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Managing the Unexpected

What Business Can Learn from High Reliability Organizations

Unexpected events often audit our resilience. They affect how much we stretch without breaking and then how well we recover. Some of those audits are mild. But others are brutal. This book is about both kinds of audits, as unrecognized mild audits often turn brutal.

Consider some examples. People did not expect that Pentium computer chips would make incorrect calculations, that a new soft drink formula would unleash protests rather than praise, that bottled water would be tainted with benzene, that fresh spinach would cause serious illness, that pet food would be tainted with poison, that patients supposedly suffering from St. Louis encephalitis were actually victims of the West Nile virus, or that pediatric deaths during cardiac surgery would be excessive. All of these were the mild audits that grew into substantial problems for Intel, Coca-Cola, Perrier, Salinas Valley spinach growers, Menu Foods, the Centers for Disease Control and Prevention, and the Bristol Royal Infirmary, respectively. In each case, small failures went unnoticed, simple diagnoses were accepted, frontline operations were taken for granted, recovery was treated as routine, and experts deferred to authorities. These troubled organizations might have acted differently had they modeled themselves after a family of organizations that operate continuously under trying conditions and have fewer than their fair share of major incidents. These *high reliability organizations* (HROs) practice a form of organizing that reduces the brutality of audits and speeds up the process of recovering. They are the focus of this book.

The Basic Message of This Book

This book is about organizations, expectations, and mindfulness. Our basic message is that expectations can get you into trouble unless you create a mindful infrastructure that continually does all of the following:

- Tracks small failures
- Resists oversimplification
- Remains sensitive to operations
- Maintains capabilities for resilience
- Takes advantage of shifting locations of expertise

Failure to move toward this type of mindful infrastructure magnifies the damage produced by unexpected events and impairs reliable performance. Moving toward a mindful infrastructure is harder than it looks because it means that people have to forgo the "pleasures" of attending to success, simplicities, strategy, planning, and superiors.

This first chapter presents an overview of what it takes to organize for high reliability. We anchor this overview in a devastating incident, the Cerro Grande wildland fire, which caused $1 billion of damage to Los Alamos, New Mexico, and the adjacent Los Alamos National Laboratories in May 2000. As you will see, events overwhelmed a crew and a system that planned to burn out a hazardous 300-acre area at the Bandelier National Monument. Without much warning, unexpected winds forced the system to deal with a task that was exactly the opposite of the one they were prepared for. Instead of managing an intentional prescribed burn, people in the system suddenly had to suppress an unintentional active fire that had escaped its intended boundaries. Although the Cerro Grande fire is a dramatic event, it involves moments of organizing that are common to organizations of all kinds. The organizing for the Cerro Grande fire started with a plan, vague notions of contin-

gency resources, incomplete knowledge of the system, unexpected changes in staffing, uneven communication, quotas, and shifting command structures. When the unexpected wind swirled into this system, the vagueness, the incompleteness, and the shifting command were the weak points that gave way.

The Cerro Grande Fire: A Brutal Audit

Consider Pat Lagadec's vivid words: "The ability to deal with a crisis situation is largely dependent on the structures that have been developed before chaos arrives. The event can in some ways be considered as an abrupt and brutal audit: at a moment's notice, everything that was left unprepared becomes a complex problem, and every weakness comes rushing to the forefront."[1]

Lagadec's description pinpoints potential threats to managing the unexpected. "Structures developed before the crisis arrives" include both routines and special resources for the crisis such as SWAT teams. All of these help people deal with the disruption, except that the crises that are envisioned seldom resemble the crises that actually unfold. This mismatch means that a brutal audit uncovers vulnerability in the form of unforeseen collapses in functioning.

A brutal audit also uncovers unforeseen weakness in resilience—the capability to recover. Resilient action that enables recovery from setbacks is built out of a broad repertoire of action and experience, the ability to recombine fragments of past experience into novel responses, emotional control, skill at respectful interaction,[2] and knowledge of how the system functions. Structures of resilience reflect lessons that HROs have learned the hard way. The best HROs know that they have not experienced all of the ways that their system can fail. They also know that they have not deduced all possible failure modes. And they have a deep appreciation for the liabilities of overconfidence. This appreciation takes the form of ongoing mindfulness embedded in practices that enact alertness, broaden attention, reduce distractions, and forestall misleading simplifications. How HROs pull this off, and how you can do the same,

are what this book is about. For the moment, the key point is that ongoing mindful practice reduces the severity and frequency of brutal audits, accelerates recovery, and facilitates learning from the audit.

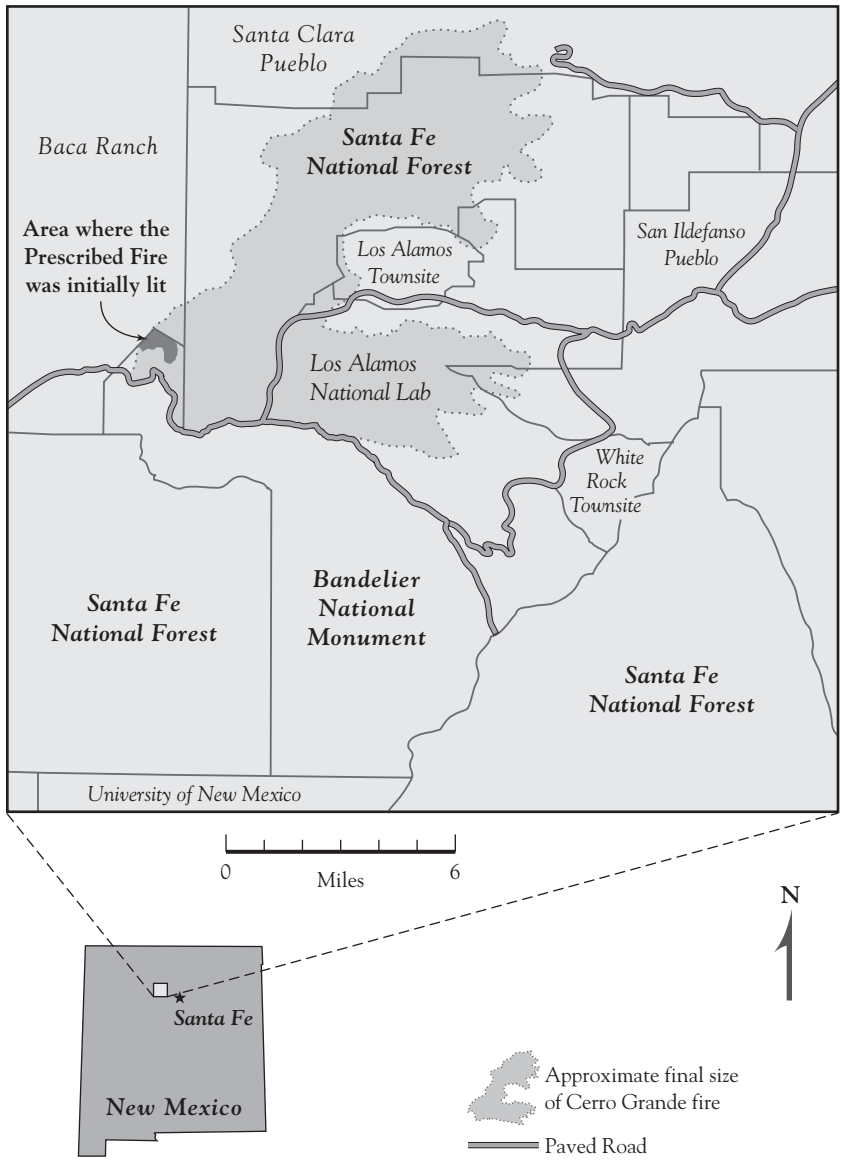
The Events at Cerro Grande

The successes as well as the failures of wildland firefighters can teach us a lot about managing the unexpected.

Normally, wildland firefighting is reactive, as is true for most settings where people describe themselves figuratively as "putting out fires." Reactive action occurs when firefighters respond to fires that are already burning (such as those started by lightning). Reactive action among nonfirefighters occurs when they respond to "fires" lit by disgruntled customers, shifts in financial markets, or supply chain breakdowns. Wildland firefighting, however, has become more *proactive* and preemptive as forests have become more dangerous due to dead trees and debris on the forest floor. When fires break out in debris-laden forests, they burn faster and hotter, are more difficult to control, and can threaten a larger number of homes and businesses. To prevent such disasters, crews now ignite small preemptive fires, which they try to contain within prescribed areas. A prescribed burn reduces the fuel load that could lead to much larger fires. But prescribed fires are complex events. "Because of the potential for unintended consequences, prescribed fire is one of the highest-risk activities land management agencies undertake. Contingency planning, which includes identifying necessary resources should a planned ignition exceed prescription parameters, is an essential component of a burn plan."[3]

The prescribed burn at Cerro Grande was just such a preemptive, prescribed fire. Plans were made to burn 300 acres in the upper portion of the 32,727-acre Bandelier National Monument near Santa Fe, New Mexico (see Figure 1.1). The area of the burn was a south-facing slope between 9,000 and 10,000 feet elevation with a 2 to 20 percent rise.

Figure 1.1 Bandelier National Monument and Vicinity



Thursday evening, May 4, 2000, a crew of ten Black Mesa firefighters from the Northern Pueblo Agency and ten United States Park Service firefighters plus a fire observer (renowned firefighter Paul Gleason) made a 1-acre test burn at 7:20 P.M. to see whether the grass was dry enough to continue with the planned burn. The test was successful, and at 8:00 P.M., the ignition crew began to insert fire into the prescribed area. Their first action was to create a blackline around the outside edge of the planned burn area, starting on the east side. To construct a blackline, a drip torch is used to ignite the grass, the fire is allowed to burn a path about 3 feet wide, and then the outer and inner edges of the fire are extinguished. A blackline prevents unintended fire spread later when the actual prescribed burn is ignited. As the ignition proceeded, the inner edge of the blackline proved hard to extinguish, so the burn boss,[4] Mike Powell, decided to extinguish only the outer edge and to let the inner edge keep burning into an area that was to be burned out later in the season. Around midnight, the Black Mesa crew was responding slowly and seemed to be exhausted. Burn boss Powell, fearing that the crew members might endanger themselves because of their condition, sent them back down the mountain along with five of the Park Service people. This left only six people to hold the surprisingly active fire, two on the west side and four on the east side. At 3:00 Friday morning, Powell called the dispatcher at the regional Santa Fe Zone Dispatch center and requested a fresh crew of twenty hotshots for 7:00 that morning. To his surprise, Powell heard the dispatcher say that he couldn't approve this and would have to wait and ask his supervisor who came in at 7:00. In disbelief, Powell tried to call other people he knew to help him and finally contacted a two-person Bandelier National Monument fire engine crew who did arrive at 6:00 A.M.

Paul Gleason had been observing the firing operation earlier in the evening. He was to be the burn boss of a fire in the same area at a later date and wanted to survey the site. When Gleason returned to the fire at 6:00 Friday morning, he was worried about two things: the fire was moving faster than expected, and no fresh resources had been ordered. Powell again tried to call Santa Fe dispatch, but this

time no one answered the phone. Gleason then called the Bandelier Monument superintendent, Roy Weaver, and explained the problem. After heated negotiations between dispatch (which began to answer the phone again at 7:30 A.M.) and Bandelier personnel over who would pay for the requested resources, Gleason got a promise that a twenty-person crew would be there at 9:00 A.M. and that a helicopter would be there shortly thereafter to drop water on the flames. Gleason took over the burn boss duties at 10:00 A.M. and told Powell to get some sleep. The crew that was promised for 9:00 did not arrive until 11:00, and the helicopter arrived at 10:30 without a water bucket. Partly because insufficient resources were focused on the fire, it spotted and "slopped over" the fireline on the east side, igniting combustible bunchgrass. At 1:00 P.M. Friday, the fire escaped the prescribed burn area and was declared a wildland fire that now had to be extinguished. The suppression strategy was to adopt an indirect attack, which meant that backfires would be lit some distance away from the current flames. These backfires, however, were lit in an area that was scheduled to be burned later in the spring. The intent of the backfiring was to remove fuel that would accelerate the escaping fire.

This plan worked well from Friday until Sunday at 11:50 A.M. when unexpected winds of up to 50 miles per hour blew in from the west and shoved the fire into adjacent canyons. These canyons channeled the winds and intensified their speed, both of which effects increased the flame heights and the rapidity with which the fire moved. The fire exploded toward the city and laboratories of Los Alamos, eighteen thousand people were evacuated, and by late Tuesday, 235 homes had burned to the ground and thirty-nine laboratory buildings had been destroyed. The fire, started on May 4, was finally stopped on May 19 after it had been fought by one thousand firefighters, consumed 48,000 acres, and inflicted $1 billion worth of damage. As Ed Hiatt, one of the firefighters on the east side, reported, "It all started with a one-inch-wide band of fire that crept across the fireline into fresh grass." This tiny spot fire kept flaring up every time firefighters thought they had put it out.

Understanding the Events at Cerro Grande

A one-inch band of fire that produces $1 billion in damage is a classic pattern in unexpected events. Small events have large consequences. Small discrepancies give off small clues that are hard to spot but easy to treat if they are spotted. When clues become much more visible, they are that much harder to treat. Managing the unexpected often means that people have to make strong responses to weak signals, something that is counterintuitive and not very "heroic." Normally, we make weak responses to weak signals and strong responses to strong signals.

To understand more clearly what happened at Cerro Grande, we can compare how the burn project was organized with the ways that HROs are organized. As we said earlier, systems that mismanage the unexpected tend to ignore small failures, accept simple diagnoses, take frontline operations for granted, neglect capabilities for resilience, and defer to authorities rather than experts.[5] Fragments of this pattern are visible in Cerro Grande.

To start, think about what the members of the team at Cerro Grande expected. They expected that their burn plan was doable and met objectives, that the fire itself would be of low to moderate complexity, that they had a capable crew and resources, that the dispatch system was reliable and responsive, that contingency resources were on standby, that weather forecasts did not preclude burning, and that local conditions (such as low residual dampness despite recent snow) were at a preparedness level such that burning was possible. The very fact that so much of the success of this project was tied to these expectations suggests the importance of continuing mindfulness to see if expectations were being fulfilled and to catch early indications that they weren't. One way to be more mindful of emerging unintended consequences is to apply the principles of high reliability organizing. As you will see, early clues that expectations were being frustrated began to pile up and endanger the project.

To continue our analysis, let us reintroduce the five key ideas of mindful infrastructure, viewing each one now as a principle underlying the performance of highly reliable organizations. As we will discuss more fully in later chapters, the first three principles involve mainly an HRO's capacity to anticipate "unexpected" problems, while the fourth and fifth have more to do with capacity to contain them. You will see the extent to which the system that attempted to control the Cerro Grande incident was able to implement these principles.

HRO Principle 1: Preoccupation with Failure. HROs are distinctive because they are *preoccupied with failure*. They treat any lapse as a symptom that something may be wrong with the system, something that could have severe consequences if several separate small errors happened to coincide. For example, the disastrous release of 40 tons of methyl isocyanate gas used by Union Carbide in the manufacture of pesticides killed three thousand people initially on December 3, 1984, in Bhopal, India.[6] Small errors such as the failure to reinsert a water isolation plate, malfunctioning storage tanks, inoperative gauges and alarms, English-language manuals that could not be read by plant personnel, and high turnover with a consequent loss of experience all contributed to the disaster. HROs encourage reporting of errors, they elaborate experiences of a near miss for what can be learned, and they are wary of the potential liabilities of success, including complacency, the temptation to reduce margins of safety, and the drift into automatic processing. They also make a continuing effort to articulate mistakes they don't want to make and assess the likelihood that strategies increase the risk of triggering these mistakes.

At the Cerro Grande fire, there were several small failures that signaled larger problems. For example, agencies that managed land adjacent to Bandelier were nervous about the planned burn because four prescribed fires nearby had escaped their intended boundaries in the two weeks prior to the planned Cerro Grande burn.[7] Further-

more, there were two small but significant failures once the fire was ignited Thursday night. First, the inability to extinguish the inner edge of the blackline burn suggested a more active fire than had been anticipated. Once the fire was allowed to burn freely inside the blackline, the crew lost the option *not* to ignite the interior fire. Second, the release of personnel at midnight reduced the ability of the on-site crew to deal with further unexpected events. Once the Black Mesa crew left the mountain, there was only a skeleton crew left to handle whatever came up. These failures, coupled with temporary staffing of the dispatch center and the dispatcher's refusal to order a fresh twenty-person crew meant that small failures were beginning to pile up.[8] These weak signals of failure required a stronger response that could mobilize fresh resources. While there were growing signals of system failure, each signal was itself weak and was handled with a weak response. The burn boss tried to locate fresh resources by calling people he knew, but he reached only two people who said they would arrive at 6:00 A.M.

HRO Principle 2: Reluctance to Simplify. Another way HROs manage for the unexpected is by being *reluctant to accept simplifications*. It is certainly true that success in any coordinated activity requires that people simplify in order to stay focused on a handful of key issues and key indicators. But it is also true that less simplification allows you to see more. HROs take deliberate steps to create more complete and nuanced pictures of what they face and who they are as they face it. Knowing that the world they face is complex, unstable, unknowable, and unpredictable, HROs position themselves to see as much as possible. They welcome diverse experience, skepticism toward received wisdom, and negotiating tactics that reconcile differences of opinion without destroying the nuances that diverse people detect. When they "recognize" an event as something they have experienced before and understood, that recognition is a source of concern rather than comfort. The concern is that superficial similarities between the present and the past mask deeper differences that could prove fatal.[9] For example, the burst of debris

at the root of the left wing of the *Columbia* space shuttle, which was observed 82 seconds into the launch on January 16, 2003, was interpreted as an event that was "almost in-family." By this, NASA top management meant that the event was largely analyzed, reportable, and understood. They were wrong.

Simplification played a necessary but also disrupting role in Cerro Grande as it does in other efforts to organize for reliable functioning. The burn plan was constructed on the basis of ratings of how complex the burn was likely to be. Ratings of complexity convert information about things like elevations (steep slope versus flat land), fuel types (short grass, open timber, long-needle litter under a closed stand of timber), changes in weather, and other local conditions (such as private land adjacent to the burn area) into a number that simplifies those features.

But the complexity of the Cerro Grande burn was misestimated because the wrong system was used to predict how complicated the burn would be. Burn boss Powell rated the complexity of the burn using a scale of 1–2–3 to rate individual contingencies where 3 was high complexity. However, he should have used a National Park Service scale of 1–3–5 where 5 was high complexity.[10] He used the incorrect scale because it was posted on the Internet and no one at the five federal wildland agencies had detected the incorrect posting.[11] The incorrect scale, which Powell used correctly, estimated that the fire would be of low to moderate complexity. Had the correct rating scale been used, the sum of the same individual ratings would have indicated that the fire would be of moderate to high complexity. This difference is important because as a burn boss, Powell was qualified to direct a low complexity event but not a high-complexity event. Furthermore, the number of resources needed to hold the fire to the prescribed area and the number that need to be on standby are greater for high-complexity burns and greater than the number that were requested for Cerro Grande.[12]

There were other troublesome simplifications. Planners misjudged the intensity of individual elements that were summed into the overall complexity rating. This was true for at least one of the

three categories of elements—the three being threats to boundaries, fuels and fire behavior, and objectives.[13] Each misjudgment erred in the direction of underestimating difficulty. Finally, all of these ratings were completed weeks before the burn and were not reevaluated on the day of the burn, most probably because such updating is not required by policy.[14]

The members of the burn crew did exhibit some reluctance to simplify when they conducted a test burn. The data from the test burn can be used to update earlier judgments of complexity. We say "can be used" because, as with all projects that are under way, people are prone to interpret new data in ways that confirm their expectations. It is hard to spot signs that burning is unwise when twenty people are standing around ready to start the burn.

There is no question that when you organize, you simplify. But you don't need to simplify casually or habitually or instantly. People can be more deliberate in their choices of what to simplify. To be more deliberate means to be more thorough in articulating mistakes you don't want to make. In the case of prescribed burns, one mistake you don't want to make is to misjudge the complexity of the burn. As the Cerro Grande Board of Inquiry said, there are strong links among complexity ratings, resources deployed and on standby, and contingency plans.[15] If simplifications lead to misspecification of any one of those elements, brutal audits are more likely. Again, this is not a problem unique to the world of firefighting. Everyone makes assumptions about how complex a project will be, what resources are needed to complete the project, and how to avoid entrapment. Those assumptions can be rough or nuanced. Resilience lies in the direction of nuance.

HRO Principle 3: Sensitivity to Operations. HROs are *sensitive to operations*. They are attentive to the front line, where the real work gets done. The "big picture" in HROs is less strategic and more situational than is true of most other organizations. When people have well-developed situational awareness, they can make the continuous adjustments that prevent errors from accumulating and en-

larging.[16] Anomalies are noticed while they are still tractable and can still be isolated. All of this is made possible because HROs are aware of the close ties between sensitivity to operations and sensitivity to relationships. People who refuse to speak up out of fear undermine the system, which knows less than it needs to know to work effectively. People in HROs know that you can't develop a big picture of operations if the symptoms of those operations are withheld. It makes no difference whether they are withheld for relational reasons such as fear, ignorance, or indifference. If managers refuse to examine what happens between heads, they'll be eternally puzzled by what appears to happen inside individual heads.

When Santa Fe dispatch finally picked up the phone at 7:30 A.M. Friday morning, a stalemate occurred. The burn boss was finally able to request a fresh twenty-person crew. Dispatch asked, "Are you declaring this an escaped fire?" The swift reply was, "No, I'm trying to prevent it from becoming an escaped fire." To which dispatch replied, "I can't release fresh resources until it is declared an escaped fire." Conflicting interpretations of policy stalled operations until the issues were sorted out. Park Service personnel managing the burn believed that once the availability of contingency resources had been confirmed in the burn plan, they would be available if requested. Dispatch, however, interpreted the policy as saying that contingency resources would be made available only when a prescribed fire escaped and was declared a wildfire.[17]

While all the haggling was going on, the fire kept getting bigger and the exhausted skeleton crew members found it harder and harder to keep the blaze from circling around behind them. As Paul Gleason said after the event, "If someone phones and needs help, don't talk budget. This is fire! Do the money thing later."[18]

Budgets are often insensitive to operations. The problem at Cerro Grande was that budgets were insensitive to operations three times over. First, they were insensitive to the need for instant activation of standby resources to back up the frontline workers. Second, they were insensitive because there were conflicting definitions of "standby resources." Standby was interpreted to mean

either available in the area or unassigned to other activities and available for immediate support.[19] Third, the budgeting operations themselves were poorly understood, which meant that the system was insensitive to bottlenecks in its own functioning.

Many readers will see these insensitivities and stalemates as normal and natural trouble whenever interactions occur between agencies, divisions, silos, jurisdictions, or functions. Although insensitivity may be normal trouble, it becomes big trouble when unexpected audits dissolve coordination that was tenuous to begin with.

HRO Principle 4: Commitment to Resilience. No system is perfect. HROs know this as well as anyone. This is why they complement their anticipatory activities of learning from failure, complicating their perceptions, and remaining sensitive to operations with a *commitment to resilience*. "The essence of resilience is therefore the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress."[20] HROs develop capabilities to detect, contain, and bounce back from those inevitable errors that are part of an indeterminate world.[21] The hallmark of an HRO is not that it is error-free but that errors don't disable it.

Resilience is a combination of keeping errors small and of improvising workarounds that allow the system to keep functioning. Both of these pathways to resilience demand deep knowledge of the technology, the system, one's coworkers, and most of all, oneself. HROs put a premium on training, personnel with deep and varied experience, and skills of recombination and making do with whatever is at hand. They imagine worst-case conditions[22] and practice their own equivalent of fire drills. Psychologist Gary Klein, an expert in high-stakes decision making, suggests that the most effective fire commanders have rich fantasy lives and mentally simulate potential lines of attack.[23]

The Cerro Grande fire makes several problems of resilience more visible. The system keeps getting stretched. But it never quite

recovers to the point where it started on Thursday or to a point that fosters continued coping. Consider the crew itself. Crew members had reported for work at 7:00 A.M. Thursday morning, May 4, and had been used from that time on to preposition tools and equipment at the top of the hill. This meant that they were walking up a steep slope carrying heavy equipment, a hike that took 90 minutes to reach the top. They did this several times. The burn itself was supposed to be lit in the afternoon but was postponed until evening, which kept the crew on site longer. Recall that the Black Mesa holding crew was released from the fire at midnight, which increased the burden on the workers who stayed behind. Finally, the remaining crew had been working for close to thirty hours by the time fresh resources arrived late Friday morning. The normal work-rest cycle is sixteen hours on, eight hours off (a ratio of 2 to 1).[24] The capabilities for recovery, containment, fresh thinking, and creative solutions to unexpected problems were severely diminished.

Formal investigations conducted in the aftermath of the Cerro Grande fire circled around the question of whether the burn boss was sufficiently "aggressive" in conveying "a sense of urgency" regarding the need for fresh resources.[25] Answers to that question remain in dispute. But what is not in dispute is that the unavailability of fresh resources at 7:00 A.M. Friday morning meant that exhausted firefighters had to cope with the unexpected spot fires and slopover of fire on the east side until relief came late Friday morning. Try as they might, the overextended crew simply could not handle the setbacks the way a fresh crew could. The crew at Cerro Grande was losing its flexibility as well as its ability to restore the lost flexibility. A nondynamic crew was facing a dynamic environment. That spells trouble.

HRO Principle 5: Deference to Expertise. The final distinctive feature of HROs is their *deference to expertise*. HROs cultivate diversity, not just because it helps them notice more in complex environments, but also because it helps them do more with the complexities they do

spot. Rigid hierarchies have their own special vulnerability to error. Errors at higher levels tend to pick up and combine with errors at lower levels, thereby making the resulting problem bigger, harder to comprehend, and more prone to escalation.

To prevent this deadly scenario, HROs push decision making down and around.[26] Decisions are made on the front line, and authority migrates to the people with the most expertise, regardless of their rank. This is not simply a case of people deferring to the person with the "most experience." Experience by itself is no guarantee of expertise, since all too often people have the same experience over and over and do little to elaborate those repetitions. The pattern of decisions "migrating" to expertise is found in flight operations on aircraft carriers, where "uniqueness coupled with the need for accurate decisions leads to decisions that 'search' for the expert and migrate around the organization. The decisions migrate around these organizations in search of a person who has specific knowledge of the event."[27]

Issues of expertise, authority, and deference were complicated at Cerro Grande, as they are in everyday life. There was deference to the person at Cerro Grande who had the most expertise, Paul Gleason. He is a legend in the fire world. Gleason intervened to solve the impasse over fresh resources, agreed to be burn boss Friday morning so that Mike Powell could get some sleep, assumed the position of incident commander when the fire escaped on Friday at 1:00, and continued as incident commander when the fire exploded on Sunday until a complete incident command team could get to the fire. Gleason received the deference he deserved, but there were two problems. First, he made good decisions, but many were not implemented. Second, he may have been the object of too much deference. This is an easy point to misunderstand. There is the remote possibility that the sheer power of Gleason's expertise led others on the scene to let up in their monitoring of the situation in the belief that if something were amiss, a person of Gleason's stature would surely catch it.[28] In other words, if Gleason doesn't see it, it's not happening. Gleason was well aware of his own limitations and fal-

libilities. But others may not have been. In their veneration of Gleason, they inadvertently discounted their own impressions of the fire, which could have captured details that Gleason missed.

But there was also too little deference to expertise in the events preceding the blowup at Cerro Grande. Anyone in a dispatcher role is less of an expert on specific fire behavior than the on-scene person who is face to face with the fire. Likewise, a temporary dispatcher is less of an expert on local practices and personnel than the regular dispatcher assigned to a post. A dispatcher who waits to make a decision until his superior arrives at 7:00 A.M. rather than try to fill the urgent needs of an on-scene fire boss at 3:00 A.M. clearly defers to authority rather than to expertise. How aggressively that expertise was asserted at 3:00 A.M. can be debated. But less debatable is where that expertise was located.

Cerro Grande and the Concept of Mindful Management

Is Cerro Grande really that different from what all of us experience? Is it really all that rare to have optimistic plans, insufficient staff, misestimated complexity, broken promises, overlooked details, turf battles, loss of control, unanticipated consequences? No! The board of inquiry said as much when it described judgments at Cerro Grande as "not arbitrary, capricious, or unreasonable in light of the information they had prior to the burn."[29] But the information prior to the burn could have been better. And the information during the burn could have been much better. For example, it is not clear whether the dispatcher knew that the Black Mesa crew had left the mountain when Powell called in at 3:00 A.M. requesting fresh resources.

What does it mean, then, to manage an unexpected event well? Good management of the unexpected is *mindful* management. That answer comes from careful study of high reliability organizations,[30] which operate under very trying conditions all the time and yet manage to have fewer than their fair share of accidents. HROs include power grid dispatching centers, air traffic control systems, nuclear

aircraft carriers, nuclear power generating plants, hospital emergency departments, wildland firefighting crews, aircraft operations, and accident investigation teams. The better of these organizations rarely fail even though they encounter numerous unexpected events. They face an "excess" of unexpected events because their technologies are complex, their constituencies are varied, and the people who run these systems have an incomplete understanding of the systems and what they face. HROs are not magic. But they are deliberate in their attempts to deal with such problems.

We attribute the success of HROs in managing the unexpected to their determined efforts to act *mindfully*. By this we mean that they organize themselves in such a way that they are better able to notice the unexpected in the making and halt its development. If they have difficulty halting the development of the unexpected, they focus on containing it. And if the unexpected breaks through the containment, they focus on resilience and swift restoration of system functioning.

By *mindful*, we also mean striving to maintain an underlying style of mental functioning that is distinguished by continuous updating and deepening of increasingly plausible interpretations of the context, what problems define it, and what remedies it contains. The big difference between functioning in HROs and in other organizations is often most evident in the early stages when the unexpected gives off only weak signals of trouble. The overwhelming tendency is to respond to weak signals with a weak response. Mindfulness preserves the capability to see the significance of weak signals and to respond vigorously.

What Can We Learn from People Who Face Catastrophe?

HROs may seem exotic and of little practical interest because their stakes are so high and their losses can occasionally include actual loss of life. Of course, other losses—of assets, careers, reputations, legitimacy, credibility, support, trust, or goodwill—can be devastat-

ing, too, and result from unexpected events. But a loss of any kind is an outcome, and outcomes are *not* what is of primary interest to us about HROs or, in a sense, to the HROs themselves. What matters instead are their practices. Those practices produce reliable, mindful, flexible functioning because they convert concerns about failure, simplicity, operations, resilience, and expertise into routines that reduce and mitigate misspecificiation, misestimation, and misunderstanding.[31] In other words, they struggle to maintain continuing alertness to the unexpected in the face of pressure to take cognitive shortcuts. Shortcuts stem from prior success, simplifications, strategies, plans, and the use of hierarchy to pass responsibility upward. Brutal audits lie in the path of those same shortcuts.

One source of misunderstanding about the relevance of HROs to non-HROs involves a misunderstanding of issues of scale. If the activity being observed is an assembly line, for example, an unexpected shutdown is not a severe crisis (there was no fatality). But it is a crisis relative to what the supervisor expected would not fail and a crisis relative to precautions taken so that it wouldn't fail. A visit from the Securities and Exchange Commission to a CEO's office does not produce fatalities, but it can affect markets, share price, and liability. In each case, the meaning of the unexpected is contextual. Once we understand the context, the precautions, the assumptions, the focus of attention, and what was ignored, it becomes clear that many organizations are just as exposed to threats as HROs are, and just as much in need of mindfulness. In all organizations, people do things that they expect to continue doing reliably and for which unexpected interruptions can eventually turn disastrous if they manage the unexpected poorly. This possibility is more at the center of attention for HROs than for most other organizations. But it is a possibility that haunts all organizations.

All organizations, not just HROs, develop culturally accepted beliefs about the world and its hazards. All organizations develop precautionary norms that are set out in regulations, procedures, rules, guidelines, job descriptions, and training materials, as well as informally on the grapevine. And all organizations accumulate unnoticed

events that are at odds with accepted beliefs about hazards.[32] It is similarities such as these that warrant transfer of the lessons from HROs to other organizations. For example, HROs develop complex beliefs about the world and revise these beliefs, but they revise them more often than most other organizations. Likewise, HROs develop precautionary norms just like everyone else. But unlike everyone else, they use both small failures and the liabilities of success as inputs when they develop these precautions. And like all organizations, HROs accumulate unnoticed events that are at odds with what they expected. But they also tend to notice these accumulating events sooner, when they are smaller. Each of these elaborations of the basics by HROs suggests directions in which other organizations can make their own elaborations in the interest of heightened mindfulness.

The environment of HROs is one in which there are high-risk technologies. These technologies must be mastered by means other than trial-and-error learning, since in many cases the first error will also be the last trial. HRO environments unfold rapidly, and errors propagate quickly. Understanding is never perfect, and people are under pressure to make wise choices with insufficient information. But whose environment isn't like this? In fact, you could say that how well or how poorly people manage the unexpected is a fundamental issue that underlies the handling of any pressing business problem. Thus the difference between an HRO and a non-HRO is not as large as it might appear. In both settings, trouble starts small and is signaled by weak symptoms that are easy to miss, especially when expectations are strong and mindfulness is weak. These small discrepancies can cumulate, expand, and have disproportionately large consequences. This path of development is also similar across organizations. What differs across organizations are variables such as how much value people place on catching such developments earlier rather than later, how much knowledge people have of the system and its capacity to detect and remedy early indications of trouble, and how much support there is from top management to al-

locate resources to early detection and management of the unexpected, error-acknowledging communication, and commitment to mindfulness at all levels.

Chapter Summary

Unexpected events can get you into trouble unless you create a mindful infrastructure that continually tracks small failures, resists oversimplification, is sensitive to operations, maintains capabilities for resilience, and monitors shifting locations of expertise. When these five principles are violated, as they were by the system that was built to manage the Cerro Grande prescribed burn, people fall back on practices that deny small failures, accept simple diagnoses, take frontline operations for granted, overlook capabilities for resilience, and defer to authorities rather than experts. In the early stages of the Cerro Grande burn, personnel realistically expected that the burn plan was doable, resources were sufficient, the dispatch system was responsive, and the weather conditions were acceptable. However, as the prescribed burn became unexpectedly more active and complex, small misjudgments grew into larger problems that were easy to detect but hard to solve. This progression is not unique to wildland firefighting, however. We find failures of expectations everywhere, which is why managing the unexpected is so crucial.

Lessons concerning ways to cope with the unexpected were drawn from high reliability organizations (HROs). The best of these organizations operate under trying conditions all the time and yet manage to have fewer than their fair share of accidents. These trying conditions stem from complex technologies, contentious constituencies, and managers and operators who have an incomplete understanding of their own systems and what they face. Success in working under these conditions is due in part to mindful organizing that allows people to notice the unexpected in the making, halt it or contain it, and restore system functioning. The hallmark of an HRO is not that it is error-free but that errors do not disable it.

In Chapter Two, we take a closer look at the foundations of resilient, reliable functioning, namely, the nature of expectations and unexpected events and the ways in which a general capability for mindful organizing halts the development of unexpected events. After that, we examine the specifics of mindful organizing, focusing on three principles of anticipation that involve failures, simplification, and operations in Chapter Three and then on two principles of containment that involve resilience and expertise in Chapter Four. In the final three chapters, we discuss audits, culture changes, and managerial practices that can lead to more mindful organized action.