

LEARNING FROM ESCAPED PRESCRIBED FIRES – LESSONS FOR HIGH RELIABILITY



Deirdre Dether and Anne Black

Meeting national goals for hazardous fuels reduction and ecosystem restoration would be difficult—if not impossible—without utilizing prescribed fire. Suspension of prescribed fire programs, as often happens following an escape, limits Federal capacity to meet programmatic, social, and ecological goals.

Thus, meeting these goals requires that fire programs—both prescribed fire and wildland fire use (WFU)—operate with “high reliability.” In other words, they go about their work with less than their

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fair share of accidents (Weick and Sutcliffe 2001).

In this article, to understand how to improve future performance, we summarize a recent review (Dether 2005) of escaped prescribed fires from the perspective of high reliability (see “The Five Key High Reliability Organization Activities”

sidebar). Our intent is to identify potential “weak signals” or “early warning signs” that fire use practitioners might want to heed as they prepare for future fire use as well as suppression events.

Getting a Leg Up On Reliability

Unexpected events surprise us. Managing for the unexpected implies a consciously nurtured and honed ability to attend to small surprises—to recognize, *early*, that events are not proceeding accordingly to plan. And then respond decisively.

Yet, as authors Karl Weick and Kathleen Sutcliffe explain, the human tendency is to “search for confirming evidence which postpones the realization that some-

The Five Key High Reliability Organization Activities

Through their research into the successful operations of organizations involved in high risk operations—including nuclear aircraft carriers, air traffic control, emergency rooms, and fire operations—Weick and Sutcliffe (2001) have identified five activities in which all successful high reliability organizations engage to manage unexpected events:

1. Preoccupation with Failure,
2. Reluctance to Simplify,
3. Sensitivity to Operations,
4. Commitment to Resiliency, and
5. Deference to Expertise.

These five activities can be grouped into two functional categories, “mindful anticipation,” and “mindful containment.”

Mindful anticipation includes actions that focus on:

- Identifying and responding quickly to conditions that can lead to failure (Preoccupation with Failure),
- Seeking and maintaining a diversity and complexity of perspectives (Reluctance to Simplify), and

- A constant vigilance to operations and updating our understanding of events based on our observations (Sensitivity to Operations).

Mindful containment includes:

- Decisive response and adaptation to unexpected developments (Commitment to Resiliency), and
- A deference to those with greatest expertise and firsthand knowledge of the developing events (Deference to Expertise).

Constantly Looking for Ways To Improve Program

Tim Sexton

During the past few years, the USDA Forest Service's prescribed fire program has demonstrated a record of success and improvement. Analyses completed in 2002 and 2006 demonstrated a high rate of success and an improving trend (see table).

Most of the 38 escapes during this 3-year study were not significant in that they did not burn private lands, did not significantly damage natural resources, nor cause large, costly suppression actions.

While the agency's prescribed fire program has a high rate of success, we are constantly looking for ways to improve. Deirdre Dether and Anne Black's article "Learning From Escaped Prescribed Fires –

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USDA Forest Service prescribed fire escapes and success rates.

	1996-2001	2003 -2005
Prescribed Fires	24,133	10,920
Annual Average	4,022	3,640
Acres Burned	6,406,217	4,928,766
Annual Average	1,067,703	1,642,922
Escapes	235	38
Annual Average	39.2	12.7
Average Success Rate	99.0%	99.7%

Lessons for High Reliability" in this issue of *Fire Management Today* suggests that we can increase our prescribed fire program success rate through instilling high reliability organization (HRO) concepts more fully.

The authors have reviewed many escapes (USDA Forest Service as well as U.S. Department of the

Interior) and identified areas where application of HRO concepts might have resulted in a more favorable outcome.

It is important to remember that the examples of prescribed fire escapes cited in the article represent a very small fraction of the number of prescribed burns implemented by these agencies.

thing unexpected is developing. If you are slow to realize that things are not the way you expected them to be, the problem worsens and becomes harder to solve. When it finally becomes clear that your expectation is wrong, there might be few options left to resolve the problem" (Weick and Sutcliffe 2001:39).

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Using the Concept of Surprise

Weick and Sutcliffe use the concept of surprise to help develop an understanding of unexpected events. Surprises come in a number of varieties (Kylan 1985):

1. An event for which you had no expectation, no prior model of the event, no hint that it was coming;
2. A recognized issue, but one that moves in the wrong direction;
3. An event you know will happen, when it will happen, and in what

- order, but you discover that the timing is off;
4. An event for which the expected duration of the event proves to be wrong; and
 5. An expected event, but of the wrong amplitude (Weick and Sutcliffe 2001:36-39).

In our study, we examine previous escaped prescribed fires through two lenses:

1. First, by considering the types of surprises noted in escape review reports,
2. Second, by fitting these identified surprises into the five activities common to high reliable organizations (HROs) (see sidebar).

Surprises can indicate where we have faulty assumptions and expectations. By looking at multiple events across agencies and conditions, we can identify the lessons that we might be learning in our individual units through direct experience, yet not incorporating into our broader, collective toolbox of organizational knowledge.

It is our hope and intent that this summary helps increase our individual and organizational capacity to mindfully anticipate and respond to these inevitable and unexpected occurrences.

The Prescribed Fire Escape Review

The review, “Prescribed Fire Lessons Learned: Escaped Prescribed Fire Reviews and Near Miss Incidents—Initial Impressions Report” (Dether 2005), represents the first known attempt to use an HRO framework to evaluate and synthesize causes and commonalities in reviews of escaped prescribed fires and near misses.

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The 30 prescribed fire escape reviews and near misses studied in this review were:

- Obtained from the Wildland Fire Lessons Learned Center, Tucson, AZ,
- Collected from agency websites by agency personnel, or
- Located in personal collections.

Although all accessible documents were analyzed, this was by no means a comprehensive sweep of escape reviews. Because some agencies do not systematically report escapes or near misses and there is no central repository for this documentation, this report represents a “grab” sample. Even so, this effort represents a significant step in helping to identify common threads in lapses of mindfulness.

Documents reviewed ran the gamut from slide show presentations to final reports. They occurred from 1996 to 2004 under significantly different policy, as well as varied burning conditions—from February to October. Reviews from all four Federal land management agencies (USDA Forest Service, USDI Bureau of Land Management, USDI Fish and Wildlife Service, and USDI National Park Service) were evaluated—covering landscapes from Alaska to Florida.

Reviewed prescribed fire vegetation–fuel complexes included:

- Ponderosa pine,
- Mixed conifer,
- Subalpine fir,

- Pinyon–juniper,
- Chaparral,
- Sagebrush–aspen,
- Oak brush,
- Grass, and
- Activity fuels (slash).

The number of acres planned for ignition ranged from less than 5 acres (2 ha) to more than a 1,000 acres (405 ha) for individual burn blocks, with several of the more recent escapes involving multiple burn blocks.

Common Surprises During Implementation

The most common form of unforeseen and unanticipated events and outcomes noted in the reviews were surprises due to unexpected amplitude of events (see “Varieties of Surprise” sidebar), including greater than expected fire behavior due to winds, fuel moistures, fuel complexes, and unexpected complexity.

One burn boss described unexpected fire behavior in standing dead piñon–juniper. The bug-killed trees had no needles left in their crowns, yet fire was able to move into the crowns and sustain fire spread through the aerial fuels much like a typical crown fire. In this case, an adequate control line stopped the spread of fire, preventing the prescribed fire to escape.

In another prescribed fire treatment, unexpected heat and spotting came from a small pocket of fuels adjacent to the burn area boundary. This was not the dominant fuel

Varieties of Surprise

1. **First Form.** Something appears for which you had *no expectation, no prior model* of the event—no hint that it was coming.
2. **Second Form.** The issue is recognized, but the *direction* of the expectation is wrong.
3. **Third Form.** Occurs when you know what will happen, when it will happen, and in what order—but you discover that the *timing is off*.
4. **Fourth Form.** Occurs when the expected *duration* of the event proves to be wrong.
5. **Fifth Form.** Occurs when the problem is expected, but the *amplitude* is not.

— WEICK AND SUTCLIFFE (2001)
CHAPTER 2, PAGES 36-39

type within the burn area. It had not been noted in the burn plan.

People on escapes were frequently surprised by fire behavior unexpectedly more intense than anticipated in the burn plan. Placing test fires in unrepresentative locations and fuel types—such as in cooler or moister locations than characteristic across the unit, or in fuels with a less extreme fire behavior potential than the main burn area—also led to misconceptions of expected fire behavior.

Weakness in Burn Plans

Reviewers noted common weaknesses in burn plans surrounding:

- Complexity and risk assessments,
- Thoroughness of the ignition, and
- Holding and contingency plans.

Although analysis of burn complexity changed considerably from 1996 to 2004, correct assessment is still a critical step to success. Underrating complexity led to ineffective or underdesigned ignition, holding, and contingency plans. Planners and implementers commonly underrated both individual and overall prescribed fire complexity.

In several cases, this was due to the burn plan preparer not following agency direction. This underrating also occurred when burns that were implemented simultaneously were rated separately.

Review teams often noted that the depth and detail of analysis for complex burns was insufficient. Large-scale burns will likely have multiple aspects, variable vegetation–fuel complexes, and resource objectives and constraints that—to implement successfully—require more complex planning and burn organization.

Burn Boss Qualifications

Almost invariably, these escape reviews also noted surprises due to events or conditions outside the experience of the people involved in the burn. While people's burn qualifications was an issue in only two of the reviews studied, several reviews noted that burn bosses—while technically qualified—were still inexperienced with the fuel type.

The lack of appropriate “mental models”—expectations and assumptions—included weather, test firing, control points, and expectations for implementing a previously written burn plan. In several cases, lack of understanding of what constituted a logical or realistic control point led to indefensible burn block boundaries.

In some cases, even though burn personnel knew model predictions would not be accurate, the actual rate of spread, flame lengths, and resultant spotting were still beyond their experience—and, often times, even their imaginations.

How Weather Contributed

Weather was cited as the immediate causal factor of nearly 50 percent (14) of the escapes. This included increased or shifting winds and drops in relative humidity that lead to spotting beyond burn perimeters. Weather conditions were often cited as not being “normal” or being “more than normal” (such as periods of drought and untypical warmer and drier circumstances) prior to ignition. On some burns, it was noted that these weather-related conditions became progressively warmer and drier prior to escape.

Unexpected winds—in both strength and duration—were commonly cited as contributing factors to escapes. Some burn personnel reported being surprised by the effect of strong, erratic winds on

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their fire that resulted from nearby thunderstorm development. In one case, the storm was forecast. The crew could see the thunder cells developing. But because the storm was approximately 30 miles (48 km) away, they decided that it posed no threat and proceeded with ignition.

Mop-up and Patrolling

In most cases, burns were patrolled on a daily basis. In burns of longer duration, the patrols noted activity—visible smoke or open flaming of fuels—increasing inside the burn unit. On some escapes, while the patrols noted these “smokes,” they—wrongly—thought they would not threaten the burn’s boundaries. On other burns, personnel knew other prescribed burns had recently escaped within their geographical area. Despite these signals, they did not alter mop-up protocols or utilize heat-detecting equipment.

Another form of surprise occurred when fuels, change of vegetation type, or nighttime humidity recovery—despite the burn plan’s predicted fire behavior descriptions—failed to check the spread of fire. On one burn, aspen stands that were intended to check the fire’s spread failed because the burn was not implemented during the planned season when aspen could reasonably be expected to function as a natural barrier.

In another case, a wetland adjacent to the burn area was identified as a natural barrier. Yet when the burn was implemented, this preplanned natural barrier was dry. On several of these prescribed burns, nighttime humidity recovery was expected to stop or check the spread of fire, but failed. In these cases, burn

personnel did not gather onsite information to confirm planned or expected conditions.

Unforeseen Events

In several cases, unexpected fuels or conditions, and thus fire behavior, resulted from the unexpected timing of events. When burn personnel did not recognize these changes or update their expectations, they often received dire surprises.

Several escapes noted that fine fuel loadings at the time of implementation differed from burn plan

Planners and implementers commonly underrated both individual and overall prescribed fire complexity.

expectations and fuel condition assumptions. In some cases, this was due to seasonal variation, such as a wetter-than-normal growing season preceding implementation. In another prescribed fire escape, the “resting” of a pasture for 2 years prior to the burn implementation increased fine fuel loads. Unfortunately, this change of condition was not captured or discussed in the burn plan or was otherwise noted prior to ignition.

Timing surprises often occurred at the margins of prescription parameters when either the conditions occurred sooner than expected, or delays in implementation resulted in ignitions already being in progress when conditions exceeded prescription parameters.

Surprise, Mindfulness, and High Reliability

By considering these prescribed fire escapes through the lens of high reliability, we see undue confidence placed in burn plans as well as a lack of testing, confirming, and updating of knowledge based on real-time, on-the-ground information—also known as situational awareness.

These are failures of “mindful anticipation” (see “The Five Key High Reliability Organization Activities” sidebar). They tend to group into lapses of “Preoccupation with Failure” and “Sensitivity to Operations.” Lapses in “Preoccupation with Failure” occurred in the planning stages (such as improper fuel models used), as well as in implementation (such as test firing in nonrepresentative fuel types).

We also see signs of a lack of “Sensitivity to Operations” through a reliance on information in the burn plan without confirming that conditions at the time of ignition conform to those addressed in the burn plan. These lapses in “Sensitivity to Operations” also include failing to note small signals that indicate prior experience or planning might no longer match actual conditions (such as changes in fuel loads), and failures to capture changes in significant fire behavior parameters (such as fuel moisture recovery).

Next Steps to High Reliability Organizing

In retrospect, while many of the surprises can be viewed as failure to follow policy, we feel confident that no one intentionally set out to violate policy. Good policy is essential and must be followed. While

improvements to policy give practitioners better “whats,” we also need better “hows” and a deeper understanding of the “whys.” Following policy is critical. But it does not necessarily increase our ability to identify and respond to the numerous “weak signals” encountered during fire operations.

Building this capacity is key to improving our performance as individuals and as a HRO. This is achieved through both individual and organizational actions. Individual and organizational capacity includes the individual knowledge and experience necessary to successfully implement policy, as well as the organizational structures that support ongoing learning at both individual and organizational levels.

Activities include tangibles such as internal HRO “audits,” local and national training and mentoring programs, and mechanisms for transferring and institutionalizing lessons learned—as well as the broader intangibles such as becoming a “learning culture.” Approaches such as the Forest Service’s new fire suppression doctrine* appear to address this less tangible aspect of capacity.

Because the process of understanding our weaknesses and strengths is a key first step to improving reliability, the rigorous evaluations of existing practices and local efforts to improve mindfulness can also help build capacity for improving our performance.

Important Disclaimer

It is also important to remember that the original prescribed fire

* For more information on fire suppression doctrine, see the Spring 2006 *Fire Management Today* issue on “Safety” (66(2)).

This effort represents a significant step in helping to identify common threads in lapses of mindfulness.

escape reviews that we examined in this study were not conducted for the purpose of ascertaining strengths and weaknesses in high reliability. Thus, we can only draw inferences from what is noted in these reviews.

Further, because this sample might not be representative, we must treat the generalizability of our insights cautiously. For instance, simply because 50 percent of this sample noted weather as a factor, does not mean that, overall, 50 percent of escapes involve unexpected weather events.

Unexpected events will continue to occur. How do we organize ourselves to successfully recognize and respond to them?

At the same time, we do know that weather can be problematic. We would be remiss if we didn’t conclude that we can improve our mindfulness in this area.

In summary, in planning and implementing prescribed fire events, we offer the following observations and insights for consideration:

- Ensure that expectations of fire behavior are built on conditions existing at the time of ignition and for the duration of the burn, not simply at the time the burn plan was written.

- To help build more complete mental models, ensure that multiple perspectives (from the prescribed fire planner, burn boss, holding and ignition specialists) are secured during burn plan development—then follow up by seeking multiple perspectives at implementation.
- Rather than considering—until proven otherwise—that everything is acceptable, we need to train ourselves to the opposite: that our prior experiences are invaluable, not infallible.
- We need to treat our experiences and expectations as testable hypotheses and look for disconfirming evidence—then be prepared to quickly respond to the new information that these questions reveal.

Conclusions

Unexpected events will continue to occur. How do we organize ourselves to successfully recognize and respond to them?

Are we anticipating correctly but not responding sufficiently? Or, are we missing important signals? Are these lapses idiosyncratic by individual—or systemic across the entire organization?

Applying frameworks such as high reliability systematically can help us better understand our strengths and weaknesses—both across the organization and individually.

The weaknesses noted in our study are not new. While the vast majority of fire events (wildland fire use, prescribed fire, fire sup-

pression) conclude successfully, there are common threads in those prescribed fire events that do not. Although these are “initial impressions,” we can still begin to take action.

Individually, we can view plans and expectations with skepticism and seek *disconfirming* rather than confirming evidence. We can also begin to use the frameworks of surprise and high reliability to assess our individual and local actions.

Organizationally, we might want to expand upon this effort to look comprehensively at escapes and near misses and discuss additional ways to build mindful anticipation and resiliency into our organizational structures and behavior. Consistent development and central collection and storage of escape and near miss reviews would surely assist such an effort.

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We need to learn from the experiences—both positive and negative—of those who have been the focus of these reviews. Their experiences are an invaluable asset to the organization as a whole.

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WHAT WAS YOUR BIGGEST SURPRISE ON A PRESCRIBED FIRE?

What was your biggest surprise on a prescribed fire or wildland fire use fire? What was your most stressful situation on a prescribed fire or wildland fire use fire? What was the most significant lesson you learned on a prescribed fire or wildland fire use fire?

These questions, and others, are posed to a panel of veteran burn bosses in the video/digital video disc (DVD) production “Burn Boss Stories: Learning From Veteran Prescribed Fire and Wildland Fire Use Practitioners.” Their answers prove informative and insightful.

The production, available in 40- and 20-minute versions, can be acquired through the Wildland Fire Lessons Learned Center, Tucson AZ. For more information, and to peruse the other available wildland fire learning organization-themed video/DVD productions, access the Wildland Fire Lessons Learned Center Website at <myfirecommunity.net>. ■

