there is adequate emphasis on the incident commander's responsibility in managing fatigue.

A-6 The Director of Human Resources will evaluate existing training in fatigue awareness and other associated management training, and make training available to all employees.

A-7 The Directors of Human Resources and F&AM will develop protocols for the accident investigation process to evaluate fatigue as a

factor in all ground and aviation incidents, including entrapments and accidents. This should include a 72-hour work/rest history with quantitative analysis.

A-8 The Director of F&AM will issue direction that:

- A-8-a Requires forest fire management organizations, including the agency administrators, fire program managers, and incident commanders, to meet annually to review the responsibilities, expectations, and authorities of the type 3-5 incident commanders in fire suppression operations and incident operations protocols. Review should include the following:
 1. Provide for the safety and welfare of all personnel and civilians.
 2. Develop and implement viable strategies and tactics for the incident.
 3. Monitor the effectiveness of the planned strategy and tactics.
 4. Disengage suppression activities immediately if strategies and tactics cannot be implemented safely.
 5. Maintain command and control of the incident.*
- A-8-b Establish procedures to ensure that arriving resources have positive contact with the incident commander, operations section chief, or other appropriate incident management personnel. This must occur prior to commencing work on the fire.

A-9 The Director of F&AM will review all existing fire training courses to ensure that the course content adequately teaches the

management skills necessary for the successful transition from initial attack through a type 1 incident.

A-10 The Director of F&AM will evaluate current training courses for type 3-5 incident commanders to seek opportunities to strengthen competencies.

A-11 The Director of F&AM will develop a standardized briefing format for type 3-5 incidents.

A-12 The Director of F&AM will ensure that local fire mobilization plans provide direction that requires dispatch centers to:

- A-12-a Implement a standard protocol ensuring that dispatch centers inform all resources of the name of the assigned incident commander and all other pertinent information.
- A-12-b Announce all changes in incident command leadership to all assigned and incoming resources for initial- and extended-attack incidents and relay that information to the duty officer and forest fire management staff.

A-13 The Director of F&AM will initiate a proposed revision of the NWCG Fireline Handbook (PMS 410-1) and all other related documents that would change incident classifications from the current structure—initial attack, extended attack, type 2, and type 1—to another structure—type 5, type 4, type 3, type 2, and type 1. Initial attack and extended attack will be reserved as terms describing the stages of an incident, not the command level required.

A-14 The Director of F&AM will assess the need for a complexity analysis for type 3-5 incidents that

*A policy letter on January 11, 2002, from Forest Service Chief Dale Bosworth, designed to implement action plan items, added a sixth bullet: "Use local rules and specific criteria to determine when a fire has moved beyond initial attack."

would assist fire program managers in determining the appropriate level of management. Factors such as historical levels of fire danger, fuels, fire history, fire potential, and historical fires in the vicinity should be considered.

A-15 The Director of F&AM will ensure that fire management plans require a single dedicated incident commander for all type 3 to type 5 incidents. Incident command responsibilities should not be diluted with collateral duties. The exception would be as a trainer or as an evaluator of an assigned trainee.

A-16 The Director of F&AM will initiate development of a standard operations guide for type 3, type 4, and type 5 incidents.

A-17 The Director of F&AM will initiate the adoption of an inter-agency “Standards for Fire Operations” handbook modeled upon the Bureau of Land Management’s “red book.” The interagency handbook should be developed to ensure that each agency’s unique standards are maintained.

A-18 The Directors of F&AM and Human Resources will work with the Forest Service Line Officers Team to develop core fire management competencies for agency administrators with fire program responsibilities. They will also seek inclusion of these competencies in the position descriptions and in selection criteria for agency administrators.

A-19 The Director of F&AM will adopt and implement newly developed “Interagency Fire Program Management Qualifications” for the key fire program management positions.

Evaluate existing training in fatigue awareness and other associated management training | and make training available to all employees.

A-20 The Director of F&AM will initiate actions to widely distribute the findings, recommendations, and causal factors from this accident

investigation. Additionally, the Director will work with the NWCG to ensure that the results of the accident investigation are



Smokejumpers in training. The Thirtymile Fire Prevention Action Plan modifies management of the type 3–5 incidents often handled by smokejumpers. Photo: Paul S. Fieldhouse, USDA Forest Service, Missoula Smokejumper Base, Missoula, MT.

Disengage suppression activities immediately if strategies and tactics cannot be implemented safely.

incorporated into the leadership training curriculum.

A-21 The Director of F&AM will review the fire simulation program currently being developed by the



Torching in a coniferous forest. Torching on the Thirtymile Fire helped spread the fire into drier fuels and steeper terrain, starting the transition to a crown fire. The Thirtymile Fire Prevention Action Plan calls for increased situational awareness on transition fires. Photo: Paul S. Fieldhouse, USDA Forest Service, Missoula Smokejumper Base, Missoula, MT.

San Dimas Technology and Development Center to ensure its release for the 2002 training season.

A-22 The Forest Service Chief, regional foresters, forest supervisors, and district rangers will personally communicate their expectation of leadership in fire management. This should be completed prior to the 2002 fire season and in conjunction with leadership team meetings and annual fire schools.

A-23 The Directors of Human Resources and F&AM should work with the Forest Service Line Officers Team (Tom Thompson, chair) to assess the roles, responsibilities, and methodologies needed to develop future fire management leaders. This would include fitness assessments to deal with performance expectations and issues surrounding fire leadership.

A-24 The Director of F&AM shall utilize the findings from the Thirtymile Fire Accident Investigation Report in preparedness training. This training will be available to all firefighting personnel. It will be mandatory for all new fire employees.

A-25 The Director of F&AM will work with the NWCG in the development of the leadership curriculum to ensure that there is adequate emphasis on preparing fire personnel to effectively exercise personal responsibilities and leadership. The curriculum must specifically address how group dynamics influence situational awareness, communications, group judgments, decisionmaking, and responsibility for individual personal actions.

Ensure that fire management plans require a single dedicated incident commander for all incidents, type 3–5.

A-26 The Directors of Human Resources and F&AM should develop and implement a comprehensive safety and health program utilizing all of the tools available. This should include risk management, system safety analysis, compliance, inspection, oversight, human factors, and behavior modification. In addition, use a behavior-based safety program for fire management that:

1. Focuses on active agency administrator involvement;
2. Encourages monitoring and intervention;
3. Promotes individual safe behavior on the fireline;
4. Rewards safe behavior; and
5. Reinforces the agency's commitment to safety through the use of incentives, recognition, and disciplinary procedures.

Additionally, develop procedures and protocols to ensure accountability at all levels of the organization. These procedures and protocols should enable fireline supervisors, fire

management personnel, and line officers to perform safely at all times.

A-27 The Director of F&AM will adopt and implement the formal risk management process endorsed by NWCG.

A-28 The Directors of F&AM and Engineering will review the current fire shelter development program to determine the possibility of accelerating the development of an improved fire shelter. The current timeline provides for completion in 2003.

A-29 The Directors of F&AM and Engineering will revise fire shelter training to emphasize entrapment avoidance. Incorporate information from this accident in revising the training. This training will include the proper use of personal protective equipment (including gloves and shrouds), the importance of crew cohesion in deployment, alternative deployment site selection, shelter deployment

preparation and training, and deployment site command and control.

A-30 The Director of Engineering will work with the Missoula Technology Development Center to review and appropriately incorporate into the program of work the recommendations found in the Equipment Appendix of the Thirtymile Fire Investigation Report.

A-31 The Directors of Wildlife, Fish and Rare Plants and F&AM will review and clarify issues of firefighter safety, fire potential, and use of tactical resources during developing fire emergencies with regard to threatened and endangered species. Such review will include coordination and clarification of existing protocols with the U.S. Department of Commerce, National Marine Fisheries Service, and U.S. Department of the Interior, U.S. Fish and Wildlife Service. ■

INITIAL HAZARD ABATEMENT PLAN



Editor's note: On July 10, 2001, four firefighters died in a burnover on the Thirtymile Fire on the Okanogan National Forest near Winthrop, WA. The Occupational Safety and Health Administration investigated the accident and cited the USDA Forest Service for five violations of the Code of Federal Regulations, part 1960—Elements for Federal Employee Occupational Safety and Health Programs. On February 7, 2002, as required by law, the Forest Service released an Initial Hazard Abatement Plan. The plan is reprinted here, lightly edited; the plan's appendix A is reprinted on page 22.

The Occupational Safety and Health Administration (OSHA) notified the Forest Service of the findings of its investigation of the Thirtymile Fire on the Okanogan–Wenatchee National Forest in July 2001. OSHA cited the Forest Service for two willful and three serious violations.

In response to the violations, the Forest Service is immediately implementing all of the actions described below. In addition, the Forest Service is amending the Accident Prevention Plan (dated December 14, 2001, and updated January 14, 2002) by letter to all Forest Service field units; and consulting with member agencies of the National Wildfire Coordinating Group to address the hazards identified by OSHA across the wildland firefighting community.

OSHA Violation 1— Serious

29 CFR 1960.8(a): The agency did not furnish employees employment and a place of employment which was free from recognized hazards that were causing or likely to cause death or serious physical harm in that employees were exposed to the hazards of burns, smoke inhalation, and death from fire-related causes.

The Chief's letter of January 11, 2002, requires that every fireline-qualified individual will receive training on entrapment recognition and deployment protocols.

OSHA Hazards Identified

Hazard 1-A. Work/rest cycles developed by the Forest Service were not followed. This resulted in a lack of situational awareness and impaired judgment in responding to critical fire situations.

Abatement Action: Washington Office Human Resources staff will coordinate with the Partnership Council to clarify or modify work/rest guidelines in order to ensure adequate levels of rest.

Hazard 1-B. An incident commander for all stages of the Thirtymile Fire was not clearly assigned. Incident command was not formally passed between various leaders.

Abatement Actions:

- Document all actions on appropriate incident action records and include the formal assignment of incident command responsibilities in the D-311 Initial Attack Dispatcher curriculum, to be released in 2003.

OSHA VIOLATION CATEGORIES*

The Occupational Safety and Health Administration (OSHA) gives the following definitions for the two violation categories cited in its report on the Thirtymile Fire:

- **Willful violation:** A violation that the employer intentionally and knowingly commits. The employer either knows that what he or she is doing constitutes a violation, or is aware that a hazardous condition exists and has made no reasonable effort to eliminate it.
- **Serious violation:** A violation where there is substantial probability that death or serious physical harm could result and that the employer knew, or should have known, of the hazard.

* Based on the Small Business Handbook posted by the U.S. Department of Labor on the World Wide Web at <<http://www.dol.gov/asp/programs/handbook/osha.htm>>.

- In addition, the completion of items in the Forest Service Accident Prevention Plan will abate this hazard. Specifically, these action plan items require:
 - Item A-12-a: Implement a standard protocol whereby dispatch centers inform all resources of the name of the assigned incident commander and all other pertinent information.
 - Item A-12-b: Announce all changes in incident command leadership to all assigned and incoming resources for initial and extended attack incidents and relay that information to the duty officer and wildland fire management staff.
- The Forest Service Chief's letter of January 11, 2002, requires that the National Mobilization Guide will include direction to dispatch centers that will ensure that all resources know the name of the assigned incident commander and announce all changes in incident command. Geographic Area Mobilization Guides, Zone Mobilization Guides, and Local Mobilization Guides should include this direction as they are revised for the 2002 fire season.

Hazard 1-C. Fire shelter deployment procedures had not been developed for firefighters whose escape routes were compromised. All firefighters must begin preparing for deployment of fire shelters when they are surrounded by fire, even if they believe they are in a safety zone.

Abatement Actions:

- Completion of Accident Prevention Plan item A-29 will abate this hazard. Specifically, the item requires the Forest Service Director of Fire and Aviation

Management and the Director of Engineering to revise fire shelter training to emphasize entrapment avoidance and incorporate information from this accident into revision of the training. This training will include the proper use, care, and storage of personal protective equipment (including gloves and shrouds); the importance of crew cohesion in deployment; alternative deployment site selection; shelter deployment preparation and training; and deployment site command and control.

- The Chief's letter of January 11, 2002, requires that every fireline-qualified individual will receive training on entrapment recognition and deployment protocols. This training should be conducted in conjunction with refresher training and/or annual fire schools. The principles outlined in the entrapment avoidance attachment will be incorporated into the next iteration of wildland fire shelter training.
- The Chief's letter of January 11, 2002, also requires that the Fire and Aviation Ground Safety Manager will issue guidelines, prior to the 2002 western fire season, for crew actions in the event of entrapment and in preparation for deployment. These guidelines will include specific actions necessary for entrapment avoidance, safety zone characteristics and selection, crew deployment training, and emergency deployment supervision when surrounded by fire.

**OSHA Violation 2—
Serious**

29 CFR 1960.11: Each agency did not ensure that any performance evaluation of any management

official in charge of an establishment, and supervisory employee, or other appropriate management official, measures that employee's performance in meeting requirements of the agency occupational safety and health program.

OSHA Hazard Identified

Hazard 2-A. Evaluations of supervisory and management officials at the Okanogan and Wenatchee National Forests, above the level of crew boss, did not have performance elements relating to their support of, or meeting the requirements in, the occupational safety and health program.

Abatement Action: Washington Office Human Resources staff will coordinate with the Partnership Council to ensure that performance elements for line officers, fire managers, and incident commanders evaluate performance in the area of safety and health. These safety and health elements, at a minimum, will include performance measures based on the Ten Standard Firefighting Orders and the Eighteen Situations That Shout Watch Out.

**OSHA Violation 3—
Serious**

29 CFR 1960.55(a): The agency did not provide occupational safety and health training for supervisory employees.

OSHA Hazard Identified

Hazard 3-A. A member of Northwest Regular Fire Crew #6 who had not completed his task book and required courses was assigned as a squad boss.

Abatement Action: All Fire Qualification Review Committees will annually review qualifications, as required by Forest Service Hand-

book 5109.17. Results of this annual review will be shared with affected employees. Forest fire management officers will maintain a complete and current record of all qualified personnel dispatched by the forest.

OSHA Violation 4—Willful

29 CFR 1960.8(a): The agency did not furnish employees employment and a place of employment which was free from recognized hazards that were causing or likely to cause death or serious physical harm in that employees were exposed to the hazards of burns, smoke inhalation, and death from fire-related causes.

OSHA Hazard Identified

Hazard 4-A. All Ten Standard Firefighting Orders in the National Wildfire Coordinating Group's Fireline Handbook 410-1 were violated. Supervisors at the Wenatchee National Forest and at the Thirtymile Fire did not ensure that the Fire Orders were followed.

Abatement Actions:

- Regional foresters, forest supervisors, and district rangers will emphasize their commitment to the Ten Standard Firefighting Orders through annual meetings with incident commanders and fire management personnel. Documentation of these meetings will be required. Additionally, any corrective actions related to the Fire Orders will be documented.
- The Forest Service is also developing standard disciplinary and accountability standards for violations of the Ten Standard Firefighting Orders and Eighteen Situations That Shout Watch Out

to raise awareness and penalize infractions in order to emphasize the importance of the orders and situations.

- The Forest Service Accident Prevention Plan extensively addresses the serious failure to follow the Fire Orders on the Thirtymile Fire. Twelve of the action items (Accident Report Items A-1, A-2, A-3, A-5, A-6, A-7, A-8, A-11, A-12, A-15, A-17, and A-25) require, taken together, 28 separate actions, including changes in transition operations, changes in briefing format, changes in communication direction, and continuing emphasis on the leadership training curriculum.

OSHA Violation 5—Willful

29 CFR 1960.8(a): The agency did not furnish employees employment and a place of employment which was free from recognized hazards that were causing or likely to cause death or serious physical harm in that employees were exposed to the hazards of burns, smoke inhalation, and death from fire-related causes.

OSHA Hazards Identified

Hazard 5-A. Management failed to conduct inspections of firefighting operations, including onsite, frontline evaluations of type 3, 4, and 5 fires to ensure that established firefighting practices were enforced.

Abatement Actions:

- Fire managers and line officers will periodically review a representative number of type 3, 4, and

5 fires on their unit(s), both onsite and through after-action activities. These reviews will include evaluation and documentation of fire management operations, with the Ten Standard Firefighting Orders and the Eighteen Situations That Shout Watch Out as the standard for measuring safety and health performance.

- In addition, fire managers and line officers will review a sufficient number of type 3, 4, and 5 fires to document trends and identify safety and health hazards and/or violations of the Fire Orders and Watch Out Situations.
- The Fire and Aviation Ground Safety Manager will complete and implement the Safe Practices Spreadsheet program to improve and standardize documentation of violations and good safety and health performance in order to identify hazards and trends.

Hazard 5-B: After-action reports prepared for out-of-forest firefighting crews on type 3, 4, and 5 fires did not identify safety and health hazards.

Abatement Action: After-action reports, individual overhead performance evaluations, and crew evaluations will be completed on every fire assignment. These evaluations will use the Ten Standard Firefighting Orders and the Eighteen Situations That Shout Watch Out as the standard for measuring performance. Corrective action, even if satisfactorily completed, will be documented in the reports and evaluations. Local units will keep these records and share them with the evaluated resource and the resource's home unit. ■

CROSSWALK BETWEEN OSHA VIOLATIONS AND ACCIDENT PREVENTION PLAN*



The following table shows how safety violations identified by the Occupational Safety and Health Administration (OSHA) during its investigation of the Thirtymile Fire accident correspond to action items called for under the USDA Forest Service's Thirtymile Fire Accident Prevention Plan.

OSHA Investigation			Accident Prevention Plan	
Violation	Hazard	Description	Item	Description
29 CFR 1960.8(a)	1-A	Work/rest cycle	A-1	Fatigue policy
			A-5-a-d	Manage fatigue
			A-6	Fatigue awareness
			A-7	Fatigue evaluation
			A-8-a	Type 3-5 incident command responsibilities
	1-B	Command unclear	A-8-b	Documented contact
			A-9	Transition training
			A-10	Strengthen competencies
			A-11	Briefing format
			A-12-a	Command broadcasted
			A-12-b	Broadcast command changes
			A-25	Leadership curriculum
	1-C	Shelter deployment procedures	A-29	Entrapment avoidance training
			A-30	Equipment recommendations
			A-17	Fire operations handbook
			A-20	Share findings
			A-18	Administrator competencies
29 CFR 1960.11	2-A	Performance elements for safety and health	A-23	Fire management leadership
29 CFR 1960.55(a)	3-A	Uncompleted task book	A-26	Behavior-based safety and health program
29 CFR 1960.8(a)	4-A	Ten Standard Firefighting Orders	--	Standard operating procedure
		1. Safety first	A-17	Fire operations handbook
		2. Overextended	--	Standard operating procedure
		3. Spot forecast	A-3	Fire danger awareness
		4. Unclear/conflicting instructions	--	Standard operating procedure
			A-8-a	Type 3-5 incident command responsibilities
			A-8-b	Documented contact
			A-12-a	Command broadcasted
			A-12-b	Broadcast command changes
			A-15	Dedicated incident commander
			A-25	Leadership curriculum
		5. No current fire information	A-1	Transition from initial to extended attack
			A-2	Fire danger/staffing
			A-3	Fire danger awareness
			A-8-a	Type 3-5 incident command responsibilities
			A-11	Briefing format
		6. Communications	A-8	Type 3-5 incident command responsibilities
			A-12	Command broadcasted
			A-15	Dedicated incident commander
			A-17	Fire operations handbook
		7. Safety zones and escape routes	--	Standard operating procedure
		8. Lookouts	--	Standard operating procedure
		9. Leadership fragmented	A-8-a	Type 3-5 incident command responsibilities
			A-8-b	Documented contact
			A-12-a	Command broadcasted
			A-12-b	Broadcast command changes
			A-15	Dedicated incident commander
			A-25	Leadership curriculum
		10. Fatigue	A-5-a,b,c	Manage fatigue
			A-6	Fatigue awareness
			A-7	Fatigue evaluation
			A-8-a	Type 3-5 incident command responsibilities
			A-11	Briefing format
			A-25	Leadership curriculum
29 CFR 1960.8(a)	5-A	No inspections/oversight	A-1	Transition from initial to extended attack
			A-2	Fire danger/staffing
			A-3	Fire danger awareness
			A-8-a	Type 3-5 incident command responsibilities
			A-11	Briefing format
	5-B	No safety/health hazards identified in after-action reports	--	

* Based on appendix A in the USDA Forest Service's Initial Hazard Abatement Plan, released on February 7, 2002, in response to OSHA's Thirtymile Fire investigation report.

THIRTYMILE FIRE: FIRE BEHAVIOR AND MANAGEMENT RESPONSE*



Hutch Brown

"t's licking; it's rolling; it's alive; it's screaming at us!" That's what the Thirtymile Fire looked and sounded like to one firefighter just before it hit with a wall of heat and flame (Rutman 2001). On a blazing July afternoon, the fire had entrapped 16 people in a steep canyon formed by the Chewuch River on the Okanogan National Forest in north-central Washington. Four firefighters perished.

Sizeup Disparities

Earlier, things had looked quite different. The 21 members of the Northwest Regular (NWR) #6 Type 2 Fire Crew arrived on the fire just after 9 a.m. on the morning of July 10, 2001. They were eager to suppress the spot fires in Chewuch Canyon and perhaps move on to the Libby South Fire, a much larger incident with a smoke column visible 50 miles (80 km) to the south. In briefing the crew boss trainee, the fire management officer for the Methow Valley Ranger District, Okanogan National Forest, said the Thirtymile Fire was "basically a mopup show," a view that would be repeated by the media.

The earliest sizeup report had been more ominous. Late on July 9, a

Topography, fuels, and weather conditions in Chewuch Canyon all pointed to the possibility of extreme fire behavior.

three-person initial-attack crew arrived after a plane first detected the fire in Chewuch Canyon. The incident commander (IC) reported that 3 to 8 acres (1.2–3.2 ha) were burning on the canyon floor just north of the Chewuch River, with two spot fires visible across the stream.

One spot fire, the IC believed, was already burning dangerously close to the canyon's heavily forested south slope. Unless controlled, he warned, "it will grow, hit the slope, and get larger."

Asked by the district duty officer and Okanogan National Forest Dispatch whether the fire could wait until morning, the IC replied that it needed "to be taken care of tonight, because if it hits that slope, it is going to the ridgetop." That assessment ultimately proved correct. On the next afternoon, the fire not only went to the ridgetop, but also swept upcanyon. Within hours, four firefighters lay dead.

Following the accident, the USDA Forest Service immediately assembled an investigation team. The Thirtymile Fire Investigation Report, released on September 26 and amended on October 16, 2001, suggests that serious mistakes were

made by those responsible for safely managing the fire. What does the Thirtymile Fire teach? What lessons can be learned from the fire's behavior and the management response?

Environmental Conditions

On the morning of July 10, conditions in Chewuch Canyon were dangerous. Topography, fuels, and weather conditions all pointed to the possibility of extreme fire behavior. Escape from the canyon would be difficult, and there were no safety zones inside the canyon.

Topography. The Thirtymile Fire ignited about 20 miles (32 km) north of Winthrop, WA, on the banks of the Chewuch River, a beautiful stream in a V-shaped canyon carved by glaciers (fig. 1). A single unimproved road follows the river upcanyon along its north bank. The road dead-ends at Thirtymile Campground, a trailhead for wilderness travel.

The canyon runs from northeast to southwest, the same orientation as the prevailing southwest winds. The canyon floor narrows from about 1,500 feet (460 m) at the point of ignition to about 900 feet (270 m) at the point where firefighters

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* This article closely follows the Thirtymile Fire Investigation Report: Accident Investigation Factual Report and Management Evaluation Report (Winthrop, WA: USDA Forest Service; September 26, 2001, as amended October 16, 2001), particularly the Fire Behavior Appendix, pp. 54–65. Unless otherwise referenced, all information in this article is from the investigation report and followup investigation.

deployed their fire shelters (Roeder 2001). The elevation at the point of ignition is about 3,440 feet (1,040 m). The canyon slopes are 70 degrees or more and about 3,000 feet (910 m) high.

Fuels. The canyon floor supports a forest of spruce, Douglas-fir, lodgepole pine, and (on streambanks) cottonwood. At the point of ignition, the floor was strewn with decomposing woody debris, much of it highly flammable. Ladder fuels were plentiful, including shrubs, understory conifers, and drooping boughs from overstory spruce. Overall, fuel model 10 applied (see

sidebar), although some areas resembled fuel models 8 (timber, low fuel load) and 12 (slash, moderate fuel load).

Forest cover in Chewuch Canyon is normally heavier on the cooler, shadier south (north-facing) slope than on the drier north (south-facing) slope. Before the fire, the south slope was densely covered by Douglas-fir and lodgepole pine. Branches hung down to within a few feet of surface fuels; fuel models 8 and 10 applied. On the more open north slope, ponderosa pine and Douglas-fir prevailed, with grasses and brush dominating in many

areas. Fuels and vegetation became more continuous near the ridge-line. Vegetation on both sides of the canyon was broken by occasional rockslides and scree slopes.

Weather. The winter of 2000–01 was the area's second driest in 30 years. Precipitation from April through June remained well below normal. The Palmer Drought Index of July 14, 2001, showed severe to extreme drought for the region. By early July, weather and fuel moisture conditions in Chewuch Canyon resembled normal conditions for early August, the peak of fire season.

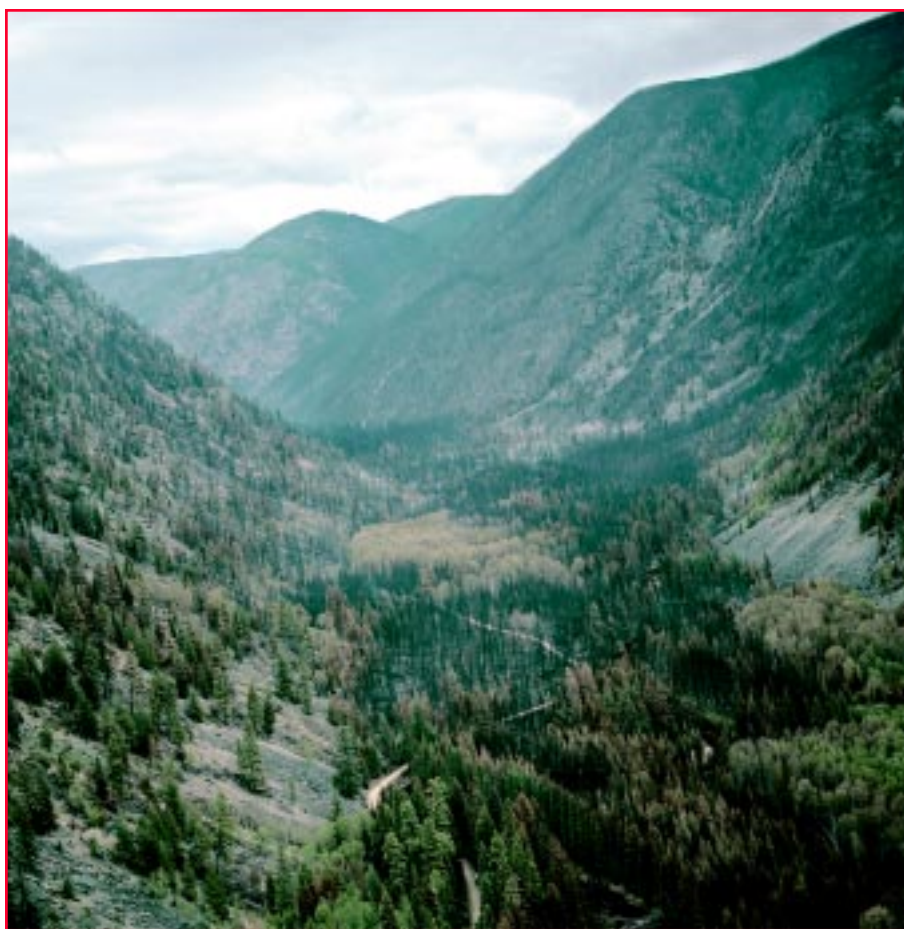


Figure 1—Chewuch Canyon after the Thirtymile Fire on July 10, 2001. Scree slopes are visible on both sides; heavier vegetation is on the south slope (right). The fire burned upcanyon from lower right to upper left, crossing the “S” in the road at center and entrapping the firefighters. Photo: Ben Croft, USDA Forest Service, Missoula Technology Development Center, Missoula, MT, 2001.

FUEL MODEL 10

Fuel models, based on factors such as type and amount of vegetation on a site, help fire managers assess fire hazards. On much of the Thirtymile Fire, fuel model 10 prevailed, described by Anderson (1982) as follows:

The fires burn in the surface and ground fuels with greater fire intensity than the other timber litter models. Dead/down fuels include greater quantities of 3-inch (7.6-cm) or larger limb wood resulting from over-maturity or natural events that create a large load of dead material on the forest floor. Crowning out, spotting, and torching of individual trees are more frequent in this fuel situation, leading to potential fire control difficulties. Any forest type may be considered if heavy down material is present; examples are insect- or disease-ridden stands, windthrown stands, overmature situations with deadfall, and aged light thinning or partial-cut slash.

On July 10, relative humidity dropped to 8 percent and temperatures reached a high of 94 °F (34 °C). Fuel moistures approached historical lows:

- 10-hour fuels = 3 percent
- 100-hour fuels = 5 percent
- 1,000-hour fuels = 10 percent

Large-diameter fuels were so dry that many burned almost completely in the fire. Live foliar moisture probably dipped below 100 percent, making conifers more susceptible to torching.

The closest fire weather stations classified the fire danger on July 10 as “very high.” The station at First Butte Lookout, about 12 miles (19 km) to the south, registered the highest energy release component (ERC) for that day since record-keeping began in 1970. ERC is a measure of the potential available energy per unit area within the flaming front at the head of a moving fire. Since April 14, the ERC at First Butte had approached record levels almost every day.

The prevailing winds on July 10 remained light—2 to 4 miles per hour (0.9–1.8 m/s). However, as temperatures rose during the day and the flames grew in intensity, the fire sucked air into its base, creating its own winds. During the afternoon, a helicopter pilot observed drafts of 20 to 30 miles per hour (9–13 m/s), and the entrapped firefighters had trouble deploying their fire shelters in the fire-induced winds.

Atmospheric conditions were conducive to the formation of fire columns. At Spokane, WA, the mid-level Haines Index on July 10 was 6, and the high-level Haines Index reached 4. The Haines Index

Escape from the canyon would be difficult, and there were no safety zones inside the canyon.

measures atmospheric dryness and stability on a scale of 2 to 6; unstable atmospheric conditions (Haines Index 5 or 6) are often associated with large fire growth.*

Overall, conditions in Chewuch Canyon were unseasonably ripe for extreme fire behavior. The firefighters did not obtain the fire weather forecast issued at 8:30 a.m. on July 10. Their only weather information came from a spot weather report for the Libby South Fire issued a day earlier.

Initial Attack

On July 9, just as on the previous 5 days, the relative humidity in Chewuch Canyon did not reach its usual nighttime peak. In the relatively dry nighttime conditions, the Thirtymile Fire spread at the rate of about 86 feet per hour (26 m/h) through the large-diameter fuels on the north bank of the Chewuch River. Flame lengths reached about 2.3 feet (0.7 m).

Profuse deadfall and ladder fuels carried the surface fire into some treetops. The torching trees spewed embers, igniting at least six spot fires and sending the fire across the river. The fire moved generally upcanyon from the point of ignition, with spot fires scattered toward the base of the south slope.

The first crew arrived on the scene at about 11 p.m. on July 9. The firefighters soon found the source

of the blaze—a streamside cooking fire abandoned by picnickers. Forest officials believed that if the fire was allowed to burn under the severe environmental conditions in Chewuch Canyon, it could spread across thousands of acres, threatening lives and crossing onto non-Federal lands. Another major fire in the region might overtax fire suppression resources already stretched thin. In accordance with the Okanogan National Forest’s fire management action plan, forest officials decided to suppress the fire as quickly as possible.

Recognizing the opportunity to apply water in the riparian zone, the first IC requested two engines, a Mark 3 pump, hoses, and a hand crew of at least 10 people. A little after 1 a.m. on July 10, the Entiat Interagency Hotshot Crew relieved the first crew on the fire. The new IC decided that lining spot fires would most effectively control the fire.

The hotshots went to work on the north bank. At 2:15 a.m., they crossed the river to tackle the fires on the south bank. The IC now saw that the job was bigger than at first thought. He ordered a reconnaissance aircraft, another crew, and two Mark 3 pumps with kits and 1,500 feet (457 m) of hose.

Working through the night, the hotshots dug containment line and surrounded spot fires. By 6 a.m., the fire had lost intensity; by midmorning, only eight scattered hotspots remained. At about 9 a.m., the forest and district fire management officers (FMOs) arrived. The

* For a good description of Haines Index application in the West, see John Werth and Paul Werth, “Haines Index Climatology for the Western United States,” *Fire Management Notes* 58(3): 8–18. See also the article by Brian Potter and others beginning on page 41 in this issue.

Large-diameter fuels were so dry that many burned almost completely.

forest FMO estimated that about 3 acres (1.2 ha) of active fire were left, spread over a 5-acre (2-ha) area. He judged fire behavior to be “very benign.”

The hotshots badly needed sleep, so the NRW #6 crew took over at about 9:30 a.m. According to one arriving firefighter, only a few flames were visible (Hamilton and Earls 2001). The firefighters were confident that they could easily finish the job. Although several crew members had little or no experience, all had the requisite training. Their leaders had many decades of fireline experience among them, although the FMOs had no recent experience with initial and extended attack.

Transition

The NRW #6 crew boss passed IC responsibility to the crew boss trainee, standing by in case the trainee needed help. At about 11 a.m., the trainee led the crew across the river to the south bank. Using two pumps, the crew applied water to the remaining spot fires while digging fireline. However, the firefighters had trouble keeping the pumps running. Several hoses burst and four pulaskis broke.

By noon, conditions were deteriorating. Since midmorning, the relative humidity had been rapidly falling and the temperature rising. Now, surface fires were becoming more active, with flame lengths approaching 8 feet (2.4 m). More trees were torching, and spot fires were crossing containment lines.

At about noon, the crew boss trainee decided to change tactics.

Abandoning the pumps, the crew started constructing fireline ahead of the fire, trying to pinch the fire's head with a line from the river to a scree slope (Solomon and Welch 2001a). However, the many roots in the soil hampered progress.

At 12:08 p.m., the crew boss trainee requested a helicopter with bucket and longline. Twenty minutes later, he ordered additional crews. At about 2 p.m., the Entiat Hotshots returned to reinforce the NRW #6 crew; by 2:38 p.m., a type 3 helicopter was making water drops. Still, the fire kept crossing containment lines.

The crew boss trainee decided that the fire could not be controlled and moved the firefighters back across the Chewuch River to the north bank. The crew boss now assumed the IC role. Sometime after 2 p.m., the crew boss removed the sole lookout from a patch of scree on the south slope for fear that her escape route might be cut off. An air attack plane diverted from the Libby South Fire now acted as lookout, but smoke limited its effectiveness.

By 2:50 p.m., the fire had gained a foothold on the south slope. The fire, now entirely unconstrained, spread at a rate of about 710 feet per hour (220 m/h). By 3:20 p.m., it covered about 50 acres (20 ha) on the valley floor.

At 3:20 p.m., the fire at the base of the south slope reached critical mass. Driven by convective winds through dense fuels on 100-degree slopes, the fire began uphill crown-

ing runs at about 1.25 miles per hour (2 km/h). Within 15 minutes, the fire doubled in size to about 100 acres (40 ha). A huge convection column formed, with pervasive spotting as far away as 0.4 miles (0.6 km). “We were losing it,” a firefighter remarked (Solomon and Welch 2001a), “but it was one of the most fantastic things I’ve ever seen.”

The crowning runs signaled a new level of fire activity. At the point of origin, spruce dominates the site, with alder in the understory and aspen nearby. The site is wetter than surrounding areas of pine and Douglas-fir, so the fire was initially limited to torching and spotting. In fact, most fuels in the area of ignition remained unburned (fig. 2). But as the day warmed and the fire reached drier sites, its intensity grew and the rate of spread increased. Indrafts and spotting from the blaze on the south slope further intensified fire activity on the canyon floor. From about 3 p.m. to 4 p.m., as the firefighters lunched and rested, conditions further deteriorated. By 4:20 p.m., the fire on the canyon floor had begun a sustained run through tree crowns.

Entrapment

By 3:30 p.m., two engines had arrived on the fire. Both were ordered by Air Attack at 2:27 p.m. Without checking in with the IC, they drove past the NRW #6 crew to attack spot fires upcanyon.

At about 4 p.m., the IC made the fateful decision to send a squad from the NRW #6 crew to support the engines ahead of the main fire. By 4:30 p.m., two squads were fighting spot fires along the road upcanyon from the lunch spot, although the engines had withdrawn.

“No one associated with this fire
gave it the respect it was due.”

—*Thirtymile Fire Investigation Report*

The fire was spreading upcanyon generally parallel to the road along the Chewuch River. However, just upcanyon from the lunch spot, the road makes a 90-degree turn towards the river (fig. 3). At this point, the fire spread was perpendicular to the road. The area was densely forested, with a heavy understory of shrubs and young conifers. At about 4:30 p.m., fed by the ladder fuels, the fire made a torching run that swept across the

river and threatened to cross the road behind the NRW #6 crew.

Seeing the danger, Air Attack and the crew leaders ordered everyone out. But for the IC and 13 other firefighters, it was too late. At 4:34 p.m., the fire cut off their only escape. Led by the IC, the firefighters retreated about 1 mile (1.6 km) upriver to a site selected for survivability. Shortly after 5 p.m., the crew was joined by two

civilians who had been camping at the end of the road (see the sidebar on page 28).

By 5 p.m., the fire was scouring the canyon on both sides of the Chewuch River, from the base of the north slope to the top of the south ridge. Two convection columns formed, one from the south slope fire and another from the fire on the canyon floor. The hillside fire drew strong upcanyon winds that probably drove the fire on the canyon floor, flattening its convection column. “It was rolling like a little tornado on its side,” observed the Air Attack pilot (Solomon and Welch 2001a). With its flattened convection column aimed straight at the deployment zone, the fire swept upcanyon at a rate of more than 1.6 miles per hour (2.5 km/h).

Deployment

The IC had chosen a good deployment zone (fig. 4). A bend in the river widened the stream, forming a sandbar against the north bank. Across the river was an extensive, lightly vegetated rock slump behind a narrow band of conifers along the stream. Adjacent to the road was a scree slope and lightly vegetated hillside. Just to the north and east of the deployment site, within about 20 feet (6 m), was a timbered area (fuel model 10) that extended upcanyon for several miles.

The rock slump across the river hid the approaching fire on the canyon floor from view. However, the firefighters could see the plume from the fire on the south slope. The plume might have led the IC to believe that the fire’s convection column would be vertical, carrying heat and flame upslope across the river, well away from the deployment zone. “I think he thought we were completely safe where we



Figure 2—Area of early fire activity. Initially, the Thirtymile Fire was a series of slow-moving, occasionally torching spot fires, leaving most fuels near the point of origin unburned (lower left). As it spread upcanyon, the fire reached drier fuels and transitioned to a crown fire, severely burning most stands (upper right). Photo: Ben Croft, USDA Forest Service, Missoula Technology Development Center, Missoula, MT, 2001.

were,” one firefighter later told reporters (Roeder 2001). Although the firefighters waited in the deployment zone for about half an hour before the fire arrived, they did nothing to prepare the site, such as removing flammable materials. Some spent the time taking photos or making journal entries.

Nobody considered moving to the sandbar, possibly the safest deployment site. Most formed a loose group on the road near the IC, but some joined a squad leader on the scree slope, partly for a better view of the approaching fire (Roeder 2001). One firefighter on the scree slope wore no gloves. A second squad leader climbed through the scree, assessing its viability as a deployment site. Nobody offered the civilians extra fire shelters or other personal protective equipment.

Just before 5:24 p.m., the situation abruptly changed. The sky darkened and embers began to pelt the firefighters, who draped themselves with their fire shelters for protection. The fire came into view, howling and roaring as it sped through the trees. Then it hit with a plume of hot gases. Caught by surprise, the firefighters hurriedly deployed their fire shelters. Some mistakenly deployed with their heads toward the fire; others dropped their packs next to their shelters or even took them inside—an extreme fire hazard, because packs and other gear can ignite, compromising the effectiveness of fire shelters.

Despite the mistakes, all eight firefighters who deployed on the road survived. The two civilians took shelter with one of them; all three survived with minor injuries. However, six firefighters were caught on the scree slope up to 100

feet (30 m) above the road. In a tight group, they deployed in rocks that were 1 to 3 feet (0.3–0.9 m) in size, with duff and rotting wood lodged in the crevices. Four died from asphyxia due to inhaling superheated gases, probably because they could not get a good seal for their fire shelters. Two survived the fire’s initial blast, then fled downhill—one into the river, the other into a van on the road. Both lived, one with severe burns.

The deployment zone was well chosen; it was probably the only survivable site in the canyon. The scarcity of fuels on the hillside above and on the rock slump across the river limited the amount and duration of heat on the road. Also, the narrow band of conifers on the south side of the river might have partially shielded firefighters on the road from the initial blast of heat from the fire. However, the deployment zone was no safety zone. By

CIVILIANS ENTRAPPED AT THIRTYMILE

In a twist of fate, a civilian couple was saved by a firefighter entrapped on the Thirtymile Fire. How did it happen?

The only road into Chewuch Canyon ends at Thirtymile Campground, a trailhead for wilderness travel. On July 10, between 10 a.m. and 11 a.m., the district fire management officer ordered the road closed due to danger from the Thirtymile Fire. However, no action was taken for the next 4 to 5 hours. At 3:17 p.m., an engine finally posted a sign at the road’s entrance.

Before the sign was posted, at about 1 p.m., a couple drove up the road to Thirtymile Campground, where they planned to

spend the night. On the way, they saw burned areas but no firefighters.

Between 3 p.m. and 4 p.m., the superintendent of the Entiat Interagency Hotshot Crew, together with his next-in-command, drove to the campground to make sure nobody was there. He noticed three cars parked at the trailhead but did not see the couple or their vehicle.

Just before 5 p.m., the couple noticed a smoke column down-canyon and decided to get out. Driving down the road, they met the 14 entrapped firefighters at the deployment zone near a sandbar on the river. The firefighters explained that they were all entrapped, offering advice and encouragement.

The civilians put on heavy clothes to protect themselves from falling embers, but they did not have personal protective equipment. When the fire arrived and the firefighters deployed their fire shelters, the couple sought shelter with one of the firefighters. It saved their lives.

Investigators concluded that the civilians were entrapped because the road was not closed in time and because evacuation of the upper canyon failed. If firefighters had not themselves become entrapped, the civilians probably would not have survived.

the time the firefighters realized that, it was too late for some of them.

Preventable Tragedy

Forest Service investigators found that the entrapment and subsequent fatalities were preventable. “The lessons to be learned as a result of the fatalities on the Thirtymile Fire in July 2001 are mostly about what was not done that should have been done,” concluded the Thirtymile Fire Accident Review Board. Independent investigations reached similar conclusions (Roeder 2001; Solomon and Welch 2001b).

Investigators found 14 significant causal factors for the accident (see the list beginning on page 9). Among the most important were the violation of all of the Ten Standard Firefighting Orders and the failure to observe 10 of the Eighteen Situations That Shout Watch Out. In addition, a lack of situational awareness, exacerbated by fatigue, led to poor strategic and tactical decisions.

After the fire, some of the survivors commented to reporters on their own mistakes (Solomon and Welch 2001b). “We even made a joke of it,” said the assistant foreman on one of the engines. “Where’s our escape routes? Where’s the safety zones? Why didn’t we say anything?” “I failed to do a lot of things after lunch,” admitted one of the entrapped squad leaders on the NRW #6 crew. “I put my trust in other folks.”

That trust had seemed well placed. Good leaders were on the fire, people deeply respected for their knowledge, experience, and ability. However, fatal incidents often involve a series of events that form

a chain leading to tragedy. Fire managers and ICs must provide the leadership necessary to break the chain.

Deceptive Situation

In congressional testimony, Forest Service Chief Dale Bosworth offered a compelling reason for what went wrong (Bosworth 2001). “The people on this fire were dedicated people,” he said. “They intended to do the right things, but they were deceived by the fire, and the situation changed on them quickly.”

The Thirtymile Fire was a transition fire—a fire that rapidly changed from a low-intensity surface fire

into a high-intensity crown fire. Transition fires are complicated by the need for constant reassessment and readjustment to a rapidly changing situation. Common denominators of fire behavior on tragedy fires—fires that cost lives—include small size and deceptively innocent appearance before a rapid transition to extreme fire behavior (NWCG 1996). Most tragedy fires are transition fires (see the article by Jerry Williams beginning on page 6).

The Thirtymile Fire Prevention Action Plan is designed, among other things, to improve situational awareness on transition fires (see

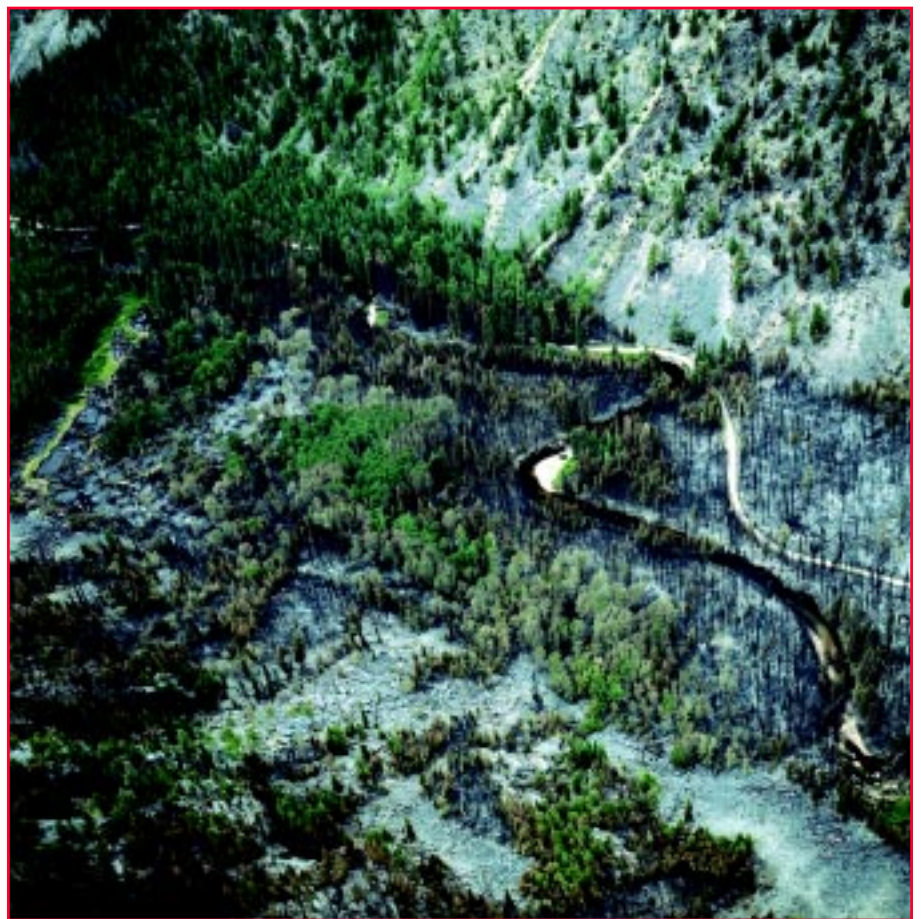


Figure 3—Entrapment site, facing north across the river. The main fire was burning in dense fuels (center, in the crook formed by the river), spreading upcanyon to the right. Firefighters moved ahead of the main fire to fight spot fires along the “S” in the road (right and far right). At 4:34 p.m., the fire made a crowning run across the “S,” entrapping 14 firefighters. Photo: Ben Croft, USDA Forest Service, Missoula Technology Development Center, Missoula, MT, 2001.

the plan beginning on page 14). By implementing the action plan, the wildland fire community can strengthen its capacity for safely managing transition fires.

Could Thirtymile happen again? Investigators on the South Canyon Fire concluded that “a similar alignment of environmental factors and extreme fire behavior is not uncommon and will happen again” (Butler and others 2001). The same holds true for the Thirtymile Fire. Firefighters will face other transition fires under similar circumstances. Their safety will depend on

fully understanding what the fire is doing at all times—and always putting safety first.

Acknowledgments

The author wishes to thank everyone who contributed to the Thirtymile Fire Investigation Report, especially those who wrote the Fire Behavior Appendix, for the outstanding work on which this article is based. The author also thanks Ben Croft of the Forest Service’s Missoula Technology Development Center in Missoula, MT, for furnishing photos for this article.

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Figure 4—Deployment zone, facing downriver. Eight firefighters deployed their fire shelters on the road above the sandbar (lower center), one together with two civilians; all survived. Six firefighters deployed in the scree above the road (center right); four died. Photo: Ben Croft, USDA Forest Service, Missoula Technology Development Center, Missoula, MT, 2001.

RUSH TO JUDGMENT ON THE THIRTYMILE FIRE



Hutch Brown

Dale Bosworth, Chief of the USDA Forest Service, was concerned. "There has been a whole lot of speculation about why this tragedy occurred," he told a gathering in Coeur d'Alene, ID (Bosworth 2001). "Some people get one piece of the puzzle, then loudly proclaim that they have the whole picture. This speaking out of turn without all the facts does a disservice to our fallen firefighters, to their families, and to the truth."

Postfire Speculation

Bosworth was speaking about the Thirtymile Fire on July 10, 2001, when four firefighters perished in a remote canyon on the Okanogan National Forest near Winthrop, WA. He put his finger on a problem that has long plagued the interagency wildland fire community: premature public speculation about tragedy fires—incidents that cost lives. Professional investigators often take months to prepare a detailed report. Meanwhile, stories based on half-truths circulate in the media, distorting public perceptions and undermining the investigation.

The Thirtymile Fire was no exception. Long before the investigation team released its findings, one explanation after another surfaced in the media:

- A wind event caused the tragedy;
- Firefighters were too young and inexperienced;
- Fire shelters failed; and

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Stories based on half-truths circulate in the media, distorting public perceptions and undermining the investigation.

- A helicopter was delayed from dropping water due to the Endangered Species Act.

Each explanation contained enough plausibility to feed speculation. Each, however, represented a misleading rush to judgment, and none proved to be a significant causal factor.*

Wind Event?

Weather-induced winds can change fire behavior in seconds. In 1910, a windstorm powerful enough to snap mature trees whipped smoldering fires in the Northern Rockies into the Big Blowup. In 1937, a passing weather front in Wyoming changed the wind direction by 90 degrees, entrapping dozens of firefighters on the Blackwater Fire. In 1994, sudden winds blew a surface fire on Colorado's Storm King Mountain into a raging inferno that took 14 lives.** In view of these and other tragedy fires, news of every burn-

over justifiably triggers questions about weather and wind.

For weeks after the Thirtymile Fire, media stories focused on a "weak disturbance" in the upper atmosphere over the fire and a possible inversion break in the steep, V-shaped canyon where the fire was burning (Garber and others 2001; Paulson 2001a; Solomon and Welch 2001a; Solomon and others 2001). According to one story (Garber and others 2001), a cold front nosing into the area clashed with the warm, dry air over the fire. Within seconds, tremendous winds swept through the canyon and caused a blowup, entrapping the firefighters. It was, the reporters announced, "the equivalent of a meteorological sneak attack," impossible for firefighters to predict or detect in advance.

Observations taken by firefighters in the canyon do not support media speculation about weather-induced winds. From 1:30 a.m. to 7:00 p.m. on the day of the entrapment, windspeeds generally ranged from calm to 2 to 4 miles per hour (0.9–1.8 m/s). The fire itself generated gusts and strong winds after it began upslope runs at about 3:20 p.m., but these winds were not weather related.

Moreover, the investigation team found no reason to suppose that an

* See Thirtymile Fire Investigation Report: Accident Investigation Factual Report and Management Evaluation Report (Winthrop, WA: USDA Forest Service; September 26, 2001, as amended October 16, 2001). Unless otherwise referenced, all information in this article is from the investigation report.

** For more on the Big Blowup, see Stephen J. Pyne, "A Story To Tell," *Fire Management Today* 60(4): 6–8; and Hutch Brown, "The 1910 Fires: A New Book by Stephen J. Pyne," *Fire Management Today* 61(4): 45–47. On the Blackwater Fire, see Karl Brauneis, "1937 Blackwater Fire Investigation: Boost for Smokejumpers?," *Fire Management Today* 62(2): 24–26. On the South Canyon Fire, see Bret W. Butler and others, "The South Canyon Fire Revisited: Lessons Learned," *Fire Management Today* 61(1): 14–20.

Observations taken by firefighters in the canyon do not support speculation about weather-induced winds.

inversion break (see sidebar) caused a blowup. Fire behavior on the Thirtymile Fire was entirely consistent with unseasonably dry conditions, unstable atmospheric conditions, and high fire danger in explosive fuels. Although the firefighters did not obtain a local weather forecast, conditions in the canyon were known or knowable, and extreme fire behavior was foreseeable.

Youth and Inexperience?

“Leadership flows from experience and training, and the Forest Service appears to have a bias against both,” intoned an editorial after the Thirtymile Fire (Seattle Times 2001). Two of the four firefighters who died on the fire had no experience, and a third had spent only 1 year fighting fires; all three were less than 22 years old. Critics asked whether the Forest Service was putting people on firelines who

were too young, inexperienced, and poorly trained to safely fight fires (Holt 2001; Milstein 2001; Rivera and Solomon 2001; Stover and Roeder 2001).

Firefighters must be adults (at least 18 years old), pass a physical examination and rigorous exercise test, and take about 40 hours of training in fire behavior and firefighting techniques. After meeting the basic requirements, hundreds or even thousands of firefighters with little or no experience safely fight fires each year. Moreover, the fourth victim on the Thirtymile Fire was a 30-year-old with 12 years of firefighting experience, a well-trained squad leader revered by the young firefighters he led.

According to Forest Service investigators, the firefighters on the Thirtymile Fire were generally well qualified. Many were highly skilled

and experienced; the Northwest Regular (NRW) #6 Fire Crew boss alone had more than two decades of firefighting experience. Investigators concluded that causal factors other than youth and inexperience contributed to the fire tragedy, especially management’s underestimation of the fire danger.

Investigators found two areas where deficient training and experience might have played a role in what happened on the Thirtymile Fire:

- According to some NRW #6 crew members, the crew boss trainee was “fast-tracked” for the crew boss position. He might not have had sufficient experience to fully understand the risk inherent in some of the tactics employed under the dangerous conditions prevalent on the Thirtymile Fire.
- Several crew members did not properly deploy their fire shelters, perhaps because the fire caught them by surprise. Some deployed with their heads toward the fire, and others took their packs inside their shelters or dropped them nearby (a fire hazard).

In addition, an investigation by the Occupational Safety and Health Administration (OSHA) found that supervisory personnel on the fire above the level of crew boss lacked sufficient OSHA-related training, and that one of the squad bosses on the fire could not document completion of every task required for his position. (See OSHA violations 2 and 3 in Forest Service’s Initial Hazard Abatement Plan, reprinted beginning on page 19.)

Fire Shelter Failure?

Four firefighters perished inside their fire shelters, raising questions about the technology (CBS 2001; Garber and others 2001; Paulson

INVERSION BREAKS

Nighttime inversions are common in the deep, steep valleys and canyons of the West. At night, the ground cools more quickly than the air. The ground cools adjacent air, which sinks downslope and collects in the valley bottom. A warm layer of air above traps cooler air below on the valley floor. Smoke from smoldering nighttime fires rises only to the point where its temperature equals the warmer temperatures above. One sign of an inversion on a fire is a flat layer of smoke trapped in a valley.

However, as daytime temperatures rise and fire activity grows, air on the valley floor can become warm enough to break through the inversion layer. Warm air from below rapidly rises, and cool air from above rushes in to replace it. Within seconds of an inversion break, winds can rise and fire behavior can become extreme.



Firefighters learning how to deploy a fire shelter. Every firefighter takes about 40 hours of basic training in wildland fire behavior and firefighting techniques before ever stepping onto a fireline. Photo: USDA Forest Service.

2001b; Slivka 2001; Wiley 2001). Critics charged that the Forest Service had ignored fire shelter development or prevented better fire shelter designs from being adopted. However, a process for improving fire shelter design was already underway (see sidebar).

The main cause of burnover fatalities is damage to lungs and airways from flames and hot gases. Fire shelters protect firefighters by trapping breathable air and by reflecting 95 percent of a fire's radiant heat; they are not designed to withstand direct flames.

Firefighters are trained to use fire shelters for the specific protections they provide. For example, firefighters learn that they should choose deployment sites that will give them a good seal against the ground, well away from natural fuels and flammable equipment.

Since they were first introduced in 1974, fire shelters have saved more than 250 lives and have prevented hundreds of serious injuries and illnesses from burns and smoke inhalation. On the Thirtymile Fire, fire shelters saved 12 lives; even improperly deployed fire shelters offered good protection on suitable sites. For example, one fire shelter held three people—a firefighter and two civilians—even though, like every fire shelter, it was designed for only one. All three survived with only minor injuries.

On the Thirtymile Fire, the entrapped firefighters had enough time—about half an hour—to

FIRE SHELTER DEVELOPMENT

Any product can be tested to look good or bad. Firefighter safety demands a standard, reliable, repeatable, and impartial performance test for fire shelters. Until recently, there has been no such test. The USDA Forest Service's Missoula Technology and Development Center (MTDC) in Missoula, MT, set out to get one.

The first step was to describe the fire environment for the fire shelter. Working with the Forest Service's Fire Sciences Laboratory in Missoula, MT, and the University of Alberta in Edmonton, Alberta, Canada, MTDC gathered the necessary data during the International Crown Fire Experi-

ments in Canada's Northwest Territories in summer 1999.

The next step was to use the data to develop appropriate performance tests for the fire shelter. In December 1999, the University of Alberta's Combustion and Environment Group, Department of Mechanical Engineering, contracted to develop a battery of tests:

- Full-scale radiant and convective thermal tests,
- Strength and durability tests,
- Flammability tests,
- Protocols for volume measurements, and
- Toxicity tests.

The tests had to be repeatable in a laboratory so that each shelter could be evaluated under the same conditions to ensure impartiality.

All test protocols were available for testing fire shelter designs by June 2001. Full-scale testing began in September 2001, with the current fire shelter used as a performance baseline. Successful designs were presented to decisionmakers, who adopted a new design in June 2002. Field delivery of a new fire shelter is scheduled for spring 2003.

select and prepare a good deployment site before the burnover. The four firefighters who did not survive deployed their fire shelters away from the main group, among rocks from 1 to 3 feet (0.3–0.9 m) thick, with duff and other flammable material embedded in the crevices. They died from asphyxia due to inhaling superheated gases, probably because they could not get a good seal against the ground. Investigators concluded that deployment site selection, not fire shelter failure, was a significant causal factor in all four fatalities.

Helicopter Delay?

During a congressional hearing on the National Fire Plan in late July 2001, members of the House Subcommittee on Forests and Forest Health grilled the Forest Service Chief about an obscure event on the Thirtymile Fire: a delay in helicopter arrival. They seemed to believe that it held the key to the Thirtymile Fire tragedy.

Media outlets immediately picked up the story (Dlouhy 2001; Price 2001; Solomon 2001; Soraghan 2001; Zahn and La Jeunesse 2001). “For nine hours, the trapped firefighters begged for a helicopter to drop water from the nearby Chewuch River,” one reporter declared (Price 2001). Citing unnamed sources, reports suggested that lives were lost to save fish. The helicopter was delayed, so the story went, because endangered salmonids were in the river and the Endangered Species Act therefore prohibited helicopter dipping. Statements by firefighters only fanned the flames. “I think if we’d had the water when we asked for it, none of this would have happened,” the NRW #6 crew boss told reporters (Solomon 2001; Soraghan 2001).

Investigation findings do not bear out the story. At 2:15 a.m. on July 10, the incident commander ordered two Mark 3 pumps and a helicopter for reconnaissance. The pumps were critical; the fire was on flat terrain in a riparian zone, so pumps with hoses could deliver about 10 times more water, with far more regularity and precision, than a type 3 helicopter with a longline. Indeed, the helicopter’s limited capabilities, had they been brought to bear much earlier on the Thirtymile Fire, would likely have made little difference (see sidebar), except possibly in providing better information on fire activity.

The helicopter pilot had already spent long hours on another fire nearby; to accommodate his need for an off-duty rotation, the helicopter was ordered for 10 a.m. on July 10. By then, initial attack using pumps had succeeded in reducing the fire to a few scattered hotspots with benign fire behavior.

At about 11 a.m., the NRW #6 crew began attacking the fire’s remains. The leaders decided to continue using pumps; they did not immediately ask for the helicopter. At 11:52 a.m., Okanogan National Forest

Dispatch notified them that the helicopter had arrived and was poised for action, but the leaders still did not request deployment. However, the crew was having trouble running the pumps, and the leaders at last decided to change tactics. At 12:08 p.m., they asked for the helicopter.

Before launching, dispatch decided to obtain approval from the district ranger for fear of violating the Endangered Species Act. The fear was misplaced; a 1995 memorandum from the USDI U.S. Fish and Wildlife Service made clear that firefighter safety takes precedence over the protection of endangered species or their habitat.*

The district ranger gave his approval at 2:00 p.m., a delay of about 2 hours. By 2:38 p.m., the helicopter was making water drops on the fire. Despite the water drops, the fire gained a foothold at the base of the canyon slope and began making upslope runs. The helicopter played no significant role in ensuing events, including the actual entrapment and fatalities.

* For a discussion of the negligible danger to salmonids from helicopter dipping in lakes, see Justin Jimenez and Timothy A. Burton, “Are We Scooping More Than Just Water?”, *Fire Management Today* 61(1): 34–36.

HELICOPTER CAPABILITIES

A type 3 helicopter with longline supports firefighters on the ground by cooling down hotspots and extinguishing small spot fires. However, it cannot by itself stop even a small wildland fire. A 5-acre (2-ha) fire—about the size of the Thirtymile Fire in its initial stages—covers about 220,000 square feet (20,000 m²), an area about equal to a city block of 10 to 15 houses, plus streets and improvements. A 25-acre (10-ha) fire covers more than 1 million square feet (93,000 m²), about equal to a neighborhood of more than 100 homes, including streets and improvements. A type 3 helicopter with a longline can drop 75 gallons (284 L) (the equivalent of two large bathtubs) every 5 to 10 minutes—not nearly enough to have played a decisive role at any time during the Thirtymile Fire.

The investigation concluded that the helicopter was indeed delayed, partly due to confusion about legal requirements for endangered species protection. According to the investigation report, the delay “may have reduced the effectiveness of suppression actions” before the fire established itself at the base of the slope. However, because its overall effect was minimal, investigators classified the helicopter delay as an influencing factor and not a significant causal factor in the Thirtymile Fire tragedy.

Failed Speculation

Overall, the rush to judgment on the Thirtymile Fire ended in failure. None of the speculative reasons for the tragedy—a wind event, firefighter inexperience, fire shelter failure, or a helicopter delay—proved to be a significant causal factor in the entrapment or subsequent fatalities. The investigation team found 14 totally different causal factors, mostly related to management decisions on the fire (see the list beginning on page 9). Independent investigations largely corroborated the team’s findings (Roeder 2001; Solomon and Welch 2001b).

Speculation about tragedy fires is driven by the public’s need—and right—to know why entrapments and fatalities occur on a fire. Detailed investigation reports meet the need but take time to prepare. The timelag creates opportunities for premature speculation by reporters eager for a scoop and by others with axes to grind.

After a tragedy fire, fire managers should prepare for the inevitable postfire speculation. The best response is to:

- Openly discuss known facts about the fire;
- Deplore the accident and offer condolences to the victims and their families;
- Describe the investigation, offering detailed information on its purpose, nature, and scope; and
- Decline to comment on any circumstances under investigation.

Declining to comment might seem evasive. However, media speculation following the Thirtymile Fire, partly based on comments made by firefighters and other “official” sources, produced a failed rush to judgment. The disservice done to the public gives fire managers a sound reason for declining to comment on circumstances under investigation following any future incident.

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INJURIES, ILLNESSES, AND FATALITIES AMONG WILDLAND FIREFIGHTERS*

FOREST SERVICE
TECHNOLOGY &
DEVELOPMENT
PROGRAM



Richard J. Mangan

Wildland firefighting activities take place in a high-risk environment. The firefighters involved in these activities are often at risk, both in the short term and the long term, of illnesses, injuries, and sometimes even death. In the United States, 133 individuals died in activities associated with wildland fire suppression from 1990 to 1998. Australia has also experienced numerous fire-related fatalities during the same period, and other firefighters around the world have died in Greece, Mongolia, Russia, and South Africa.

This article discusses factors that are critical to both firefighters and fire managers in ensuring a safe and productive workforce. First, it discusses such items as the work environment, the firefighter workforce, physical fitness, nutrition, work/rest cycles, lifestyle choices, and job requirements. Next, it reviews firefighter illnesses, injuries, and fatalities, with the purpose of identifying mitigation measures for reducing and/or eliminating the risks from the fire environment. The mitigation measures suggested are applicable to firefighters at all organizational

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Firefighters often come to the fireline with the same physical conditions and problems as the general population.

levels: Federal, State, rural, volunteer, and contractor.

Work Environment

A wide variety of environmental conditions exist in the world of wildland fire suppression: From the Arctic tundra to the Florida everglades; from the eucalypt forest of Australia to the chaparral of southern California; and from the ponderosa pine forests of Montana to the pine barrens of New York and New Jersey, the extent of ecosystems that experience fires is truly worldwide.

Numerous factors compound the already stressful work of suppressing fires: elevations that range from sea level to more than 6,500 feet (2,000 m); steep, uneven ground; high ambient air temperatures that often exceed 95 °F (35 °C); and above-average levels of smoke and dust. All these conditions have the potential to affect the on-the-ground performance of the wildland firefighter; they can ultimately result in illness, injury, or even death. These factors, especially for individuals not acclimated to them, can have a cumulative effect on a firefighter's ability to resist these exposures and risks.

Firefighter Workforce

The individuals who participate in wildland firefighting operations are as varied as the fuel and terrain types that they fight fire in: females and males of all racial backgrounds, at least 18 years old but often into their 60s and 70s. They might weigh less than 100 pounds (45 kg) or more than 250 pounds (113 kg) and range from less than 5 feet (1.5 m) tall to more than 6.5 feet (2.0 m) tall.

Firefighters are truly a cross-section of the population that they serve. Although some fire agencies have physical fitness requirements, firefighters often come to the fire environment with the same physical conditions as the general population: allergies to smoke and dust; trick knees; weight and fitness problems; and other preexisting conditions that might surface on the fireline.

Firefighting Job

Besides environmental and human factors, another critical factor that contributes to the illnesses, injuries, and deaths suffered by wildland firefighters is the actual job itself. Long hours of arduous work under difficult physical conditions,



Environmental smoke is a constant health hazard for wildland firefighters, whether on wildfires or prescribed burns (as here, on Nevada's Toiyabe National Forest). Photo: USDA Forest Service, 1994.

coupled with reduced sleep and dietary changes, plus working closely with a new group of individuals in a less-than-hygienic setting, with the potential for exposure to previously unseen infections during a period of reduced immunity: All these are prime conditions for illness and/or injury to the firefighter, especially on multiday fire assignments.

Fighting wildland fires has unique physical fitness requirements, unlike most other jobs in the civilian workforce. Both lower and upper body strength are needed to complete the necessary tasks, and endurance is essential to work for the extended periods of time required to control the unwanted fires. In addition, there is always the unexpected action of responding to a flareup on the control line, or, even worse, the need to make a rapid retreat when a fire threatens the firefighter's personal safety, especially after long hours on the line. Studies at the University of

Montana's Human Performance Laboratory in Missoula, MT, have shown that aerobic fitness is the primary limiting factor in the firefighter's ability to sustain hard work throughout the long workshifts.

Like athletes, serious firefighters realize that physical activity and training are a year-round requirement if they are to successfully meet the demands of the job. This requirement is often difficult to meet, especially in a workforce that has many other demands on its available time.

Individual Factors

A number of factors affect the ability of an individual to perform wildland fire suppression activities in a safe and efficient manner (Davis 1999). Some are beyond the individual's ability to influence, but many are well within the individual's total control. Factors that are inherited (such as physical height and weight) and those that are

controlled by the environment (such as heat, humidity, and elevation) are interesting to contemplate, but are beyond the scope of our ability to affect in the context of wildland firefighting.

There are, however, a number of items that individual firefighters, whether volunteer or full-timer, can affect through their own actions and attitudes. Although physical height is a genetically inherited factor, an individual has a range of options regarding lean body weight, physical fitness level, and muscular endurance. These factors are a direct result of the firefighter's choices regarding nutrition and exercise regimes—that is, the firefighter's motivation to prepare for the job at hand.

Whereas these factors are generally considered long term, other factors tend to be affected more by short-term actions. For example, acclimatization with respect to both heat and elevation can be changed within a relatively short time. As temperatures rise during the early stages of a fire season, firefighters should begin moderate levels of outside activity to prepare themselves for the inevitable fires that will require extended physical activity. Similarly, higher levels of hydration and nutrient supplements will be necessary during prolonged periods of strenuous activity during periods of high heat loads, both from the ambient air and from the fires.

Firefighter Illnesses

Infectious Disease. The illnesses that firefighters are subject to are not that different from those suffered by other large groups of individuals thrown together in a close environment—such as sailors at sea, or teachers and students in a

Long hours of arduous work under difficult physical conditions, coupled with reduced sleep and dietary changes, expose firefighters to increased risk of illness and injuries.

classroom—for extended periods of time. Infection and disease in any one individual can cause illness in other individuals who have not had previous exposure and the opportunity to develop an immune response. In addition to bringing a large group of individuals together, wildland fires also complicate matters by requiring long hours of hard work, coupled with a change in diet and sleep patterns. These factors, in addition to the exposure to smoke and dust, result in a variety of illnesses among firefighters, especially as the duration of a fire assignment progresses beyond the first week.

Environmental Smoke. The short-term and long-term exposure to high levels of environmental smoke from wildland fires was most apparent during the 1987 and 1988 fire seasons. In those years, smoke inversions plagued not only the immediate fire area, but also the incident base camps and surrounding communities for days on end. For firefighters spending multiple 21-day assignments under these conditions, the incidence of upper-respiratory-tract infections was high; infections lasted for periods as long as 3 to 4 months after the firefighting operations were over. As a result, the Health Hazards of Smoke project sponsored by the National Wildfire Coordinating Group was undertaken at the Missoula Technology and Development Center (MTDC). The 6-year project culminated in 1997 with a conference in Missoula, MT, that summarized the research findings

and developed mitigation measures for on-the-ground fire operations to reduce exposure to smoke (Sharkey 1997a).

The long fire season in northern Idaho and western Montana in 1994 offered another opportunity to look at the incidence of illness among firefighters on large incidents managed by fire overhead teams. An informal review of medical records conducted by Mark Vore from the Idaho Panhandle National Forests showed that nearly 40 percent of the visits to the incident medical units were documented as respiratory problems. These findings are consistent with the problems that surfaced in 1987–88 and could surface again, given the mountainous terrain and inversion potential on many large wildfires and prescribed burns in the Western United States.

Heat Stress. Another illness issue that appears to be on an upward trend on wildland firefighting operations is the incidence of heat stress injuries. Under conditions of both high ambient air temperatures and high radiant heat flux, the firefighter can easily become dehydrated and subject to heat stress if positive preventative measures are not implemented as a normal way of doing business on a daily basis.

An Australian study (Budd and others 1996) on work productivity among bush firefighters indicated that personal protective clothing was a key factor in reducing heat



Smokeyjumpers in training. Like athletes, serious firefighters realize that physical activity and training are a year-round requirement if they are to successfully meet the demands of the job. Photo: Paul S. Fieldhouse, USDA Forest Service, Missoula Smokejumper Base, Missoula, MT.

stress. Project “Aquarius” noted that two-thirds of the firefighter’s heat load was generated internally, with only one-third coming from the radiant heat of the fire. The study recommended that the design of protective clothing should be to “let heat out, not keep heat out.” Additionally, it recommended that wildland firefighters consider the need to consume as much as 1 liter (2 pints) of fluids per hour under high temperatures and heavy workload conditions.

The logistics of supporting this level of fluid replacement during a 12-hour operational period can be challenging, but it is certainly essential to prevent heat stress illness. Dehydration and heat stress illness can be the result of a progressive deterioration that occurs over several days of reduced fluid intake. They can also be com-

pounded by other factors, such as other illnesses or medications being taken by the individual.

Countermeasures. Fire managers and crew leaders should take positive actions to avoid working firefighters to the point of exhaustion or exposing them to excessive levels of smoke. Additional actions that can help reduce firefighter illness include:

- Reducing both physical and emotional stress;
- Enhancing rest and recuperation periods, with a target of a 2-to-1 work/rest cycle (16 hours of work, followed by 8 hours of rest); and
- Providing adequate energy and nutrients to meet the special requirements of the arduous fire job.

Firefighters have an individual responsibility to ensure their own ability to perform the job by getting and staying in good physical condition; making correct nutritional choices to sustain them on multihour and multiday fire assignments; and making healthy lifestyle choices (such as not smoking), which will help them remain on the job during periods of reduced immunity to illnesses.

Dr. Steve Wood from Abbott Laboratories has identified “immune-friendly nutrients” that enhance the function of the human immune system (Wood 1999). They include vitamins C and E, which both stimulate and enhance immune response; Beta carotene, which stimulates natural killer cells; vitamin B6, which promotes white-cell proliferation; selenium, which promotes antibacterial activity; and zinc, which promotes wound healing. All these nutrients can be helpful in reducing the risk of

firefighter illness in the bushfire environment.

Firefighter Injuries

In difficult terrain, under conditions of long hours and arduous work, injuries are one of the major perils that wildland firefighters are subject to. Although no documented records exist showing trends of firefighter injuries, on-the-ground observations by experienced personnel show several major areas where injuries occur:

- Vehicle accidents;
- Tool use;
- Slips, trips, and falls; and
- Muscle strains.

By inference, several of these injury areas can be related back to the causal factors of fitness levels and fatigue.

Fatigue. As firefighters become more fatigued from the long hours and arduous work, they become less attentive to the small things that prevent injuries under different circumstances: using care in walking on steep slopes, over logs,

and down cut slopes; clearing obstacles and using full muscle control when swinging handtools; using proper lifting techniques for heavy objects; and paying full attention to driving techniques on winding, steep, and/or unsurfaced roads.

Although accidents are not well enough documented to show their rate of occurrence during firefighting operations, experienced personnel are well aware of the risks. Better documentation will more clearly define the problems and lead to mitigation practices that will ultimately reduce the risk. The MTDC publication *Fitness and Work Capacity* (Sharkey 1997b) documents many of the conditioning techniques that can reduce firefighter fatigue by increasing work stamina.

Fitness Levels. A number of recent studies have documented the relationship between fitness levels and injury rates. In the U.S. Army, a study of 861 female and male trainees indicated that the fittest soldiers (measured by their



Firefighters relaxing. Firefighters should manage work/rest cycles to avoid needless fatigue. Photo: USDA Forest Service.

pushups, situps, and 2-mile [3.2-km] runs) experienced the lowest injury rates. Another study showed that the most fit individuals, as indicated by running speed, experienced the fewest injuries in sports training. Finally, a 1999 Australian Army study of recruits indicated a negative relationship between fitness and injuries. The implications of these studies for firefighters are obvious, especially for such a physically demanding activity.

Firefighter Fatalities

The first half of the 1990s saw two major wildfire fatality events that riveted the attention of the Nation: the Dude Fire in 1990 killed 6 firefighters, and 14 firefighters died on the South Canyon Fire in 1994. Although these tragic events were horrific reminders of the risks inherent in wildland fire suppression activities, they were only a few of the deaths that occurred from 1990 to 1998. In that period, 133 firefighters and others involved in wildland firefighting operations died from a variety of causes. The MTDC report *Wildland Fire Fatalities in the United States: 1990 to 1998* (Mangan 1999) documents the causes, including aircraft accidents (30 deaths), heart attacks (28 fatalities), and vehicle accidents (25 deaths).

Numerous opportunities exist to reduce firefighter fatalities away from the immediate fire ground through many of the same actions that will reduce illness and injuries. Prevention of heart attacks offers the best opportunity to reduce the number of deaths. However, preventing heart attacks will require a major lifestyle change for many firefighters.

In the progression of events, it can be surmised that fatalities on wildland firefighting operations are, in many cases, the logical extension of early failures to address issues of illness and injuries that manifest themselves throughout the fire season. It is imperative that we break the chain if we are to ultimately reduce firefighter fatalities.

Toward Safety and Health

The safety and health of the wildland firefighting workforce is critically important to the firefighters and their families, the fire management organization, and the community it serves. There are numerous opportunities, both short-term and long-term, to improve the health and safety of the wildland workforce for all firefighters:

- First and foremost, individual firefighters must take positive and affirmative actions to ensure their own health and safety. This includes maintaining an appropriate height/weight ratio, participating in an exercise program, and minimizing high-risk activities that threaten good health.
- Fire agencies have a major obligation to provide an environment that fosters a safe and healthy workforce. This can include health-screening programs; exercise facilities; and, in some cases, work capacity testing.
- Fire agencies should provide specialized training in high-risk activities, such as emergency vehicle operation; and create a culture that does not condone or tolerate unsafe work practices, even during a fire emergency.

- During multiday firefighting operations, fire managers and crew leaders should ensure that fluid and nutritional needs are met and that work/rest cycles are managed to prevent unnecessary fatigue among both firefighters and fire managers.
- Fire agencies should develop, maintain, and monitor an illness and injury data base, preferably at the national level, to identify health and safety trends in the wildland fire community.

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KEEPING HAINES REAL—OR REALLY CHANGING HAINES?



Brian E. Potter, Dan Borsum, and Don Haines

Most incident command teams can handle low- to moderate-intensity fires with few unanticipated problems. However, high-intensity situations, especially the plume-dominated fires that often develop when winds are low and erratic behavior is unexpected, can create dangerous situations even for well-trained, experienced fire crews (Rothermel 1991). Plume-dominated fires have a strong convection column that towers above the fire rather than leaning over before the wind. They differ from wind-driven fires in that the winds are lower and primarily fire induced. Some authors (Byram 1954) have called plume-dominated fires “blowup fires,” but that name is now commonly used for any sudden increase in fire activity.

This article updates the uses of the fire severity index called the Haines Index (HI). We discuss the original intended use of HI, its current operational use, some ways that users have modified it, and different aspects of HI that researchers are examining to improve its predictive value.

Plume-Dominated Fires

Haines (1988) suggested that the growth of plume-dominated fires depends on the moisture content of

The Haines Index is a quick and easy tool for summarizing two atmospheric parameters.

the air overlying the fires, the environmental lapse rate (temperature difference within a vertical layer of that air), and negative vertical wind shear (Haines 1988). He noted that researchers could use measurements of these atmospheric features to construct a severity index. However, no features could be identified from the usual surface weather measurements; therefore, mathematical descriptors of the features had to be constructed using above-surface observations.

The HI is an indicator of the potential for extreme fire behavior based on two of the three features Haines (1988) described—the dryness and the stability of the atmosphere. HI uses measures of the dryness of air above the fire to calculate the likelihood that an unstable lapse rate will help that air reach the ground. Haines did not include a wind shear term in HI because of disagreement among researchers over the meteorological importance of various wind profiles (see the sidebar on page 42).

Ideally, atmospheric features should be measured in the region just above the mixing layer, where air is mixed by convection. One of the synoptic patterns (atmospheric, weather, or other conditions that exist simultaneously over a broad area) that fire weather meteorologists look for is an upper level ridge

of building high pressure, followed by a trough of low pressure. High-pressure areas are characterized by subsiding air that is warmed through adiabatic compression (when expanding air cools and contracting air warms), which occurs because atmospheric pressure decreases with height, whereas the rising air cools and sinking air warms. The air is prevented from reaching the surface because of the cooler, underlying mixing layer. Temperatures within the mixing layer decrease with altitude, but the air just above the mixing layer, having been warmed through the adiabatic process, is often much warmer than the air at the top of the mixing layer. Therefore, a temperature inversion usually separates the mixing layer from the compressed, warm air above (fig. 1).

This situation is ideal for plume-dominated fire development. A breakdown of the upper level ridge, with a cooling of the air aloft and the subsequent instability, often produces the potential for intense plume-dominated fires, especially in the Northwestern United States (Gibson 1996).

Structure of HI

HI ranks the moisture and stability of the lower atmosphere by assigning to each term a value from 1 to 3, as follows:

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WIND SHEAR AND THE HAINES INDEX

The Haines Index is an indicator of the potential for extreme fire behavior based on two of the three features Haines (1988) described—the dryness and the stability of the atmosphere. The Haines Index is used to calculate the likelihood that atmospheric instability will bring dry air to the ground, contributing to fire activity.

Another way to bring dry air to a fire is through wind-induced mixing by means of negative vertical wind shear, the third feature described by Haines (1988). However, a wind shear term was not included in the Haines Index because of disagreement among researchers over the meteorological importance of various wind profiles. For example, Byram (1954) listed six types of wind profiles that could be “potential trouble makers,” too many to incorporate into a predictive model. Another problem with including wind profiles is the duration of wind events, which can vary from downburst outflows (including those generated by fire), to gust fronts, to nocturnal drainage, to synoptic or geographically preferred areas of low-level jets.

Recently, computer simulations of fire spread have produced interesting results when wind shear is considered (Coen and others 1998; Jenkins 2000). Perhaps this line of research will provide a future, usable solution.

The simplicity inherent in the Haines Index limits its use as an indicator of broad fire potential.

- 1 = Stable air/Moist air
- 2 = Moderately unstable air/Moderately dry air
- 3 = Unstable air/Dry air

When the values of the two terms are added, HI can range from a minimum value of 2 to a maximum value of 6. For example, a moist and stable atmosphere above the fire has an HI value of 2; dry and unstable air has an HI value of 6 (table 1).

HI can be calculated over one of three layers between 950 and 500 millibar, depending on the surface elevation. The layer used should be high enough above the surface, usually just above the mixing layer, to avoid the major diurnal variability of surface temperature extremes and surface-based inversions. Although this lessens the diurnal effects, there is no way to totally negate their influence. For step-by-step procedures about how to calculate HI, see Haines (1988) and Werth and Ochoa (1990).

Using HI

Use HI when you have substantial available fuels, when you have an ongoing fire or are confident of ignition, and when you might expect a plume to build above the fire. A high HI value will indicate the likelihood of rapid fire growth and erratic, extreme fire behavior. A low HI will mean that the smoke column should not extend to a significant height and that there is a low possibility of rapid fire growth and erratic, extreme fire behavior.

Could low moisture and instability in the overlying air contribute to a wind-driven fire? Possibly, but a mechanism to bring the overlying air down to the fire is not obvious. The downdrafts that, on a plume-dominated fire, would carry the air down are conveyed away from the fire by the wind. Fires are complex, turbulent structures; like the proverbial snowflake, no two are exactly alike. Further observations, research, and computer modeling

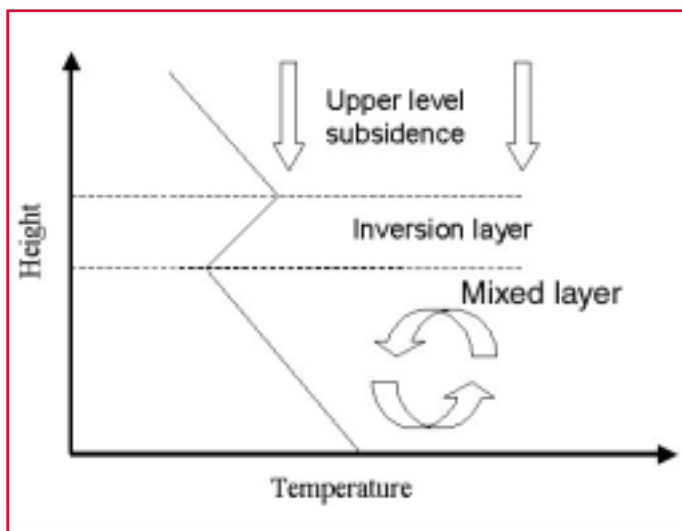


Figure 1—*Temperature profile of an idealized atmosphere that could produce an explosive, plume-dominated fire. Although not the only situation where this might occur, it is an occasion where downdrafts originating in the region above the mixing layer can bring warmer and drier air to an existing fire.*

Table 1—Numeric values of the Haines Index and descriptions of extreme fire risk.

<i>Haines Index</i>	<i>Potential for rapid fire growth or extreme fire behavior</i>
2 or 3.....	very low
4.....	low
5.....	moderate
6.....	high

are needed to answer this question (Jenkins 2000). For now, we know that the components of HI can make a major contribution during the growth of plume-dominated fires.

Because there is no wind component in HI, it should not be used to predict the behavior of wind-driven fires. HI can tell you little when strong horizontal winds cause fire-induced winds to shear ahead of the fire. The resulting separation of the fire and the winds generated lessens the possibility of the fire feeding back on its own circulation.

Nevertheless, strong winds can abate during the course of a fire, allowing a vertical smoke column to develop. This happened in May 1980 during the Mack Lake Fire near Mio, MI (Simard and others 1983). Two hours after ignition, strong wind gusts and lowered relative humidity caused a prescribed burn to escape across firelines. The fire burned a total of 24,000 acres (9,700 ha), mostly by the evening of the first day.

During its major run, the Mack Lake Fire spread about 8 miles (13 km) at an average rate of 2 miles per hour (3 km/h). Later, winds slackened, allowing a plume-

dominated fire to develop. During such times, an HI value of 5 or 6 could alert firefighters to unexpected fire growth and erratic fire behavior.

HI is not a predictor of wind-controlled fire, ignition potential, fuel conditions, or the number of expected fire days. There are other methods for evaluating these factors, and the wise firefighter will use the corresponding tools.

HI Misuse

Significant changes in fire weather forecasting and, specifically, in forecasting HI occurred during the

mid-1990s. Within the National Weather Service and the fire weather program, fire-weather-forecasting responsibilities were spread to more individuals in each office; some offices that had not had fire weather programs in the past began to assume forecasting responsibilities. The new forecasters readily looked to computer-modeling data output for guidance in forecasting HI. Simultaneously, traditional forecast techniques involved analyzing morning sounding data and then predicting changes and deriving an HI forecast. With access to gridded model data, forecasters began to put more emphasis on model calculations to determine projected Haines Indices. Figure 2 shows a sample of a model-generated HI forecast.

The model output calculated higher HI frequencies of 5 and 6 than expected by experienced fire weather forecasters, numbers that less experienced forecasters were willing to accept because the calculations appeared correct. This led to concerns among more experienced forecasters that users would think the forecasters were

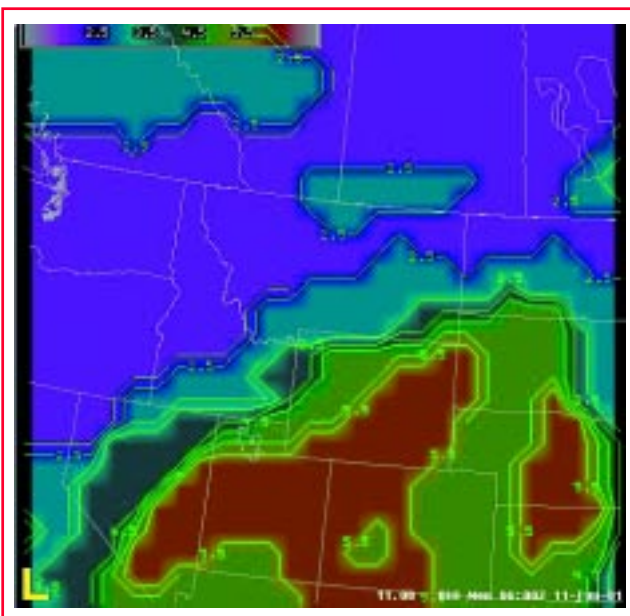


Figure 2—A sample of a computer model output for the midlevel Haines Index from the 00Z (24-hour clock that is based on midnight at the 0th meridian) on June 11, 2001.

Future studies will enable us to establish a strong relationship between the physical processes behind the Haines Index and how it is computed.

“crying wolf.” In response, some forecasters began rolling factors such as winds, fuel moistures, and fire dangers into calculations that they still called HI. Thus, forecasters-in-training have heard experienced fire weather forecasters comment, “It’s not really a 6 Haines day.”

Whereas that comment might sometimes be valid, the guidelines for making it are at best nonstandardized and are often nonexistent. The problem illustrates the need to emphasize proper HI use and calculation on the part of both users and forecasters. It is important to understand that HI is used on a national basis and that there is no systematic method for modifying HI values, even though forecasters might develop local methods for doing so. HI is a quick and easy tool for simultaneously summarizing two atmospheric parameters, moisture and stability. Any effort to use HI as a broad fire potential index is constrained by its inherent simplicity.

HI is similar to another meteorological parameter, the Lifted Index, which is used to assess potential fire instability. Like HI, the Lifted Index does not take all levels of the atmosphere into account in assessing the convective potential. Forecasters now use multiple parameters to assess the overall potential indicated in the atmosphere. Methods for modifying HI through more detailed analysis are appropriate, especially where locations are near the dividing line between high and middle eleva-

tions. However, changes to HI calculations should be made in a systematic way across the Nation, not office by office.

Examination of computer model soundings can help forecasters tell where calculated HI values do not fully reveal the true atmospheric potential, for example when:

- A strong inversion is present below the lower level used for Haines calculations and the fire will not likely interact with the Haines layer (fig. 3). This is common along the Pacific Coast of the United States.
- The moisture content of the atmosphere dramatically changes

just above the Haines moisture level so that the values used by HI do not depict the true nature of the atmosphere (fig. 4).

- The mixing layer of the atmosphere extends through the Haines layer, yielding abnormally high instability values (fig. 5). This is of particular concern in areas using the midlevel HI due to their elevation, but where deep mixed layers may develop during the summer.

Even in these situations, a forecaster would be limited to arbitrarily lowering or raising the HI. For example, a forecaster would not know whether to drop an HI value of 6 to 5 or to 4. The only truly

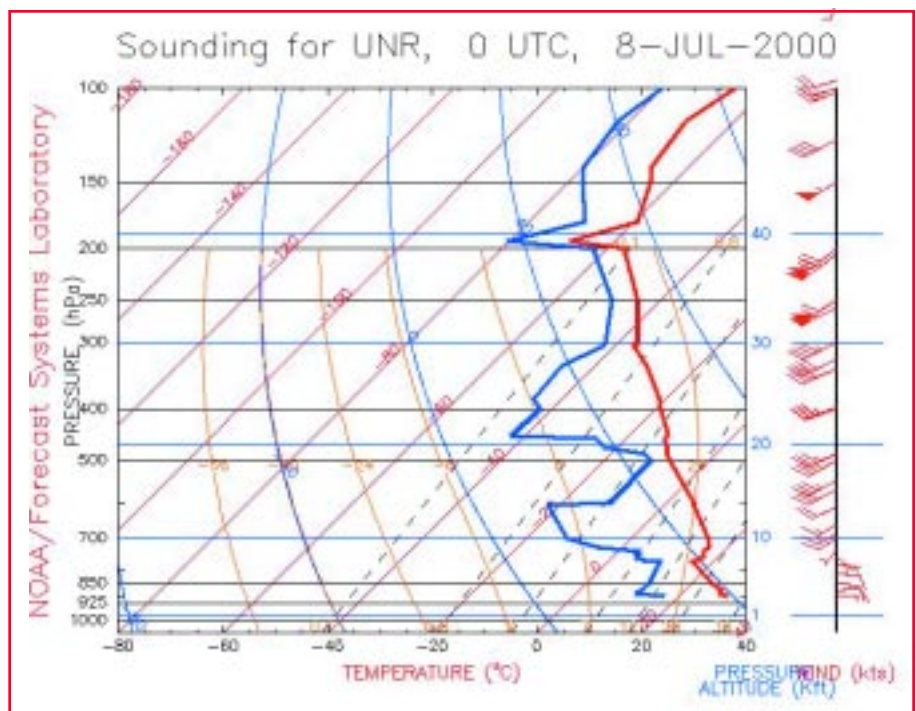


Figure 3—Upper air sounding from Rapid City, SD, at 00Z (24-hour clock that is based on midnight at the 0th meridian) on July 8, 2000. The low-level inversion would have isolated the surface from the upper air and inhibited the Haines Index layer—700 to 500 millibar—from reaching the ground.

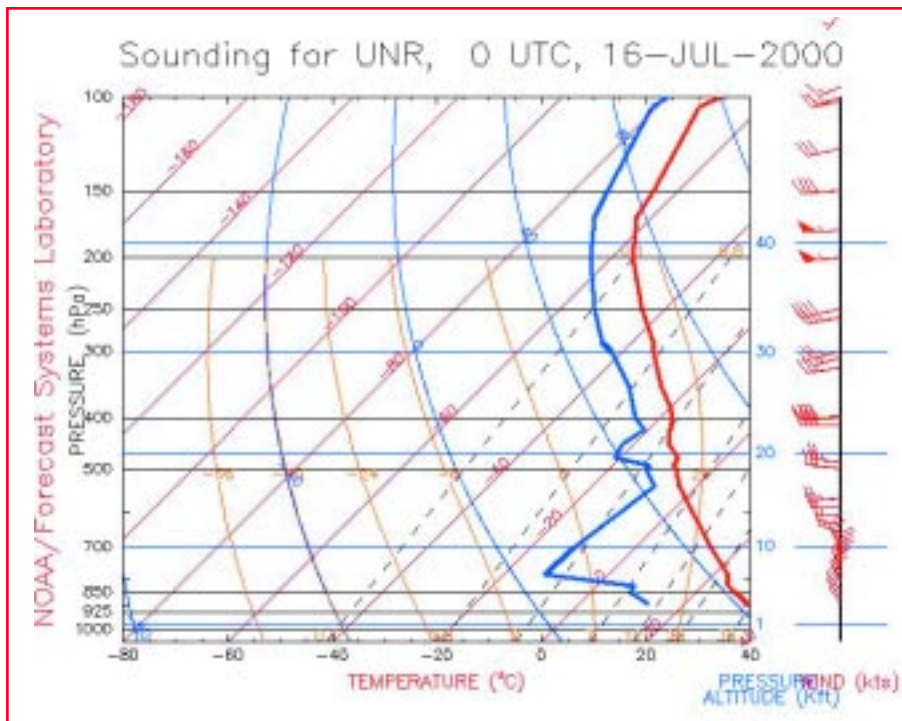


Figure 4—Upper air sounding from Rapid City, SD, at 00Z (24-hour clock that is based on midnight at the 0th meridian) on July 16, 2000. The moisture at 700 millibar was not representative of a high-elevation Haines Index layer—700 to 500 millibar.

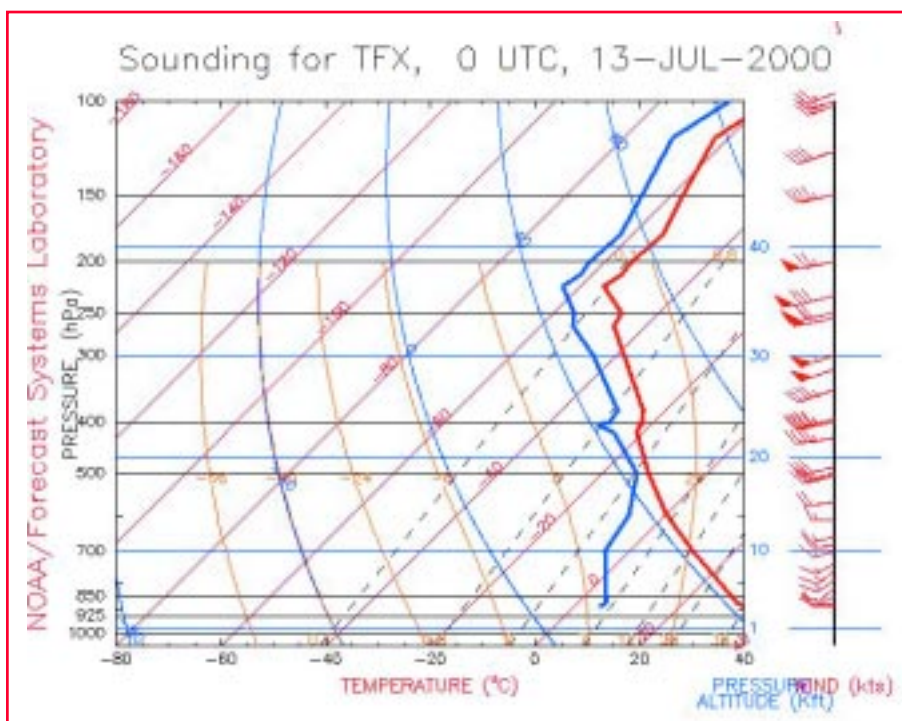


Figure 5—Upper air sounding from Great Falls, MT, at 00Z (24-hour clock that is based on midnight at the 0th meridian) on July 13, 2000. The 700 millibar level is deep within the mixing layer, possibly causing a misleadingly high Haines Index for this high-elevation site.

appropriate practice would be to provide the calculated HI while making note of any atmospheric conditions that might limit or enhance it.

Improving HI

The uses and interpretation of HI are gradually changing, for two primary reasons:

1. There is no “finish line” in science—each question that is answered raises several new questions; and
2. Operational use of HI is pushing it beyond its original purpose and ability.

The climatology used in Haines (1988) relied on two station locations and a single year. At the time, such a climatology required many hours of tabulation and calculation. Today, with greater computer power and data that are more accessible, it is possible to produce a climatology for multiple stations and years. Werth and Werth (1998) did this for 20 stations in the Western United States, covering 5 years at each station. Their analysis showed that the high frequency of HI 5 and 6 values noted in the 1990s was not a product of the computer models—in some areas it is real. Some stations in the high-elevation regions of the West differ significantly from the climatology used in Haines (1988).

With funding from the National Wildfire Coordinating Group and the National Fire Plan, meteorologists at Jackson State University in Jackson, MS, and at the USDA Forest Service’s North Central Research Station in East Lansing, MI, are creating an HI climatology for the United States, including Hawaii, Alaska, and Puerto Rico, for 1961 to 1990. When complete, the

Meteorologists are creating a Haines Index climatology for the United States, including Hawaii, Alaska, and Puerto Rico, for 1961 to 1990.

climatology will allow fire weather forecasters across the United States to see how HI behaves in their region during the year and how it compares to other areas of the Nation. The climatology will also provide a starting point for researchers as they try to determine whether or how they should adjust their methods of calculating HI.

The inspiration for HI and the basis for its reliance on stability and moisture came from the observations and experiences of numerous firefighters, researchers, and forecasters over many years (Haines 1988). They enabled Haines to create an index that clearly reflects two important variables in fire weather. Because HI is based on formal and informal observations, it is not explained in terms of physical processes, air motion, or the way that the elevated layer of air used to calculate HI affects a fire on the ground. Understanding these processes would perhaps allow improvements in HI generally, or at least specifically at locations where it is thought to break down.

Piecing Together the Puzzle

We cannot ignite fires under controlled atmospheric conditions to make the needed observations.

Instead, we must rely on data from a few fires where all of the relevant measurements were made, and on computer simulations of fire-atmosphere interactions. Using computer models similar to those used for regular weather forecasts and for studying thunderstorms, researchers at Los Alamos National Laboratory, the National Center for Atmospheric Research, the University of Utah, and the North Central Research Station, among others, are trying to refine our understanding of fire weather. Using these models, researchers can specify the stability, wind, and moisture. In turn, the computer simulation provides information on how the atmosphere interacts with an intense fire.

Future studies will enable us to establish a strong relationship between the physical processes behind HI and how it is computed. Whatever the changes, HI will retain its original focus and character—measuring the ability of the atmosphere to turn a low- or moderate-intensity fire into an explosive, dangerous, “blowup” fire under low-wind conditions. This piece of information from HI will fit together with other puzzle pieces, allowing us to calculate the fire risk for a specific situation.

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BURNING UNDER OLD-GROWTH PONDEROSA PINES ON LAVA SOILS



Peter Z. Fulé, Greg Verkamp, Amy E.M. Waltz, and W. Wallace Covington

Every year, fire managers successfully restore surface fires to ponderosa pine forests that have not burned for a century or more. Nevertheless, the power of fire can have unanticipated effects on stressed trees. In northern Arizona, an episode of unusual old-growth tree mortality, after two prescribed burns on shallow volcanic soils, provided managers with a learning opportunity and a lesson in caution.

High Tree Mortality

Ponderosa pine forests at the base of Mt. Trumbull in the Grand Canyon–Parashant National Monument have been the focus of extensive research in ecological restoration since 1995. Sponsored by the USDI Bureau of Land Management, Arizona Game and Fish Department, and Northern Arizona University, the research gives managers information about how to restore natural surface fire regimes and open forest conditions using productive native vegetation. Since 1995, 650 acres (260 ha) have been treated with thinning, fuel reduction, and prescribed fire. An additional 396 acres (160 ha) have been treated with fire alone.

Most treatments in the forest have had good initial results (Fulé and others 2001). However, two prescribed burns resulted in the death

Prescribed burning on volcanic soils in the Grand Canyon's Parashant National Monument produced unanticipated results.

of an alarming amount of old-growth ponderosa pines. In October 1999, 5 acres (2 ha) at the Old Folks Home site were burned and in March 2000, 25 acres (10 ha) at experimental block (EB) 1 were burned. The sites were on two edges of a large, shallow-soiled lava flow, which historically had high-frequency, low-intensity surface fire regimes but had remained largely fire free for 130 years. The area had experienced severe drought in 1977, 1989, 1996, and 2000.

Before conducting the burns, all old-growth trees at both sites were protected against heat damage to the cambium layer by raking accumulated forest floor litter away from the tree trunks; research has shown that removal of deep forest floors prevents tree girdling by fire (Sackett and others 1996). The 1999 burn site had no tree thinning before burning, whereas the 2000 burn site was previously thinned to help restore the conditions that existed before the frequent fire regimes were disrupted (Covington and others 1997).

Shortly after the 2000 fire, postburn measurements at EB1 indicated minimal fire effects; however, field observation in May 2001 showed that many old trees were dying. Mortality of the large trees was also

observed in 2001 at the Old Folks Home site (figs. 1 and 2). Younger ponderosa pine trees at both burn sites were not killed.

The unusual mortality seemed confined to the lava flow region. High mortality was not observed on the adjacent thinned 650 acres (260 ha) or unthinned 396 acres (160 ha), which were burned between 1996 and 2001. However, Swezy and Agee (1991) found high old-growth ponderosa pine mortality following a fire at Crater Lake, OR, in another ponderosa forest on shallow lava soils. They suggested that the cause was heat injury to fine roots (fig. 3). Other hypotheses include reduced tree vigor, drought stress, or lack of wind to disperse heat during the Old Folks Home burn.

A census of trees greater than 5.9 inches (15 cm) in diameter was conducted on the site of the Old Folks Home burn on June 5 and 6, 2001 (fig. 4). Of 247 ponderosa pine trees, 91 (37 percent) were dead. Five of the dead trees had great decay, suggesting that they probably died before the prescribed burn. Not counting these trees, the mortality rate was 35 percent. The pattern of mortality varied with tree size. Only 19 percent of the trees that were less than 20 inches (50 cm) died, compared with a 67-percent mortal-

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Figure 1—Mortality of mature trees on lava soils at the Old Folks Home burn site at the base of Mt. Trumbull, AZ. The burn occurred in October 1999. Photo: Greg Verkamp, Ecological Restoration Institute and School of Forestry, Northern Arizona University Flagstaff, AZ, 2001.

ity rate for trees that were greater than 20 inches (50 cm) in diameter. A similar comparison will be done at EB1 in a few years, when the fire-caused mortality is fully evident.

Future Trends

Conservation of the old-growth trees that are scattered across the landscape is an important project goal. The Old Folks Home and EB1 sites make up less than 3 percent of the total area burned at Mt. Trumbull, so the death of old trees is not widespread. However, it might be necessary to stop burning on the lava flow pending further information from both experimental sites. Researchers might repeat pre- and postburn measurements on permanent monitoring plots and compare them with a nearby control site; they might also study fine-root mortality and drought stress on old-growth trees in the lava area. Additionally, managers should consider using only nonfire treatments, such as thinning alone, for forests on lava soils.



Figure 2—Large trees dying after prescribed burning on lava soils in an unthinned stand. Note the surviving trees in background and at left. Photo: Greg Verkamp, Ecological Restoration Institute and School of Forestry, Northern Arizona University, Flagstaff, AZ, 2001.

Unfortunately, the true extent of tree mortality on the EB1 and Old Folks Home experimental sites remains unknown. Several years might pass before needles on the remaining large ponderosa pine trees, which appear to be alive and well, begin prematurely to brown and fall.

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Figure 3—Exposed tree root on shallow soils. A mix of dying and surviving trees is evident in the background. Photo: Greg Verkamp, Ecological Restoration Institute and School of Forestry, Northern Arizona University, Flagstaff, AZ, 2001.

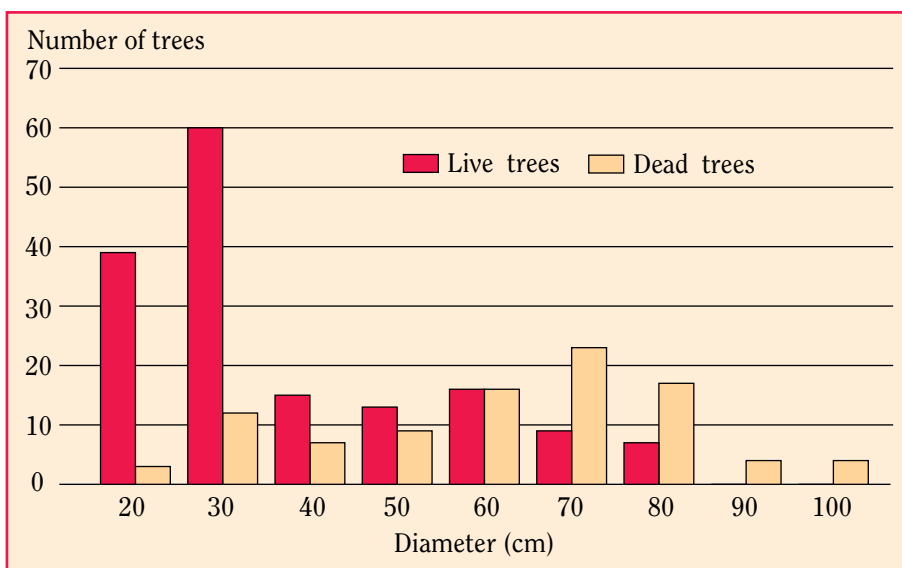


Figure 4—Diameters of living and dead ponderosa pine trees at the Old Folks Home burn site. Most large trees were killed, whereas most small trees survived.

GUIDELINES FOR CONTRIBUTORS

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Fire Management Today (FMT) is an international quarterly magazine for the wildland fire community. *FMT* welcomes unsolicited manuscripts from readers on any subject related to fire management. Because space is a consideration, long manuscripts might be abridged by the editor, subject to approval by the author; *FMT* does print short pieces of interest to readers.

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Aviation	Firefighting experiences
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To help prepare your submission, see "Guidelines for Contributors" in this issue.

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Fire Management Today invites you to submit your best fire-related photos to be judged in our annual competition. Judging begins after the first Friday in March of each year.

Awards

All contestants will receive a CD-ROM with all photos not eliminated from competition. Winning photos will appear in a future issue of *Fire Management Today*. In addition, winners in each category will receive:

- 1st place—Camera equipment worth \$300 and a 16- by 20-inch framed copy of your photo.
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- The contest is open to everyone. You may submit an unlimited number of entries from any place or time; but for each photo, you must indicate only one competition category. To ensure fair evaluation, we reserve the right to change the competition category for your photo.
- Each photo must be an **original color slide** or **print**. We are not responsible for photos lost or damaged, and photos submitted will not be returned (so make a duplicate before submission). **Digital photos will not be accepted** because of difficulty reproducing them in print.
- You must own the rights to the photo, and the photo must not have been published prior to submission.
- For every photo you submit, you must give a detailed caption (including, for example, name, location, and date of the fire; names of any people and/or their job descriptions; and descriptions of any vegetation and/or wildlife).
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