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Large Fires of 2002—Part 2

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Erratum

In *Fire Management Today* volume 64(4), the article "A New Tool for Mopup and Other Fire Management Tasks" by Bill Gray shows incorrect telephone and fax numbers on page 47. The correct numbers are 210-614-4080 (tel.) and 210-614-0347 (fax).

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On the Cover:

Tree silhouetted against the massive Biscuit Fire as it makes its way through Oregon's Siskiyou National Forest toward the Illinois Valley. Photo: Thomas Iraci, USDA Forest Service, Portland, OR, 2002.

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.

FIRE 21

Firefighter and public safety is our first priority.

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Short Features

Monster in the Woods: The Biscuit Fire*

Beth Quinn

A vast plume of thick gray smoke billowed 30,000 feet (9,000 m) into the sky over southwestern Oregon, dwarfing ridgetops on the Siskiyou National Forest. Six more mushroom clouds rose above nearby ridges like volcanic eruptions. Trees 150 feet (45 m) tall torched like matchsticks.

Valley in Danger

By mid-July 2002, the Florence Fire (later known as the Biscuit Fire**) was burning with a destructive power rarely seen. Already the biggest Oregon blaze in more than a century, it was poised to roar down into the heavily populated Illinois Valley. Two weeks of ceaseless struggle had done almost nothing to stop it, and firefighters put the chances of losing towns in the valley at 75 percent.

Beth Quinn is a southern Oregon correspondent for The Oregonian*, Portland, OR.*

Greg Gilpin, a fire manager for the Oregon Department of Forestry, could sense the fear in the 1,500 people gathered before him at the Illinois Valley High School on Sunday, July 28. His job was protecting their homes and lives, and he knew that the situation was even worse than it looked.

Nearly 7,000 of the Nation's best firefighters defied the odds and held off an inferno that threatened hundreds of square miles and thousands of homes.

On the other side of those ridges, just out of sight, a 20-mile (32-km) wall of fire was moving through a wilderness of tinder-dry trees and brush. Every firefighter facing the blaze had fallen back, leaving no defenses between the flames and the 17,000 people living in the Illinois Valley towns of Selma, Kerby, Cave Junction, and O'Brien.

Gilpin stepped onto the polished wooden floor, stood under a basketball hoop and spoke into a microphone. "There is a very good chance that this fire is going to reach the valley floor," he said. "It is so big and so awesome, there is absolutely nothing you can do to stop this fire."

Yet the worst never came to pass. Nearly 7,000 of the Nation's best firefighters defied the odds and held off an inferno that threatened hundreds of square miles and thousands of homes. The Biscuit Fire, which eventually eclipsed the infamous Tillamook Burn as Oregon's signature fire, offers lessons for every State in the West.

Ignition

Southwestern Oregon baked under a blistering heat wave. Sunrise on July 13 marked the 53rd day since the last rain, and the weather forecast that day called for a high of 105 °F (41 °C). The forests in the Illinois Valley were as parched as kiln-dried lumber.

Biscuit Fire on August 16, 2002. A smoke plume rises from the vicinity of Snow Camp Lookout as the northwest flank of the fire creeps down into the Lawson Creek drainage. In the foreground are Oak Flat and the Illinois River. Photo: Gary Percy, Siskiyou National Forest, Gold Beach, OR, 2002.

* The article is based on a series that appeared in *The Oregonian* (Portland, OR) on November 2, 3, and 4, 2002. Reporter Alex Pulaski and researchers Lynne Palombo and Kathleen Blythe of *The Oregonian* staff contributed to the series.

**Florence became Biscuit to avoid public confusion about the location of the fire. Some people wondered whether the fire was near Florence, a community adjacent to the popular Oregon Dunes National Recreation Area on the Siuslaw National Forest. Consistent with normal nomenclature for wildfires, this article refers to the fire for the most part as Florence.

Conditions were perfect for the dry lightning that strikes when heat evaporates a thunderstorm's raindrops before they reach the ground. One-third of forest fires begin with a single explosion of dry lightning.

Firespotters eyeballed the woods from glass-walled lookouts on five different mountaintops. At midday, thunderheads rose above the mountains. The storm erupted just after 2 p.m., unleashing a fusillade of thunderbolts on the thickly forested land along the California–Oregon border. Sensors recorded 581 downstrikes in Jackson and Josephine Counties, with 23 thunderbolts blasting onto the Siskiyou National Forest. Not a drop of water slaked the thirsty Earth.

One lightning bolt struck near Florence Creek, touching off a small fire that hid beneath heavy brush and thick trees in the Kalmiopsis Wilderness. Firefighters call them "sleepers," fires that can creep unseen for days before exploding.

As the storm abated, a Siskiyou National Forest reconnaissance plane took flight to search for fire. The spotter and pilot quickly found two other blazes pumping out smoke visible from the air.

Bob Del Monte, assistant fire management officer for the Siskiyou National Forest, immediately recognized the danger. The isolated Kalmiopsis Wilderness was a fortress for fire. A vertical landscape of sharp ridges and plunging canyons, threaded by rushing water and scarred by old burns, the wilderness contained only a handful of roads—rough tracks that demand four-wheel drive.

Del Monte asked for smokejumpers, but dispatchers at the Redmond Air Center turned him down. The smokejumpers were fighting fires elsewhere in Oregon and the region. None would be available for at least 48 hours. Del Monte was on his own.

Initial Attack

A trail passed near one of the fires, and Del Monte sent two local fire crews on a 7-mile (11-km) hike. Their orders were to contain the fire and, if possible, put it out.

Del Monte climbed aboard a helicopter for a short flight to the other fire. The view across the sea of green ridges was ominous: Two fires were evident where the day before there had been just one. Both were on steep and rocky slopes, where a glowing red edge of fire moved through Douglas-fir and white fir.

Del Monte sent a team with two bulldozers to widen the rough jeep tracks near the two fires. He knew from the beginning that the effort was likely to be futile, at least in the short run. The fires would almost certainly be out of control before heavy equipment could use the tracks.

Local crews could fight small fires, but not three blazes that were miles apart, each burning through roadless areas.

The Siskiyou fire managers quickly agreed that they were overwhelmed. Local crews could fight small fires, but not three blazes that were miles apart, each burning through roadless areas. They asked for a type 2 team, but they were hardly the only ones making such a request. This was the second-worst western fire season in 50 years. Across the Pacific Northwest, fires were erupting on a broad front. A dozen major fires were burning on nearly 100,000 acres (40,000 ha) in Oregon alone. The Northwest Interagency Coordination Center in Portland weighed the desperate pleas from local fire managers.

Federal rules set strict guidelines for making such decisions. The first priority is human life, then towns and historically significant cultural resources, such as American Indian pictographs or archeological sites. Farther down the list are vacation homes and, finally, timber in uninhabited forests such as the Kalmiopsis. Del Monte's trees would have to wait their turn.

Federal fire coordinators informed the Siskiyou fire managers that they were second in line for a type 2 team, behind crews fighting the Trimbly Creek Fire in eastern Oregon, where a mile-wide flame front threatened six homes.

The situation turned grimmer on July 15, when a resident reported yet another fire in the rough backcountry. And then, that afternoon, a reconnaissance flight spotted one more fire, this one on a south-facing slope near Florence Creek, 27 miles (43 km) north of the other blazes. Florence had finally reared its flaming head.

First View of Florence

Del Monte had a single fire crew in reserve, which meant he could fight only one of the other four fires burning on the Siskiyou. He chose Florence because it posed the greatest danger to a populated area. It was only 6 miles (10 km) from the hamlet of Oak Flat, a 480-acre (190-ha) island of private land on the Siskiyou National Forest, including 2 homes and 12 summer cabins. Del Monte had confidence in the crew boss, Paul Hiebert, who had experience as a hotshot.

The crew set out for the fire at 7:45 p.m. on July 15. After hiking 4 miles (6 km) into the darkness, the crew bedded down beside the trail. They couldn't see, smell, or hear the fire. Early next morning, they set out again, catching their first sight of Florence at 8:15 a.m., just as they rounded a bend along the Illinois River.

It was already an impressive specimen. The flames had spread across 50 acres (20 ha) and were tearing through 15-foot (5-m) brush and a tangle of dead trees along the canyon wall. Embers wafted by upslope winds carried spot fires hundreds of feet up the ridge. Fingers of flame crawled toward the river on fallen snags.

Hiebert's heart sank. The fire had covered 6 acres (2.4 ha) when the team was dispatched and had grown 10 times as large in just a day. Hiebert had hoped the fire would be high on the ridge, but instead it was burning close to Florence Creek and a smaller creek nearby. That made it even more dangerous.

Sizeup

Hiebert left his crew beside the river and sized up the fire. The standard tactic for taming such a blaze was a direct attack. Once the fire was contained, Hiebert could run a hose to the river and use a portable pump to douse the flames. Or he could call in an airstrike of water or retardant.

As he calculated the angles of possible attack, Hiebert thought about his crew's safety. No one fighting wildfires had forgotten the deaths of four firefighters on the Thirtymile Fire during the previous summer. The watchword among fire managers was "safety first," and Hiebert wouldn't risk lives to protect an uninhabited forest. He plotted an escape route to use if the winds shifted and the fire wheeled around his crew.

The watchword among fire managers was "safety first," and they wouldn't risk lives to protect an uninhabited forest.

Florence was well dug in. The flames were about a quarter mile (0.6 km) from the Illinois River, a steep uphill hike. The only possible route for retreat was through a deep, boulder-strewn creek bed. If the crew had to run for it, Hiebert thought, someone could fall and break a leg.

Hiebert went over the options again and again. His crew couldn't get around the fire, which was spreading in all directions. He radioed the bad news to Del Monte. As Hiebert waited for an answer, the crew set to work clearing brush along Florence Creek.

As they worked, the fire grew—jumping across one of the creeks and thundering up the ridge with a shriek that reminded Hiebert of a jet engine's roar. By midafternoon, the fire had swelled to 300 acres (120 ha). At 8 p.m., Del Monte told the crew to pull out.

Florence had won the first round. Although two crews had contained one of the Siskiyou fires, the others were burning out of control.

Dwindling Options

Florence doubled again in the day after Hiebert's retreat and was sending columns of smoke 10,000 feet (3,000 m) into the air. If not stopped now, it could burn until late fall, scorching the forest through the dry days of August and September.

Del Monte studied the map, searching for a strategy that would keep Florence contained in the wilderness until help could arrive. The terrain offered some outer boundaries for the blaze. To the north, a gravel barrier, Bald Mountain Road, served as a fire break. To the south, the Illinois River provided what might be a sufficient natural barrier.

Biscuit Fire nearing the Illinois River and threatening small communities. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

Yet every direction posed serious problems. Winds blowing every afternoon along the Illinois River canyon had already nudged Florence east toward Oak Flat. If the fire jumped the narrow river and headed south, it would storm into the Kalmiopsis and its enormous amounts of fuel and lack of natural barriers.

Air tankers could push back a fire of this size. But the 10 Oregon tankers were already protecting homes threatened by fires in eastern and central Oregon. The danger to Oak Flat wasn't enough to justify a change in plans.

On July 21, a week after the Northwest Interagency Coordination Center approved the request, a type 2 team arrived. Glenn Joki, a fire manager with 37 years of experience, led the team, which worked out of Arizona. The firefighters were just off the giant Rodeo–Chedeski Fire, a conflagration that made the tiny Arizona town of Show Low the national focus for the summer's wildfires.

Joki flew over the fires. He didn't want to see flames; he wanted to see country. From the air, the forest's web of creeks was invisible, running through the bottom of deep and narrow canyons. In the distance, Joki could see roads through the forest, but only Bald Mountain Road lay close to the Florence Fire. Joki looked for a place where his firefighters could dig in and know the fire wouldn't get around them. He found few good options.

The three other fires burned toward one another through the southern end of the Siskiyou National Forest, miles away from Florence. Joki realized that he couldn't battle big blazes so far apart. He and the Siskiyou fire managers asked again for reinforcements, calling for a type 1 team.

But 14 of the 16 type 1 teams were already committed elsewhere, including 4 on other Oregon fires. The coordination center in Portland turned him down. The Siskiyou blazes, the fire coordinators said, posed no imminent threat to human life or communities. Instead, Portland sent a second type 2 team to the Illinois Valley to battle the southern fires: Biscuit 1, Biscuit 2, and Sourdough.

That day, the three fires merged into a single blaze. The fire managers named it Sour Biscuit.

Joki turned back to the bigger, more dangerous threat: the implacable, capricious Florence blaze.

> Fire managers have acknowledged that they were stretched thin by an outbreak of wildfires across 11 States and missed an early chance to put out the Florence blaze.

Digging In

Joki launched an ambitious plan. He sent half of his crews to build a 5-mile (8-km) fireline along Florence's eastern flank. They set to work more than 4 miles (6.4 km) northeast of the fire, a decision that consigned thousands of additional acres to the flames. Joki felt he had little choice. No place closer to the fire offered an adequate margin of safety.

Florence was teaching a lesson: With today's huge fuel loads, fires in rough country such as the Kalmiopsis can easily overrun direct-attack firelines. Again and again, the southwestern Oregon crews had to fall way back from the leading edge of the fire, sacrificing huge stands of timber in exchange for a safe place to make a stand.

Joki deployed a second team of firefighters along Bald Mountain Road. Their mission was to keep the fire, growing slowly northward, penned in the wilderness. But Florence had its own strategy. As the crews dug in with their bulldozers and chain saws, the fire suddenly turned east, galloping along the road toward Oak Flat.

Threat to Oak Flat

Firefighters raced ahead to set up a new blocking position that would protect the 14 houses in Oak Flat, now just 4 miles (6.4 km) from the flame front. Joki ordered his crews to prepare the ground for a huge burnout, as large as 1,920 acres (780 ha). The firefighters planned to blacken 3 square miles (8 km^2) of forest between Florence and the hamlet.

Joki wanted to know what route civilians and firefighters could take if the fire turned unexpectedly, and he scouted the ground himself. The Illinois River Road, he saw, was surprisingly rugged. It was a narrow, partially paved track with hairpin turns, steep grades along a cliff above the river, and washouts. A retreat along this road would be slow and dangerous.

The scene at Oak Flat was even more discouraging. Joki's trained eyes saw homes nestled deep in the woods, with trees directly overhead. Many sat at the end of driveways so overgrown they looked like tunnels. His firefighters attempted to clear brush and build a perimeter around the houses, reducing the chance that stray embers could set them afire.

As Joki's crews worked in Oak Flat, Florence once again changed directions, moving south toward the Illinois River, posing a whole new set of dangers. The fire could follow the river into Oak Flat, forcing evacuation. And Joki began to wonder: What if Florence leapt across the 100-foot-wide (30-m-wide) Illinois River, the only natural barrier left between the fire and the people living in the Illinois Valley?

The answer came the next day. On July 24 at 4 p.m., Joki took a call as he left a meeting of fire managers in Medford. Florence had jumped the river and was tearing up a slope toward the next mountaintop. Three helicopters were dousing the fire with water, to no effect. "There it goes," Joki told his colleagues.

The Better Part of Valor

On July 24, the fire crews that had been frantically clearing brush around the hamlet of Oak Flat watched in horror as the Florence Fire revealed its new, nightmarish powers.

A plume of brilliant white smoke and steam spiraled above a nearby ridge, forming the thunderhead that signals unpredictable, explosive fire danger. The blaze that had broken out just 11 days earlier was now spawning a tornado of fire, fueled by dense forest and fanned by blistering winds. Firefighters immediately recognized the danger. When the plume topped 25,000 feet (7,600 m), it would collapse, spewing embers miles from the fire's leading edge.

The firefighters told Oak Flat residents to flee. But one stubborn couple refused to leave their farm undefended, so firefighters handed them a pair of fire shelters. If the flames overwhelm you, they said, run into the blackened meadow and crawl inside. The firefighters lighted a burnout to clear the threatened ground near homes. They waited just long enough to see the brush burst into flames, then they jumped into their rigs and raced out of Oak Flat.

Out of Control

Over the next week, the firefighters retreated again and again as Florence unleashed plume after plume. After leaping 100 feet (30 m) across the Illinois River, the fire churned toward the valley towns, its flames whipped by 60-mile-per-hour (100-km/h) winds from Oregon's inland high desert. The Chetco winds, named for the river valley they follow to the sea, usually arrive in late October. But, for the first time in anyone's memory, they were blasting through July afternoons, with temperatures topping 100 °F (38 °C), working like a bellows on a fire that already had ample fuel and momentum.

"You have to recognize that it's beyond your control," said Joki. "On those days, the dragon wins." But Joki could not let this dragon prevail. His firefighters, 663 strong, formed the last line of defense for the Illinois Valley. It was a daunting prospect.

Sikorsky helicopter taking on retardant at the confluence of the Illinois and Rogue Rivers while battling the Biscuit Fire on August 20, 2002. Photo: Gary Percy, Siskiyou National Forest, Gold Beach, OR, 2002.

> With today's huge fuel loads, fires in rough country such as the Kalmiopsis Wilderness can easily overrun direct-attack firelines.

A fire hot enough to create plumes is a capricious beast. Such wildfires don't follow the usual paths along river bottoms or up slopes. And no matter which direction a plume takes, the fire races at speeds of up to 10 miles per hour (16 km/h), far too fast for firefighters to outrun.

The plumes were awe inspiring, frightening even to men who spent their lives around fire. They made a sound unlike anything else on Earth, an ear-splitting shriek caused by winds uprooting trees, tossing logs, and filling the air with burning mis-

Biscuit Fire glowing eerily as it makes its way toward the Illinois River. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002

siles—the cones of ponderosa pines and the limbs of burning trees.

Illinois Valley Imperiled

On July 25, the day after they had fled Oak Flat, firefighters returned to see what had survived. Their desperation move had worked, up to a point. The fire reached Oak Flat, incinerating two cabins, a barn, a Quonset hut, and a shed. Ten cabins and two homes survived, as did the couple who had refused to leave.

Joki saw it as a victory. He walked among the fire crews scattered throughout the hamlet, surveying the scorched homes near the river and the blackened canyon walls rising above. But Oak Flat was not yet safe. Fire could still burn through the forest from the north. The crews set to work again, dousing hotspots and building a new fireline.

That night, Joki faced about 300 Illinois Valley residents at the Josephine County Building in Cave Junction. Joki stood before the crowd and delivered the grim news. The first of Florence's plumes had collapsed that day, and the fire had taken off in every direction, chewing up 10,000 additional acres (4,000 ha) in the Kalmiopsis Wilderness. That brought the fire to 15,932 acres (6,373 ha) and put it on a course directly toward the Illinois Valley.

"Ten thousand acres in one day?" one woman asked.

Joki struggled to explain. The terror of an uncontrolled wildfire was unimaginable for most people, even those whose backyards were a 1.2 million-acre (490,000-ha) national forest. Little more than a month before, Joki had watched residents in Arizona absorb similar terrifying news, even as the Rodeo–Chedeski Fire was sending 426 houses up in smoke. For the public, wildfire didn't seem real until the blowtorch headed for their homes, their subdivisions, or their towns.

Joki had more worrisome predictions for local residents. The meteorologists on his team warned of more hot, dry, blustery weather, which could cause additional explosive fire plumes. Gilpin, the State fire manager, warned that the fire could return to areas already burned, so residents of Oak Flat wouldn't be allowed back to their homes.

The weather cooperated on July 26, with a layer of warm air trapping the cooler air below, temporarily slowing the fire. But Florence roared back the next day. As the day warmed and the winds began to blow, it spun out another plume and bolted south, toward Oak Flat.

Joki's firefighters again set off a burnout. But instead of retreating up the Illinois River Road, they remained in Oak Flat in a new safety zone—a burned-over meadow—and watched the fire erupt around them. With them were 17 civilians, including the same couple who had refused to leave their farm undefended when Florence had roared into Oak Flat three days earlier. They were joined by 15 visiting family members and friends.

Florence assaulted Oak Flat with 100-foot (30-m) flames, searing heat, and powerful winds that launched spot fires 2 miles (3.2 km) ahead of the flame front. As the woods burned around them, Joki's firefighters and the civilians saw several more outbuildings go up in smoke. And they heard deafening explosions erupt as flames detonated propane tanks stashed as far away from homes as possible.

Fire managers wondered whether Oak Flat was a harbinger of the fate facing the entire Illinois Valley. They told residents of 30 houses and of the historic McCaleb Ranch along the Illinois River Road to abandon their homes, and they warned another 742 homeowners near Selma to prepare for evacuation within 48 hours of official notice. By day's end, the Florence Fire had grown to 23,270 acres (9,308 ha).

In Eagle Creek, 250 miles (400 km) north, Mike Lohrey's cell phone rang. On the line was Bob Del Monte, under normal circumstances a member of Lohrey's type 1 team. "I think you're coming down here," Del Monte told Lohrey. "This thing has gone nuts."

Monster on the March

Late that night, Florence's orange glow was visible to Interstate Highway 5 travelers descending into Grants Pass, 26 miles (42 km) away. In 37 firefighting seasons, Joki had never seen a fire like Florence. Every wildfire in his experience would slow at night, as the temperature fell. But this one had so much heat and momentum that it cranked right through to morning, making tremendous runs after dark and burning intensely 24 hours a day.

> When the plume topped 25,000 feet, it would collapse, spewing embers miles from the fire's leading edge.

The weather forecast was nightmarish: hot days, cloudless skies, and bone-dry winds across the ridgetops.

On July 28, a hot blue-sky Sunday afternoon, Florence kicked up seven billowing plumes. Each collapsed, spitting flame 2 miles (3.2 km) ahead of the fire's core. Through the afternoon, each rose and fell 3 times, for a total of 21 separate incidents.

That day, Florence chewed through 45,000 acres (18,000 ha). The fire traveled nearly 7 miles (11 km) north and 9 miles (14 km) south. When the day was done, the McCaleb Ranch and a remote forest cabin had been incinerated.

That evening, 1,500 frightened people streamed into the parking lot at Illinois Valley High School. Throughout the afternoon, they'd watched the plumes climb and collapse in the clear blue skies. Along a 20-mile (32-km) stretch of U.S. Route 199, a two-lane road that bisects the Illinois Valley, the view to the west was an ominous string of plumes towering over the valley. Knots of anxious people gathered outside the high school and watched the Florence Fire advance to the ridgetops, torching 150-foot (45-m) trees.

Inside the gym, Gilpin scanned the worried faces. Gilpin knew these woods, knew just how volatile these forests were, and yet in 25 seasons he had never seen a fire run this hard at this many people.

"If you live anywhere in the Illinois Valley, you need to start thinking about what you'll do if you have to evacuate," Gilpin said. "We do need to be prepared for the possibility of fire on the valley floor in the next 24 to 36 hours."

It was time to gather irreplaceable items, Gilpin told the stunned residents, and to pack them into cars and trucks, then to turn those vehicles around and to park them facing out of their driveways. To Gilpin, the unthinkable was now a stunningly real possibility. The unseasonable Chetco winds out of the northeast had fanned the Florence Fire into a 20-mile (32-km) flame front. If and when the normal west winds of July returned, the long wall of fire would blow into the Illinois Valley.

The Northwest Interagency Coordination Center in Portland had reached the same conclusion. Citing the flame front paralleling U.S. Route 199, they said there was a 75-percent chance that the fire would reach one or all of the Illinois Valley's four towns in the next 2 to 5 days. Six days after Siskiyou fire managers first asked for a type 1 team, the Portland center forwarded the request to the Multiagency Coordinating (MAC) Group in Boise, which assigns the Nation's 16 type 1 teams. The MAC Group didn't hesitate. Lives were threatened. It was time to call in the best firefighters the Nation could muster.

Days of Fear

The Florence Fire's Sunday rampage persuaded many Illinois Valley residents to evacuate even before an official notice. A steady stream of packed vans, campers, utility trailers—anything with wheels—headed out of the Illinois Valley.

Heading into the remote valley was another convoy of vehicles—bulldozers on huge flatbeds, red and yellow fire engines from almost three dozen Oregon communities, vans and school buses carrying firefighting crews. But for every Illinois Valley resident choosing to evacuate, many more elected to stay—at least temporarily—and a few even talked about making a private stand against the approaching flames.

At the Selma Market, information officers huddled with worried residents, tracing the fire's perimeter on 3-by-5-foot (0.9-by-1.5 m) maps and advising people to leave immediately rather than risk an enormous traffic jam—like "getting caught in a grade B movie," they called it—if the evacuation order came.

To the south, things looked dicey. A separate fire near Gasquet, CA, had closed U.S. Route 199 south, leaving open only two roads leading from the Illinois Valley to safety: U.S. Route 199 north to Grants Pass and a backcountry route up Deer Creek on forest roads to Williams, OR. The Illinois Valley Fire District designated two fireproof schools standing in acres of cleared land. Firefighters and residents could take shelter there if Florence crossed the highway.

Firefighters fanned out across the valley to protect 3,429 homes; 250 commercial buildings; and 2,200 barns, sheds, and garages, assessing each for defensibility against fire. They removed brush, limbs, and trees where possible and plotted the location of each with a satellite global positioning system.

Local officials recognized that they were confronting a force of nature that could blaze any path it chose. "For everything we've tried to do," said Illinois Valley Fire District Chief Kyle Kirchner, "this fire has reared up and kicked us in the face."

The unseasonable Chetco winds died down, a significant break for the firefighters. Florence, however, continued its march. And the Sour Biscuit blaze that was born in the same lightning strike as Florence had picked up momentum as well and now burned just 3 miles (4.8 km) from the larger fire. Soon, they would join.

> Florence assaulted Oak Flat with 100-foot flames, searing heat, and powerful winds that launched spot fires 2 miles ahead of the flame front.

Thirty Minutes To Evacuate

On July 30, Mike Lohrey's type 1 team moved into position near Selma. A thick haze of smoke hugged the ground, hiding the flames. The choking smoke sent more Illinois Valley residents in search of clearer air. Motels in Grants Pass offering steep discounts to evacuees soon filled up.

Local radio stations broadcast that night's public meeting, but hundreds of people still gathered at the high school to hear the latest fire news. Maps hanging outside told part of the story: The Florence Fire had reached 141,650 acres (56,660 ha) and the Sour Biscuit 33,287 acres (13,315 ha).

The gym was eerily dark, the lights left off in hopes of keeping the air cooler.

Gilpin stood before the crowd arrayed across a wall of bleachers, turning a slow half-circle as he described a 30-mile (48-km) makeshift rescue line to protect their homes, a line that remained days from completion. "I want you to be very aware that when the wind switches, even if we have a line on the east side of the fire," Gilpin said, "I can't guarantee that we're going to hold that line. If this fire moves to the valley floor, I cannot guarantee that we can stop it on the valley floor.

"We're looking at a fire that effectively at this point in time is uncontrolled. We're looking at the possibility of this fire burning to the Rogue River," Gilpin said. "We're looking at the possibility of this fire jumping the Rogue River. And we're looking at the possibility that this fire could go to 500,000 acres [200,000 ha]."

Everyone in the Illinois Valley should be prepared to evacuate their homes within 30 minutes of receiving notice, he said, and those already packed should seriously think about leaving immediately.

Gilpin took his seat knowing that even some of his colleagues found his assessments alarmist. Lose the whole Illinois Valley? See the Florence Fire grow to 500,000 acres? It seemed implausible.

But Gilpin knew that Florence had already forced fire managers to throw out their normal strategies. They'd long ago given up on the idea

Rogue River Hotshots fortifying a fireline for a burnout operation on the Biscuit Fire. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

of controlling the boundaries of the fire, and they had allowed Florence to grow unchallenged in any direction except east into the Illinois Valley. They'd given up even trying to douse the head of the blaze. The goal now was simple: Save the communities of the Illinois Valley from a wall of flames, the advance of which seemed inevitable.

For years, Gilpin had preached that losing a subdivision to wildfire wasn't a question of if, just a question of when. But even he had never imagined losing the entire Illinois Valley. Never until July 30.

In the previous 24 hours, the Florence Fire had gobbled another 65,000 acres (26,000 ha), an expanse two-thirds the size of Portland. It had run 5-1/2 miles (8.9 km) in just 90 minutes. At that rate, the fire could be in Selma in less than an hour. And as Gilpin sat in the darkened gym, he figured there was a good chance that the Florence Fire would enter the Illinois Valley in several places and at a dead run.

One veteran wildland firefighter sitting nearby had no quarrel with Gilpin's grim assessment. Lohrey was the man chosen to rescue the threatened valley. And the next day at 6 a.m., he took command.

Shift in Strategy

At 5 a.m. on July 31, Lohrey crawled out of his two-man tent and took command of the fight against the Florence Fire. Immediately, he faced a crucial question: Was sacrificing another 547 square miles (1,417 km^2) of forest his best shot at stopping the blaze?

One of the Nation's most experienced fire managers, Lohrey viewed firefighting as a battle of wits. Every blaze had a personality, a character whose vulnerabilities could be exploited.

But Florence was especially savvy and strong. In nearly three decades in the woods, Lohrey had seldom seen a fire that combined its brute force, unpredictability, and preternatural ability to leap barriers, manmade or natural. This was an audacious fire, he felt, one that could be vanquished only with audacious tactics.

Florence's exploding growth was due in part to fire managers' initial decisions to fight blazes elsewhere in the West that more directly threatened buildings and people. But now, Florence was a powerful monster, and the Nation's best firefighters were here to stop it.

Lohrey had studied the map, memorizing the twists and turns in the terrain. He knew that if the fire wasn't stopped immediately, it could become the most destructive wildfire in modern history, burning to the Pacific Coast, the California redwoods, and the Rogue River, threatening the lives and homes of 50,000 people.

Lohrey reviewed the previous plans for corralling Florence. They were textbook examples of how fires are fought every summer in the United States, frontal attacks in which crews closed in on the flames and created a fireline by clearing brush and chopping down trees.

The approach was sound, but Lohrey believed it would not work on this blaze. The planned firelines had been dug too close to Florence, a fire so powerful it could throw flaming missiles 2 miles (3.2 km) ahead. He began drawing a new map in his head, one in which the fire, or the firefighters, would be allowed to burn through an unprecedented amount of timber. Victory through retreat.

Lohrey believed in surrounding himself with take-charge leaders who would solve day-to-day problems on their own. His job was to craft an

> Along a 20-mile stretch of U.S. Route 199, the view to the west was an ominous string of plumes towering over the valley.

overall strategy and to set the tone, even when events turned chaotic. "You have to be calm," he said. "You have to be the calm in the eye of the storm."

The First Day

Just before 6 a.m., Lohrey walked through the hodgepodge of tents and equipment that the firefighters had instantly dubbed Yurt City. At the other end of the fire camp, 100 firefighters in Nomex—branch directors, division superintendents, and crew bosses—gathered under some tall ponderosa pines. They would, they hoped, lead Lohrey's 1,546 firefighters to the rescue of the Illinois Valley.

One by one, Lohrey's chiefs delivered the latest intelligence on Florence's movements. The first report was bad: A shift in the winds had postponed a burnout needed to protect Selma from the advancing flames.

On the plywood podium, a meteorologist recited the brutal weather forecast: sunny, hot, and a red-flag warning for northeast winds.

Then, Erik Christiansen, the team's fire behavior analyst, went through the basic variables: wind, humidity, temperature, and the fire's heat. All were at historic levels for the Siskiyou National Forest—conditions perfect for explosive fire spread. It had been several days since Florence had spun up a plume, but Christiansen said it could happen again by afternoon.

Lohrey's operations chief described the day's work ahead, pointing to a big map tacked to a plywood stand. Firefighters were preparing for a massive burnout on a curved line that stretched 30 miles (48 km) along the eastern edge of the fire. The plan was to stop Florence's advance to the east by blackening nearly 200 square miles (518 km^2) of forest.

Lohrey had never come close to attempting a burnout of this size. Once, in New Mexico, he had considered torching 39 square miles (101 km^2), but the sheer scope of the operation had given him pause. Then the winds had changed, and he had chosen direct attack.

Everyone present understood the risks. A sudden shift in wind, and the burnout could turn on the firefighters and the Illinois Valley. Lohrey was not much for inspirational speeches, preferring to lead by example. This was his first day as the new commander, a risky moment. Lives could be endangered by a missed communication.

"Today the emphasis needs to be on making sure you give clear orders," he told his aides. "And that you understand the instructions you're given. It's going to be a long season," he added. "It already has been."

The First Burnout

After the meeting, Lohrey and his operations and planning chiefs gathered at the large map. He listened intently as they pointed to the immediate dangers, but then his eyes slid toward areas miles away from the front line. It was Lohrey's job to think days, even weeks ahead, to figure out every move the fire might make and to get there first.

Already, he'd sent a team of fire managers to Gold Beach to prepare a new fire camp for another type 1

Firefighter firing off an incendiary flare to aid in a burnout operation on the Biscuit Fire. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

team that would eventually protect communities on the Oregon coast. At dusk, his crews began burning the fireline that would protect Selma. The aim was to create a blackened band that would halt Florence in its tracks.

The wind fanned the flames on the ground, pushing fire upslope through grasses on the forest floor and into brush. Here and there, a tree caught fire, flaming up with a brilliant flare that quickly disappeared. Soon all the ridges northeast of Selma glittered orange as stars sparkled in the night sky.

The next morning, Lohrey's crews moved onto the blackened ground to make sure wind couldn't whip the fire back to life. Timber cutters downed fire-weakened trees and snags that could fall on firefighters working below. Ground crews followed with water to douse logs still burning on the ground and tree roots burning underground. Some of the firefighters removed their thick leather gloves and ran their hands along the ground, seeking tactile confirmation that the ashes were cold. When they were done, they had created a dead zone half a mile (0.8 km) wide, broad enough to stop Florence at its most fierce.

Meanwhile, Florence probed an entirely different corner of the map. The flames had licked to within 5 miles (8 km) of Agness, a hamlet near the confluence of the Illinois and Rogue Rivers.

At that morning's briefing, the meteorologist forecasted cooler temperatures with a chance of rain. The report was not welcome. A splash of rain would not stop Florence; the fire was hot enough to dry its own fuel as it pushed through the woods. Rain, however, would make the burnouts much tougher. Lohrey was racing the weather, as well as Florence.

A sudden shift in wind, and the burnout could turn on the firefighters and the Illinois Valley.

The Sacrifice Line

Tom Link was the acting district ranger on the Illinois Valley Ranger District when Florence reared its head. A career timber manager, Link had hiked most trails in the old-growth forest. He knew its rivers, streams, and peaks the way some people know their home town.

On August 2, Lohrey came to his office carrying a plan for letting much of the surrounding forest burn. The two men spread a map of the national forest, and Link peered at the jagged circle drawn around the edges that marked how much of his district would have to be surrendered to quell this monstrous blaze.

The line was huge—405 miles (652 km) long—and the area within it beyond imagining—500,000 acres (200,000 ha), or 781 square miles (2,023 km^2), an expanse larger than Washington County, OR.

Florence had already burned through 165,000 acres (67,000 ha). Lohrey was recommending that firefighters deliberately double or triple the amount of burned forest. Link looked glum. He pressed Lohrey to save more.

Lohrey wouldn't budge. The amount of territory to be surrendered had to be huge because firefighters would need that much time to build a wide-enough cordon around the fire. Both men knew that the previous plans had drawn much tighter lines, which Florence had skipped over with ease.

Explosive charge detonating to clear a quarter-mile fireline on the Biscuit Fire. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

"Worst case is worst case," he told Link. "That's what you have to think of."

"We've gone through a couple of worst cases already," replied Link, weary after 3 exhausting weeks fighting Florence. "We've had a mind-expansion process in what we think is bad."

Lohrey needed the district ranger to approve his plan, but Link was unpersuaded. Wasn't Lohrey giving Florence too much room?

"The reality is, 500,000 acres [200,000 ha] is not unreasonable given the time of the year, and where we are in the season, and how much fire we've got," Lohrey replied.

"Fires are not unlike floods. People's memories are short," said Lohrey, who compared Florence to a hundred-year flood. Living memory—50 years—"is a short timespan for the way these things happen," he said.

Link stared at the map silently, his eyes darting from ridge to peak to creek to forest road. He nodded. Lohrey had his approval.

That night, Link had second thoughts. He approached Lohrey after an evening meeting at Yurt City and walked him to the map. Would it be possible to slide the line in two environmentally sensitive areas: the southeastern corner of the forest, a habitat for rare plants that grow only in the Siskiyou Mountains; and a stretch of land north of the Kalmiopsis Wilderness that was home to 49 pairs of northern spotted owls?

"That's a big burnout," Link said, referring to the plans for the south. "It's a question I'm going to get from the public. Why did we need to burn out 8 miles [13 km]?"

Lohrey respectfully declined. Shifting the burn line would leave open a backdoor route for Florence to escape and encircle the Illinois Valley.

"I don't want to leave the back door open," Link agreed.

The situation was little better in the north. If the line was closer and Florence jumped it, the road to Grants Pass would be wide open. The terrain would drive the fire toward the town.

Link traced the topographical map with his fingers. Lohrey had a point. "The ridges are all the wrong way," Link said.

The debate was over. The sacrifice line had been drawn.

> The amount of territory to be surrendered had to be huge because firefighters would need that much time to build a wide-enough cordon around the fire.

Slamming the Back Door

Over the next 4 days, Lohrey's crews worked to build the first 30 miles (48 km) of fireline. It was a staggering project. No Federal fire manager had ever attempted to create a cordon of this size.

Day and night, the burnouts continued, looping around threatened homes near Selma, Kerby, Cave Junction, and O'Brien. Florence continued to test the defenses, throwing up columns that threatened to become full-fledged plumes. But none did. The rains that had worried Lohrey failed to materialize. The temperature dropped, delaying some of the burnouts.

On August 7, the firefighters marked a historic occasion. The bulldozers scraping the fireline northward from the smaller Sour Biscuit blaze kissed blades with the bulldozers plowing south from the Florence Fire. Within days, the fires united, merging into a single titanic conflagration. Lohrey and the fire managers retired the name Sour Biscuit. At that point, the historic 2002 wildfires in southwestern Oregon all became known as Florence.

The fire mounted one last charge along the eastern front, just where Lohrey had feared it might. The flames advanced toward U.S. Route 199, angling for a 2-mile (3.2-km) hole in the line. This was the "back door" that Link and Lohrey had worried about in their conversation days earlier.

The following afternoon, Florence charged the line. Fanned by northeast winds, she crossed the fireline along a narrow 6-mile (9.6-km) stretch. Lohrey's firefighters had fire in their faces. For the first time since Lohrey took charge 9 days earlier, his crews retreated and began a new fireline.

Lohrey considered a daring countermove: going on the attack against the implacable blaze. He now had hotshots galore. But even the Nation's best wildland firefighters couldn't attack a fire kicked up by those northeast winds.

Two days later, the winds shifted enough to allow a direct assault on the fire. Helicopters dropped bucket after bucket of water on the flames, and then 80 hotshots moved off the forest road into the rocky drainage of Whiskey Creek, backed by four experienced Forest Service hand crews. The hotshots worked a 12-hour shift through the night, tearing down trees and brush with hand tools and chain saws. By daybreak, the line extended 2,000 feet (610 m).

Lohrey sent in fresh crews the next morning. The winds cooperated, and within 24 hours the back door had been slammed shut, completing the 30-mile (48-km) line.

The Illinois Valley was safe. For the first time since his arrival, Lohrey felt confident that he had the upper hand on Florence.

Lohrey left the valley on August 13 and headed home to Portland. The fire was not yet fully corralled; much work remained to be done along its northern and western flanks. But the most serious danger had passed.

Sign posted along the road to fire camp on the Biscuit Fire, August 2002. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

Aftermath

Fire managers declared the fire contained on September 5—54 days after lightning had struck near Florence Creek. The official fire size, determined by aerial mapping, was set at 499,570 acres (202,169 ha). The worst-case scenario Lohrey outlined for Link in August had turned out to be all too true.

In the end, the damage to property and people was startlingly small. Florence claimed four summer cabins, nine outbuildings, and the historic Snow Camp Mountain lookout.

Experts are continuing to study Florence's toll on the Siskiyou National Forest. An estimated 38 percent of the 500,000 acres (200,000) within the fireline was reduced to charcoal and ash. The trees left standing in this blackened moonscape are all dead. Another 41 percent of the land was less severely damaged, and ecologists think the thinning will eventually improve forest health. About 20 percent of the land within Lohrey's sacrifice line did not burn at all.

Reevaluating Strategies

The experience of battling the Florence Fire calls into question the priorities that drive national firefighting. Longstanding policy requires protecting people and buildings first. When Florence was burning in uninhabited timber, fire managers attacked other fires that posed a more immediate threat to homes and subdivisions. Usually, that sort of policy makes perfect sense. But in this case, it allowed Florence to grow so big and hot that it became almost impossible to stop, eventually threatening the entire Illinois Valley.

The problem has been compounded by 80 years of suppressing wildland fires, which have left many forests choked with fuel. A wave of lightning strikes on a hot summer day can overwhelm the fire crews assigned to snuff out small fires before they become conflagrations.

An estimated 38 percent of the 500,000 acres within the fire perimeter was reduced to charcoal and ash.

Fire managers have acknowledged that they were stretched thin by an outbreak of wildfires across 11 States and missed an early chance to put out the Florence blaze. Helitack crews and smokejumpers in the region had already been sent to fires elsewhere in the West. Fire managers say that they are reevaluating their strategies for attacking wildfires in light of what they learned during 2002 in Oregon.

Today's tinder-packed forests burn hotter and faster, making traditional frontal attacks on fires more difficult. The tactic that eventually contained the blaze in southwestern Oregon—penning the fire within a vast perimeter—involved surrendering more forest to the flames than had ever been accepted before.

The firefighters relied on a proven approach—burning the fuel in front of the advancing flames. But they did so on a larger scale than had ever been attempted anywhere in the United States and in circumstances that left no margin for error.

"There was at least a week or two there," Gilpin said, "that I felt there was a good chance we could lose either the Illinois Valley or a big portion of it."

A Flammable World

Lohrey gave up more acres than firefighters were accustomed to surrendering, but he had no second thoughts. Relinquishing a half-million acres, he thought, was better for the forest, cheaper for the taxpayers, and safer for the firefighters.

His contest with Florence had been closely fought, and Lohrey knew that good fortune had played a role. At the most critical moments, the winds blew in exactly the right directions. "We could have been in trouble," he said. "It could have been a lot bigger."

Lohrey feels certain the forests of the West will spawn more Florences. The woods are packed with fuel, the legacy of generations of suppressing fire.

"It's a flammable world," he said. "Fires need to burn and will burn." ■

Websites on Fire*

Partners in Protection

Partners in Protection

The threat of fire in the wildland/urban interface (WUI) is constant and real. Partners in Protection helps those living in the WUI by providing information about disaster services, fire management, safety, education, and prevention; and by encouraging community-based initiatives. Based in Alberta, Canada, Partners in Protection is a multidisciplinary group of professionals from government associations and agencies responsible for emergency services as well as for land management and planning.

The Website provides tools to help communities learn the principles of FireSmart. Visitors can download an interactive planning manual—FireSmart: Protecting Your Community From Wildfire—and learn about how to mitigate the risk of fire in their community. The site also provides two practical assessments to help individuals and agencies determine the fire hazard in a given part of the WUI. The new FireSmart multimedia CD, which can be ordered online, includes a manual on hazard assessments and the video Wildfire! Preventing Home Ignitions. The site also has useful links to agencies and organizations involved in disaster relief and fire education and safety.

Found at <http://www.partnersinprotection.ab.ca/>

* 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 the Chief, Yates Building, 4th Floor Northwest, 201 14th Street, SW, Washington, DC 20024, 202-205-0878 (tel.), 202-205-1765 (fax), hutchbrown@fs.fed.us (e-mail).

How Did Prefire Treatments Affect the Biscuit Fire?

Crystal Raymond and David L. Peterson

Most scientific literature supports forest thinning to reduce the severity of wildland fires, but the effectiveness of thinning in modifying fire behavior has not been well documented. The Biscuit Fire of 2002 offered a great opportunity to study the effects of mechanical thinning on fire behavior during a megafire.

The Thinning Theory

Forest thinning is done to prevent surface fires from transitioning to crown fires. Theoretically, reducing canopy fuels and eliminating ladder fuels will decrease the probability that a crown fire will initiate and spread (Cron 1969; Omi and Martinson 2002; Pollet and Omi 2002; Scott and Reinhardt 2001; Stephens 1998).

Most studies on fuel treatment efficacy focus on forests with low-severity, high-frequency fire regimes, such as ponderosa pine and Douglas-fir forests in the Interior West. As a result of fire exclusion, these forests are dense, producing greater canopy and ladder fuel loadings (Agee 1993).

At the opposite end of the spectrum are forests with high-severity, low-frequency fire regimes, such as Pacific coastal, subalpine, and boreal forests. However, because weather influences fire behavior more than fuels in these ecosystems (Bessie and Johnson 1995; Turner and others 1994), thinning is less effective in reducing fire severity than it is in forest ecosystems with a higher fire return frequency.

Aerial view of fire damage on thinned and untreated plots 1 month after the Biscuit Fire. Thinned plots are circled in orange and untreated plots are circled in red. Photo: USDA Forest Service, 2002.

Little information exists for forests with mixed-severity fire regimes, which encompass a wide range of fire frequencies, extents, and severities. The result of this variability makes it more difficult to quantify the ecological role of fire than in forests with low-severity fire regimes.

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Biscuit Fire: A Research Opportunity

In 1992, scientists from the USDA Forest Service's Pacific Northwest Research Station started the Long-Term Ecosystem Productivity (LTEP) study on the Siskiyou National Forest in southwestern Oregon. The initial goal was to assess the effects of plant community composition and large woody debris on the processes that affect forest ecosystem productivity. When the Biscuit Fire roared through the area on August 16, 2002, the goal changed.

The Biscuit Fire was Oregon's largest recorded fire and one of the largest ever to occur on national forest land. It burned more than 499,000 acres (202,000 ha), and cost more than $150 million to suppress. Although weather contributed to fire severity through high temperatures, low nighttime relative humidity, and dry east winds, the LTEP sites burned under more moderate weather conditions.

Data are sparse for forests with mixed-severity fire regimes that encompass a wide range of fire frequencies, extents, and severities.

The LTEP sites were on the western perimeter of the Biscuit Fire, about 12.5 miles (20 km) inland from the coast. Douglas-fir, with a small amount of sugar pine and knobcone pine in the overstory, dominates the area. The subcanopy is composed of hardwoods (tanoak, Pacific madrone, and chinquapin) and Douglas-fir. These stands, established approximately 100 years earlier following a stand-replacing fire, have seen little active management. The area is classified as a mixed-severity fire regime with a fire return interval of 90 to 150 years.

Crown scorch of overstory trees on a thinned plot (left) and an untreated plot (right). The thinned plots studied suffered more damage in the Biscuit Fire than the untreated plots, probably because there were more fine woody debris and dense hardwood sprouts, fueling a more intense surface fire. Photo: Crystal Raymond, Fire and Mountain Ecology Lab, University of Washington, Seattle, WA, 2003.

By the time of the Biscuit Fire, the LTEP sites had been carefully studied, with plenty of prefire data collected. A wildland fire burning through the area was a great opportunity to study the effects of thinning on fire severity in forests with mixed-severity fire regimes.

Experimental Treatments

In the winter of 1996, 10 of the 27 LTEP treatment plots, each from 15 to 20 acres (6–8 ha) in size, were mechanically thinned using a helicopter to remove the logs. The other 17 plots were either clearcut or left undisturbed to serve as a control. Thinning from below removed most of the subcanopy hardwoods and conifers, reducing tree density from approximately 419 trees per acre (1,035 trees per ha) to 85 trees per acre (210 trees per ha). Logging slash was minimally treated on the thinned plots. On eight treatment plots, tree crowns were removed together with the last log; on two others, crowns were left onsite. In the fall of 2001, Siskiyou National Forest resource managers conducted prescribed burns in the understory of thinned plots where crowns were left onsite.

The Biscuit Fire burned through three thinned plots, one thinned–underburned plot, and two untreated plots with minimal torching of overstory trees. Burned plots are from 2,690 to 3,610 feet (820–1,100 m) in elevation, with southeast and north–northeast aspects and slopes of from 15 to 40 percent.

Study Tactics

Before the Biscuit Fire, researchers collected extensive fuels and vegetation data before and after thinning, including data on forest structure and dead and down woody debris. Following the harvest, researchers established five permanently marked and mapped 0.08-acre (0.03-ha) tree plots per treatment plot. We tagged all live trees and snags and measured diameter, species, crown class, tree height, and canopy base height. Stem mapping of trees in the plots helped us locate all trees following the fire.

In the summer of 2003, 1 year after the Biscuit Fire, we again measured stand structure and fuels and collected additional data to assess fire damage to overstory trees. Tree damage measurements included maximum bole char height, maximum crown scorch volume height, crown scorch volume (in percent—a visual estimate), and percent cambium kill. We extracted four cores per tree (uphill, downhill, and two cross-slope samples) at 1.6 feet (0.5 m) above the ground to assess cambium status. We tested each cambium sample for the presence of peroxidase, an enzyme found in all living plant tissue. One dead sample equates to approximately 25 percent cambium girdling, two samples to 50 percent girdling, and so forth.

Trees often take several years to succumb to fire damage, so mortality data collected a year after a fire do not reflect total tree mortality. However, previous studies of fire-caused Douglas-fir mortality show that percent crown scorch and percent cambium kill are the most important damage variables for predicting mortality (Peterson and Arbaugh 1988). These variables therefore allowed us to predict total fire-caused tree mortality. Crown scorch height and bole char height are more superficial damages and indicate less about long-term fire effects.

How Did Thinning Pan Out?

Our study encompassed only a few stands, and the sample size is not large enough for rigorous statistical inferences about differences in treatments. Therefore, the data presented here should be considered limited and observational rather than statistically based.

> A wildland fire burning through a long-term experiment with pre-fire data created a great opportunity to study the effects of thinning on wildland fire severity

Maximum bole char height and maximum crown scorch height were similar on all treatment plots. However, there were definite variations in crown scorch volume (fig. 1) and some variations in percent cambium girdled (fig. 2). On the thinned plots, overstory trees with a diameter at breast height of greater than 10 inches (24 cm) had the highest crown scorch volume and cambium death. On the thinned–underburned plots, overstory trees had the least crown scorch volume and cambium death. On the untreated plots, overstory trees had moderate damage and the most variability in crown scorch volume and cambium death.

The Biscuit Fire burned through the thinned and untreated plots as an intense surface fire but stopped at the edge of the thinned–underburned plot, unable to spread through the sparse surface fuels. On the thinned plots, the fire consumed the subcanopy layer of 5-year-old hardwood sprouts and the extensive fine wood that resulted from thinning. Crowns of overstory trees were nearly 100 percent scorched.

On the untreated plots, there was no evidence that subcanopy hardwood and conifer trees served as ladder fuels. The older, larger hardwood trees were not consumed. The untreated plots and the thinned–underburned plots had much lower quantities of fine woody debris prior to the fire and lower consumption of fuels during the fire.

Lessons Learned

Greater fire damage to trees from radiant and convective heat rather than crowning occurred in the thinned plots. Using Rothermel's (1983) fire prediction models in hypothetical stands, Graham and others (1999) provided a theoretical basis for greater surface fire intensity resulting from residual slash fuels and higher windspeeds in thinned stands. The high level of crown scorch within the thinned LTEP plots most likely resulted from convective heat rising from the intense surface fires below. The intensity of these surface fires was exacerbated in the thinned plots where there was more fuel in the form of fine woody debris and dense hardwood sprouts. These fuels were not present in the untreated plots, and they were consumed in the prescribed burning treatment in the thinned–underburned plot.

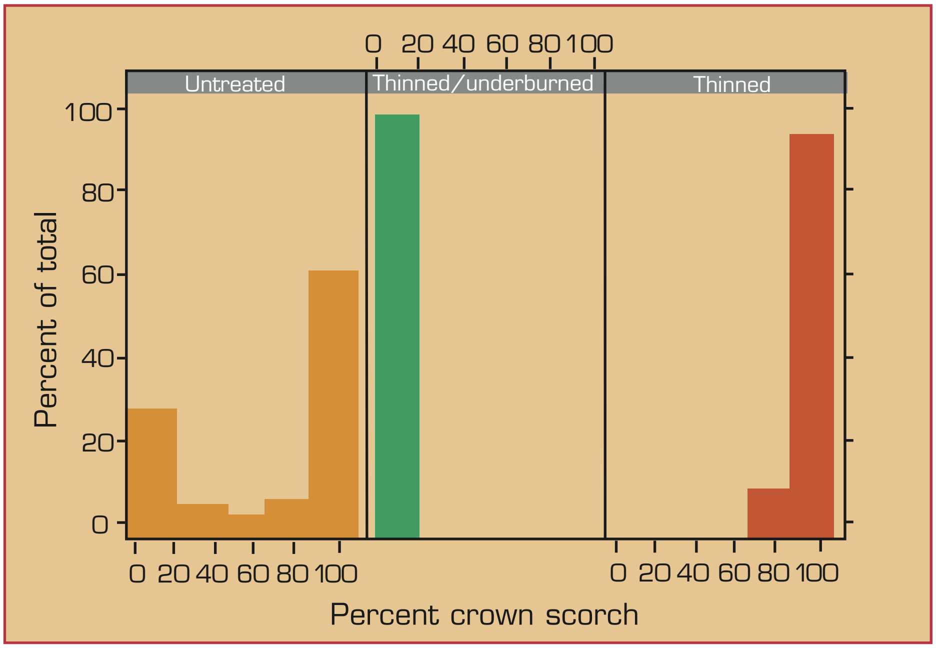

Figure 1—*Percent crown scorch in overstory trees on untreated, thinned–underburned, and thinned research plots following the Biscuit Fire of 2002. Damage was high on thinned plots, mixed on untreated plots, and low on thinned–underburned plots.*

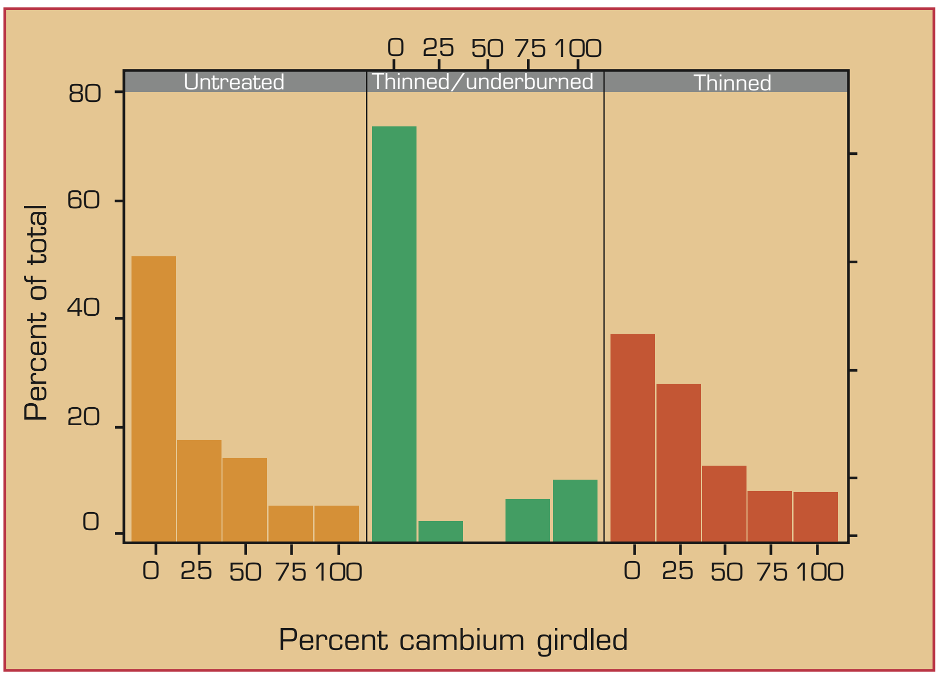

Figure 2—*Percent cambium girdled in overstory trees on untreated, thinned–underburned, and thinned research plots following the Biscuit Fire of 2002. Damage was higher on thinned and untreated plots than on thinned–underburned plots.*

In forests with mixed-severity fire regimes (especially where hardwoods are present), removing ladder fuels might actually increase damage to the remaining stand in a subsequent wildland fire. In the Biscuit Fire, the hardwood subcanopy affected fire behavior in ways other than serving as a ladder fuel. It is possible that shading by the hardwoods slowed the desiccation of dead surface fuels prior to the fire. During the fire, the hardwoods possibly decreased windspeeds in the untreated stands. In the thinned plots, consumption of hardwood sprouts probably contributed to crown scorch, whereas the older hardwoods in the untreated plots might have prevented the upward movement of heat to overstory conifers.

Observations suggest a two-step process to prevent wildfires from crowning in forests with mixed-severity fire regimes:

1. Thin dense stands to decrease ladder fuels; and
2. Remove post-thinning slash and other accumulated surface fuels to confine subsequent fire behavior to a relatively cool surface fire.

Although this two-step process is more time consuming and costly than thinning or prescribed burning alone, it appears to be more effective in enhancing suppression efforts and in reducing undesirable damage to overstory trees.

Fine fuel accumulation before (above) and after (below) the Biscuit Fire. Fine fuels accumulated following a thinning treatment after tree crowns were removed, but the Biscuit Fire almost completely consumed them. Photo: USDA Forest Service, 2003.

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Snow Camp Lookout: Remembering a Biscuit Fire Casualty

Jan Robbins

Lonely souls, perched high in their lookouts, were once the first to spot forest fires and put the suppression machine into action. Often a romantic stereotype, lookouts have become synonymous with the USDA Forest Service.

Forest fire lookouts have operated for more than a hundred years—the first was erected in 1902. Men, women, and couples, some paid and some volunteers, took their turns at this solitary activity. Some found the job trying, but others thrived.

> For a lookout, the ever-changing view can bring raptors riding on afternoon thermals, Bolander's lily in bloom, or anvil clouds foretelling thunderstorms.

Lookout History

Snow Camp Lookout on the Siskiyou National Forest in Oregon was first used during World War I, even before a structure was built on the site. The original building was constructed in 1924. During World War II, lookouts occupied Snow Camp year-round and scanned the horizon for enemy warplanes as well as smoke.

Figure 1—*Snow Camp Lookout after renovation in 1989. Photo: USDA Forest Service.*

In 1958, the Forest Service replaced the original building with a 15-by-15-foot (4.6-m x 4.6-m) "modern" lookout structure. The lookout was staffed through the 1972 fire season, then virtually abandoned for many years. In 1989, the agency began renovating the building and, in 1990, opened it to the public as a rental cabin (fig. 1).

On August 13, 2002, despite the efforts of firefighters, the Biscuit Fire incinerated Snow Camp Lookout (fig. 2). All the equipment, maps, lumpy beds, outhouse, and everything that made Snow Camp Lookout a home to so many for so many years burned to the ground.

In some ways, the panorama from the top of Snow Camp Mountain was unchanged by the fire. Clefts formed by rivers and streams, the shape of the mountains and hills, and some of the vegetation remain untouched. And eventually, of course, the forest will again be whole.

Jan Robbins is a hydrologist for the Siuslaw National Forest, Walport, OR.

Figure 2—*The remains of Snow Camp Lookout following the 2002 Biscuit Fire. Photo: USDA Forest Service.*

Place of Beauty

Snow Camp Lookout was a place of growth, beauty, and quiet joy. It provided a unique opportunity to enjoy the patterns of life and landscapes while nurturing relationships in relative comfort and privacy. In the confined space of Snow Camp, friendships were deepened, anniversaries celebrated, family ties strengthened, and endurance tested.

A fire can destroy many things, but memories are fireproof and can sometimes give new life to the past. Dedicated volunteers, some who remember and some yet to experience, are rebuilding the Snow Camp Lookout. To the delight of many, the Forest Service will again offer the building for public rental and enjoyment. ■

Contributors Wanted

We need your fire-related articles and photographs for Fire Management Today! Feature articles should be up to about 2,000 words in length. We also need short items of up to 200 words. Subjects of articles published in Fire Management Today include:

Aviation
Communication
Cooperation
Ecosystem management
Equipment/technology
Fire behavior
Fire ecology
Fire effects
Fire history
Fire science
Fire use (including prescribed fire)
Fuels management
Firefighting experiences
Incident management
Information management (including systems)
Personnel
Planning (including budgeting)
Preparedness
Prevention/education
Safety
Suppression
Training
Weather
Wildland/urban interface

To help prepare your submission, see “Guidelines for Contributors” in this issue.

Prediction Errors in Wildland Fire Situation Analyses

Geoffrey H. Donovan and Peter Noordijk

Wildfires consume budgets and put the heat on fire managers to justify and control suppression costs. To determine the appropriate suppression strategy, land managers must conduct a wildland fire situation analysis (WFSA) when:

- A wildland fire is expected to or does escape initial attack,
- A wildland fire managed for resource benefits exceeds prescription parameters, or
- A prescribed fire exceeds its prescription and is declared a wildfire.

On large wildfires, land managers sometimes conduct five or more WFSAs.

Although the WFSA process is important and land managers are required to use it, research on the accuracy of WFSA predictions is lacking. We used data from the 2002 fire season to determine how WFSA-predicted outcomes compared to actual outcomes in terms of final fire size and suppression costs.

What Is a WFSA?

The WFSA process is not prescriptive. Instead, it is a decision analysis tool that requires land managers to evaluate different suppression strategies. There are three stages of a WFSA (MacGregor 2000):

1. Criteria for evaluating suppression alternatives are identified and measurable objectives are established. Criteria include firefighter safety, potential resource damage, and loss of private structures.
2. Plausible suppression alternatives are developed. All alternatives have a strategic plan focusing on firefighter and public safety, available resources, containment time, probability of success, final fire size, resource damages, and suppression costs.
3. Suppression alternatives are analyzed. Managers assess the compatibility of a suppression strategy with forest plan objectives, safety, and probability of success. Then they select the alternative that minimizes resource damages and suppression costs.

Managers use several variables and probability estimates to assign an overall score to alternative suppression strategies. The alternatives evaluated are typically associated with either the objective (minimizing fire size, suppression costs, and so on) or the suppression strategy (direct attack, indirect attack, and so on). Most WFSAs evaluate two or three different alternatives. For each alternative, users define a target and a worst-case outcome, and they might also define an intermediate fallback outcome. For each outcome, users estimate the probability, associated suppression costs and resource damages, final fire size, and objective score.

An objective score indicates how well a particular outcome meets a series of objectives. Although users can define their own objective categories, the default categories are safety, economic, environmental, social, and other. For each alternative, users calculate an expected objective score by multiplying the probability of each outcome by its objective score, then summing the resulting scores. The expected suppression cost and resource damage are calculated in the same way. Users display estimates in a decision tree format (fig. 1).

Predicted Versus Actual Outcomes

We obtained data from the USDA's National Information Technology Center on fire size and suppression cost for 157 wildfires handled by type 1 and type 2 incident management teams during the 2002 fire season. Since WFSA data are not collected nationally, we contacted local land managers responsible for each of the 157 fires and requested their completed WFSAs. We received WFSAs for 49 fires—42 fires with only one WFSA and 7 with multiple WFSAs, for a total of 58 WFSAs. The 49 fires varied in size from 87 acres (35 ha) to about 151,000 acres (61,000 ha). The fires burned a total of almost 805,000 acres (326,000 ha) at a suppression cost of about $312 million, for an average per-acre suppression cost of about $388.

To determine the accuracy of WFSA probability estimates, we compared the estimated probability of target outcome success to the actual outcome. We asked two questions:

1. Was actual fire size smaller than target size?
2. Was actual suppression cost less than target cost?

Geoffrey Donovan is a research forester and Peter Noordijk is a research assistant, USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Across all WFSAs, the mean estimated probability of success of the target outcome was 71 percent. Actual fire data showed that fire size was smaller than target fire size for 63 percent and actual costs were lower than target costs for 44 percent of the WFSAs. Fire managers often underestimated the probability of a given wildfire exceeding its target size and costs, although they were better at predicting fire size than costs.

We used data from the 2002 fire season to determine how WFSA-predicted outcomes compared to actual outcomes.

We used a similar process to determine the accuracy of worst-case probability estimates. Across all fires, the mean estimated probability of the worst-case outcome occurring was 16 percent. Actual fire data showed that fire size exceeded worst-case fire size by 7 percent and that actual costs exceeded worst-case costs by 19 percent. Fire managers tended to overestimate the probability of actual fire size exceeding worst-case size but to slightly underestimate the probability of costs exceeding worst-case costs.

The seemingly inconsistent results are perhaps attributable to how fire managers estimate suppression costs. We hypothesize that fire managers estimate suppression costs by first estimating fire size and then estimating per-acre cost, with suppression cost being a product of the two. To determine the accuracy of per-acre cost estimates, we compared actual, worst-case, and expected per-acre costs (fig. 2).

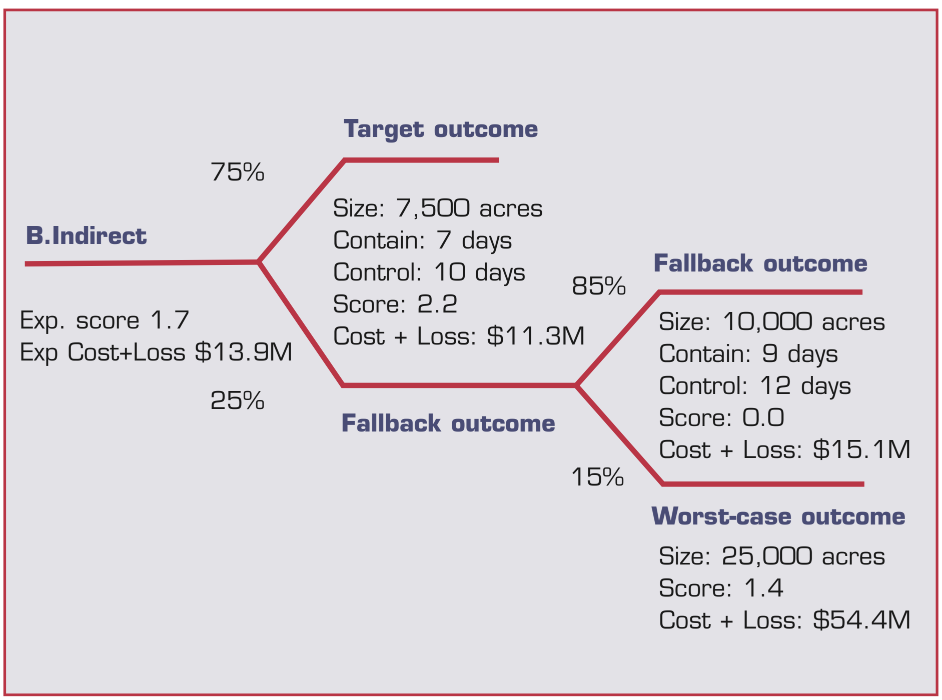

Figure 1— *This wildland fire situation analysis decision tree was used to evaluate an indirect suppression strategy for the Grizzly Complex Fire in Lake County, OR. Other alternatives (such as A. and C.) included direct attack. Percentages are probabilities of realizing a particular outcome.*

The differences between estimated worst-case and actual per-acre costs help explain why worst-case cost probability estimates are approximately correct. For fires smaller than 18,000 acres (7,300 ha)—39 of the 49 fires in our sample—worst-case per-acre costs underestimated actual per-acre costs. The tendency of fire managers to overestimate the probability of a fire exceeding its worst-case size is equivalent to overestimating fire size. If an overestimated fire size is multiplied by an underestimated per-acre cost, the two errors in estimation usually cancel each other, making worst-case cost estimates approximately correct.

This hypothesis also explains why target cost estimates are less accurate than target size estimates. Figure 2 shows that for all fires, estimated target costs underestimate actual per-acre costs. The tendency of fire managers to underestimate the probability of a fire exceeding its target size is equivalent to underestimating fire size. If an underestimated fire size is multiplied by an underestimated per-acre cost estimate, the result is a cost estimate that underestimates actual cost more frequently than target size underestimates actual size.

The data in figure 2 raise the question of why there is a difference in per-acre cost between target and worst-case outcomes. Fire size, fuel type, topography, weather, and resource availability can affect per-acre costs. However, why would labeling an outcome as target or worst-case affect per-acre costs? Such a classification is subjective and does not affect fire behavior, values at risk, or resource availability.

It appears that the optimism associated with target outcome estimates also affects per-acre cost estimates, which for the majority of fire sizes

> Fire managers often underestimated the probability of a given wildfire exceeding its target size and costs.

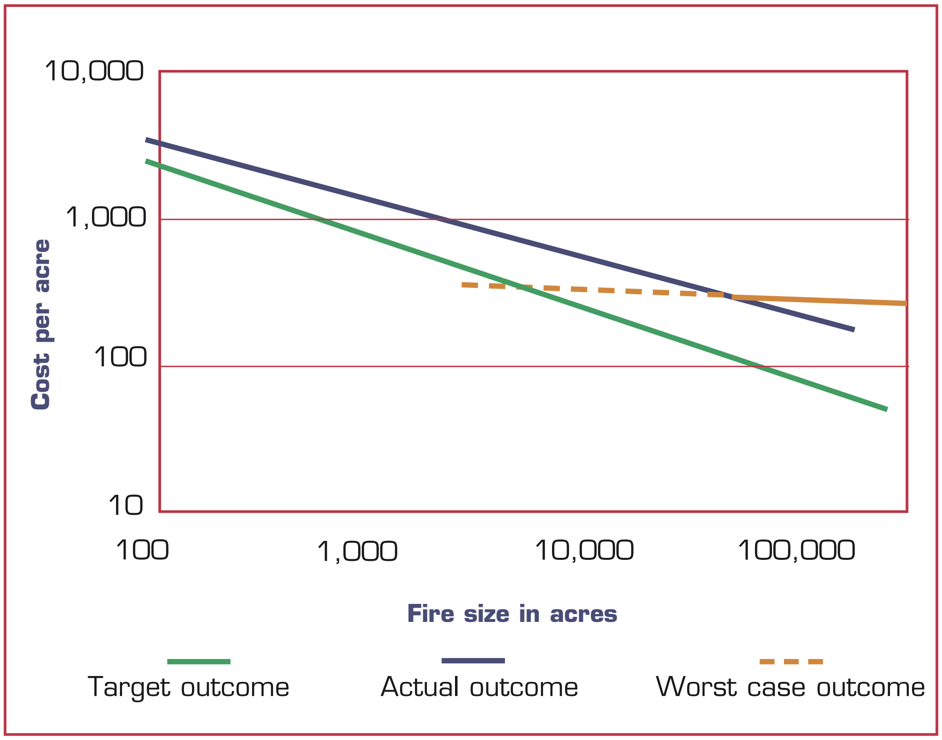

Figure 2—*Per-acre costs as a function of fire size for target outcome, worst-case outcome, and actual outcome. The trend lines do not imply a strict linear relationship between per-acre costs and fire size. The general relationship between fire size and per-acre cost is sufficient; therefore, individual data points were excluded for clarity.*

are lower than worst-case per-acre cost estimates. In addition, target per-acre cost estimates decline more with increasing fire size than worst-case per-acre cost estimates. In contrast, worst-case per-acre cost estimates are higher and show little decline with increasing fire size.

Improving Estimates

Estimating probabilities is challenging. Our results are consistent with previous research showing that people tend to underestimate the probability of likely events occurring and overestimate the probability of unlikely events occurring. For example, Lichtenstein and others (1978) asked people to estimate the frequency of various causes of death in the United States. Respondents consistently overestimated the probability of dying from unlikely causes such as tornadoes or food poisoning while consistently underestimating the probability of dying from likely causes such as heart disease or cancer.

Past research also suggests some possible ways to improve estimates. Baron (2000) has shown that when people first list the factors that they believe will influence the probability of an event occurring, their subsequent probability estimates are more accurate. Perhaps fire managers should first list factors that could influence the success of a particular strategy—such as weather, resource availability, and topography—before estimating the probability of the strategy succeeding. We also found that managers tend to estimate fire size more accurately than suppression costs. Using available historical per-acre fire costs might help improve suppression cost estimates.

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Fire in Our Mountains—and Mountains in Our Rivers*

Thomas W. Swetnam

THE UNIVERSITY OF ARIZONA TUCSON ARIZONA

A familiar statement in the media these days goes something like this: "It's the largest recorded fire in the history of the State." There is both truth and historical naiveté in that statement. Our shock over the size of these conflagrations highlights a growing problem: We are faced with a serious threat to our current course of population growth and development in the West, but we continue to ignore key lessons of the past. The truth is that part of what we are witnessing is new to our written histories. At the same time, this assertion of "largest in history" ignores the essential fact that much larger areas burned in the not-so-distant 19th century. How quickly newspapers forget their own words. On April 16, 1882, for example, the *Arizona Daily Star* noted that, "Prairie and wood fires have been raging in southern Arizona and western New Mexico recently. The territory burned over is reported to cover forty miles square [about 1 million acres or 400,000 ha]...."

Historical Fires

There are numerous other historical accounts by soldiers and pioneers of gigantic burned areas in the West during the 19th century, and we know from tree-ring studies that fires were frequent and very large. Typically, these fires burned through ponderosa pine forests about once or twice per decade. This high frequency of fire occurrence ensured that the flame lengths were low—about 1 to 3 feet (0.3–0.9 m) in height—because dead branches and other fuels were regularly consumed and so did not accumulate. The large, mature pine trees were left unharmed, except for a few that incurred "fire scars" at their base. It is from tree-ring dating of these fire scars that we find the same fire dates repeated over and over from one mountain range to another throughout the Southwest. Burning unhindered for months, fires swept over millions of acres in 1748, 1851, 1879, and 1882. The big fire years of the 20th century—1994, 1996, 2000, and 2002—are impressive to modern Arizonans, but in terms of area burned, they pale in comparison to the big fire years of previous centuries.

> The big fire years of the 20th century pale in comparison to the big fire years of previous centuries.

And yet, the big fires we are witnessing today are different in important ways from those of the past. Contrast the image of low-intensity flames a few feet in height sweeping through grass and pine needles, with the image we see today of an inferno with flames 200 feet (60 m) high rolling through the crowns of large trees. The difference is caused by changes in the fuels. The frequent low-intensity fires were eliminated between 1890 and 1900 in most Arizona forests when large numbers of sheep and cattle began to feed on the grass that was so important to the spread of surface fires. Livestock numbers fell after World War I, but then government agencies began to be more effective at detecting and putting out wildfires.

Fire Impacts Today

During the rest of the 20th century, living and dead fuels accumulated to the point that surface fires now can rapidly "ladder up" into the canopies of large trees. The very high intensity and extent of these crown fires are unprecedented in southwestern ponderosa pine forests. One of the most worrisome indications is the erosion and flooding that often follow these crown fires. Loss of ancient soils and formation of deep arroyos have occurred following recent fires in southern Arizona and elsewhere in the West.

Now add two more factors to this mix of dense forests choked with living and dead fuels: people and drought. People love to live in the midst of pine forests. The attraction is akin to our desire to build along picturesque flood plains or hurricane-prone coastlines. People usually say, "Yes, I know it's a risky place, but it's not that risky, and I'll take my chances." But of course it's not just their "chance," and they won't bear the costs alone when the worst scenario plays out. This kind of risk taking involves all of us, and it is particularly dangerous in regions

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* This article first appeared as an opinion piece in the *Arizona Republic* and the *Arizona Daily Star* on June 25, 2002.

such as the Southwest, where drought is a fact of life.

The year 2002 is panning out to be one of the driest in a century, and if we look to history we are reminded that it could get worse. Both rain gauge and tree-ring records tell us that the worst droughts in the past 1,000 years have tended to come in strings of dry years. A multiyear dry spell in the 1950s, for example, led to massive forest fires, bankruptcy of livestock ranches, and water rationing in New Mexico and Arizona. President Eisenhower declared New Mexico a disaster area and allocated Federal relief. Consider the consequences today of a 1950s-magnitude drought in the Southwest, with greatly increased populations, numerous housing developments in dense forests, and our increasing dependence on surface water from the Colorado River and Rio Grande. It's not a pretty picture.

Doing Something About It

All of this "sky-is-falling" fretting does not mean that we can't do anything about our predicament. We can save some of our forests by getting on with the job of reducing the fuels. We should keep in mind that this problem does not extend to all forests, and small-diameter trees in pine forests are the main type of tree that needs thinning. This is going to take all the tools we have at our disposal, including chain saws and prescribed fire, and a massive effort (and many dollars) for many years to come.

There is a century of collective and cumulative responsibility for this problem, and it is time to get over the blame game. Land management agencies can move beyond the "analysis paralysis" and litigation in the courts by focusing their forest thinning work on the small-diameter trees. People living in the forest can take responsibility for the risks they have exposed themselves and us to by removing fuels from around their houses and by replacing flammable roofs with metal. It is also time to enact policy, zoning, and insurance measures in "fire plains," just as we do in flood plains. If we intend to keep catastrophic fire off our mountains—and our mountains out of our rivers—we must find a way to live within a changing environment.■

Homes incinerated by the Rodeo–Chediski Fire. When it comes to policy, zoning, and insurance measures, it's time to treat our western "fire plains" just like we do our flood plains. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

Treatment Success on the Rodeo–Chediski Fire

Paul Keller

Visitors to Arizona's White Mountains come for the trees—beautiful, fragrant ponderosa pines. Sadly, many trees now resemble charred toothpicks stuck into a scorched and barren landscape. They stand in testimony to Arizona's largest recorded wildfire. The Rodeo–Chediski Fire charged across the land in the summer of 2002, decimating life above and on the ground.

Thankfully, due to appropriate forest management, many trees did survive (fig. 1).

Paul Keller, a former hotshot and journalist, is a contract writer/editor for the USDA Forest Service's Fire and Aviation Management Staff, Washington Office, Washington, DC.

> "Most places where we were able to thin and burn in the last 10 years still have green trees."
> –District Ranger Ed Collins

National Fire Plan Success

I took a drive with District Ranger Ed Collins into the burn's interior on the Apache–Sigreaves National Forest. On Collins's Lakeside Ranger District, the Rodeo–Chediski Fire charred 48,300 acres (19,546 ha), or almost 20 percent of the district's 270,000 acres (110,000 ha).

"Most places where we were able to thin and burn in the last 10 years still have green trees," said Collins. "Where we thinned and chipped, most of the trees also made it. Many will survive." Shaking his head, he added, "But a total of 32 percent of my ponderosa pine habitat was completely burned in the fire. That's what really hurts."

National Fire Plan funding helped Collins implement the fuel-density-management activities that absorbed the fire's wrath. "When a wildfire has that much energy, there's nothing to actually stop it. But look how this treated area here got the fire out of the tops of the trees and back down on the ground. By golly, it worked!" Collins motioned to a stand of ponderosa pines where flames touched the trunks but left the tops resplendent with green needles. "See, it didn't hurt these trees."

Figure 1—*Ponderosa pines in the foreground, after thinning and prescribed burning, survived the Rodeo–Chediski Fire. District Ranger Ed Collins surveys the fire's devastation in the background, where no treatments occurred. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002*

More Treatments Needed

A few miles down another drought-stricken, dusty forest road, Collins pulled his rig over.

"Look here," he said. "Over on this side of the road where we had already done thinning and prescribed fire, the trees still have their green needles—they're going to make it. If we could only do more of this thinning on a landscape scale. Right now, we're way behind the power curve. It's really sad."

He pointed to the opposite side of the road, where treatments had not been implemented, and shook his

Figure 2—*The Rodeo–Chediski Fire burned around this house but left it untouched, despite adjacent ornamental trees. The wide circular defensive space, coupled with adjacent cleared, open spaces, probably saved the home. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.*

head. Thickets of tree boles, now charred the color of obsidian, leaned up from a parched, bare earth. Where a forest once thrived, there was now no life to be seen.

Of course, due to landforms and the brute energy of the Rodeo–Chediski Fire, in some areas the thinning treatments could not save the trees. But the treated areas often knocked the fire down enough to leave brown needles on the trees—unlike the completely denuded trees where the fire was more severe.

"From a watershed point of view, these brown needles are still good for the ecosystem," Collins continued. "They will fall to the ground and help stabilize the soils. So the treatments still worked for us here, too."

Thankful Residents

When Tom Beddow, fire management officer on the Apache–Sitgreaves National Forest, drove his green Forest Service rig through the small subdivisions sprinkled among Forest Service lands, the thankful residents waved and smiled. Others stopped their vehicles and approached Beddow's idling truck. They all thanked him for protecting their homes. "You guys did a tremendous job," said one man. "You saved my home."

Not everyone was so lucky. Here and there, houses had completely disappeared—consumed by the fire. However, many homes survived thanks to fuel treatments around their perimeters (fig. 2). Beddow said that thinning and treatments in the surrounding forested areas also influenced the fire's pattern.

> Many homes survived the Rodeo–Chediski conflagration, thanks to treatments around their perimeters.

"We know something about the dynamics of fire behavior," he said. "These treatments help restructure the fire's burning characteristics. They can manipulate the fuel–air ratio in the canopy."

Lesson Learned

Less than a mile from where the fire completely incinerated dozens of homes, Beddow walked into a stand of ponderosa pine that had been thinned, logged, and understory-burned. Although the fire swept through this area, it never crowned and the trees survived.

The lesson was clear, for homes and ponderosa pine ecosystems alike: Treatments work, and we can't afford to put them off. Surveying the damage, Ed Collins summed it up. "This pains me," he said. "So much of this damage could have been lessened." ■

Operation Success: Columbia Space Shuttle Recovery

Traci Weaver

When the Space Shuttle Columbia exploded in the Texas sky on February 1, 2003, it ignited emotions and burned a memory into the collective American mind. The space shuttle disaster initiated one of the largest search efforts in U.S. history, involving more than 25,000 people and 450 organizations from all over the country. Largely due to an efficient Incident Command System (ICS), the wildland fire community remembers the 100-day Columbia Space Shuttle recovery effort as more than a tragedy—it was also a successful recovery mission.

The space shuttle disaster was a national disaster, but the Columbia recovery mission was widely seen as a success.

Firefighters: A Crucial Component

National Aeronautics and Space Administration (NASA) officials, who were initially skeptical about including firefighters, soon praised their efforts.

"Using wildland firefighters with the incident management teams was the perfect tool for the job," said Sam Ortega, NASA deputy lead onsite representative. "From the overhead to the individual crews, I never saw anything less than pure dedication to the mission. They are the reason that we are able to start a return to flight effort so quickly."

"It became evident early on that it was going to require a long-term organized effort beyond what volunteers could sustain," Stanford said, adding that recommending fire crews to NASA and the Federal Emergency Management Agency (FEMA) made sense.

Texas Forest Service

Providing 20 incident management teams and nearly 600 hand crews, the Texas Forest Service soon became a key player in the shuttle recovery effort. The search was the first incident under the new U.S. Department of Homeland Security and one of only a few Federal incidents in which a State agency had a lead role. The goals of the Texas Forest Service during the recovery mission were to ensure public safety, recover the crew, retrieve evidence, and provide public assistance.

"Initially, some questioned why the Texas Forest Service was given a lead role in Columbia recovery," Stanford said. "The answer was simple. Most of the shuttle material was recovered on private lands. We have the authority to enter private property." Texas Forest Service liaisons worked with each of the incident management teams to contact landowners, gain access to private land, and collaborate with local governments and businesses.

The Search

In 3 months, search crews located 85,000 pounds (38,600 kg) of material. That was nearly 38 percent of the reentry weight of Columbia, exceed-

Searchers sweep through a field looking for debris following the Columbia Shuttle disaster in February 2003. Photo: Jan Amen, Texas Forest Service, Lufkin, TX, 2003.

Traci Weaver is a fire prevention specialist for the Texas Forest Service, Granbury, TX.

ing the National Transportation Safety Board's initial estimate that crews would recover less than 20 percent. Searchers combed 700,000 acres (280,000 ha) by ground and 1.6 million acres (540,000 ha) by air. In the East Texas counties of San Augustine and Sabine, workers recovered the remains of the crew in just 12 days.

Enough crucial pieces of the shuttle were discovered for investigators to pinpoint the cause of the accident. A Florida interagency hand crew in Sabine County found the OEX data recorder, or "black box," which had been missed during two earlier volunteer searches.

"Our crews managed to search the entire targeted area along the flight path—a 2-mile-wide [3.2-km-wide] strip stretching from west of Corsicana to Toledo Bend Reservoir," said State Incident Commander Mark Stanford, Chief of Fire Operations for the Texas Forest Service. "Searchers traversed a mind-boggling 552,000 miles [888,000 km]."

Early search points were based on where other key elements of the shuttle were found. By March 1, NASA had opted for a grid search along the flight path. Incident management teams were tasked with planning the searches 24 to 48 hours in advance to allow for ample notification of landowners.

"Parts of the incident were routine, like briefings and planning meetings," Stanford said. "Some things were unique, like the search-and-rescue training all of the crews had to undergo. Initially, NASA wanted the search tight enough to produce a 90-percent probability of detection. They realized that was going to take too long, so they relaxed it to 80 percent."

From the beginning, it was apparent that technology would play a vital role in tracking the shuttle material and mapping the searches.

Search Challenges

An unusually wet Texas winter prompted FEMA to approve extra boots and boot-drying trailers for searchers. Much of the search area was thickly wooded and covered with briars. As spring approached, snakes and severe weather, including tornados, joined the list of hazards.

"Despite adverse weather conditions, our crews searched every day but two, and that was when Corsicana was hit with an ice storm," Stanford said. "We were under time constraints, too. We tried to cover as much ground as possible before greenup, because we knew it would be more difficult to find material once trees leafed out and everything began to grow."

Weather and critters were not the only dangers. Each crew was briefed on hazardous materials. Fifty potentially hazardous items were recovered. Searchers were also told not to key their radios within 50 feet (15 m) of suspected explosive material. No one was exposed or injured.

Because many key agencies were unfamiliar with ICS, organizational struggles developed. Those with a basic understanding of the system were able to focus efforts more quickly.

"Understanding ICS and how wildland fire agencies operate helped me early on," said geographic information system (GIS) coordinator Ronald Langhelm. "Based on our experience in New York City after 9/11, we immediately put together an interagency GIS team, which got us started on the right foot. Without that link, it could have been easy for several entities to be operating in their own bubbles."

FEMA and the U.S. Department of Homeland Security are moving toward ICS, and the Environmental Protection Agency has since adopted the system (see the sidebar on page 34).

ICS Flexibility

Flexibility during large-scale efforts is crucial, according to Paul Hannemann, Texas Forest Service chief regional fire coordinator.

"All-risk incidents are not like fire," he said. "Every one of them is different. Teams must be flexible. ICS is simply a management tool. It's our responsibility to stay focused on the mission, be flexible, and be responsive to changing demands."

Flexibility helped bring FEMA on board, said Wayne Fairley, FEMA's chief of operations for the Columbia recovery. "We accepted a system that was a little rigid to us," Fairley said. However, by being flexible, firefighters allowed the system to accept FEMA procedures.

"The ICS format that was used in the shuttle recovery provided the working avenue to bring a lot of very different agencies together to accomplish one mission," said Fairley, who has been involved in recovery efforts for 68 major national disasters. "This incident brought out the most unique interagency cooperation I've seen in my entire career."

Organization of the disaster field office (DFO) illustrates the impor-

Other Agencies Learn Value of Incident Command System

Three major national incidents prompted the Environmental Protection Agency (EPA) to begin adopting the Incident Command System (ICS), with Columbia recovery serving as the final clincher.

"The anthrax scares, 9/11, and the space shuttle disaster, all coming within a 17-month period, convinced the EPA that it had a lot to learn about crisis management and large-scale operations," said EPA Team Leader Jim Mullins.

"We had to learn to work well together nationally, not just with other agencies, but also with our own regional offices," Mullins said. "We used to function as 10 separate regions. Now we know we need to work as one corporation with 10 field offices."

The EPA had been leaning toward ICS for large-scale incidents, using the USDA Forest Service playbook for guidance. "We had learned about ICS from the wildland fire service, but most of the exposure we'd had was academic. We hadn't truly lived it," Mullins said. "The shuttle recovery propelled us a long way down the track to affirming that ICS is what we wanted to do. Living and seeing ICS in action was much more effective than reading about it in a book."

While the EPA has learned a lot about ICS from wildland fire managers, growing pains still exist, Mullins said. "Once there is an incident, and there's an incident management team in place, you work for the incident commander and not your normal boss, in an uncertain situation, for an uncertain amount of time," he said. "It's been a cultural shift for the EPA, but we absolutely believe it's the right thing to do."

The recovery effort also encouraged the Federal Emergency Management Agency (FEMA) to incorporate ICS, although the agency's version of the system is tailored, said Wayne Fairley, FEMA's chief of operations for the Columbia recovery.

"Because our disaster responses are so very different—floods, tornadoes, tropical storms and hurricanes, terrorism, etc.—FEMA had to incorporate an ICS that was just a little more flexible than that used by the Forest Service," Fairley said.

Modified or not, Mullins is optimistic that ICS can work. "It takes mountain-sized problems and breaks them down into something we can all get our arms around. The Columbia recovery was a perfect example of that."

tance of flexibility. Originally, FEMA set up DFOs in three locations. Later, the three DFOs were consolidated into one central location in Lufkin, TX.

"We were often asked why we didn't set up area command," Stanford said. "It was because this incident was unique." The DFO was a multiagency coordinating group, and it was carrying out the functions of area command, he said. "But what was really unique was that it had an operational role of coordinating the search."

Astronauts at the DFO advised the GIS lab about search locations. The GIS lab then developed the maps that were delivered to the base camps.

Role of Air Search

The air search was another unique aspect of the mission. "NASA was actively involved in the air operations," Stanford said. "The need for an air search was apparent early on because the ground crews were only searching a 2-mile-wide [3.2-km-wide] strip on either side of the flight path. The air search covered an additional 5 miles [8 km] on either side of the flight path. Team transitions would have interrupted air operations."

However, the air search, which involved 5,000 flight hours, came with a high price. A Bell 407 helicopter crashed on March 27, killing contract pilot Jules "Buzz" Mier and Charles Krenek, a Texas Forest Service aviation specialist. Three others onboard the helicopter were injured.

Sharing Lessons Learned

"It's important to carry forward and share the lessons learned," Stanford said. "By doing our jobs more efficiently and effectively, we allow Americans to begin the healing process, just like the wildland fire agencies' efforts helped NASA in its quest to return to flight."

The need to provide a continued high level of national security will likely mean that the skills and resources exemplified by wildland firefighters during the Columbia recovery mission are destined to become increasingly vital. ■

Shuttle Recovery: Largest GIS Emergency Response to Date

Traci Weaver

Many aspects of the Space Shuttle Columbia recovery were overwhelming from the start—the size and scope of the disaster, the number of agencies and organizations involved, the urgency to find crewmembers, and the need to determine the cause of the accident. Good management, technology, and organization were essential.

Gathering the Troops

Investigators had to recover as much shuttle material as possible and record where it was found to determine the cause of the accident. These tasks were compounded by the immensity of the debris field—more than a million acres (400,000 ha)

From the beginning, it was apparent that technology would play a vital role in tracking the shuttle material and mapping the searches. Images from weather radars and satellites on the morning of the accident, February 1, 2003, helped determine the debris field. To map and coordinate the information, searchers quickly turned to geographic information systems (GISs).

On February 2, Greg Atwood, district forester for the Texas Forest Service (TFS), was one of the first to respond to the disaster field office (DFO) in Lufkin, TX. He was armed with a general knowledge of GISs and a desire to help.

Atwood's first big challenge was trying to organize the members of the different agencies involved, who were "all yelling loudly … that their project was top priority and not to do anyone else's," he said.

Ron Langhelm from the Federal Emergency Management Agency (FEMA) arrived later in the afternoon to coordinate the interagency GIS. Having coordinated the GIS efforts for the 9/11 World Trade Center response, Ron came with experience.

He called an interagency meeting among FEMA, the National Aeronautics and Space Administration (NASA), and the TFS. "Interagency coordination was the key. It could have been easy for several entities to be operating in their own bubble."

Gathering the Information

Because GIS played such a pivotal role, it became an entity unto itself, although it still technically stayed under the planning section. "Because of the scope of operation and the integration of GIS into the management of the recovery effort," said TFS Fire Risk Assessment Coordinator Tom Spencer, "GIS was much more than a technical specialty on this incident."

Langhelm and John Perry, also from FEMA, organized the GIS lab at the DFO in Lufkin by function—data management, product development, and product function. A special team was brought in to handle technology management so that servers, printers, and networking were all properly functioning. Assignments were made to cover printing, data input, data presentation, and focus areas. The Environmental Protection Agency (EPA) and NASA assigned representatives to the lab to handle their agencies' special requests.

The GIS lab served multiple purposes. A phone bank took public calls when people found possible shuttle material, and TFS personnel entered the information into a database and sent it to the GIS lab. An EPA scout team then arrived at the site. Using a personal digital assistant device, the team recorded the latitude and longitude of the material. Then the material was labeled and collected. Every evening, the team downloaded the information into a database. When field searchers found shuttle material, they flagged it and an EPA recovery team followed the same procedure in retrieving the material. Maps were then made with the collected information to delineate where the shuttle material was found.

Traci Weaver is a fire prevention specialist for the Texas Forest Service, Granbury, TX.

Devising a Standard

Formatting the maps was controversial throughout the incident. "The information coming from others in the field was being delivered in a multitude of formats," Langhelm said. "A standard for data collection was necessary in our evolving data collection plan."

"The first ground search crews requested that the maps be formatted in decimal-degrees to match the settings of their [global positioning system] units, which would make it easier for them to place items on the map," said Spencer, who served as the link between the field and the DFO for GIS products. "We agreed. As other crews and teams arrived to the incident, some requested that the maps be changed back to degrees, minutes, [and] seconds. Since we had already made the decision to go with decimal-degrees, we decided to keep this format throughout the incident."

"It was an important lesson learned," he added. "Make sure you include as many key people as possible when you make the initial decision, then clearly communicate to everyone why those choices were made."

Grid Maps

Providing grid maps for such a large geographical area was challenging. For phase two of the incident, four incident management teams were brought in and set up in Corsicana, Hemphill, Nacogdoches, and Palestine. Even though the camps were spread across 190 miles (306 km) of East Texas, search managers made the decision to keep all the GIS mapping at the DFO.

"The maps were considered a matter of national security," said Incident Commander Mark Stanford. "When there are sensitive issues involved—as there always are with shuttle launches—you have to work under somewhat rigid requirements."

Some maps were archived for the historical record and the rest shredded. Initially, maps were banned from public viewing. They were off limits for use in media briefings and were not allowed for posting in public areas at the base camps until cleared by NASA.

"We learned that it is critical to be very clear upfront about any restrictions regarding GIS products, as well as the importance of proper handling of sensitive items," Spencer said. "Maintaining the integrity and proper use of the lab products had to be a total team effort between the field and the lab. There were some concerns along the way, but the teams did an outstanding job of adapting to the demands of this response."

> "Interagency coordination was the key. It could have been easy for several entities to be operating in their own bubble."
>
> –Ron Langhelm, FEMA

By mid-March, NASA had relaxed its restrictions on the incident maps. While some of the teams were cleared to make their own maps for tactical purposes, the search data were still recorded on the official map at the DFO for the archive.

By the end of the response, 115 people from across the country had worked in the GIS lab, an average of 35 people a month. The lab produced 30,000 maps, sometimes as many as 1,000 in a day, making it the largest GIS effort to date.

"There were problems, but we worked pretty aggressively to resolve any issues that would arise day-to-day, like connectivity or firewall problems," Langhelm said. "But the success part of this incident and GIS operation was incredible. To bring 115 people together, most of whom had never met, and get everyone in there working together to meet the objective is pretty amazing. In a peacetime environment, it's easy for people to get frustrated and walk away. We don't do that in a disaster mode."

Langhelm said that every disaster is different, requiring responders to adapt to an ever-changing environment. "The shuttle was a completely different scenario than 9/11," he said. "This was such a huge area, but the core management of the incident was quite small. In New York, it was the opposite."

"Interagency coordination is key, beyond that it's very dynamic," Langhelm said. "For the most part, GIS people supporting wildfire have that market cornered. It's when a new event crops up that it's challenging. Having the ability to utilize your knowledge base and technology to adapt to a new environment is critical." ■

USING SATELLITE IMAGERY FOR BURNED AREA EMERGENCY RESPONSE

Andrew Orlemann, Jess Clark, Annette Parsons, and Keith Lannom

Burned area emergency response (BAER) teams are among the first onsite specialists to visit a postfire area. BAER team members need burn severity maps within a few days of any fire so they can quickly focus their field time on assessing and mapping ecological and safety concerns.

Traditionally, burn severity maps were "quick-and-dirty" jobs made from helicopters hovering over a burn. The mapper hand-drew large, imprecise polygons on a topographic base map (fig. 1). Aerial observations were then supplemented with a cursory drive-through.

But times have changed. Through remote sensing, BAER teams now have technologically advanced maps, enabling them to quickly access the information they need.

BAER Teams Go Digital

For more than 30 years, BAER teams have conducted rapid assessments and identified potential flood and sediment source areas that could potentially pose threats to downstream life, property, and resources. When threats are identified, the teams pinpoint opportunities for remediation.

Andrew Orlemann, formerly lead analyst for the BAER mapping program at the USDA Forest Service's Remote Sensing Applications Center (RSAC), is the environmental coordinator for the Escalante Ranger District, Dixie National Forest, Cedar City, UT; Jess Clark and Annette Parsons are remote sensing/GIS analysts for RSAC; and Keith Lannom, the former operations program leader for RSAC, is now the district ranger on the Tellico Ranger District, Cherokee National Forest, Telico Plains, TN.

BAER team members need maps of burn severity within a few days after a fire so they can quickly focus on mapping ecological and safety concerns.

In 1996, the USDA Forest Service's Remote Sensing Applications Center (RSAC), in conjunction with several Forest Service hydrologists and soil scientists, tested an airborne color infrared digital camera for its ability to quickly record postfire conditions. The resulting image mosaic proved useful and led to further technique refinement and eventually commercialization. Today, BAER team leaders hire contractors to fly over and build a digital image of a burned area.

Although an excellent source of information, the process is often technologically cumbersome. The imagery must be a mosaic that is reprocessed before use. Availability is also an issue, especially in areas without contractors or aircraft to gather the data. As a result, RSAC began looking for other options.

In 2001, RSAC conducted a pilot project to provide BAER teams with moderate-resolution satellite imagery and derived products. The pilot project was so successful that RSAC acquired funding from the National Fire Plan through the Forest Service's Watershed and Air Management Staff in Washington, DC, to continue the program into 2002.

RSAC Products and Services

The basic product RSAC provides to field-level BAER team members is a satellite image (fig. 2). Whether in digital or paper form, the image provides a synoptic view of the burned area and allows for consistent mapping decisions. In addition, the image is often used to provide information to the public.

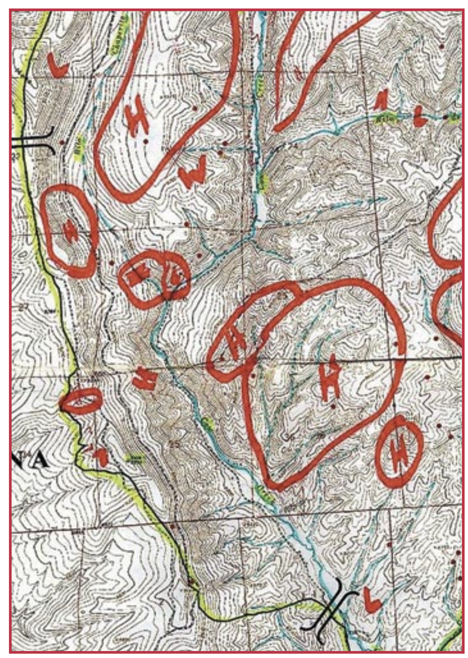

Figure 1—*Example of an early BAER burn severity map. These maps were often created by drafting rough polygons on forest visitor or topographic maps.*

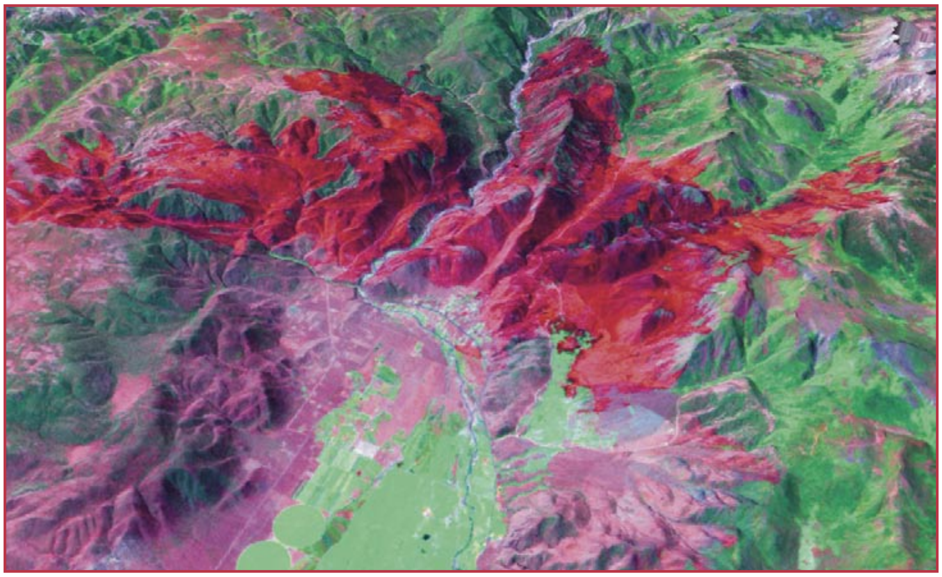

Figure 2—*Landsat 7 ETM+ image of the Cannon Fire, June 22, 2002. Burned areas appear red, healthy vegetation appears green, and bare ground or light grasses appear pink.*

If the image is cloud and smoke free, RSAC will provide a burned area reflectance classification (BARC) map. The map is typically created using change detection on band ratios, such as the Normalized Burn Ratio or the Normalized Difference Vegetation Index. The BARC output is delivered to the field in two forms. One has four classes—high, moderate, low, and unburned. The other has 255 discrete values that allow field users to make their own classification decisions.

Digital elevation models and derived products, such as slope, elevation, and aspect, are available for each BAER team. In addition, if a BAER team requests, RSAC uses the digital elevation models to create and deliver three-dimensional visualization tools, such as fly-throughs.

BAER teams use RSAC products to:

- Focus the team on areas of greatest concern,
- Develop a BAER burn severity map,
- Help predict runoff response in hydrologic models,
- Create three-dimensional models of the burned area, and
- Prepare graphics to publicize areas with increased erosion potential.

> Feedback was positive: Like Biscuit, Rodeo–Chediski was too big to effectively map in any other way.

Since its inception, the RSAC BAER support team has provided emergency satellite imagery acquisition and burn severity mapping services to more than 160 BAER teams. RSAC has purchased more than 260 satellite images and delivered imagery and derived products to BAER teams within 12 to 24 hours after satellite acquisition.

RSAC also provides technical support. Specialists work with BAER team members to help them understand and use the furnished products. They provide both onsite and online training and are prepared to join BAER teams when requested.

Examples From 2002

Hayman Fire. The Hayman Fire burned from June 8 to July 2, 2002. At 138,000 acres (56,000 ha) it was the largest fire in Colorado history, and it affected critical water supplies for Colorado's booming Front Range communities. The BAER team was under pressure to quickly create a high-quality burn severity map so treatments could begin.

On June 16, 2002, RSAC acquired a Landsat image that was only marginally useful, because it was very cloudy and the fire was still growing. Finally, on June 23, RSAC obtained virtually smoke-free imagery from both SPOT and Landsat. BARC mapping efforts began, and the BAER burn severity map was ready days later.

Biscuit Fire. Biscuit was huge, burning from mid-July 2002 into the first week of September and covering nearly 500,000 acres (200,000 ha) on the Siskiyou National Forest in southwestern Oregon. As early as August 15, RSAC obtained a Landsat image and produced a BARC map for the initial BAER team, but the image was partly smoke obscured. On August 30, RSAC obtained a nearly smoke-free Landsat image (fig. 3) and issued a new BARC map on August 31. After several helicopter reconnaissance flights and a few days of editing, the BAER burn severity map was finalized.

The feedback from the Biscuit BAER team was positive. For a fire of this size, the traditional methods of mapping via helicopter or road overlook were impractical. Other options, including high-resolution fixed wing mosaics or IKONOS images, were costly and time consuming. A 90-foot (30-m) Landsat-derived BARC map proved its worth, and the BAER team was able to complete its work in record time.

Rodeo Fire. Rodeo–Chediski was nearly as big as Biscuit, covering about 460,000 acres (184,000 ha) and threatening numerous small towns around the Apache–Sitgreaves National Forest in Arizona. Soon after it started in mid-June, a BAER team began making field observations, but afternoon clouds building along the Mogollon Rim effectively prevented the acquisition of satellite imagery.

Finally, on July 7, 2002, the day the fire was contained, RSAC obtained mostly cloud-free coverage from both Landsat and SPOT. Feedback was again positive: Like Biscuit, Rodeo–Chediski was too big to effectively map in any other way. Satellite-based postfire condition maps saved the BAER team days, perhaps weeks, of helicopter sketch-mapping. Other agencies acquired high-resolution images of the Rodeo Fire from a commercial vendor, but large file size dramatically slowed processing.

McNally Fire. The McNally Fire started on July 21 near Kernville, CA. By August 28, it had burned more than 150,000 acres (60,000 ha) on the Sequoia National Forest. The BAER team began assembling early, and RSAC collected four satellite images of the burned area, but only the fourth, acquired on August 27—1 day before containment—was a smoke-free image of the entire burned area.

The fire threatened a number of small towns, along with rare sequoia groves on the Giant Sequoia National Monument. RSAC specialists worked with BAER team members to refine BARC map production for that particular ecosystem. In the end, Sequoia National Forest personnel called RSAC's satellite support a major factor in the McNally BAER team's success.

The Remote Sensing Application Center has provided emergency satellite imagery acquisition and burn severity mapping services to more than 160 BAER teams.

The Future

Past success has shown that satellite data can facilitate the quick evaluation of postfire effects. Remote sensing technologies also promise to play a growing role in long-term BAER treatment monitoring. Recent studies by the General Accounting Office, among others, have pointed to the lack of monitoring as a problem that forest managers must begin addressing in a systematic manner. To that end, RSAC, along with its partners in Forest Service Research and the U.S. Department of the Interior U.S. Geological Survey, is building satellite-based tools and products to help rehabilitation program managers with effectiveness monitoring. For example, RSAC worked in 2004 with rehabilitation staff on the Hayman (2002) and Cerro Grande (2000) Fires to provide satellite-based vegetation recovery estimates.

For more information on RSAC or the BAER support program, visit our Website at <http://www.fs.fed.us/eng/rsac/baer>. ■

Figure 3—*Landsat 7 ETM+ image of the Biscuit Fire, August 30, 2002. The Biscuit Fire burned about 500,000 acres (200,000 ha) on the Siskiyou National Forest in southern Oregon and northern California. This image is displayed using band combination RGB = 7,4,3.*

Satellite Mapping of Wildland Fire Activity

Keith Lannom, Brad Quayle, and Mark Finco

> The MODIS sensor is well suited to the broad-scale mapping and monitoring of wildland fires.

The USDA Forest Service's Remote Sensing Applications Center (RSAC) uses satellite imagery to detect active fire locations and produce national- and regional-scale maps of wildland fire activity (fig. 1). Maps and other geospatial data on the Website provide a spatial component for the National Interagency Fire Center (NIFC) Incident Management Situation (Sit) Report. The active fire maps provide information on a fire's geographic extent and recent activity, whereas the Sit Report lists large fires, resources allocated, estimated containment date, and costs to date.

Satellite Fire Detection

In December 1999, the National Aeronautics and Space Administration (NASA) launched Terra, the first of a new generation of Earth Observation System satellites. Onboard the Terra satellite was the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor, designed for global-scale monitoring of the land, oceans, and lower atmosphere. MODIS is well suited to broad-scale mapping and monitoring of wildland fires because of its thermal imaging capabilities, wide field of view, and multiple daily overpasses.

In May 2002, NASA launched a second satellite, Aqua, with a MODIS sensor onboard. With the addition of Aqua, the number of images acquired each day by a MODIS instrument doubled.

Each MODIS sensor contains several thermal channels for identifying fire activity, a footprint 1,448 miles (2,330 km) wide that provides a synoptic view of large areas, and an orbit configuration that allows each sensor to collect thermal image data over middle to high latitudes at least twice daily.

Terra and Aqua satellites broadcast imagery data collected by each MODIS sensor in real time. Direct broadcast stations receive the data in real time, which then permits near-real-time imagery analysis.

MODIS Rapid Response

In the spring of 2001, RSAC, NASA's Goddard Space Flight Center (GSFC), and the University of Maryland (UMD) established MODIS Rapid Response—a program that exploits the capabilities of MODIS imagery to provide spatial information about wildland fires. UMD and GSFC developed algorithms that analyze MODIS imagery to detect active fire locations. RSAC operates a MODIS receiving station in Salt Lake City, UT (fig. 2).

MODIS Rapid Response makes it possible to detect fires in the Western United States in near-real time using image data collected by RSAC's receiving station. UMD and GSFC concurrently developed a system for detecting fires worldwide using MODIS imagery from the National Oceanic and Atmospheric Administration's Near-Real-Time Processing System. RSAC uses data from this system to obtain information about fires in the Eastern United States and Alaska, which are locations currently beyond the range of RSAC's receiving station.

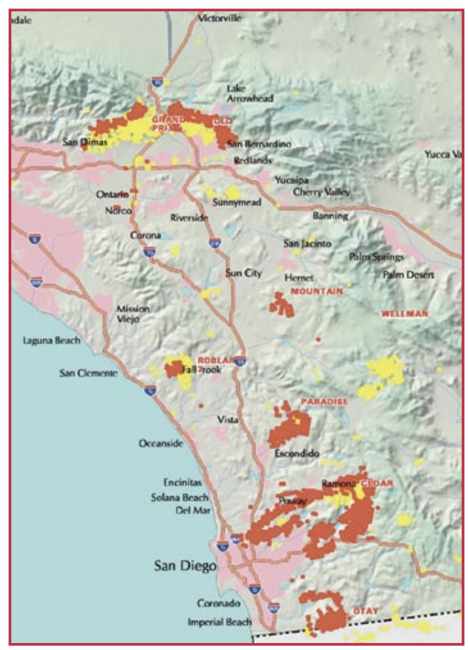

Figure 1—*Example of an active-fire map from October 27, 2003. Several wildfires occurred concurrently in wildland/urban interface areas of southern California in late October 2003. The red areas represent locations with fire activity within the previous 24 hours, and the yellow areas show locations with fire activity before that.*

Keith Lannom, the former operations program leader for the USDA Forest Service's Remote Sensing Applications Center (RSAC), Salt Lake City, UT, is the district ranger on the Telico Ranger District, Cherokee National Forest, Telico Plains, TN; Brad Quayle is the remote sensing/GIS specialist and is the senior scientist, Red Castle Resources.

Figure 2—*The Remote Sensing Applications Center's MODIS receiving station in Salt Lake City, UT, downloads imagery directly from the Terra and Aqua satellites six to eight times daily.*

Active Fire Maps

The MODIS sensor collects imagery at any location in the middle to high latitudes of the Earth at least twice daily. Some of the extreme northern latitudes are captured four to six times a day. For example, Terra collects imagery over the contiguous 48 States at approximately midday and midnight. Aqua captures the same areas about 2-1/2 hours later.

When either the Terra or Aqua satellites pass over the Western United States, the RSAC receiving station tracks the satellite and acquires MODIS data as they are broadcast from the satellite (fig. 3). The acquired data are compiled and further processed to identify active fire locations for the Western United States, Canada, and Mexico. GSFC performs similar operations to acquire imagery and detect fires on the East Coast and in Alaska.

The Aqua and Terra MODIS fire detection data from both facilities are combined and mapped on the basis of topography, State boundaries, urban locations, and major road systems to create active fire maps. Active fire maps, produced since July 4, 2001, are developed for several geographic areas that cover the entire United States and are provided in Adobe Acrobat PDF and JPG formats. The maps are updated several times daily at strategically designated times to coincide with Aqua and Terra MODIS passes. They are posted on the MODIS Active Fire Map Website at <http://activefire-maps.fs.fed.us>.

> The MODIS sensor collects imagery at any location in the middle to high latitudes of the Earth at least twice daily.

Applications of Active Fire Maps

The purpose of this project was to produce a national- or regional-scale perspective on the current wildland fire situation for wildland fire managers. Several active fire map users have developed some creative mapping applications. A county management agency in Oregon downloaded the map for their county each day and posted it on the county Website to keep the residents informed about local fire activity. Incident information staff have selected the area around their fire and posted it on the incident's Website. Using active fire maps, RSAC fulfilled an e-mail request from a tourist who was planning a vacation and wanted to avoid active fire areas.

Figure 3—*MODIS imagery of northern Utah acquired on August 12, 2001. The Great Salt Lake is visible on the left.*

Fire researchers and GIS specialists also benefit from the MODIS Rapid Response when they integrate fire point geospatial data into their research or mapping activities. The active fire detection GIS geospatial data files are available from the Forest Service Geospatial Data Clearinghouse at <http://fsgeodata.fs.fed.us>. The 2004 file is updated hourly, the 2002 and 2003 files are for each year, and the 2001 file covers July 4, 2001, to December 31, 2001.

Thanks to the collaborative efforts of RSAC, GSFC, and the UMD, the MODIS active fire maps provide a rapid, consistent, and easily accessible source of fire mapping for the United States. Active fire maps are used with the NIFC Sit Report as well as for strategic planning by the interagency fire community and for general public information. ■

Guidelines for Contributors

Editorial Policy
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.

Submission Guidelines
Submit manuscripts to the general manager at:

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Attn: Melissa Frey, F&AM Staff
Mail Stop 1107
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Washington, DC 20250-1107
tel. 202-205-0955, fax 202-205-1401
e-mail: mfrey@fs.fed.us

Mailing Disks. Do not mail disks with electronic files to the above address, because mail will be irradiated and the disks could be rendered inoperable. Send electronic files by e-mail or by courier service to the managing editor at:

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Attn: Hutch Brown, Office of the Chief
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201 14th Street, SW
Washington, DC 20024
tel. 202-205-0878, fax 202-205-1765
e-mail: hutchbrown@fs.fed.us

If you have questions about a submission, please contact the managing editor, Hutch Brown.

Paper Copy. Type or word-process the manuscript on white paper (double-spaced) on one side. Include the complete name(s), title(s), affiliation(s), and address(es) of the author(s), as well as telephone and fax numbers and e-mail information. If the same or a similar manuscript is being submitted elsewhere, include that information also. Authors who are affiliated should submit a camera-ready logo for their agency, institution, or organization.

Style. Authors are responsible for using wildland fire terminology that conforms to the latest standards set by the National Wildfire Coordinating Group under the National Interagency Incident Management System. *FMT* uses the spelling, capitalization, hyphenation, and other styles recommended in the United States Government Printing Office Style Manual, as required by the U.S. Department of Agriculture. Authors should use the U.S. system of weight and measure, with equivalent values in the metric system. Try to keep titles concise and descriptive; subheadings and bulleted material are useful and help readability. As a general rule of clear writing, use the active voice (e.g., write, "Fire managers know…" and not, "It is known…"). Provide spellouts for all abbreviations. Consult recent issues (on the World Wide Web at <http://www.fs.fed.us/fire/fmt/index.html) for placement of the author's name, title, agency affiliation, and location, as well as for style of paragraph headings and references.

Tables. Tables should be logical and understandable without reading the text. Include tables at the end of the manuscript.

Photos and Illustrations. Figures, illustrations, overhead transparencies (originals are preferable), and clear photographs (color slides or glossy color prints are preferable) are often essential to the understanding of articles. Clearly label all photos and illustrations (figure 1, 2, 3, etc.; photograph A, B, C, etc.). At the end of the manuscript, include clear, thorough figure and photo captions labeled in the same way as the corresponding material (figure 1, 2, 3; photograph A, B, C; etc.). Captions should make photos and illustrations understandable without reading the text. For photos, indicate the name and affiliation of the photographer and the year the photo was taken.

Electronic Files. See special mailing instructions above. Please label all disks carefully with name(s) of file(s) and system(s) used. If the manuscript is word-processed, please submit a 3-1/2 inch, IBM-compatible disk together with the paper copy (see above) as an electronic file in one of these formats: WordPerfect 5.1 for DOS; WordPerfect 7.0 or earlier for Windows 95; Microsoft Word 6.0 or earlier for Windows 95; Rich Text format; or ASCII. Digital photos may be submitted but must be at least 300 dpi and accompanied by a high-resolution (preferably laser) printout for editorial review and quality control during the printing process. Do not embed illustrations (such as maps, charts, and graphs) in the electronic file for the manuscript. Instead, submit each illustration at 1,200 dpi in a separate file using a standard interchange format such as EPS, TIFF, or JPEG, accompanied by a high-resolution (preferably laser) printout. For charts and graphs, include the data needed to reconstruct them.

Release Authorization. Non-Federal Government authors must sign a release to allow their work to be in the public domain and on the World Wide Web. In addition, all photos and illustrations require a written release by the photographer or illustrator. The author, photo, and illustration release forms are available from General Manager April Baily.

Photo Contest Announcement

Fire Management Today (*FMT*) invites you to submit your best fire-related images 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 with the images and captions (as submitted) remaining after technical and safety reviews. Winning images will appear in a future issue of *FMT* and will be publicly displayed at the Forest Service's national office in Washington, DC.

Winners in each category will receive:

- 1st place—Camera equipment worth $300 and a 20- by 24-inch framed copy of your image.
- 2nd place—A 16- by 20-inch framed copy of your image.
- 3rd place—An 11- by 14-inch framed copy of your image.
- Honorable Mention—An 8- by 10-inch framed copy of your image.

Categories

- Wildland fire
- Prescribed fire
- Wildland/urban interface fire
- Aerial resources
- Ground resources
- Miscellaneous (fire effects; fire weather; fire-dependent communities or species; etc.)

Rules

- The contest is open to everyone. You may submit an unlimited number of entries taken at any time. No photos judged in previous *FMT* contests may be entered.
- You must have the right to grant the Forest Service unlimited use of the image, and you must agree that the image will go into the public domain. Moreover, the image must not have been previously published.
- We prefer original slides or negatives; however, we will accept duplicate slides or high-quality prints (for example, those with good focus, contrast level, and depth of field). Note: We will not return your slides, negatives, or prints.
- We will also accept digital images if the image was shot at the highest resolution using a camera with at least 2.5 megapixels or if the image was scanned at 300 lines per inch or equivalent with a minimum output size of 5 × 7. Digital-image files should be TIFFs or highest quality JPGs.
- You must indicate only one competition category per image. To ensure fair evaluation, we reserve the right to change the competition category for your image.
- You must provide a detailed caption for each image. For example: *A Sikorsky S–64 Skycrane delivers retardant on the 1996 Clark Peak Fire, Coronado National Forest, AZ. Photo: name, professional affiliation, town, state, year image captured.*
- A panel of judges with photography and publishing experience determines the winners. Its decision is final.
- We will eliminate photos from competition if they are obtained by illegal or unauthorized access to restricted areas; lack detailed captions; have date stamps; show unsafe firefighting practices (unless that is their express purpose); or are of low technical quality (for example, have soft focus or show camera movement).
- You must complete and sign a release statement granting the USDA Forest Service rights to use your image(s). Mail your completed release with your entry or fax it to 970-295-5815 at the same time you e-mail your digital-image files.

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Fire Management Today Photo Contest
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Fort Collins, CO 80526
or
e-mail images and captions to:
mdillon@fs.fed.us and
fax signed release form to
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Postmark Deadline

First Friday in March

SAMPLE PHOTO RELEASE STATEMENT

Enclosed is/are _________(*number*) image(s) for publication by the USDA Forest Service. For each image submitted, the contest category is indicated and a detailed caption is enclosed. I have the authority to give permission to the Forest Service to publish the enclosed image(s) and am aware that, if used, it/they will be in the public domain and appear on the World Wide Web.

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