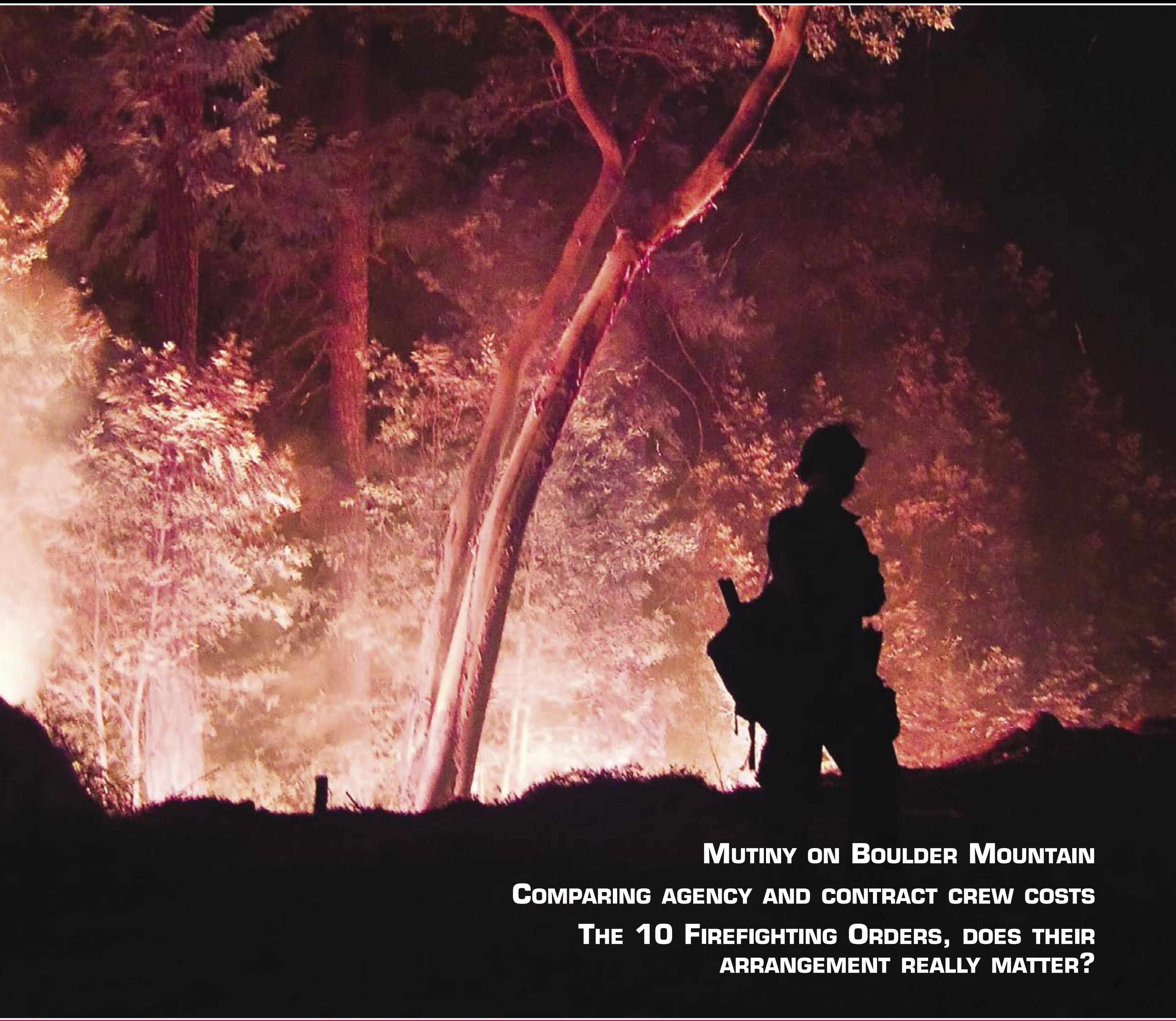
Fire Management today

Volume 67 • No. 1 • Winter 2007



MUTINY ON BOULDER MOUNTAIN

COMPARING AGENCY AND CONTRACT CREW COSTS

THE 10 FIREFIGHTING ORDERS, DOES THEIR ARRANGEMENT REALLY MATTER?

United States Department of Agriculture
Forest Service

Coming Next...

Just 16 years after the Wright brothers' historic first flight at Kitty Hawk, the Forest Service pioneered the use of aircraft. The next issue of Fire Management Today (67[2] Spring 2007) will focus on the rich history and role of aviation in wildland fire. This issue will include insights into the history of both the rappelling and smokejumping programs, the development of the wildland fire chemical systems program, and what's new with the 747 supertanker. The issue's special coordinator is Melissa Frey, general manager of Fire Management Today.

Fire Management Today is published by the Forest Service of the U.S. Department of Agriculture, Washington, DC. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department.

Fire Management Today is for sale by the Superintendent of Documents, U.S. Government Printing Office, at:
Internet: bookstore.gpo.gov Phone: 202-512-1800 Fax: 202-512-2250
Mail: Stop SSOP, Washington, DC 20402-0001

Fire Management Today is available on the World Wide Web at <http://www.fs.fed.us/fire/fmt/index.html>.

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On the Cover:

On the Cover: Beauty and the Beast—A wildland firefighter is silhouetted under a madrone tree during night burnout operations on the 2005 Blossom Complex on the Siskiyou National Forest, Medford, OR. This photo earned second place honors in the "ground resources" category in Fire Management Today's *2006 photo contest. It was taken by Eli Lehmann, squad leader on the Baker River Hotshot Crew, Mount Baker–Snoqualmie National Forest, Concrete, WA.*

The Forest Service's Fire and Aviation Management Staff has adopted a logo reflecting three central principles of wildland fire management:

- *Innovation:* We will respect and value thinking minds, voices, and thoughts of those that challenge the status quo while focusing on the greater good.
- *Execution:* We will do what we say we will do. Achieving program objectives, improving diversity, and accomplishing targets are essential to our credibility.
- *Discipline:* What we do, we will do well. Fiscal, managerial, and operational discipline are at the core of our ability to fulfill our mission.

Firefighter and public safety is our first priority.

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Mutiny on Boulder Mountain

James M. Hagen

The year was 1943. The United States was at war. Manpower here on the homefront was short on strong, able-bodied men. Women, old men, and young boys were filling the gaps left by our men who were away in the Armed Forces.

I was one of those boys—an Eagle Scout, 16 years old. I was spending the summer on the staff of Boy Scout Camp Geronimo near Payson, AZ. In those days, the camp was located across the road from Kohl's Ranch on Tonto Creek. (It has since been relocated closer to Pine, AZ.)

I—along with friend and fellow scout, John Shipley—was in charge of the handicraft lodge where many of the scouts would work on craft kits or make articles from leather. Moccasins and tooled-belts were the favorites. The aroma of the fresh leather, purchased from Porter's Saddle Shop in Phoenix, added to the pleasantry of our craft shop environment.

> We had absolutely no knowledge of this firefighting business and were literally conscripted into service.

At the end of a very hot summer day, we had just gathered to eat in the dining hall when some Forest Service personnel came in and asked for all young men 16 years and older to stand up.

I stood. So did 10 other young men, mostly fellow camp staff members.

Whatever this was, it sounded very serious. There was no time, however, for questions and answers—only to listen and respond. "Come with us" were our orders. Before we knew it, we found ourselves recruited as firefighters.

> "Come with us" were our orders.

We had absolutely no knowledge of this firefighting business and were literally conscripted into service. But, of course, all of us were excited at the prospect of a great adventure.

With no time for packing, planning, or other preparations, we were herded into the back of a stake-body truck and sent speeding southward through the dust of the Bush Highway, predecessor to today's Highway 87. Back then, the Bush Highway was unpaved, narrow, and always a difficult and hazardous travel route.

Our destination was still unknown to us.

Our driver, known as "Punjab," was a big, burly East Indian man who drove the winding roads with a vengeance. When we sailed through the Sycamore Creek area, we had to hit the deck on the truck's bed to avoid being whipped by the Sycamore tree branches.

The tiny community of Sunflower—usually just a pit stop for something cold to drink—was about half way to Phoenix. Just before this more or less wide spot in the road, we pulled over at the Forest Service's Sunflower Ranger Station (part of today's Mesa Ranger District, Tonto National Forest). By now, it was dark. The ranger suggested we get some sleep before starting out for the fire front. Most of us had grabbed our sleeping bags as we'd exited Camp Geronimo. This would be the last good night's sleep we would get for nearly 2 weeks.

Meet the Brush Hook

Before daylight, we were awakened and given our firefighting tools and marching orders. The fire was on Boulder Mountain, located southeast of Sunflower. There in the early dawn we could see the smoke nearly 5 miles away.

James Hagen, 80, of Payson, AZ, was a 16-year-old Boy Scout in 1943 who was conscripted into helping suppress the Boulder Mountain Fire on the Tonto National Forest. He would be dispatched to two other Arizona wildfires during his Boy Scout years. He went on to fly airplanes in the U.S. Navy, and, at age 40, earned a B.S. in physics while working full time. In 1994, before retiring from a 46-year career in engineering, he designed a countermeasures system for the Air Force One presidential 747 aircraft to protect it from shoulder-fired heat-seeking missiles. Fire Management Today *is indebted to Cindy Frantsen, a resource clerk for the Payson Ranger District, Tonto National Forest, for bringing this article by Mr. Hagen to our attention.*

We would have to "hoof it" to the fireline.

Each of us was given a firefighting tool—axe, rake, hoe—that would become our constant companion. I received a tool I'd never even heard of before: a brush hook. With its heavy head and long, sharp-curved blade, this hybrid between an axe and a scythe was used to cut and clear brush.

Whatever tool you ended up with pretty much determined what tasks you would be assigned. I was to soon learn that just a few hours of swinging that brush hook could tire out even a strong adult.

The next thing we know, an older man says "come," and off we go—leaving everything behind except the clothes on our back and our one assigned firefighting tool. (We would sorely miss our sleeping bags.) It was rough climbing and a long hike up the mountain to get to the fireline—especially when carrying such a heavy tool.

Communications were utterly lacking. Our parents, siblings, and friends would not know about our "adventure" until it was completely over. There were no news helicopters or journalists to let the rest of the world know that this fire even existed. We were going off into the wild unknown.

Out-of-Control Fire

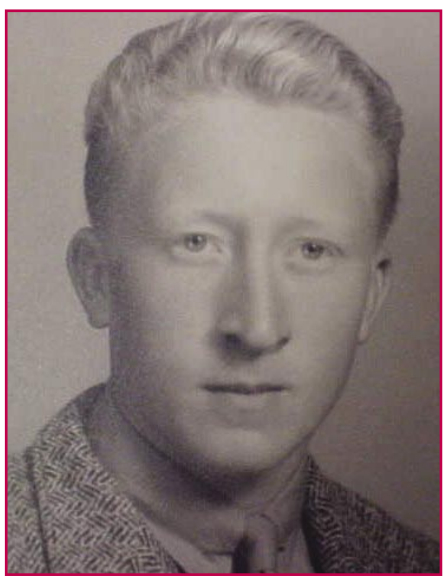
As we approached the fire, we heard a noise that was ominous—almost frightening. It sounded like the roar of Niagara Falls. Our leader explained it was the fire devouring everything in its path. That roar never let up. It only, at times, intensified. Our previous thrill of adventure was now taking on a more serious tone.

> This would be the last good night's sleep we would get for nearly 2 weeks.

Our 11 young, inexperienced—but energetic—scouts were joined by 10 seasoned, experienced, and much older men. That made a total of 21 of us to fight a completely out-of-control fire that had already burned more than 1,000 acres (405 ha) of cedar, scrub oak, mesquite, and manzanita.

The fire was burning westward on the north side of Boulder Mountain, which is comprised of a series of north–south ridges that drop down into the valley below. Each ridgetop would be a potential place where a firebreak might stop the raging inferno's advance.

> After several days, our confidence and morale were approaching the breaking point.



Jim Hagen, at 17, 1 year after the young Eagle Scout experienced the trials and tribulations of being a conscripted wildland firefighter.

John Shipley and I had known each other for many years. We worked closely together on the fireline just like we had labored together at different tasks many times before. While we were good friends, we were opposites in personality. John was a laidback, fun-loving and joking type of person. I tended to be more quiet and serious. We complemented each other and worked well together.

Laboring in close proximity on the fireline proved to be a good bonding experience.

The Fury and Power

The first day's assignment was to build a firebreak down a long north–south ridge located west of the fire. This would consume all of what was left of the day. Even though the work was difficult, we tackled the job with enthusiasm. Much of the brush was stubborn manzanita that could not be hoed, chopped, axed or otherwise moved—not even with the brush hook. Consequently, we learned that the firebreak had to detour around such obstacles.

Late that evening, we quit due to lack of visibility and moved out of the danger area onto a high point away from the fire. That night we watched as the fire crossed the bottom of the canyon and roared (loud as a jet plane) up the hill right toward our firebreak.

Reaching the hilltop, the flames leaped hundreds of feet into the air, scattering sparks everywhere. We watched in amazement and wonder at the awesome force of this firestorm. That wildfire—with its power, fury, and thunderous noise—was like nothing any of us had ever experienced before.

We watched as the fire jumped our line and started its slower burn down into the side of the next canyon. Our job the next day would be to once again build a firebreak down another ridge—out ahead of the fire.

In case you're wondering: *"Where were the hotshots, the water-drop helicopters, the slurry bombers, the bulldozers?"*—that's easy to answer. They didn't exist.

Fires, back then, were fought the old-fashioned way: with handtools and hard labor. Of course, even then, we were wondering if there wasn't a better way. The thrill of our new adventure was soon gone. It was now just a hot, dusty, smoky, and backbreaking full-time task.

We Were Approaching the Breaking Point

Our second day was a repeat of the first: work a 16-hour day hoeing, raking, axing and whacking down bushes and small trees to make a not-very-wide break down a very long ridge. Then, just before dark, we would retreat to a safe spot to watch the fire advance and jump our firebreak—again and again.

Feelings of hopelessness were gradually creeping into our minds. But, even so, we approached each new day with a determination to conquer this ugly beast.

> Mutinous talk began circulating among our band of scouts.

The rugged, rocky terrain took its toll on us in many ways: wounds from cactus and sharp brush; sprains from stumbling over rocks; and sunburn from long, hot days with absolutely zero shade.

After several days, our confidence and morale were approaching the breaking point. By about the sixth day, my boot soles had come loose. With every step, they clacked like a pair of flippers. But I lived with it. There wasn't even such a thing as "duct tape" to mend them.

> Our parents, siblings, and friends would not know about our "adventure" until it was completely over.

We wore the same clothes for the duration of the fire. With barely enough water to drink, there was no water to wash with or to brush our teeth—even if we had possessed a toothbrush.

The older men couldn't shave. Their beards became traps for dust and the soot from the fire. Those few who had hats had a distinct white band across their foreheads, just above the black of their faces. We had become quite a motley crew.

In case you're wondering: "*Where were the hotshots, the water-drop helicopters, the slurry bombers, the bulldozers?"*—that's easy to answer. They didn't exist.

Huge Rattlesnake

The work went on and on each day. It was always a repeat of the previous day. We would spend an entire day building a firebreak—only to watch the fire jump our barrier that night and head toward the next ridge.

This became extremely frustrating and heartbreaking. It made the whole situation seem futile.

One day we had a couple of spot fires outside the main fire area. John Shipley and I were assigned to get to these quickly and put them out before they could spread. We made a good team and the task was soon done. That work was exciting and rewarding. But even more thrilling was the huge diamondback rattlesnake that we discovered.

That snake was at least 6 feet (1.9 m) in length and 3 to 4 inches (8–10 km) in diameter. It was the largest rattler either of us had ever seen. We wanted to kill him for the skin and rattles, but he escaped into a cavern under a large rock shelf. Rather foolishly, we grabbed a long yucca stalk and tried to pull him out. We poked and prodded, but the rattlesnake was deeply entrenched in his rocky retreat. We needed to get back to the main fireline. This wouldn't be the last rattler that we would see on that mountain.

Mutinous Talk Begins

One day when our drinking water was almost gone, our leader showed us how to find water by digging a deep hole in the sand of an arroyo

The Tricks of Firefighter Survival

On the 1943 Boulder Mountain Fire, T-shirt and blue jeans were our firefighting uniforms. This might have been fine down in the valley. But up there on that mountaintop, the night air became very cold. Not one of us had a jacket or even a warm shirt.

How could you get any sleep when you had goose bumps and your teeth were chattering?

One of the old timers finally showed us how to sleep warmly. Making a bed of hot coals and covering it with dirt provided a warm—albeit unique—way to survive the night. You had to be careful, though. You didn't want to toss or turn too much in your bed—you might stir up the coals. Throughout the night, more than one *"ouch!"* could always be heard.

What about food and water? A light aircraft, flown out of Phoenix by A.L. Moore and Sons Mortuary and a Civil Air Patrol member, attempted to drop us food, tools, and water.

No Drinking Water, A Few 'Dog Biscuits'

We got the food. But the tools—floated down by parachute—drifted off into a distant canyon. We never found them. The water, on the other hand, was pointed right at our location. This seemed to be a perfect drop. But when its parachute opened, the handle ripped off of the water canister and all the water shot down like a bomb, exploding in our midst—right along with our parched hopes for good, clean potable water.

Our food was Army K-rations. This consisted of a wax-sealed box that contained a small can of precooked food, a few hard "dog biscuits," and a bar of high melting-point chocolate. Beggars can't be choosers. Each day, we were glad for our two or three K-rations. And that chocolate was as precious as gold.

Every day someone took our one pack mule and went to a distant horse-watering trough to bring back our drinking "water." It was always brackish. We drank it anyway.

Our first casualty was a scout who fell off the mule into a cactus. He got cactus spines under his skin that could not be removed without surgery. He was sent out—leaving 20 of us to continue on.

At first, we felt sorry for him. But we later realized that he was the lucky one.

- James M. Hagen

near green vegetation. He dug the hole and found moisture that, given time (probably hours), would seep into the hole and provide enough water for survival. We were too busy to wait for the water to seep in. But just the knowledge that it was there was somehow comforting.

By about the seventh or eighth day, we were 10 young men who were tired, hungry, thirsty, and completely ragged. The blistering days and frigid nights and hard work were taking their toll on the morale of the troops. It didn't seem to bother the older men, but the rest of us were mumbling in our beards—that we didn't even have yet!

> There were no news helicopters or journalists to let the rest of the world know that this fire even existed. We were going off into the wild unknown.

What little food and water we were given had become even further rationed. The brackish water that they supplied us was hardly fit to drink. And there was absolutely no way that the 21 of us could possibly stop that fire. Mutinous talk began circulating among our band of scouts. We desperately wanted to leave and return to civilization.

Our talk included how we might slip away. How we might get back the 60 miles or so to Camp Geronimo. But, if we did this, what fate would await us? Walk the plank? Face a firing squad? By comparing our situation to that of our faraway friends in the Armed Forces, we managed to squelch our overriding urge to mutiny. We finally realized that, compared to soldiers in combat, we had it good—or, at least, so we rationalized.

Rejuvenation and Reinforcements

I think it was the eighth day—wonder of wonders—that the Forest Service came driving up the mountain in 4-wheel-drive trucks with food, water, and more than 100 American Indians from New Mexico to join our effort. Instead of bugle calls and shouts of "the cavalry is coming," it was truck horns blowing and "Indians to the rescue!"

That night they prepared a true feast for us. Huge steaks broiled over a bed of coals, fried potatoes, corn, biscuits, fresh water, and coffee. All you could eat. Nothing could ever have tasted better. Our thanksgiving for this was surely as great as that of the pilgrims at Plymouth Rock. We, too, were outnumbered by American Indians—and we were truly thankful for their presence.

> We approached each new day with a determination to conquer this ugly beast.

> As we approached the fire, we heard an ominous noise. It was the fire devouring everything in its path.

With a rejuvenated crew of 21 and more than 100 reinforcements, over the next 2 days the fire was contained. It had burned nearly 20,000 acres (8,094 ha) before being stopped. A crew of happy men—and boys—left that Boulder Mountain area rejoicing that a difficult mission had been accomplished.

Jim Hagen, 80, with the firefighting brush hook tool that his teenage hands had wielded on the Boulder Mountain Fire more than 6 decades ago. Photo by: Gloria Alliger, Forest Service, Payson Ranger District, Tonto National Forest, 2006.

At $1 per hour, 10 scouts went home a bit richer materially, but far richer for their experience on the fireline. The mutiny never occurred, nor was it mentioned aloud (outside our group of young men), and we were thankful for that and for the lessons learned.

These lessons would last a lifetime: firefighting techniques, the value of hard work, the spirit of cooperation, patience, persistence, endurance, and survival skills. Such things cannot be bought at any price. The reward for our efforts was the satisfaction of accomplishing a seemingly impossible task under extremely difficult situations. ■

Comparing the Costs of Agency and Contract Fire Crews

Geoffrey H. Donovan

Has the increasing use of contract fire crews (20-person type 2 fire crews) by our public land management agencies over the past 5 years contributed to these agencies' rising fire suppression costs? (See table 1.)

A superficial comparison of the wage rates of agency and contract firefighters would seem to indicate that contract crews are more expensive. Such a comparison, however, is misleading for two main reasons:

- The wage rate of a contract crew includes a number of costs not included in agency crew wage rates, such as training and equipment expenses.
- Contract crews are only called on—and paid—when needed. An agency crew is paid irrespective of whether actual fire suppression work is available, although agency crews often do other work, such as fuel management, when not engaged in actual fire suppression.

To provide managers with better information about the relative cost of contract and agency fire crews, I have synthesized the results of two recent studies. The first study compared the cost of Forest Service and contract fire crews that were dispatched in Oregon and Washington (The Pacific Northwest Region) during the 2003 fire season (Donovan 2005). The second study,

Geoffrey Donovan is a research forester for the Forest Service, Pacific Northwest Research Station, Portland, OR.

The results of two recent studies were combined to provide managers with better information about the relative costs of contract and agency fire crews.

Important Caveat

One key assumption of the studies summarized in this article needs to be noted.

The author assumed that all 20-person type 2 fire crews are equally productive. Conversations with managers by this article's author, however, suggest that this is not the case. Some contract crews are just as productive as agency crews; whereas, others are not.

"However," explains Geoffrey Donovan, the article's author, "nobody was able to suggest a simple way to determine a crew's productivity in advance."

Donovan continues: "Less costly contract crews were not necessarily less productive than more expensive crews. Nonetheless, as long as systematic differences in productivity exist, extra care should be taken when interpreting the results presented here."

In addition, Donovan said that the modeling approach he outlines in this article could also be used in other regions of the country for comparing other types of resources such as engines and aerial resources.

Table 1 – *Total Federal wildfire suppression costs and the number of private fire crews under contract in the Pacific Northwest from 1999 through 2004.*

Year	Total Federal suppression costs	Number of crews under contract in PNW
1999	$523,468,000	78
2000	$1,362,367,000	117
2001	$917,800,000	207
2002	$1,661,314,000	264
2003	$1,326,138,000	297
2004	$890,233,000	298

which built on the first, developed a model to identify the optimal mix of agency and contract fire crews for an upcoming fire season (Donovan 2006).

To correctly estimate the price tag of an agency fire crew, a variety of costs besides wages must be considered.

Forest Service Fire Crew Costs

To correctly estimate the price tag of an agency fire crew, a variety of costs besides wages must be considered, including:

- Retirement,
- Healthcare,
- Social Security,
- Workers' compensation—the Forest Service is self-insured for workers' compensation claims,
- Human resource support,
- Training,
- Vacation,
- Unemployment,
- Equipment, and
- Transportation.

The most significant of these costs are retirement, healthcare, and Social Security. When combined, these three expenses add 26 percent to the base cost of a permanent firefighter and 8 percent to the cost of a temporary firefighter.

Table 2 shows the contribution of the other cost categories. All costs were estimated based on a 14-hour workday with a total of 90 workdays in a fire season. These costs were calculated for a sample of 33 crews dispatched in the Pacific Northwest Region during the 2003 fire season. Several simplifying assumptions were also made. (For a complete discussion of how these costs were estimated, see Donovan 2005.) Overall, the data in this table provide insight into the general magnitude of these costs.

Other Cost Factors

Other factors that significantly affect costs are overtime and hazard pay. Government scale (GS) firefighters receive an additional 50 percent in pay for all hours over a normal 8-hour workday. Furthermore, all GS firefighters receive an additional 25 percent increase in pay if their assigned fire is categorized as "uncontrolled." (For this study, an assumption was made that 80 percent of hours were on uncontrolled fires.)

Combining all these categories of costs provided a mean daily cost (14-hour day) of $5,539. For comparison, just considering the base wage rate of crew members (with no overtime or hazard pay) results in a daily cost of $3,023.

The majority of this study's 33 crews reflected a daily cost of between $5,200 and $5,700. Four crews, however, had a daily cost that exceeded $5,700. One crew's daily cost was $7,500.

This variation was due to differences in the crew members' pay grade. The more expensive crews were typically ad hoc crews whose members had permanent nonfirefighting jobs within the agency.

In contrast, dedicated fire crews, comprised mainly of temporary employees, tended to be less costly. Although there might be good reasons for including higher grade employees on a fire crew, managers should be aware that doing so can significantly increase a crew's cost.

Contract Crew Costs

In contrast to agency crews, most of the cost of hiring a contract crew is included in its wage rate. Similar to agency crews, contract crew costs vary significantly.

In the Pacific Northwest Region, these private fire crews sign contracts with any one of 13 dispatch centers, agreeing on the price and number of crews to be provided. When a fire occurs, dispatch responsibility goes to the closest dispatch center. Agency (Federal and State) crews are dispatched first.

Should insufficient agency crews be available, the dispatch center calls

Table 2 – *The contribution of vacation, training, equipment, workers' compensation, unemployment, human resource support, and transportation to the daily cost of a Forest Service 20-person type 2 fire crew.*

Cost category	Daily cost
Vacation and training	$163
Equipment	$154
Workers' compensation and unemployment	$197
Human resource support	$67
Transportation	$121

on contract crews—dispatching the least costly crews first. Thus, as more of these crews are dispatched, the cost of contract crews increases.

During the 2003 fire season, the Forest Service's Pacific Northwest Region used 2,831 contract crew days. The daily cost of one of these private crews ranged from $6,970 to $11,270 (roughly $25 to $40 per hour per person) with an average of $7,791 for a 14-hour workday.

Comparing Agency and Contract Crew Costs

A comparison of the average daily cost of agency and contract fire crews reveals that the cost of an agency crew is just over 70 percent of the cost of a contract crew. This should not imply, however, that contract crews should never be used.

This finding indicates that if agency crews have continuous work, they are less costly. Contract crews can be laid off when work is not available. Agency crews must continue to be paid, although they are typically paid less on nonsuppression days.

To illustrate this point, consider a crew that is engaged in fire suppression on only half of a season's possible workdays. In addition, we initially make the assumption that the crew does no work on nonsuppression days but still receives 8 hours of nonhazard pay. (We address the more realistic case of a crew that does other work on nonsuppression days next.) Using the same assumptions as utilized in the previous analysis, the cost of an 8-hour day was therefore calculated to be $2,819.

The cost of the agency fire crew engaged in fire suppression must now include the wage costs from the days it does not work. Therefore, the daily cost of an agency fire crew is $8,358—more costly than the average cost of a contract fire crew.

Fire crews seldom do nothing when they are not engaged in fire suppression. They could conduct prescribed burns or perform trail maintenance, for example. If the cost of completing the work that crews do on nonsuppression days is similar to their wage rate, then the crew's wages on these nonsuppression days do not need to be added to the cost of operating the crew while engaged in fire suppression. However, sometimes the value of the work that crews do on nonsuppression days is less then their wage rate.

During the 2003 fire season, the Forest Service's Pacific Northwest Region used 2,831 contract crew days.

A colleague refers to all such work as "painting outhouses." In such cases, some portion of a crew's wage rate on nonsuppression days should be added to the cost of operating the crew while engaged in fire suppression.

Finding an Optimal Mix

The results outlined above suggest that it would be cost effective to hire agency crews, as long as managers believe an upcoming fire season will provide close to continuous work—or that work of equal value can be provided on nonsuppression days.

The challenge, of course, is for managers to actually apply this principle in practice. This was the goal of the second of the two papers summarized in this article. Rather than describe the model in detail here, I have:

- Outlined its general modeling approach,
- Presented some of the model's results, and
- Suggested other ways in which the model can be applied.

The model divides the fire season in the Pacific Northwest into seven 2-week periods. There is a demand for fire crews during each period. The model identifies the mix of agency and contract fire crews that meets this demand at least cost.

The Model Used

This demand for fire crews was estimated by using CHEETAH 2 software, which has data on all fires that have burned on Federal lands from 1980 to 2002. The user is prompted to enter data on the number of crews sent to different sized fires and the length of time that the crews stay in fire status.

These data were obtained from the Northwest Interagency Coordination Center in Portland, OR. For example, between 2001 and 2003, 12.6 type 2 crews were typically dispatched to class-F fires. On average, these crews stayed on these fire assignments a total of 10.4 days.

Given data on fire suppression demand and the cost of agency and contract fire crews, the model can therefore determine the optimal number of agency crews to hire before the start of a fire season. Any demand that cannot be met by these agency crews is met by contract crews.

Comparing the average daily cost of agency and contract fire crews reveals that the cost of an agency crew is just over 70 percent of the cost of a contract crew. This should not imply that contract crews should never be used.

Problem Solving

Unfortunately, managers do not know in advance what the demand for fire crews will be throughout a fire season. Therefore, a solution based on knowing crew demand in advance is of limited use. However, the model can accommodate uncertain demand by solving for a range of possible fire crew demands.

For example, managers often have forecasts for the overall severity of an upcoming fire season. Given such a severity forecast, a manager might be able to estimate crew demand in reference to previous fire seasons. For instance, a manager might believe that an upcoming fire season is going to be more severe than normal. The four most severe fire seasons out of the last 10 approximate the range of variability for that estimate.

In this case, running the model by using crew demand data from these past four most severe fire seasons would be reasonably representative of the manager's decision process.

As one would expect, the optimal number of agency crews increases as the expected severity of an upcoming fire season increases. What might be less intuitive is that the optimal number of agency crews is not very sensitive to periods of high demand. Rather—because peaks in demand tend to be met by contract crews—it is the periods of low demand that influence this solution.

The challenge is for managers to actually apply this principle in practice.

During periods of low demand, work of similar value to an agency crew's wage might not be available and the optimal number of agency crews is sensitive to these nonsuppression day costs.

Conclusions

Even though contract crews have a higher daily cost than agency crews, because of their greater flexibility, their use has the potential to reduce overall suppression costs.

The key to achieving this cost reduction is to use the most efficient mix of agency and contract crews. To do this, managers could use the model I have outlined.

Less formally, managers might be able to reduce the combined cost of agency and contract fire crews by ensuring that close to continuous work—either fire or nonfire suppression-related—is available for agency crews. If this work is nonsuppression work, then the value of that work should be comparable to the wage costs of the crew.

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Appearances, Reality, and the Rhetoric of Fighting Wildfires

An opportunity to refresh that which is good and to modify that which could be better

Alan P. Church

Because the wildland fire environment will never be innocuous, we should always desire more and better training and continue to study past mistakes to ensure that everyone dispatched to a fire makes it back home alive.

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Once we are engaged in a fire, the arrangement of the 10 Standard Firefighting Orders does not matter.

In recent years, fatality fire tragedies such as South Canyon and Thirtymile have served as a catalyst for after-action reviews that emphasize the need for situational awareness. Recently, this led to reevaluating training tools and the 10 Standard Firefighting Orders, resulting in the 2002 National Wildfire Coordinating Group (NWCG) recommendation to abandon the acrostically arranged orders in favor of their current (and original) form (see sidebar on page 16).

A Serious Student of Wildland Fire

Alan P. Church

I do not have the experience or qualifications of dedicated fire management professionals like John Krebs, Karl Brauneis, and Craig Goodell (all referred to in the accompanying article). I have only 7 years of seasonal experience. The highest qualification I have achieved is squad boss.

Although I have a Ph.D. and nearly 20 years of college teaching experience, being a professor is not likely to carry the same ethical appeal to many in the fire community. After all, my area of specialization is not fire science but literature and rhetoric.

Nevertheless, my years as a seasonal firefighter provided me with some of the most formative and cherished experiences of my life. I approached my duties as a wildland firefighter as a serious student of fire. I was surprised when criticism first arose about the acrostic Standard Firefighting Orders, for I, myself, had never experienced difficulty understanding how they functioned on the fireline.

Krebs, Brauneis, and Goodell are not only experienced firefighters who love the culture of wildland fire, but they are also dedicated teachers in their own right. This explains their motivation to help shape the current culture of wildland fire by sharing their ideas in print and elsewhere.

I imagine that the firefighters who served under these men have benefited from their years of experience and love of what they do. I say all this to make it clear that I am not arguing against these men, nor am I arguing for a reversal in the recent decision to abandon the acrostic Standard Firefighting Orders.

Instead, I see in this discussion an opportunity for further thinking about the relationship between training and experience—an opportunity to refresh that which is good and to modify that which could be better.

I want to make it clear that while I am not arguing against this decision, I do believe the issue deserves further scrutiny.

First, the arguments made to persuade the wildland fire community that the 10 Standard Firefighting Orders change was necessary were presented and received as a logical, commonsense solution to a perceived problem. In reality, the logical appeals of the arguments do not seem as persuasive as the ethical appeals—the fact that those arguing for the change are widely respected in the wildland fire community—as well as the emotional circumstances surrounding the issue.

Second, I believe that focusing on the actual order and arrangement of the 10 Standard Firefighting Orders was a red herring. The real issue should have been how to bridge the gap between classroom training and actual fireline experience. Once we are engaged in a fire, the arrangement of the orders does not matter. They are not recalled linearly as a process or checklist, rather they are dynamically triggered in response to many variables that we recognize as part of situational awareness.

My first argument is the more difficult of the two, not because it is hard to demonstrate, but because it will challenge what is currently a widespread belief.

Basic Assumption Is Challenged

The basic assumption of John Krebs (1999; 2003) and Karl Brauneis (2001; 2002) obviously resonated ethically, emotionally, and logically within the wildland fire community. They believed that the 1980s revi-

Focusing on the actual order and arrangement of the 10 Standard Firefighting Orders was a red herring. The real issue should have been how to bridge the gap between classroom training and actual fireline experience.

sion of the Standard Firefighting Orders into the acrostic mnemonic device "FIRE ORDERS" had been an illogical decision that resulted in mere memorization that served to disconnect classroom training from the reality of the wildland fire environment.

After the South Canyon tragedy, Krebs had suggested that those responsible for training had "failed" by replacing the "deliberately arranged," "logically grouped," and "practical" original orders with "an exercise in rote memory" (1999).

Brauneis's original *Smokejumper* article (2001) directly blamed the acrostically arranged orders as being dangerous. He urged his fellow firefighters to:

> *Throw away the listing of the Ten Orders as written in today's literature. The Orders as written will compromise your safety. The present listing was developed as a catchy way for you to memorize the orders. It will not help you in real-world terms to effectively implement them. For the orders to make sense, you must understand the original intent of the engagement and disengagement process. The orders are, in fact, your rules of engagement.*

Such hyperbole is noticeably lacking in the revised version of the article in *Fire Management Today* (2002), which was edited "to be more friendly in nature" (Brauneis 2006). Like Krebs, Brauneis emphasized the original intent of the Standard Firefighting Orders that needed to be "used as they were intended and not become just a list of items to be memorized."

These arguments of Krebs and Brauneis began circulating widely in the wildland fire community. But if there were any counterarguments *in favor* of the acrostic orders, they did not make their way into print. The National Interagency Fire Center Web site suggests that the debate has ended (National Interagency Fire Center, Safety 2006), affirming Krebs and Brauneis' claims that the intent of the original Orders were more logical than the acrostic ones:

> *The NWCG Parent Group just approved the revision of the 10 Standard Fire Orders in accordance with their original arrangement. The original arrangement of the orders are logically organized to be implemented systematically and applied to all fire situations… The 10 Standard Fire Orders are firm. We Don't Break Them; We Don't Bend Them. All firefighters have a Right to a Safe Assignment.*

Beware of Appearances

With the life-threatening reality of wildfires an ever-present concern and after action reviews of South Canyon and Thirtymile conclud-

In which order did these firefighters learn the 10 Standard Firefighting Orders? Article author Dr. Alan P. Church explains why that's largely irrelevant. Photo—taken on the Black Mountain 2 Fire on the Lolo National Forest the night it blew up—by Kari Greer, National Interagency Fire Center, 2003.

ing that the Standard Firefighting Orders and most of the 18 Watch Out Situations were violated—leading to firefighter fatalities—it is understandable why any argument calling for change in the status quo would be persuasive.

> My first argument is the more difficult of the two, not because it is hard to demonstrate, but because it will challenge what is currently a widespread belief.

But appearances are not always what they seem. When decisions are based on *appearances* as much as reality, we are clearly in the realm of rhetoric. Rather than rely on logical proof alone, rhetoric relies on other factors, like emotion and character.

While I do not doubt the reality or validity of the emotional and ethical appeals intrinsic to the arguments for restoring the 10 Standard Firefighting Orders to their original form, what resonates as a logical, commonsense decision to reimpose the original orders, in reality, relies on questionable, unsubstantiated claims about the intent of the acrostically arranged orders.

The acrostically arranged FIRE ORDERS was intended as a mnemonic device. It was never considered an end in and of itself, or to be something disconnected from the actual process of fighting wildfires. Furthermore, there is some inconsistency among the arguments for a return to the original orders.

Acrostic Devices Help Memorization Process

Krebs (1999), for instance, claims that the *original* version of the Standard Orders was easy to remember. But if memorizing has any value, then why is an easier-to-remember mnemonic device less desirable than one that is not as easy to remember? Acrostic devices do facilitate memorization. If there is any inherent value in memorization, an acrostic device *is* desirable.

While this inconsistency is minor, a more perplexing problem concerns the mistaken belief that the acrostic device was something intended to be memorized but not understood—something that is supposed to be resolved by learning the 10 Standard Firefighting Orders as a linear process of engagement.

When the acrostic FIRE ORDERS first appeared (Standards for Survival 1988), they were not devoid of a context that clearly expressed their intended use. Buried without a proper heading on pages 30-31 of *Fire Management Notes* 49(3)—where they first appeared—is an explanation of the widely used "Standards for Survival" training course. Until recently, this training course centered on the 18 Watch Out Situations and the 10 Standard Firefighting Orders, acrostically arranged.

The article claims that the acrostic arrangement was designed to "promote retention of information" *without* affecting the orders' original meaning. The mnemonic was a device "to trigger recall" of the orders in situations such as those presented in the "Standards for Survival" training program:

> *The "Standards for Survival" training course is a 1-hour videotape supplemented with student workbook and exercises. Eight "scenarios"—reenactments of dangerous fireline situations that led to fatalities—are used to pinpoint critical fireline events. Students are asked to identify hazardous situations noted in the scenarios, key them to the 18 "Watch Out!" situations, and then state the appropriate Fire Orders that must be observed.*

Brauneis's original *Smokejumper* article directly blamed the acrostically arranged 10 Standard Firefighting Orders as being dangerous.

Ten Standard Firefighting Orders History

The original 10 Standard Firefighting Orders were developed in 1957 by a Forest Service task force commissioned by then Chief Richard E. McArdle. The task force reviewed the records of 16 tragedy fires that occurred from 1937 to 1956. The orders were based in part on the successful "general orders" used by the U.S. Armed Forces. These 10 firefighting orders were "organized in a deliberate and sequential way to be implemented systematically and applied to all fire situations:"

The 10 Standard Firefighting Orders

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.
4. Identify escape routes and safety zones and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.
7. Maintain prompt communications with your forces, your supervisor, and adjoining forces.
8. Give clear instructions and insure they are understood.
9. Maintain control of your forces at all times.
10. Fight fire aggressively, having provided for safety first.

In the 1980s, the 10 Standard Firefighting Orders where rearranged into an "acrostic" series in which the first letter in each line spelled out: "FIRE ORDERS:"

F ight fire aggressively, but provide for safety first.
I nitiate all actions based on current and expected fire behavior.
R ecognize current weather conditions and obtain forecasts.
E nsure instructions are given and understood.

O btain current information on fire status.
R emain in communication with crew members, your supervisor and adjoining forces.
D etermine safety zones and escape routes.
E stablish lookouts in potentially hazardous situations.
R etain control at all times.
S tay alert, keep calm, think clearly, act decisively.

In 2002, these 1980s acrostically arranged Fire Orders were disbanded and replaced by the original 10 Standard Firefighting Orders.

Nothing Illogical

It is clear from this context, and from anyone who has participated in the "Standards for Survival" training course, that the acrostic FIRE ORDERS were understood as part of a dynamic process of critical thinking desirable in the decision-making associated with fire suppression.

Contrary to what has been claimed, there was nothing illogical with the orders' mnemonic arrangement or in how they were intended to be used. Nor, in fireline training, have I ever witnessed any institutional failure in preparing young men and women to recognize the dynamic nature of the wildland fire environment or the recursive and interdependent nature of the "10/18/and 4" (10 Standard Firefighting Orders, 18 Watch Out Situations, and LCES—Lookouts, Communication, Escape Routes, and Safety Zones).

> Following the 10 Standard Firefighting Orders is not a static but a dynamic process.

If the intent of the acrostic arrangement had been only memorization, it would have been the truly pointless exercise some have perceived it to be. If those responsible for training did not routinely emphasize the relationship between the 10 Standard Firefighting Orders and the 18 Watch Out Situations in response to scenario reenactments in training or actual fire incidents, the fault does not lie with the orders—no matter their sequence—but in communicating their purpose to firefighters.

What Is the Relationship Between Classroom Training and What Actually Happens on a Fire?

This conclusion leads me to my second argument and the real issue underlying the arguments about the 10 Standard Firefighting Orders: What is the relationship between classroom training and what actually happens on a fire?

Answering this question is not as simple as suggesting that by thinking of the orders as a linear process that provides the "rules of engagement" we have "systematically" bridged the gap between the classroom and the fireline.

Viewing the orders as a linear process or a checklist is fine before and after responding to an incident. But applying the orders in the actual context of fighting a fire requires us to understand these 10 firefighting orders not as a linear and static process, but one that is recursive and dynamic.

The Thirtymile Fire Accident Review Board (2002) determined that it was necessary to "Ensure that fire program managers and incident commanders have situational awareness, assessment, and decisionmaking abilities necessary to react to significant changes in fire danger thresholds."

In his most recent comments on the orders, Krebs (2003) explains how "situational awareness" was a "buzzword" that caught his attention, leading him to rethink the nature of the orders. With the acrostic orders now abandoned, Krebs initiated a more constructive explanation of the relationship between the orders and fireline analysis necessary to achieve situational awareness—and to safely comply with the orders.

Situational Awareness

This emphasis on situational awareness is perhaps best reflected in Krebs' recommendation to slightly change the last of the 10 Standard Firefighting Orders from "Fight fire aggressively, having provided for safety first," to "Fight fire *intelligently* having provided for safety first."

In a similar vein, Craig Goodell (2005) recently presented a paper providing a constructive analysis of how the orders function in relation to situational awareness. Claiming that the wildland fire community continues "to experience a breakdown in the understanding and application of the 10 Standard Firefighting Orders and the 18 Watch Out Situations," Goodell argues that a "better system for teaching and applying" these tools is needed to move firefighters "from the realm of memorization to one of dynamic analysis in utilizing the fire orders."

He conceives of the orders as "a systematic/fluid model for developing and maintaining situational awareness, analyzing the fire environment, and appropriately engaging and disengaging the fire" (2005). His model demonstrates the linear process of engagement mandated by the orders—as argued by Krebs and Brauneis—while demonstrating how situational awareness simultaneously leads to an ongoing, nonlinear process of reassessment that reveals the relationship between the 10 Standard

Firefighting Orders and the 18 Watch Out Situations.

Goodell describes a process of reassessment crucial to situational awareness that corresponds to the intended "use" of the orders in either their acrostic or original form. Further, he illustrates them with the kinds of scenarios presented in fireline refresher training courses like the "Standards for Survival" used today. Nevertheless, Goodell fails to realize the difference between the 10 Standard Firefighting Orders and 18 Watch Out Situations, which leads him to the conclusion that many of the latter are redundant and should be removed. But there *is* a difference between these firefighting orders and the watch out situations, a difference which cognitive theory explains.

Schema Theory

In order to develop "situational awareness" we need to recognize "trigger points" as conditions that affect fire behavior and resource management to determine if a change in strategy and tactics is warranted (Greenlee 2003). When we talk about how memory is triggered in response to a particular situation that has the potential to influence the decisionmaking process, we are at the crossroads of rhetoric and a cognitive theory known as "schema theory."

Schema theory originates in the philosophy of Kant, who emphasizes that we are able to identify certain objects or ideas by relating them to already formed cognitive categories. The modern development of this theory begins with Cambridge psychologist F. C. Bartlett, who argues that schemata operate as "an active organization of past reactions, or past experiences which must always be supposed to be operating in any well-adapted organic response." Bartlett continues that these are "dynamic constructs, playing an active role in comprehension" (Semino 1997, p. 127; Bartlett 1932).

This moves schema theory away from being a static process of recognition to a dynamic, productive one. In other words, schemata are engaged not just in remembering facts but in influencing potential action.

Subsequent schema theorists in the area of artificial intelligence (Schank and Abelson 1977) recognize that upon exposure to a particular situation, schemata latent in a person's memory were triggered. This, in turn, prompts that person to respond to the triggered "scene" according to a "script" that would allow the person to implement a "plan" in the pursuit of a "goal."

Also part of the dynamic nature of schemata is that once triggered, they are either reinforced, modified, or abandoned—depending on the extent to which the current experience corresponds to the expected schemata (Rumelhart and Norman 1978).

If there were any counterarguments *in favor* of the acrostic orders, they did not make their way into print.

Wildfire Environment

Relating this to the wildfire environment will help clarify the relationship between situational awareness, the 10 Standard Firefighting Orders, and the 18 Watch Out Situations. Generally speaking, the dynamic nature of schema theory is reflected in the language imbedded in the culture of fighting fire.

Just as schemata are preexisting or previously created thought patterns, tools of training like the 10/18/and 4 are the schemata introduced to first-year firefighters *prior* to their being allowed on the fireline. Just as schemata must initially be created, *after* they are created they are refreshed or reinforced.

One way this occurs is on the fireline, where schemata learned in training are triggered and reinforced when the situations firefighters encounter correspond to what their training has taught them to expect. Schemata are also reinforced during mandatory fireline "refresher" training.

If the language of schema theory is encoded in the language of wildfire management, the relationship of the 10/18/and 4 illustrates the relationship between situations that trigger particular scripts, plans, and goals in fighting fire.

The difference between the 18 Watch Out Situations and the 10 Standard Firefighting Orders is that the former are "scenes" that lead to the scripts, plans, and goals of the Standard Orders. LCES serves as topical categories under which all such scenes, scripts, plans, and goals can be understood as operating.

Imagined Scenario

Let's suppose a firefighter encounters the following scene:

> *It's late afternoon. It's getting hotter. Near the head of the fire, ponderosa pine close to the fireline begin to torch out. Watch Out situation #14 has been triggered ("Weather is getting hotter and drier"). The torching of the pines triggers the possibility of "spotting." The fire weather forecast has predicted a weak cold front arriving before evening with gusts of 10 to 15 miles per hour. The firefighter sees what the fire is doing, knows it is getting late in the day, and recognizes that the volatile combination of wind and low humidity have created possible conditions for "spotting" beyond the fireline. There's no spotting at the moment. But what would happen if a gust of wind hits the torching pine—spreading the fire well beyond the line?*

The firefighter recognizes that it's time to reassess communications and maintain control of resources. Is the lookout aware of what is going on and what could happen? Have instructions been given and understood? If spotting occurs, how will weather, topography, and fuel influence fire behavior? Will spotting compromise escape routes and safety zones?

In this imagined scenario, perhaps the firefighter is aware that there is still another hour before the expected front arrives, that the torching pines are the only significant fuel left burning at the head of the fire, and that the fireline is wide and down to mineral soil.

> The arrangement of the 10 Standard Firefighting Orders is largely irrelevant.

Staying calm and alert, the firefighter reminds the crew about the coming front, cautions crew members to be alert, and reminds them of their escape routes and safety zones—the plan of engagement and disengagement.

Type of Thinking That Needs To Occur

While there are many variables that we could add to this scenario, this is the type of thinking that ought to occur, and—I would argue—usually *does* occur on a fire, taking place from among the incident commander down to the first-year firefighter. The scenario describes a dynamic process of situational awareness moving recursively from triggered scene and reinforced schemata to situational awareness.

Clearly, all this occurs recursively and not necessarily in a linear process. Although wildland firefighters might use the 10 Standard Firefighting Orders as a procedural checklist, in the reality of firefighting, situational awareness reveals that following these orders is not a static but a dynamic process.

Of course, the arrangement of these 10 Standard Firefighting Orders is largely irrelevant. Whether or not they are understood reflexively in relation to firefighting situational awareness is not.

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Restoring the Interior Ozark Highlands

John Andre, Mark Morales, McRee Anderson

The Forest Service's Big Piney Ranger District on the Ozark-St. Francis National Forest, Hector, AR—in concert with multiple partners—is implementing a landscape-scale, long-term project to restore and maintain the forest's fire-dependent woodland ecosystems within the Ozark Highlands.

Prescribed fire, thinning treatments, commercial timber sales, and stewardship contract sales are all included in this large-scale, ambitious undertaking, known as the Bayou Woodland Ecosystem Restoration Project.

The project's overall intent is to return this area back to the landscape condition that greeted the first European setters here—as documented in the government land office survey records for 10 years beginning in 1830.

For the project's initial phase, six ecosystem restoration areas were identified. These restoration areas represent all of the "land type associations" from the National Forest Ecological Classification System. Each is comprised of 3 to 6 landscape-scale prescribed fire units, for a combined total of 60,000 acres (24,281 ha).

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Fire and the Ozark Highlands

Fire—throughout history—has played a significant role in shaping plant and animal communities within the Ozark Highlands.

Several thousand years prior to European settlement, American Indian ecosystem management practices included setting frequent woodland fires for a variety of purposes. During the 1800s, the first European settlers continued this process—maintaining open, park-like, oak–hickory and pine woodlands with a rich mix of wildflowers and grasses.

Then, about 80 to 100 years ago, these woodlands were heavily cut. The historic fire regime was drastically altered. Next, long-term fire suppression changed these open woodlands from once having approximately 45 to 76 trees per acre, to today's dense forests with 300 to 1,000 trees per acre.

> Collaborative landscape-scale monitoring and adaptive management protocols have been developed for this project.

In 2004, 30,000 acres (12,141 ha) were burned; in 2005, an additional 22,000 acres (8,903 ha) were burned. Forest health and other noncommercial forest thinning treatments totaled 2,500 acres (1,112 ha) in 2004, and 2,000 acres (809 ha) in 2005. Commercial timber sales and stewardship contract sales treated about 6,000 acres (2,428 ha) in 2004 and 2005.

By this combination of both prescribed fire and thinning treatments, landscapes are beginning to change from Fire Regime Condition Class 3*—representing a high departure from the historic fire regime—to Fire Regime Condition Class 1—representing a low departure from the historic fire regime.

* Fire Regime Condition Class (FRCC) is an interagency, standardized tool for determining the degree of departure from reference condition vegetation, fuels, and disturbance regimes. Assessing FRCC can help guide management objectives and set priorities for treatments.

Adaptive Management

Collaborative landscape-scale monitoring and adaptive management protocols have also been developed for this project. A comprehensive monitoring program is documenting ecosystem response to prescribed fire and timber cutting treatments.

Monitoring at 96 permanent plots quantifies treatment effects on:

- The overstory,
- The understory and herbaceous plant community,

A restored post oak–white oak woodland on a south-facing slope in the Ozark National Forest. The diverse herbaceous understory developed from onsite plants and seed in the seed bank. Overstory thinning and prescribed fire produced these results.

- Fuel loads, and
- Soils.

To date, monitoring results reveal both a 40-percent increase in herbaceous species and an 11-percent increase in herbaceous plant coverage after one to two prescribed fires. The number of shrub stems per acre has decreased by 75 percent in the burned areas.

Additional detailed monitoring data have been provided via three different research projects conducted in cooperation with Arkansas Tech University and the University of Arkansas at Monticello. Two of these studies have documented the effects of oak woodland restoration on the small mammal and bird communities. The third partner-based project has documented the effects of prescribed fire on oak sprouting ecology.

In addition, to ascertain the best program for future use on the Ozark National Forest, fuel load data from the monitoring plots are currently being analyzed in three software programs:

A comprehensive monitoring program is documenting ecosystem response to prescribed fire and timber cutting treatments.

- FIREMON,
- Fuels Management Analyst, and
- FSVeg Fuels Module.

Why Restore This Forest?

While oak trees do not survive or reproduce well in shade, many other trees such as red maple, ash, elm, and black gum thrive in shade. While these tree species are part of the area's historical plant community, under the historic fire regime, they occurred in far fewer numbers than today. Decades of fire suppression have allowed the forest to

Summary of Herbs, Shrubs, and Trees		
Plants	***Treated Plots (1 or 2 burns)***	***Untreated Plots (no burns)***
Herbs		
Avg. # species/plot	7	5
Total number of species	72	63
Average % cover/plot	40	36
Shrubs		
Avg. # species/plot	4	11
Total # species	10	24
Average % cover/plot	9	18
Stems/acre	372	1,515
Trees		
Avg. # species/plot	25	36
Total # species	17	26
Stems/acre	328	470
Basal area	105	111

Quantifying the effectiveness of woodland restoration treatments is an integral component of this multipartner monitoring project. Monitoring data is essential for measuring progress, employing adaptive management techniques, and communicating success.

become much more dense—with a closed canopy.

It is under this closed canopy that these four aforementioned tree species dominate the understory and midstory. Without the reintroduction of fire, they are destined to become the overstory.

Drought and native insects—such as the red oak borer—have historically helped to produce and maintain fire-dependent oak and pine woodlands.

In dense forests, competition among plants for resources—including water, nutrients, and sunlight—is fierce. This competition has produced more than 300,000 acres (121,407 ha) of stressed, unhealthy, and dying trees in the Ozark National Forest. This widespread condition has put the forest at greater vulnerability to insect attack, drought, and premature death. These natural agents of change have an even more severe affect in dense forest.

Restoring the forest structure and implementing prescribed fire will therefore allow for a more open canopy, thereby creating conditions favorable to oak and pine recruitment, as well as an abundant and diverse herbaceous plant understory. This, in turn, will subsequently attract wildlife such as deer, elk, and turkey.

This widespread condition has put the forest at greater vulnerability to insect attack, drought, and premature death.

Big Piney Ranger District Bayou Woodland Ecosystem Restoration Project Fire Learning Network

Collaborative Landscape Goal Statement

- Landscape ecosystem components and processes are maintained within the historic range of variation by periodic fire use and ecologically-based resource management.
- Landscapes are in Fire Regime Condition Class 1, providing healthy watersheds and safety for "communities at risk."
- Ecosystems within the historic range of variation achieve biodiversity goals and provide multiple recreational opportunities.
- Promote and facilitate ecosystem restoration at other sites and develop public support with continuing partnership involvement.

The changes in structure and species composition that occurred here during the last century not only had negative consequences on the forest ecosystem, but also had a negative impact on the surrounding communities and their dependence on forest resources.

Furthermore, the increased fuel from the dense forest and dead trees poses a significant wildfire risk and threat to human life and private property within, and surrounding, the Ozark-St Francis National Forest. The potential for high-intensity wildfire also

A comprehensive monitoring program is an integral part of the Bayou Woodland Ecosystem Restoration Project. Changes in the plant community that have resulted from recent thinning and burning treatments are tracked in 96 permanent plots.

threatens municipal water sources, thereby affecting even broader populations.

Partnerships for Change

Collaborative partnerships based on a shared vision and common goals are vital to the success of the Big Piney Ranger District's Bayou Woodland Ecosystem Restoration Project.

The Arkansas Chapter of The Nature Conservancy was the primary partner that developed and institutionalized the landscape-scale monitoring and adaptive management plan to track plant community changes for achieving the desired ecological conditions on the ground. This monitoring program includes clear, measurable objectives and detailed descriptions of data collection methods that the project team has successfully implemented.

In addition to supporting on-the-ground efforts, The Nature Conservancy staff is also responsible for leading the South–Central Fire Learning Network, which provides a forum for developing:

- Scientific peer review of projects,
- Multilevel education and outreach campaign methods, and
- Long-term implementation plans.

In addition, the district's long-term participation in the Fire Learning Network (<http://tncfire.org/training_usfln.htm>) has been a productive venue for partnership development. This particular affiliation has established a best science-based project and helped accelerate various on-the-ground treatments.

The Bayou project served as the field trip site for the third national Fire Learning Network meeting (see <http://tncfire.org/documents/USfln/USFLN3_summary.pdf>).

To date, the project's other partners have included both State and Federal agencies, private organizations, and community groups who are actively participating in the project and bringing tangible, on-the-ground expertise to the success of this ongoing ecosystem restoration work. ■

> The increased fuel loadings pose a significant wildfire risk and threat to human life and private property.

Big Piney Ranger District Bayou Woodland Ecosystem Restoration Project

Collaborative Partnership List

Oak Ecosystem Team
Arkansas Chapter of The Nature Conservancy
Arkansas Game and Fish Commission
Arkansas Natural Heritage Commission
Arkansas Audubon Society
Arkansas Forestry Commission
National Wild Turkey Federation
Quail Unlimited
Southwest Fire Use Training Academy
Caddo Nation of Oklahoma
National Park Service, Buffalo National River
Forest Service, Southern Research Station
U.S. Fish and Wildlife Service, Arkansas Field Office
Arkansas Tech University

Lessons Learned From Rapid Response Research on Wildland Fires

Leigh Lentile, Penny Morgan, Colin Hardy, Andrew Hudak, Robert Means, Roger Ottmar, Peter Robichaud, Elaine Sutherland, Frederick Way, Sarah Lewis

In recent years, more researchers are collecting data either on active wildfires or immediately after wildfire occurrence. Known as Rapid Response Research, this important undertaking provides real-time information, useful data, and improved tools for managers.

Rapid Response Research can encompass fire ecology, burn severity, fire behavior, firefighter safety, emissions, erosion, vegetation response, remote sensing, and a multitude of various fire-related topics.

> Researchers must understand and work closely with fire management organizations *without* compromising these managers' primary tasks.

By using this Rapid Response Research, we have the potential to link fire effects to conditions before, during, and after fires. This information is critical to building the next generation of tools for forecasting the consequences of fire and fuels management.

In this way, Rapid Response Research products are also helping fire managers and local land

Monitoring Active Fire Behavior—Rapid Response Researcher Jim Reddering, remote sensing program manager with the National Center for Landscape Fire Analysis, University of Montana, Missoula, MT, monitors the 2003 Cooney Ridge Fire near Missoula. Photo: Andrew Hudak, research forester and landscape ecologist, Forest Service, Rocky Mountain Research Station, 2003.

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This article is a synthesis of informal discussions and a panel review held at the 2005 Joint Fire Sciences Principal Investigators Meeting. These discussions concentrated on what has been learned from Rapid Response Research, including insights from managers who provided recommendations on how to improve coordination between research and fire management teams.

managers make informed decisions about the ecological and social consequences of fire.

At the same time, however, Rapid Response Researchers can complicate resource and personnel management for managers during critical emergency periods on wildfires. Researchers must therefore be constantly aware of the challenges of conducting research on active wildfires (see sidebar). They must understand and work closely with fire management organizations without compromising these managers' primary tasks.

> The Joint Fire Science Program funding agency requires these scientist–manager partnerships to place a strong emphasis on transferring research findings to the field.

Fire scientists and fire managers have long worked closely together, but if they are to successfully address today's complex wildland fire challenges, they must now work together even *more* closely.

Teams of research scientists and technicians have an increasing presence in today's fire camps. Demands for information and accountability from the media and general public also peak during large fire incidents.

The added safety and logistical requirements required for Rapid Response Research are justifiable only if the research data can be effectively collected—and we learn information that we cannot ascertain by any other means.

Recommendations for Successful Rapid Response Research

Researchers must understand the fire organizations and their objectives. The fire managers' primary responsibility is to manage the fire safely—*not* to support research. When arriving to do research on a fire, researchers must therefore be prepared, have the necessary "red card" credentials that indicate sufficient training, fitness, and the appropriate knowledge.

Researchers must also have—and follow—an operations plan. We recommend using a liaison and building strong relationships with fire managers. Just as importantly, researchers must always share what was learned with these fire managers.

Science, guided by questions that are important to managers, is essential to improve the understanding of wildland fire dynamics and to develop strategies that address fire risk, rehabilitation, and restoration. To ensure that this occurs, researchers must be constantly aware of the potential challenges that face them while conducting research on active wildfires.

Researchers must understand that fire management organizations adhere to a strict code and follow a chain-of-command. Researchers must respect this chain-of-command by:

- Attending daily fire management meetings and briefings,
- Communicating clearly and regularly with incident management teams,
- Following the protocols established on each fire,
- Checking-in with division supervisors and fire crews working near them, and
- Following *all* safety guidelines.

The work done to nurture relationships between management and research communities outside of the actual fire season is equally important for successful Rapid Response Research on actively burning fires. This includes engaging with fire managers through workshops and trainings.

Remember, the "goodwill" built through 10 years of successful Rapid Response Research can be threatened by safety violations and poor communication. More information—including the 9 recommendations for any research team considering Rapid Response Research on wildland fire or other incidents—is available at <http://www.cnrhome.uidaho.edu/default.aspx?pid=70495>.

What Is Rapid Response Research? How Is it Different From Other Fire Research?

Certain types of information or data that are essential to our understanding of wildland fire can only be obtained during, or immediately after, a fire. Large fires can provide unique opportunities for assessing fire behavior, fire effects, fuel treatments, and social responses on a landscape scale.

Rapid, well-organized, and preplanned responses from the science community must therefore be organized to gather data on actively burning fires.

If advance planning and funding for a timely research response is not in place, critical data could be lost.

Rapid Response Teams must coordinate with fire management teams to quantify conditions immediately before, during, and after wildfires and prescribed burns.

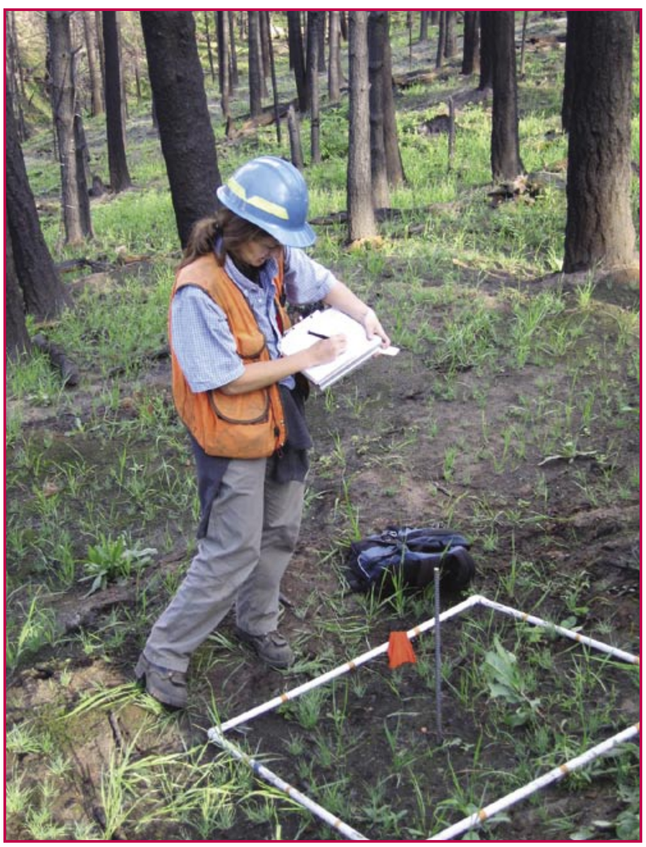
By the time funding is obtained, the research opportunity has often passed, or other factors—precipitation, faded memories, changing seasons—have masked or destroyed important information.

In the past, research on active fires has been hampered by:

- Lack of funding,
- Inadequate preseason planning and coordination,
- Poor adoption or adherence by researchers to the incident command system, and
- Lack of acceptance or tolerance of research by incident management teams (IMTs).

The governing board of the USDA/USDOI Joint Fire Science Program (JFSP), a partnership of six Federal wildland fire management and research organizations, has provided financial support for teams of research scientists and technical specialists that can mobilize quickly to investigate fire behavior or fire effects on active fire incidents.

The JFSP funding agency provides scientific information and support for fuel and fire management programs. The JFSP funding agency also requires scientist–manager partnerships that place a strong emphasis on transferring research findings to the field.



Post Fire Data—Leigh Lentile, post-doctoral research scientist with the Department of Forest Resources, University of Idaho, Moscow, ID, collects data on post-fire ground cover and vegetation response one year after the Umatilla National Forest's School Fire. Photo: Pete Robichaud, research engineer, Forest Service, Rocky Mountain Research Station, 2006.

How Is Rapid Response Research Conducted?

Advance Planning Proves to be Crucial

Rapid Response Research teams must coordinate with fire management teams to quantify conditions immediately before, during, and after wildfires and prescribed burns. Rapid Response projects are expected to take advantage of opportunities to obtain information on large fires.

Traditionally, researchers conceived research questions and designed experiments beforehand and submitted competitive research proposals. If awarded, they then developed operations' plans, participated in training sessions, and purchased equipment. With Rapid Response Research, however, the study area is not defined until after a fire ignites and various research criteria are met.

Researchers must therefore be ready to decide—within days—whether a given fire will be sampled and travel to the fire on short notice, strategize data collection, and coordinate with IMTs to ensure safe operations. Rapid Response Research teams must always be prepared for efficient mobilization, be flexible, and be cognizant of management concerns.

A Rapid Response Research team led by Elaine Kennedy Sutherland, Forest Service research biologist, performed Rapid Response Research on seven fires around Missoula, MT, in 2003. Sutherland's team focused on fire effects on fish and fish habitat.

Coordinating with local land management decisionmakers and IMTs, a crew of six researchers located small streams with known native trout populations or potential trout habitat. They then established sample sites near actively burning fires—locations likely to burn in a day or two—taking measurements, setting up instruments, and surveying fish populations.

In some of these locations, fires burned the study sites, or areas immediately upstream from the sites. Some of the sampled sites were never reached by fire. After the fires, fish populations were resurveyed and measurements were retaken. For some data, the sites were monitored for days or weeks.

While the data collected during this project addressed research objectives, it was also useful for the IMT, as well as the resource specialist and fish biologists. This information proved instrumental in developing post-fire rehabilitation objectives. Presentations were made to fire management teams during incident briefings, and the data were made available immediately post-fire.

Measuring Water Infiltration Rate—Sarah Lewis, civil engineer with the Soil and Water Engineering Research Work Unit, Forestry Sciences Laboratory, Moscow, ID, measures relative water infiltration rate to assess the degree of post-soil water repellency after the Hot Creek Fire on the Boise National Forest. Photo: Pete Robichaud, research engineer, Forest Service, Rocky Mountain Research Station, 2005.

Some fire management teams more readily welcome researchers on fires than others.

Applied Research

Applied research that provides real-time data and information builds credibility, increases the likelihood of application, and fosters opportunities for future collaboration between scientists and managers.

Familiarity with the fire management program and its science needs increases the potential for meaningful data collection and interpretation. Some fire management teams more readily welcome researchers on fires than others. This acceptance often depends on fire conditions and objectives, as well as the prior nurturing of personal relationships and credibility between researchers and team members.

For example, Peter Robichaud, Forest Service research engineer, conducts Rapid Response Research on post-fire hydrological response and soil erosion mitigation. Robichaud has provided erosion control measures information such as the effectiveness of felling trees and snags on the contour. This, in turn, has allowed Burned Area Emergency Response (BAER) teams to immediately change contract specifications, alter treatments, and improve effectiveness (Robichaud 2005).

Often times on these fire incidents, a unique window of opportunity exits to extend preliminary research results directly to end-users. For instance, when Robichaud arrives on a fire, he provides a brief justification of why his research is necessary and useful, and also provides a followup closeout presentation. Although analysis is usually incomplete before this closeout briefing, Robichaud can still share:

- Anticipated results;
- Benefits of the research; and
- How these results can enhance adaptive management, thereby improving the managers' decisionmaking and support.

Research Findings During 2003 Fires

The 2003 Montana fire season brought many opportunities for several newly funded Rapid Response Research projects. Teams led by Forest Service researchers Colin Hardy, Phil Riggan, and Andy Hudak—in collaboration with University of Montana and University of Idaho faculty members—explored alternative image acquisition and analysis methods for remote sensing of burn severity.

Mutual research objectives were to improve the predictive capabilities for fire risk, the real-time assessment of fire behavior, and the

> Rapid Response Research provides a venue for scientists to obtain information and knowledge that is not otherwise available.

post-fire mapping and description of fire effects—thus, improving the strategic effectiveness of post-fire rehabilitation efforts.

Under the supervision of Ed Mathews, the research team's IMT research liaison, small crews of research technicians were sent into areas *before* they burned to collect prefire measurements of soil and vegetation condition and to install instruments to collect heat flux, as well as other fire behavior information.

These instruments then autonomously recorded or reported observations to field personnel working in a safe zone located outside the fire perimeter. As fires burned through these field sites, a ground-based thermal infrared radiometer measured radiant heat flux emitted from points within or near the sample sites.

Additionally, the multispectral FireMapper™* image acquisition system installed on the Pacific Southwest Research Station's airborne sciences aircraft collected multiple images of the sample site at 4-minute time steps (Riggan and Hoffman 2003; Riggan and others 2003). These missions were

* The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement of any product or service by the U.S. Department of Agriculture. Individual authors are responsible for the technical accuracy of the material presented in *Fire Management Today.*

Feel the Heat—Fire-proofed video systems and instrumentation for measuring heat flux, fire behavior, and local weather are installed on the Dragon Complex Wildland Fire Use Incident on the North Rim of the Grand Canyon, AZ, by mechanical engineer Jason Forthofer (sitting) and project leader Colin Hardy. Both men are from the Fire Behavior Research Work Unit, Missoula Fire Sciences Laboratory, Missoula, MT. Photo: Dan Jimenez, Forest Service, Rocky Mountain Research Station, 2005.

Thermal Infrared—Patrick Freeborn, physical scientist with the Fire Chemistry Research Work Unit, Missoula Fire Sciences Laboratory, Missoula, MT, operates both mid- and short-wave thermal infrared cameras to monitor radiant heat flux and temperatures on the Dragon Complex Wildland Fire Use Incident on the North Rim of the Grand Canyon, AZ. Freeborn installed these cameras inside the Rapid Response Research plots. Photo: Colin Hardy, Forest Service, Rocky Mountain Research Station, 2005.

planned, executed, and monitored in full compliance with local incident aviation safety protocols, including pilot briefings, coordination with air attack, and post-mission debriefings.

These technology-produced multiband (visible and thermal) images were used to remotely determine the heat intensity of the fire. These data were merged onto a digital topographical map which was then accessed by fire commanders for potential decisionmaking on the ground.

What Is the Value of Rapid Response Research?

Rapid Response Research has great potential to promote mutual understanding between the land management and science communities. Scientists doing Rapid Response Research have a responsibility to provide land managers with defensible information and the useful tools necessary to expedite and strengthen fire management.

> Researchers learn from observing fires firsthand. They become more aware of the total management context, as well as the broader decisionmaking process.

Today, a critical need exists for researchers to evaluate the effectiveness of management actions to reduce the hazard of severe wildfire and to mitigate fire effects on human, floral, and faunal populations. To do this, scientists must understand the logistical and temporal constraints and the sociopolitical environment in which managers make most of their decisions.

One of the primary goals of Rapid Response Research on wildfires is to facilitate the interpretation and utility of research results to enable land managers to make challenging, timely decisions. Researchers learn from observing fires firsthand. They become more aware of the total management context, as well as the broader decisionmaking process.

Rapid Response Research provides a venue for scientists to obtain information and knowledge that is not otherwise available. This research allows scientists to collect real-time measurements and observations that are normally modeled or reconstructed.

Rapid Response Research on fire behavior can play a critical role in furthering our evaluation of assumptions underlying existing models, as well as providing key information for the evolution and development of new models. Rapid Response Research can assist with model calibration, provide accuracy assessments for many commonly used predictive models, and increase user confidence in these tools.

Furthermore, Rapid Response Research can provide data to test new equipment. Information from the duff moisture meter, for example, adds a new level of accuracy to predictions of duff consumption and smoke emissions (Robichaud and others 2004). Such equipment can also be used to determine the best and safest time for a prescribed burn. Improved tools to detect soil water repellency and areas at risk to erosion can help to identify hazardous situations, streamline treatments, and reduce costs.

Sharing Results

Results and recommendations from Rapid Response Research projects are being shared with many different users. Roger Ottmar has been conducting Rapid Response Research for most of his career as a Forest Service research forester. In the early 1990s, Ottmar's Rapid Response Research involved attaching instruments to interagency hotshot crew members as part of a smoke exposure study.

This ongoing research has provided important information about fuel flammability and smoke emissions—critical for both short- and long-term firefighter safety and health.

Forest Service research scientists Bret Butler and Jack Cohen's Rapid Response Research work has provided firefighters with valuable information about safety zones (Butler and Cohen 1998a, b). Due to their efforts, a combination of trainings, publications, and Web sites now provide information on how and why safety zones are used on fire incidents. In fact, their safety zone guidelines are now included in the Incident Response Pocket Guide carried by every wildland firefighter.

In Alaska, during the summer of 2004, the Rapid Response Research team led by Roger Ottmar and David Sandberg collaborated with research teams from the Forest Service, University of Idaho, Colorado State University, and Yale University to jointly sample and characterize fuels, vegetation, fire consumption, and smoke production from the same sample points before, during, and after the burn.

Their data will help to develop improved, practical indicators of burn severity that will complement existing indicators such as the "normalized burn ratio" used by BAER teams and others. Additionally, this joint effort complements ongoing research to:

- Assess the Alaska black spruce and white spruce fuel type photoseries (Ottmar and Vihnanek 1998);
- Provide calibration (Rorig and others 2003) for Canadian Forest Fire Danger Rating System (Turner and Lawson 1978), National Fire Danger Rating System (Deeming and others 1978), Consume (Ottmar and others 1993), and fuel models (Scott and Burgan 2005), and
- Evaluate duff consumption elements of predictive models (Ottmar and Sandberg 2003).

Successful field operations would not have been possible without the cooperation of the Alaska Fire Service, State of Alaska, and IMTs who tactically and logistically supported this Rapid Response Research.

Unique Opportunity

Rapid Response Research provides a unique opportunity to pursue questions important to managers tasked to integrate the best available science in their decisionmaking about fire risk, rehabilitation, and restoration. Rapid Response Research links post-fire effects, fire behavior during the fire, and prefire conditions. In this way, Rapid Response Research can build and help propel the necessary understanding for improving fire and fuels management.

Lessons learned from the pioneers of Rapid Response Research have demonstrated that the potential benefits outweigh the costs and—if researchers and managers continue to work together effectively—the challenges *are* manageable.

Thus, Rapid Response Research can continue its vital role of advancing science that is both relevant and immediately useful to all of us.

Acknowledgments

This research was supported in part by funds provided by the Rocky Mountain Research Station, Forest Service in cooperation with the University of Idaho, and additional funding from the USDA/USDI Joint Fire Science Program (Project 03-2-1-02), and the National Fire Plan. We would like to thank Erik Berg, JoAnn Fites-Kaufman, Ed Mathews, Kevin Ryan, Henry Shovic, and John Szymoniak for their insights and contributions to this article.

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Access to Critical Fire Information and Resources

The Wildland Fire Lessons Learned Center has added a new feature to its popular Web site, <http://www.wildfirelessons.net>. Called "Advances in Fire Practice," it highlights the ideas and efforts that leaders in the fire management and research communities have identified as widely applicable and innovative.

In doing so, this special area of the Web site now provides easy access to critical fire information and resources, including:

- Summaries of research articles, tools, and fire science findings.
- Synopses of many of the fire resources available from Forest Service research stations and labs.
- Fire-centered indexes of science journal articles that allow readers to scan recent abstracts and fire science titles in major journals.
- A growing collection of case studies of innovative projects that tackle the myriad challenges that continue to face fire professionals.
- Current articles on the fireshed assessments that are dramatically reshaping the California land managers' approach to fuels management.
- Articles that explore the links between forest restoration and bioenergy production—spurred by a stewardship contract in Arizona's White Mountains.
- An "Instructor's Corner" that provides resources for fire science class instructors and students, including a curriculum "swap corner" and an article review platform.

This new Advances in Fire Practice section can be accessed at <http://www.wildfirelessons.net/AFP.aspx> or through the main Wildland Fire Lessons Learned Center Web site at < http://www.wildfirelessons.net>. ■

Improving Fire Management: What Resource Managers Need To Know From Recreation Visitors

Deborah J. Chavez and Nancy E. Knap

Recreation visitors to our national forests and rangelands comprise a demographic group that doesn't receive much research emphasis, even though it is impacted by wildfire in large numbers. In fact, recreation visitors might be one of the largest groups impacted during, and after, wildfire events.

In southern California, an estimated 2,200 recreation visitors were evacuated during the 2002 Williams Fire, and more than 45,000 recreation visitors and residents were evacuated during the 2003 Old Fire and adjacent Grand Prix Fire.

After these wildfire events, visitors are often impacted by fire-related closures of public lands, restricted use of these lands, and the destruction of recreation amenities within these lands.

In an effort to improve the recreation research link to managerial interests, during the 2003 Utah State University Outdoor Recreation Short Course for Managers, we asked 34 resource managers to discuss outdoor recreation management as it relates to fire and healthy forests. These managers represented the Forest Service, USDI Bureau of Land Management, and Bureau of Reclamation.

Deborah Chavez is a project leader and research social scientist and Nancy Knap *is a social science technician for the Forest Service, Pacific Southwest Research Station, Riverside, CA.*

In general, managers of public lands who provide outdoor recreation opportunities receive direction and financial support from a variety of sources, including presidential initiatives such as the National Fire Plan and the Healthy Forests Initiative.

The resource managers involved in this study confirmed that they are looking to research for assistance in effectively managing fire and healthy ecosystems in an outdoor recreation context.

> Managers wanted to know if recreation visitors perceived the Healthy Forests Initiative to be "just logging in disguise."

Brainstorming Session

These 34 resource managers engaged in a brainstorming session that explored the National Fire Plan and Healthy Forests Initiative and their effect on forest recreation visitation. Five themes emerged:

1. Fire safety and prevention messages,
2. Treatments,
3. Closures,
4. Public funds and private holdings, and
5. Rehabilitation and restoration.

1. Fire Safety and Prevention Messages

The resource managers recognized that recreation visitors receive multiple, and sometimes conflicting, fire safety and prevention messages. They identified these inconsistencies as agency related. For example, messages differed significantly that were disseminated to the public by:

- State agencies,
- Local agencies,
- The Forest Service,
- Other Federal agencies, and
- "Environmentalists."

When these message conflicts occur, the resource managers said they wanted to know whom the recreation visitor finds most credible. Specifically, they wanted to know if Smokey Bear had lost credibility due to the introduction of the new message that fire can be beneficial to ecosystem health.

These managers also expressed interest in knowing if recreation visitors perceived the Healthy Forests Initiative to be "just logging in disguise."

Addressing such questions might logically also lead to an investigation of what makes an organization and its messages credible and how Federal land management agencies can create and sustain this credibility.

Some of the resource managers expressed the belief that recreation visitor behaviors and attitudes toward fire safety and fire prevention techniques would be better informed if these visitors were provided with effective information about these resource issues.

> Resource managers wanted to know if Smokey Bear had lost credibility with the introduction of the new message that fire can be beneficial to ecosystem health.

Specifically, the managers wanted a measure of the level of visitor knowledge—some way of assessing what and how much visitors know about:

- Fuel reduction practices,
- Restrictions on recreation activities during periods of high fire danger, and
- Fire-safe recreation.

Summary ideas for future research studies. In conclusion, an evaluation of education programs and public service announcements could result in more effective educational outreach efforts.

2. Treatments

The resource managers wanted to know the recreation visitor's preference for fuel treatments, particularly toward thinning and burning. The managers expressed a concern about visitors accepting a potential reduction in the quality of their recreation experience. Because many prescribed burns are performed during hunting season, a concern was also expressed for this particular forest-user group.

In addition, the resource managers wanted to know visitor tolerance for some of fire's negative effects, such as reduced air quality and the aesthetic of burned tree stands. The managers were also curious about the levels of landscape change that recreation visitors are willing to tolerate, such as accepting the exchange of short-term aesthetics for long-term ecosystem health.

Summary ideas for future research studies. Research might focus on visitor preferences for treatment options and how visitors are affected based on recreation activity or season.

3. Closures

The resource managers wanted to know how recreation visitors view forest closures. More specifically, they wanted to know how to reconcile limiting the recreation visitor's access with closures necessary for their safety—which is, in part, the mission of Federal land management agencies. The managers were also concerned with the economic impacts of fire-related closures on the communities that serve recreation visitors.

To reduce the severity of these impacts, while managers considered providing access to outfitter-guided groups, they were concerned that this could be perceived as inequitable—or even elitist.

> They were also concerned with the economic impacts of fire-related closures on the communities that serve recreation visitors.

Summary ideas for future research studies. Research might need to describe perceptions of closures and restricted access, as well as gauge the acceptance of permitting outfitter-guided activities into closure areas.

4. Public Funds and Private Holdings

The resource managers were aware of the growing controversy over the allocation of public funds for firefighting and fire prevention used to protect private inholdings. They wanted to know the recreation visitor's view of the fairness of using public monies (taxes and fees) for the benefit of private interests.

Summary ideas for future research studies. Research can measure the perceptions of recreation visitors, including recreation homeowners, about the appropriate use of public funds to defend private inholdings.

5. Rehabilitation and Restoration

Judging by objections that are routinely voiced at public meetings about partially burned stands of trees, the resource managers sensed that recreation visitors believe that this post-fire rehabilitation and restoration work occurs too slowly.

There might be a perceived lack of faith in the ability of Federal land management agencies to restore and rehabilitate.

Summary ideas for future research studies. Research could measure recreation visitors' expectations to determine if there is a lack of confidence in the ability of Federal land management agencies to restore and rehabilitate the landscape. Techniques for diffusing conflict could be developed.

Potential Studies

Social science research benefits from discussions such as these in providing a higher level of relevance to recreation management. This session yielded the aforementioned five topic areas suitable for further research. To provide guidance to resource managers, we encourage social scientists to address these topics.

Potential studies include:

- Determine credible messages for fuel reduction, restrictions on recreation activities during periods of high fire danger, differences between forest health practices and logging, and recognition by visitors of fire-dangerous practices (such as untended campfires or careless cigarette smoking). This research might also evaluate message source (who is best to deliver the message and how it is supplied).
- Measure visitor preferences for specific treatment options such as thinning and burning.
- Describe recreation visitor perceptions of closures and restricted access.
- Assess the perceptions of recreation visitors, including recreation homeowners, about the appropriate use of public funds to defend private inholdings.
- Quantify recreation visitor expectations about restoration and rehabilitation. Determine if there is a lack of confidence in an agency's ability to do the job.

The resource managers were aware of the growing controversy over the allocation of public funds for firefighting and fire prevention used to protect private inholdings.

Seeking resource manager input into research is important in keeping research relevant and timely. Social science research results can provide the tools that resource managers need to accomplish their work more effectively.

In addition, developing resource manager training programs that provide practical information geared toward actual application will help improve fire management and better serve outdoor recreation visitors. ■

Examining the Sources of Public Support for Wildland Fire Policies

James D. Absher and Jerry J. Vaske

Recent severe wildfires have reinforced the need for successful mitigation strategies to be coordinated across all levels of government that address the needs and concerns of homeowners who live in the wildland/urban interface (WUI).

Despite the growing body of social science literature on agency-initiated wildland fire policies and homeowner mitigation strategies, knowledge gaps surrounding these policies and strategies still exist (Cortner and Field, 2004). To better manage the human dimensions of wildland fire, a better understanding of the underlying mechanisms that influence public support for agency and homeowner behaviors is therefore needed.

We examined the influence of three sets of predictors—sociodemographic, situational, and psychological—on two agency policies, prescribed fire and mechanical thinning, and two homeowner actions, defensible space and Firewise construction.

We anticipate that the differences in the relationships among the predictor variables that are precursors to each policy provide a basis to better understand the social complexities of each wildland fire policy. Thus, our major working hypothesis is that wildland fire policies have distinct sources of public support that, to be effective, must be understood.

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Only Starting To Emerge

Half a century ago, Lasswell (1951) emphasized the importance of merging social science and policy. Work in policy arenas (such as housing and labor) has empirically linked public beliefs and policy issues (Hyman and others, 2001). Natural resource managers have similarly recognized that the social sciences can inform the decisionmaking process (O'Laughlin, 2003). Hoover and Langner (2003), for example, noted "the importance of understanding …attitudes, perceptions and beliefs about fire in developing feasible fire management strategies." Despite this recognition, social science-based analyses of wildland fire policies are only starting to emerge in the literature (Cortner and Field, 2004).

> To better manage the human dimensions of wildland fire, we must understand the underlying mechanisms that influence public support for agency and homeowner behaviors.

Predicting Policy Support

Combinations of underlying factors have been shown to influence support for wildland fire management alternatives (Kneeshaw and others, 2004; Taylor and others, 1988). In general, the wildland fire literature has addressed the three categories of predictor variables used in our study:

1. **Sociodemographic variables.** These variables are commonly measured in social science surveys and are frequently reported in wildland fire management studies. Variables such as age, sex, education, and income have been shown to be related to residents' perceptions of wildland fires and potential mitigation strategies (Hoover and Langner, 2003). Individuals with more income, for example, have more personal resources to adopt some homeowner wildland fire mitigation strategies (such as Firewise construction).

2. **Situational variables.** These factors define a given context and influence what the public perceives as acceptable or feasible (Kneeshaw and others, 2004; Taylor and others, 1988). Large tracts of forested land often surround homes built in the WUI. Proximity of a home to a forest is likely to enhance the homeowners' general awareness of the potential dangers associated with wildland fires and their willingness to accept mitigation efforts.

3. **Psychological variables.** These variables—such as specific beliefs and attitudes regarding wildfires—are perhaps most important to understanding wildland fire policy support. The public often under or overestimates wildfire risks. Large attitudinal differences sometimes exist between experts and non-experts in risk situations (Vogt and others, 2005).

Not all of these three classes of predictors, however, are likely to contribute equally to support—or oppose—agency wildland fire policies or homeowner mitigation strategies. Social–psychological theories for these disparities suggest that the "specificity" principle (the correspondence between the measured concepts) influences the strength of observed relationships between variables (Fishbein and Ajzen, 1975; Vogt and others, 2005).

This principle predicts that *general* sociodemographic variables (such as education and income) and *general* situational variables (such as home ownership) that are not wildland fire-specific will explain less of the variability in support for agency prescribed burning, for instance, or for homeowner wildland fire mitigation strategies such as defensible space.

> Wildland fire policies have distinct sources of public support that, to be effective, must be understood.

More *specific* psychological variables (beliefs about effectiveness and aesthetics of mitigation efforts) would be expected to account for relatively more variation in response. Situation variables (such as proximity to a forest) might be somewhere in between in predictive potential.

Thus, situational variables raise awareness of the potential risks of wildland fires, but are less specific than the psychological variables.

Survey and Model

Data for this study were obtained from a mail survey of residents living in six WUI counties in Colorado. A random sample of these residents was mailed a survey in May 2004. After a postcard reminder and two repeat mailings, 532 completed surveys were returned, for a 47-percent response rate.

The survey contained four separate *dependent variables* representing different wildland fire mitigation strategies. Each was introduced with a short description and a captioned illustration. Two strategies dealt with defensible space and Firewise construction homeowner activities, and two concerned the agency activities of mechanical thinning and prescribed burning.

For the homeowner activities, respondents indicated whether or not they currently practiced defensible space or Firewise construction. For the agency action strategies, respondents rated three prescribed burn questions and four mechanical thinning questions, each measured on 7-point agree–disagree scales. (For analysis consistency with the homeowner activity variables, these composite indices were collapsed into dichotomous variables where "0" reflected opposition and "1" indicated support for each agency action.)

Variables and Predictors Examined

Three sets of *independent variables* were examined. The *sociodemographic* predictors included age, sex, total annual household income, and education. Four general *situational* predictors were examined:

- Year-round residency,
- Distance of home from forested area,
- Own or rent property, and
- Years living in Colorado.

The psychological variables measured respondents' specific familiarity, perceived effectiveness, and aesthetic impacts regarding prescribed burning and mechanical thinning. For defensible space and Firewise construction, individuals also indicated whether or not the actions enhanced the safety of their property. These variables were coded on 9-point scales (1 = not at all familiar, 9 = extremely familiar).

A more comprehensive discussion of the scientific issues, methods used in this study, and full exposition of the statistical tests used are available in Absher and Vaske (2006a, 2006b).

Survey Results

More than three quarters of the WUI residents surveyed, 79 percent, practiced at least one type of defensible space activity (such as cleaning gutters or pruning trees), and 47 percent engaged in some form of Firewise construction. Nine out of 10 respondents, 90 percent, approved of mechanical thinning, and 82 percent supported prescribed burning activities.

The respondents were typically male (65 percent), about 56 years old, had at least some college education, and reported household incomes slightly more than $70,000 per year. These sociodemographic results are typical of homeowners in WUI settings. A majority of respondents were year round (84 percent) homeowners (93 percent) who lived in, or near, a forest and had resided in Colorado an average of 26.7 years.

In terms of the psychological variables, the respondents were supportive of both agency and homeowner mitigation efforts, with averages ranging from 5.32 to 6.83 on a 9-point scale.

Statistical Analyses

Separate statistical analyses (logistic regression models) were calculated for each of the three sets of predictor variables on each of the four criterion variables (see table). Significant relationships linkages are indicated by check marks. Among the sociodemographic indicators, only age (mechanical thinning model) and income (Firewise construction, mechanical thinning, and prescribed burning models) were statistically significant. None of the sociodemographic variables statistically influenced defensible space activities.

Overall, the sociodemographic variables were weakly linked to the personal action strategies and only slightly better represented in the agency actions. Again, for more detailed information on the methods or results of the statistical models and tests, please see Absher and Vaske (2006a, 2006b).

Patterns of significant linkages of sociodemographic, situational, and psychological influences on wildland fire policies.

Influences by type	"Personal Action" Policies		"Agency Action" Policies	
	Defensible Space	Firewise Construction	Mechanical Thinning	Prescribed Burning
Sociodemographic:				
Gender				
Age			✓	
Education				
Income		✓	✓	✓
Sub-group			✓	✓
Situational:				
Year-round resident				
Forest proximity	✓	✓		
Home ownership	✓			
Years in Colorado	✓			✓
Sub-group	✓	✓		
Psychological:				
Familiar with policy	✓	✓	✓	✓
Think it's effective	✓			✓
Think it's safe	✓		n/a	n/a
Think it improves look			✓	✓
Sub-group	✓	✓	✓	✓

n/a = not applicable

Three of the four situational variables (forest proximity, home ownership, years in Colorado) influenced participation in defensible space actions (see table). In the Firewise construction model, only distance from the forest was significant. None of the four situation predictors influenced mechanical thinning. In the prescribed burning equation, only years living in Colorado was significant.

Overall, the situational factors were important to defensible space decisions, but only weakly tied to the other actions.

The psychological variables explained more of the variability in both the personal and agency action models than either the sociodemographic or situational variables. Perceived familiarity with the action was significant in all four models. Effectiveness influenced defensible space and prescribed burning actions. Safety was significant in the defensible space model. Aesthetic impacts influenced ratings of agency actions, but not the homeowner actions. Taken as a whole, the subgroup of psychological variables was consistently the best predictor of policy support.

Understanding Public Support

Variables in each of the three classes of predictors can influence agency policy and individual homeowner behavior. Consistent with social psychological theory and the previously discussed specificity principle, specific wildland fire beliefs and attitudes (such as psychological predictors) had more predictive power than either the general sociodemographic or general situational indicators.

These results point to the utility of knowing the social and psychological precursors. Especially noteworthy is the fact that psychological linkages to all wildland fire policies are strong and pervasive.

The policy-specific pattern of significance also differed between the sociodemographic, situational, and psychological predictors. The sociodemographic variables had more influence in *agencywide* policy models, while the situational variables were relatively more important in understanding *homeowner* actions.

Among the psychological variables, perceived familiarity with the agency or homeowner actions had a strong and consistent influence on each policy. This suggests that greater support for these policies and actions might be possible if the communication strategy enhances residents' knowledge or understanding of the rationale for them.

A total of 90 percent of the study's respondents supported mechanical thinning; 82 percent supported prescribed burning activities.

To enhance compliance with Firewise construction and defensible space strategies, agencies should pay attention to the psychological drivers and to the situational variables such as proximity to the forest. Given the homeowners' costs associated with adopting Firewise construction and the potential barriers that these pose to compliance, our results also suggest that residential land developers and the home construction industry should be an important target for communication efforts—especially if they will agree to incorporate Firewise principles more often and more aggressively market such options to customers.

The use of social science data to inform wildland fire policy can clarify different considerations that are important in affecting support, opposition, or behavioral compliance with wildland fire policy.

This Study: Initial Step

In summary, our work in this study represents an initial step toward bridging traditional discursive policy analysis with a theoretically grounded empirical approach espoused by Lasswell (1951). Our three-factor causal model offers a theoretical framework for better understanding policy support and homeowner behavior.

Furthermore, our results support the working hypothesis of differential social causes and suggest that fire managers need to engage homeowners and the general population differently. However, because less than half of the variance was explained in any of the models, more work is needed to identify a comprehensive model of policy support for wildland fire actions—and to demonstrate its use in other geographic or resource settings.

Our general modeling approach should also be broadly applicable to other policy arenas, especially those focused on natural resource management or natural disaster issues. Recognizing these causal influences can improve policy development, communications, and local community involvement strategies.

These results also underscore the utility of including psychological determinants in the policy analysis model, as well as the need to carefully assess the role of constituent influences for a specific policy.

Psychological linkages to all wildland fire policies are strong and pervasive.

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An Invitation To Collaborate With Your Peers

The Wildland Fire Lessons Learned Center's "MyFireCommunity" Web site—located at <http://www.myfirecommunity.net>—allows wildland fire professionals across agencies and geographic areas to collaborate and communicate on the issues and challenges that face them in their day-to-day jobs.

"Neighborhood" groups have already been formed on topics such as applied fire effects, fire behavior, and aerial ignition. Members often request to join these existing groups or create new groups to share ideas, work on documents, plan meetings or workshops, and more. These neighborhood groups also provide a convenient location to share and store documents in a safe and secure environment.

New neighborhoods are continually being formed.

There are also specific practitioner groups using the "MyFireCommunity" Web site for positions such as fire use modules, fire information officers, fire behavior analyst, fire prevention/education, and interagency hotshot crews.

Fire professionals can become members of MyFireCommunity.net through an easy registration process on the Web site. They will then have immediate access to information and discussions on countless wildland fire arena topics. ■

Computing the Low Elevation Haines Index

By Brian E. Potter, Julie A. Winkler, Dwight F. Wilhelm, Ryan P. Shadbolt

When D.A. Haines introduced his Lower Atmospheric Severity Index—now known as the Haines Index—almost 20 years ago (Haines, 1988), he designed it to use the input data regularly reported as part of the upper air soundings taken by the National Weather Service (NWS).

Haines based the low-elevation version of his index on temperature observations at 950 millibar* (mb) and on temperature and humidity observations at 850 mb. In 1988, measurements were commonly taken at the 950 mb pressure level, even though this level was not a mandatory sounding level (required by NWS rules). The 850 mb level was—and remains—a mandatory level.

In 1991, the NWS introduced a new mandatory level at 925 mb. Measurements at 950 mb became less frequent. While some soundings still include 950 mb data, the majority do not. There has been no coordinated, standard adaptation of the low-elevation Haines Index to account for this change.

Index Options

Theoretically, when there is no observed 950 mb temperature, three options exist for computing the low elevation Haines Index from observational data:

1. Use the 925 mb temperature in place of 950 mb temperature,
2. Interpolate the 950 mb temperature from surface and 925 mb observations, or
3. Adjust the Haines Index thresholds to allow direct use of the 925 mb temperature.

Our goal is to determine the most accurate method for computing the Haines Index.

* A unit of atmospheric pressure equal to one-thousandth (10^{-3}) of a bar. Standard atmospheric pressure at sea level is about 1,013 millibars.

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What Is the Haines Index?

D.A. Haines developed his "Lower Atmosphere Stability Index"—now universally known as the Haines Index—in 1988 to be used to indicate the potential for wildfire growth by measuring the stability and dryness of the air over a fire.

This is calculated by combining the stability and moisture content of the lower atmosphere into a number that correlates well with large fire growth. The index's "stability term" is determined by the temperature difference between two atmospheric layers. Its "moisture term" is determined by the temperature and dew point difference.

This index has been shown to correlate with large fire growth on initiating and existing fires where surface winds do not dominate fire behavior. The Haines Index is computed from the afternoon soundings from radiosonde observation stations across North America.

The Haines Index readings range from 2 to 6. The drier and more unstable the lower atmosphere, the higher the index:

2 – Very Low Potential (moist, stable lower atmosphere)
3 – Very Low Potential
4 – Low Potential
5 – Moderate Potential
6 – High Potential (dry, unstable lower atmosphere)

When fire managers see higher Haines Index values, they know they could be facing a dry, unstable atmosphere conducive to large wildland fires. Because the Haines Index can usually distinguish between average and rapid fire growth conditions, it has become a standard tool of many fire weather forecasters and fire managers.

Our objective in this study is to present information on how well these methods reproduce the *actual* Haines Index—computed using an *observed* 950 mb temperature. Thus, our goal is to determine the most accurate method for computing the Haines Index itself. It is important to note that we make no attempt to determine how well the Haines Index compares with fire behavior or activity.

Analysis Methods

We examined 39,818 atmospheric soundings from 18 locations in the same region Haines (1988) identified for using the low-elevation version of the Haines Index (figure 1). While these soundings covered from 1958 to 2000, most were taken between 1992 and 1997.

For each sounding, we computed four values for the Haines Index:

1. **Original Haines Index** – using the observed 950 mb temperature;
2. **The "925 mb raw approach"** – using the 925 mb temperature as a direct substitute for 950 mb temperature;

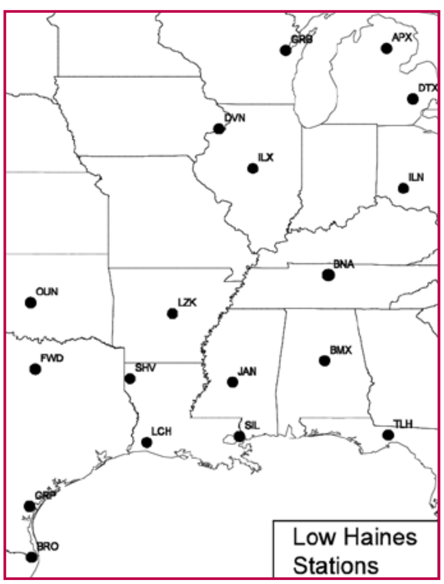

Figure 1—*Locations and abbreviations for stations used in this study.*

We make no attempt to determine how well the Haines Index compares with fire behavior or activity.

3. **The "interpolation approach"** – interpolating temperature between the surface and 925 mb to obtain a value at 950 mb; and
4. **The "new thresholds approach"** – adjusting the thresholds originally used by Haines to demarcate values of 1, 2, and 3 for the stability component of the Index.

We compared the alternative versions with the original version of the Haines Index to determine how often they agreed or disagreed. The better the agreement, the more "true" that alternative was to the original Index.

We considered only those cases in which the original Haines Index was a 5 (moderate potential for blow-up) or 6 (high potential for blow-up)—where an inaccurate value is most likely to be a fire behavior or firefighter safety concern.

(For a more detailed explanation of the methods used in our analysis, see sidebar on page 43.)

Study Results

Table 1 summarizes the results for spring (March, April, May), summer (June, July, August), autumn (September, October, November), and winter (December, January, February). The values in the table indicate the percent of soundings where the alternative approach yielded results that were lower or higher than the original Haines Index.

These results show that, most of the time, "the 925 mb raw approach" underestimates the Haines Index (and presumably the risk of large or erratic fire). The "interpolation approach" fares much better, although it also tends to underestimate the Haines Index.

Table 1—*Error rates for alternative calculations of the Haines Index for cases where the original Haines Index was a 5 or 6.*

Alternative Haines Index	Season	Error	
		% Under	% Over
925 mb raw	Spring	78	0
	Summer	81	0
	Autumn	74	0
	Winter	68	0
Interpolation	Spring	3	1
	Summer	4	1
	Autumn	14	0
	Winter	12	0
New Thresholds	Spring	11	1
	Summer	15	1
	Autumn	19	1
	Winter	23	1

The "new thresholds approach" comes close to the "interpolated approach" in accuracy.

None of the three approaches yields values higher than the original Haines Index more than 1 percent of the time. The error rates vary with season and location, as shown in Figures 2 and 3. These two figures indicate how often an alternative method yielded a value of the Haines Index that would have been higher had the "true" Haines Index been computed.

Error Values

For the "925 mb raw method" (fig. 2), the spatial pattern of errors is generally the same regardless of the season. The lowest errors are over the Gulf Coast and Mississippi River. In the Southeast, the highest error rates occur in spring, while the peak error rates for most other areas occur during the summer. The highest overall error values are found in Texas during summer, with errors as high as 80 percent.

Figure 3 shows the results of the "interpolated approach" for Haines Index readings of 4 that correspond to "true" 5 readings. (Note that the contour interval on these figures is much smaller than that on fig. 2.) There is no spatial consistency across seasons. For example, the gradient in error rate over the Great Lakes region reverses from summer to fall. The errors at Birmingham, AL, dominate the pattern for fall, but the overall magnitude of the errors is greater in fall than other seasons.

We looked at the interpolation errors from Birmingham in more detail to get an idea of what might be causing the larger fall errors at this location—and in general.

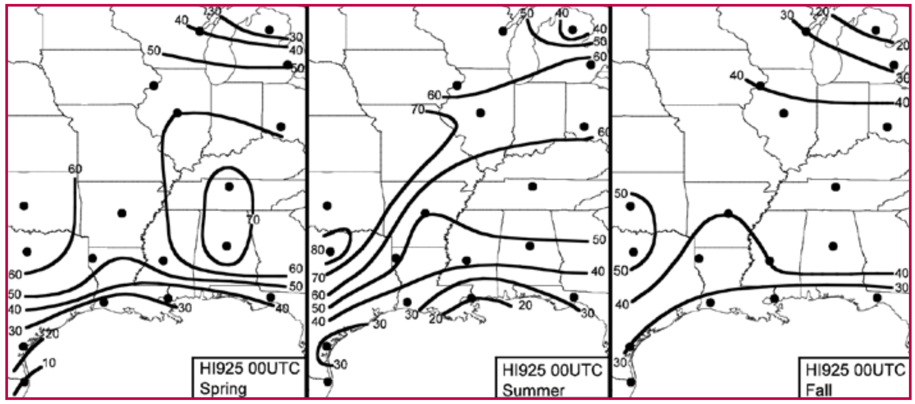

Figure 2—*Percent of 925 mb raw method Haines Index values of 4 that were "true" Haines Index values of 5 for (a) 00 Universal Time Coordinated (UTC) spring, (b) 00 UTC summer, and (c) 00 UTC fall.*

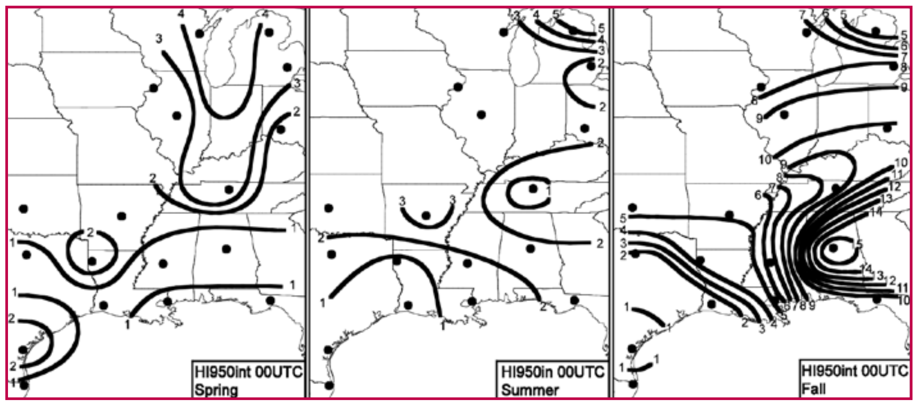

Figure 3—*Percent of interpolation method Haines Index values of 4 that were "true" Haines Index values of 5 for (a) 00 Universal Time Coordinated (UTC) spring, (b) 00 UTC summer, and (c) 00 UTC fall.*

We considered only those cases in which an inaccurate value is most likely to be a fire behavior or firefighter safety concern.

Looking at these soundings for Birmingham, we found that inversions accounted for nearly two-thirds of the days where interpolation gave a 4 and the "true" Haines Index was a 5. Nearby locations did not show such frequent inversions.

We did not examine the spatial patterns for the "new thresholds" method. This method is not currently in use anywhere and its error rate exceeds that of the interpolation method, which is presently in use. Because the new thresholds were primarily a test to determine whether there was a simple, straightforward way to adapt the Haines Index to 925 mb data, we felt that, for practical application, the greater error rates were sufficient grounds to reject this approach.

To Reduce Confusion

Our results show that a Haines Index calculated from interpolated 950 mb temperature is less likely than a Haines Index calculated with 925 mb temperature to underestimate the original formulation of the low elevation Haines Index—whether the 925 mb temperature is used with the original or modified

A More Detailed Description of This Study's Methodology

To compare the three calculation options in this study required using individual soundings that contained both 950 millibar (mb) and 925 mb temperature observations. Furthermore, the locations of these soundings had to be within the geographical region that D.A. Haines specified for using the "low elevation" version of the Haines Index in 1988.

On an unrelated project, two of this article's authors (Winkler and Shadbolt) had previously examined National Climatic Data Center sounding data spanning from 1958 to 2000 from locations between the Rocky Mountains and the Appalachians. This examination produced a data set that removed aborted soundings and those with missing observations.

While we analyzed this entire 1958 to 2000 period in this study, the majority of the soundings that contained both 925 mb and 950 mb observations came from the 1992 to 1997 period—shortly after the 925 mb level was introduced as a standard level. Overall, the analysis examined 39,818 atmospheric soundings.

For each sounding, we computed four values for the Haines Index: the original Haines Index, the 925 mb raw approach, the interpolation approach, and the new thresholds approach (see mainbar for definitions).

Interpolation Approach

For the interpolation approach, we used the natural logarithm of pressure as the vertical coordinate in the interpolation calculation. This is common when interpolating temperature vertically in the atmosphere. The equation for this interpolation is: $T_{950} = T_{sfc} + [\ln(p_{sfc}) - \ln(950)]/[\ln(p_{sfc}) - \ln(925)] * (T_{925} - T_{sfc})$.

"ln" indicates the natural logarithm, T_{950} is the interpolated 950 mb temperature, T_{sfc} is the observed surface temperature, T_{925} is the observed 925 mb temperature, and psfc is the observed surface pressure in millibars.

Haines originally used 950 mb to 850 mb temperature difference thresholds of 4 º celsius (C) and 8 ºC, with temperature differences below 4 ºC—indicating an A component of 1, differences of 8 ºC or more, indicating an *A* component of 3, and intermediate values indicating an *A* component of 2.

As a rough approximation, the layer from 925 mb to 850 mb is three-fourths of the depth of the original layer. We therefore chose new thresholds that are three-fourths of the original values. The original 4 ºC and 8 ºC thresholds became 3 ºC and 6 ºC, respectively.

thresholds. All three methods tend to produce Haines Index values lower than the original formulation.

All three methods tend to produce Haines Index values lower than the original formulation.

As we point out at the beginning of this article, our study considered how best to reproduce the original formulation of the temperature component of the low elevation Haines Index. This is completely distinct from comparing how well any calculation of the Haines Index correlates with large or erratic fire growth. This study never attempted to address or answer that question.

At present, Haines Index users might have no idea how this index is calculated. Nor might they realize that is quite possible to receive conflicting values of the Haines Index from different, equally authoritative, sources. In light of the differences noted here among the various methods for computing the low elevation Haines Index, and for the sake of consistency, if nothing else, a standardized method of computation would reduce confusion and uncertainty within the user community.

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A Fuels Management Bibliography With Subject Index

M.E. Alexander

The primary purpose of fuels management has been to lessen potential fire behavior and, thereby, increase the probability of successful containment (Alexander 2003). More specifically, it has been to decrease the rate of fire and, in turn, fire size and intensity—as well as crowning and spotting potential.

In recent years, fuels management has become viewed as a means of reducing or minimizing the adverse impacts of wildfires (Agee and Skineer 2005; Outcalt and Wade 2004; Weatherspoon and Skinner 1995).

Need for Bibliography

I've found that very few efforts have been made to summarize the existing literature on the subject of fuels management and its effectiveness in boreal and temperate ecosystems.

A few exceptions can be found on selected topics (e.g., Agee and 2000; Alexander 2002, 2004c, 2005, 2006b; Fernandes and Botelho 2003; Greenlee and Sapsis 1996; Martin and Brackebusch 1974; Martinson and Omi 2003). However, there has been no attempt to provide a comprehensive review and bibliography of the entire field.

The current efforts of the Forest Service's (2004) Applied Wildland Fire Research in Support of Project Level Hazardous Fuels Planning Project to review and summarize the existing information on fuel treatments in dry forests of the Western United States (<http://forest.moscowfsl.wsu.edu/fuels/>) are obviously a very worthy undertaking. Commensurate with this effort has been the publication of recent symposia proceedings (Omi and Joyce 2003; Andrews and Butler 2006). But much still remains to be collated and summarized.

Thus, this need for a comprehensive bibliography of relevant articles on fuels management for both manager and research alike. That is what this bibliography—presented in this article—is intended to do. It consolidates and highlights what Fire Management Today and its predecessors provide regarding fuels management, up to, and including, the Fall 2006 (Vol. 66, No. 4) issue. This fulfills a void that existing bibliographies have failed to address (Schumann 2001; Kumagai and Daniels 2002).

This comprehensive bibliography includes 117 articles—listed under 12 subject areas—that date back to 1939.

Seven-Decade Publishing Record

Fire Management Today and its predecessors, collectively, now have a 70-year record of publishing on all aspects of wildland fire management. While early emphasis was on fire protection and fire suppression, it wasn't long before articles dealing with fuels management began to appear.

Bunton (2000), in *Fire Management Today* issue 60(1), identified and indexed, by subject, *all* the fuels management related articles that had been published between 1970 and 1999 in *Fire Control Notes, Fire Management,* and *Fire Management Notes.*

Unfortunately, knowing what articles have been published on the subject of fuels management between 1936 and 1969 is not so readily available. Summary indexes were published by *Fire Control Notes* in 1942, 1955, 1963, and 1969.

Thanks to a concerted effort by several people, with Delvin Bunton, systems analyst, Forest Service, Ecosystem Management Coordination Staff, Natural Resource Information System, Sandy, OR, taking the lead, all past issues of *Fire Management Today*, as well as the journal's predecessors—*Fire Control Notes, Fire Management Notes*, and *Fire Management*—are now available on *Fire Management Today's* Web site (<http://www.fs.fed.us/fire/fmt/>) (Editor 2006). This accessibility has greatly increased the exposure of the journal for the global wildland fire management community.

Dr. Marty Alexander is a senior fire behavior research officer with the Canadian Forest Service, Northern Forestry Centre, and an adjunct professor of widland fire science and management in the Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada. At the time of this writing, he was on assignment as a senior researcher with the Wildland Fire Operations Research Group, Forest Engineering Research Institute of Canada, Hinton, Alberta, Canada.

Bibliographies By Subject

This comprehensive bibliography includes 117 articles—listed under 12 subject areas—that date back to 1939.

Broadcast Slash, Pile, and Snag Burning

Ash, L.W. 1951. Paper-covered piled slash. Fire Control Notes. 12(3): 18–19.

Fahnestock G.R. 1954. Roofing slash piles can save—or lose—you dollars. Fire Control Notes. 15(3): 22–26.

Gilmore, R.; Blaine, C. 1960. Box for paper used to cover slash piles. Fire Control Notes. 21(1): 29–30.

Johansen, R.W. 1981. Windrows vs. small piles for forest debris disposal. Fire Management Notes. 42(2): 7–9.

Johnson, V.J. 1984. How shape affects the burning of slash piled debris. Fire Management Notes. 45(3): 12–15.

Maule, W.M. 1954. Hazard reduction by snag burning. Fire Control Notes. 15(3): 27–29.

Morford, L. 1958. Slash disposal by burning on the Klamath. Fire Control Notes. 19(4): 141–143.

Schimke, H.E.; Murphy, J.L. 1966. Protective coatings of asphalt and wax emulsions for better slash burning. Fire Control Notes. 27(2): 5–6.

Stradt, G.H. 1950. Debris burning on the Ouachita. Fire Control Notes. 11(4): 4–5.

USDA Forest Service, Region 6, Division of Fire Control. 1952. Paper for covering piled slash. Fire Control Notes. 13(3): 46.

Chemical Fuel Treatments

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This Is What Fuel Management Is All About

Where we manage land for specific uses, we alter the timing, amount, and condition of the vegetation and associated debris. We change its readiness to burn. We convert green fuel to dead fuel. As a strictly functional activity of fire protection, fuel management could lead one into the trap of managing land simply for the sake of successful fire control. To avoid this trap, we must view fuel management in relation to all land management objectives. We must be keenly aware that all land use activities will some way influence the potential for vegetation to be adversely affected by insect or disease epidemics, windthrow or breakage, wildfire, and other hazards. The choices we make concerning what, where, and how we manipulate vegetation ought to be tempered by the expected hazard associated with such activities. This, basically, is what fuel management is all about.

–A. P. Brackebusch (1973)

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On Developing the Sound Principles of Fuel Reduction

The lack of factual information and specific knowledge regarding fire influences and the techniques of relative social and economics appraisals is handicap to the development of sound principles of fuel reduction. Estimating and theorizing may have to be relied on more than desirable. But if the work is done systematically, cautiously, and prudently, the guides that are developed should produce much better results than can be obtained by relying on the hurried judgements of many different administrators. The problems of fuel reduction are so complex that busy administrative men can do little more than guess, and such guesses are an obviously inadequate basis for guiding the expenditures of millions of dollars for post-war work.

–C.K. Lyman (1945)

Covered Pile Burning: A Safe and Effective Technique for Fuel Removal

The burning of piled slash is a well-established technique for disposing of thinning, logging, and other woody debris (Beaufait 1966, Luke and others 1993, Olson and Fahnestock 1955, Steele 1960). This fuels management bibliography included four long-forgotten articles on covered pile burning—see Ash (1951), Fahnestock (1954), Gilmore and Blaine (1960), and Forest Service, Region 6, Division of Fire Control (1952) on page 45.

It appears that Ash (1951), an assistant district ranger on the Rogue River National Forest in southern Oregon, originally came up with the idea of covering piled slash. To increase the ease and efficiency of burning woody debris piles, he used Kraft No. 30 waterproof paper to cover and protect the fuels from precipitation prior to burning.

Other covering or roofing materials have been tried and used over the years, including polyethylene film or "black plastic"—no longer recommended due to environmental concerns (Garrett 1994). For current information on paper specifically designed for covering slash piles, see, for example, the wax paper offered by Terra Tech, LLC* (<http://www.terratech.net/group.asp?grp=75>).

Covering slash piles should not serve as a panacea for doing a poor job of constructing slash piles that will not readily ignite and be completely consumed (Olson and Fahnestock 1955). However, covered pile burning does provide the advantage of lowering the moisture content of the protected fuels and, therefore, allows burning at a time of year when either heavy rains or a snowfall has eliminated risk of escape.

This should provide a valuable technique for fuel removal within the wildland/urban interface.

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* The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement of any product or service by the U.S. Department of Agriculture. Individual authors are responsible for the technical accuracy of the material presented in *Fire Management Today*.

Improving Wildland Firefighter and Public Safety Through Fire Behavior Research and Development

Natural Resources Canada / Ressources naturelles Canada
Canadian Forest Service / Service canadien des forêts

UNIVERSITY OF ALBERTA

M.E. Alexander

The need to accurately appraise potential wildland fire behavior is embedded in nearly every fire management decision.

And, because of potentially adverse impacts to wildland firefighter safety, the public-at-large, and other values at risk, particular emphasis needs to be devoted to the *prediction* of extreme or severe fire behavior.

In addressing these significant wildland fire safety needs, the wildland fire behavior research and development activities at the Canadian Forest Service's Northern Forestry Centre have two broad objectives:

- To conduct fundamental and applied research to develop mathematical models and operational guidelines for predicting the characteristics of the various phenomena associated with extreme fire behavior; and
- To ensure that fire managers and other clients are aware of the current state of knowledge regarding wildland fire dynamics.

Particular emphasis needs to be devoted to the *prediction* of extreme or severe fire behavior.

In recent years, the centre's focus and accomplishments have occurred in four key areas:

- Applications of fire behavior knowledge and the Canadian Forest Fire Danger Rating System directly to wildland firefighter safety and community fire protection (such as the "Grassland Fire Behavior Pocket Card" and other media, including posters).
- Wildland fire behavior training course delivery and development at the national level (including the Canadian Interagency Forest Fire Centre's Advanced Wildland Fire Behavior and Wildland Fire Behavior Specialist training courses) and several CD-ROM based courses *(Principles of Fire Behavior, Intermediate Wildland Fire Behavior, Wildland Fire–Safety on the Fireline, and*

Marty Alexander, the article's author, underburning for an experimental fuel treatment effectiveness study in a low-pruned and partially thinned 75-year-old jack pine stand in the Northwest Territories, Canada. Photo: R.A. Lanoville, June 2005.

Dr. Marty Alexander is a senior fire behavior research officer with the Canadian Forest Service, Northern Forestry Centre; and an adjunct professor of wildland fire science and management in the Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada.

This article is adapted from a summary associated with a scientific poster presentation made at the XII World Forestry Conference held September 2003 in Quebec City, Quebec. Copies of the poster are available for downloading at: <http://nofc.cfs.nrcan.gc.ca/wfc_pdfs_northern/alexander.pdf>.

Understanding the Fire Weather Index System).

- Development of new, generic models for predicting extreme fire behavior (such as the initiation and spread rate of crown fires, maximum spotting distance from crown fires).
- The International Crown Fire Modelling Experiment that has provided new insights into the nature of crown fires and the opportunity to test and evaluate several fuel management theories.

The centre's focus and accomplishments have occurred in four key areas.

These activities of the Northern Forestry Centre's wildland fire behavior research and development efforts have been accomplished with the assistance of numerous regional, national, and international partners. A strong sense of social responsibility for ultimately benefiting the environment and all of its inhabitants is a common theme that is weaved into all of these research and development undertakings.

An updated list of the publications (Alexander 2003) pertaining to this work is available upon request (e-mail Marty Alexander: malexand@nrcan.gc.ca).

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Alexander, M.E. 2003. Wildland fire behavior research at the Northern Forestry Centre. Edmonton, Alberta: Canadian Forest Service, Northern Forestry Centre <http://www.ciffc.ca/whatsup/NoFC-XIIWFC-handout (E).pdf>. ■

Web sites on Fire*

The Canadian Forest Fire Danger Rating System

The Canadian Forest Fire Danger Rating System (CFFDRS) is Canada's national system for rating forest fire danger. It was developed by the Canadian Forest Service (CFS) in cooperation with the provincial, territorial, and federal fire management agencies in Canada.

The CFFDRS includes decision aids—both existing and planned—for the evaluation of forest fire danger, description of fire occurrence, and prediction of fire behavior characteristics.

The CFS fire research group has developed a Web site to provide a source of up-to-date technical information that describes the development, structure, and application of the four subsystems or modules that comprise the CFFDRS:

- The Fire Weather Index System,
- The Fire Behavior Prediction System,
- The Fire Occurrence Prediction System, and
- The Accessory Fuel Moisture System.

Currently, the CFFDRS Web site also includes a list of selected publications and information on computer software.

A current, comprehensive summary of the CFFDRS can be found in: Taylor, S.W.; Alexander, M.E. 2006. Science, technology, and human factors in fire danger rating: The Canadian experience. International Journal of Wildland Fire. 15: 121–135. (This and other CFFDRS publications can be downloaded from the FIREhouse Web site: <http: //depts.washington.edu/nwfire/>.)

Found at **<http:// fire.cfs.nrcan.gc.ca/research/ environment/cffdrs/cffdrs_e.htm>.**

* Occasionally, *Fire Management Today* briefly describes Web sites 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 Forest Service. To have a Web site described, contact the managing editor, Paul Keller, at 503-622-4861, pkeller@fs.fed.us (e-mail).

2007 Photo Contest Announcement

Fire Management Today (FMT) invites you to submit your best fire-related images to be judged in our photo competition. Entries must be received by close of business on Friday, October 5, 2007.

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 *Fire Management Today* and may be publicly displayed at the Forest Service's national office in Washington, DC.

Winners in each category will receive:
- 1st place – A 20- by 24-inch framed copy of your image.
- 2nd place – A 16- by 20-inch framed copy of your image.
- 3rd place – A 11- by 14-inch framed copy of your image.
- Honorable Mention – A 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 in any publication.
- 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:* Slides, negatives, and prints will not be returned.
- We will also accept digital images if the image was shot at the highest resolution using a setting with at least 3.2 mega pixels. If a print or slide is scanned, use a setting of at least 300 lines per inch with a minimum output size of 5 x 7 inches. Digital image files should be TIFFs or highest quality JPGs. Note: Photos that are date stamped will be eliminated from the competition.
- 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. Example: *A Sikorsky S-64 Skycrane delivers retardant on the 1996 Clark Peak Fire, Coronado National Forest, AZ.*
- You must include the following information with your photo: your name, professional affiliation, town, State, and year that image was captured.
- You must complete and sign the Release Statement form (below) granting the Forest Service rights to use your image(s).

Disclaimer

- A panel of judges—with significant photography and publishing experience—determines the winners. The judges' decision is final.
- Photos depicting safety violations—as determined by the panel of judges—will be disqualified.
- Life or property cannot be jeopardized to obtain photos.
- The Forest Service does not encourage or support deviation from firefighting responsibilities to capture photos.
- Photos will be eliminated from the competition if they are obtained by illegal or unauthorized access to restricted areas; show unsafe firefighting practices (unless that is their expressed purpose); or are of low technical quality (for example, have soft focus or camera movement).
- You must complete and sign the Release Statement form (below) that grants the Forest Service the rights to use your image(s).

Mail your completed release with your entry or fax it to 970-295-6799 at the same time you e-mail your digital image files.

Mail entries to:

Forest Service
Fire Management Today Photo Contest
Karen Mora
2150 Centre Avenue
Building E, Suite 008
Fort Collins, CO 80526
or
e-mail images and captions to:
<kmora@fs.fed.us> and
fax signed release form to
970-295-6799 (attn: Karen Mora)

2007 *Fire Management Today* Photo Contest Release Statement and Contact Information

Enclosed is/are ________ (*number*) slide(s)/print(s)/digital image(s) for publication by the 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.

Contact information:

Name (Printed) ______________________ (Signature) ______________________

Institution affiliation, if any ______________________

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