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THE TEN AND EIGHTEEN— A MEMORY AID



Fight Fire Aggressively,
Having Provided For Safety

FIRST



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Forest Service

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On the Cover:



One of a series of images by artist and firefighter Kari Cashen to help fellow firefighters remember the 10 Standard Fire Orders and 18 Watch Out Situations. See the story by Kathy Murphy beginning on page 4.

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



Firefighter and public safety is our first priority.

CONTENTS

Visualizing the Ten and Eighteen—With Humor	4
<i>Kathy Murphy</i>	
Managing Fire-Dependent Ecosystems: We Need a Public Lands Policy Debate	6
<i>Jerry Williams</i>	
New Interagency Fire Program Analysis System	12
<i>S.L. Robertson and H. Roose</i>	
A New Tool for Fire Managers—An Electronic Duff Moisture Meter.	15
<i>Peter R. Robichaud and Jim Bilskie</i>	
Fuel Mapping for the Future.	19
<i>C.W. Woodall, G.R. Holden, and J.S. Vissage</i>	
Diversifying Fuels Management To Offset Uncertainty	22
<i>John Hof</i>	
Probability of Spot Fires During Prescribed Burns	24
<i>John R. Weir</i>	
Fires in the Wildland/Urban Interface: Best Command Practices	27
<i>Michael S. Rohde</i>	
Fire Regimes in the Northern Rockies	32
<i>Stephen W. Barrett</i>	
Keetch-Byram Drought Index: Can It Help Predict Wildland Fires?	39
<i>Daniel W. Chan, James T. Paul, and Alan Dozier</i>	
Fire Prevention Team Shows Its Worth in Georgia	43
<i>James T. Paul, Daniel Chan, and Alan Dozier</i>	
Building Group Cohesion in Type 2 Fire Crews	48
<i>Bill Lee</i>	
Wildland Fire Education: Going the Distance in Alaska	51
<i>Sandi Sturm and Matt Weaver</i>	
SHORT FEATURES	
Websites on Fire.	38
Canadian Fire Weather Index System: Training Now Available on CD-ROM.	54
<i>Paul St. John and Martin E. Alexander</i>	
“Brewer Fire Mystery” Discussion	56
Guidelines for Contributors.	58
Annual Photo Contest	59

VISUALIZING THE TEN AND EIGHTEEN— WITH HUMOR



Kathy Murphy

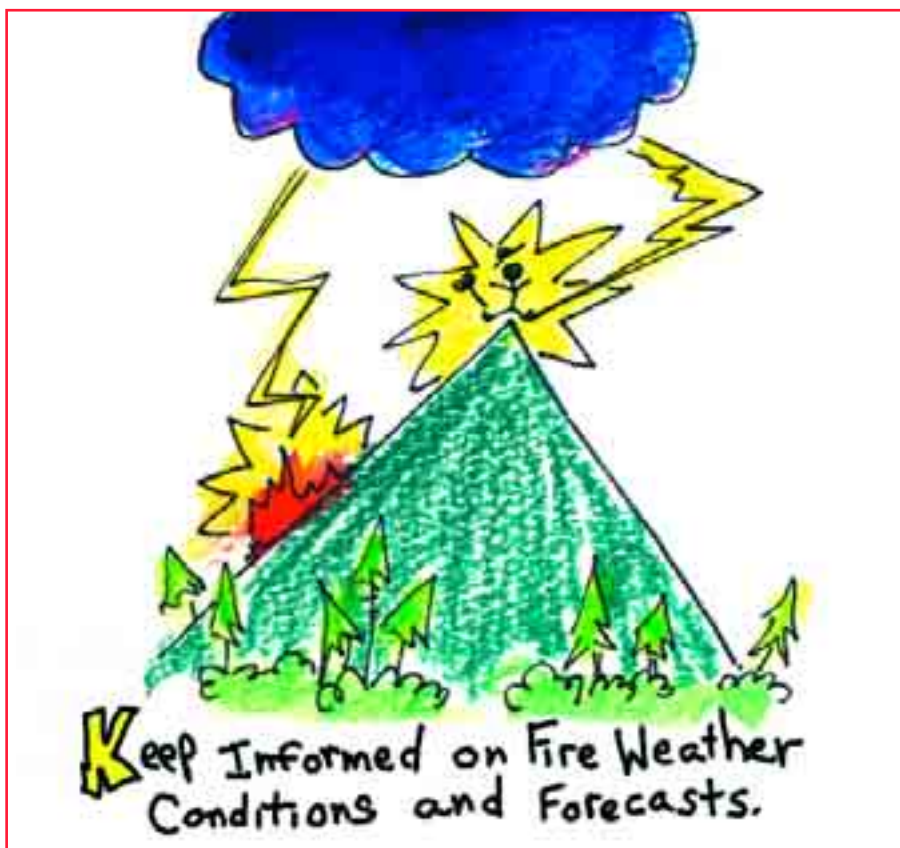
For 2 years, Kari Cashen, a firefighter with the Truckee hand crew on the Tahoe National Forest, spent the summer digging line, setting backfires, sleeping in the dirt, and enjoying the camaraderie of a fire crew. Recently, Cashen combined her passion for art and firefighting to create colorful, humorous posters to help her and others memorize the 10 Standard Fire Orders and the 18 Watch Out Situations—required for all firefighters.

For Cashen, every 10-mile run or uphill training hike was an opportunity to draw mental pictures. Throughout the gauntlet of extensive fire and physical-fitness training, Cashen focused on a Fire Order or Watch Out and crafted a related scenario based on her crew's firefighting effort. "I would draw the scene in my mind. Before I knew it, I had climbed the hill or run the 10 miles, and I would be giggling to myself about the cartoon I had envisioned."

Although the mental art was helpful and fun, seeing the images on posterboard really helped Cashen focus on the essential firefighting safety messages. "The colors are bright and eye-catching and the cartoons appeal to the sense of fun that many firefighters have," says Cashen. She shared the artwork with crew members, who especially liked the cartoon characters that



*Kari Cashen posing with her artistic rendering of the 10 Standard Fire Orders.
Photo: USDA Forest Service.*



Kathy Murphy is the fuels management specialist for the USDA Forest Service, Tahoe National Forest, Truckee Ranger District, Truckee, CA.



These sketches just might help you remember the Fire Orders and Watch Outs!

showed them and the fires that they had battled! They encouraged Cashen to perfect her work and develop the sketches into a poster format for the benefit of other firefighters.

Cashen's firefighting experience and engaging artwork visually communicate vital fire safety messages. The posters are fun and colorful, and they clearly depict the consequences of violating the 10 Standard Fire Orders and the 18 Watch Out Situations. Cashen is working to widely circulate her artwork to help wildland firefighters remember the essential safety rules.

Four examples of Cashen's artwork are shown here, including two Fire Orders and two Watch Outs. The full series is available as a screen saver, in a PowerPoint presentation, and for display at http://www.fs.fed.us/fire/safety/10_18/10_18_posters.html. ■



MANAGING FIRE-DEPENDENT ECOSYSTEMS: WE NEED A PUBLIC LANDS POLICY DEBATE*



Jerry Williams

In wildland fire management today, we know that sustaining healthy, resilient fire-dependent ecosystems is the key to protecting people and property. We have departed from the policy of fire exclusion that characterized our fire management for most of the 20th century. There will always be a need to fight fire, but the wholesale exclusion of fire was a major factor in putting our fire-dependent ecosystems at risk, particularly our long-needle pine forests, such as ponderosa pine. It is not so much that our suppression policy was flawed as it is that our fire use policy is too constricted.

Things Coming Due

In a way, things are “coming due” for wildland fire operations in the United States. Things are coming due for our workforce—we rely on retirees during difficult fire seasons. Things are also coming due for some of our equipment, such as our air tankers—our average air tanker is 46 years old. And things are coming due for our forests—nationwide, we have about 397 million acres (161 million ha) at risk from wildland fires that compromise human safety and ecosystem health.**

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

* Based on a paper presented at the 3rd International Wildland Fire Conference in October 2003 in Sidney, Australia.

** The area in fire regimes I and II, condition classes 2 and 3 (Schmidt and others 2002).

It is not so much that our suppression policy was flawed as it is that our fire use policy is too constricted.

The risk is due to altered fire regimes. Fire regimes are an expression of fire’s role in terms of historical or natural fire frequency and burning intensity. Fire managers expect large, stand-replacement fires in our long-interval fire regimes. Ecologically, that is how these forests established. Alarmingly, however, we are beginning to see landscape-scale, stand-replacement wildfires in our short-interval fire regimes, such as ponderosa pine.

Sustaining these forests will require a management approach

that uses fire as a bedrock. Historically, the ponderosa pine canopies were very open, with trees that were very big and widely spaced. Low-severity fires burned through on the ground every few years without doing much damage to the big trees. But fire exclusion and other factors allowed small trees and brush to build up in the understory. Today, where we once had a hundred large trees per acre, we might have thousands of small trees that “choke” the overstory.

In a drought, we now have continuous fuels from the ground into the



Winema Interagency Hotshot Crew member walking towards a drip torch in a May underburn in open ponderosa pine, Crescent Ranger District, Deschutes National Forest, OR. Long-needle forest types such as ponderosa pine need frequent fire use to stay healthy. Photo: Brendan O'Reilly, USDA Forest Service, Klamath National Forest, Klamath Falls, OR, 1999.

canopy. When we get a fire, it climbs into the canopy and becomes severe and stand-replacing. In 2002, four States in the West had their biggest fires ever, and a fifth State came close, partly because the fire regime has changed in our long-needle pine forests.

The USDA Forest Service recently mapped fire regime condition classes in relation to wildfire activity in the United States (Schmidt and others 2002). In many of our ecosystems, fire regimes have significantly changed from their historical range. The 397 million acres (161 million ha) most at risk nationwide constitute an area almost three times the size of France. In the West, nearly all of the area most at risk is ponderosa pine in the prolonged absence of periodic underburning.

From a social perspective, ponderosa pine forests are most common at lower elevations, where most people live, work, and play. That makes them of particular concern because of the huge fire danger they represent. It is no coincidence that many of our most costly, damaging, and destructive wildfires occur in these changed ponderosa pine forests, often in close proximity to the wildland/urban interface (WUI). Stand structure is much more dense, with small trees and undergrowth choking the forest. Species composition has often shifted to Douglas-fir and other fire-intolerant species. And people have moved into the forest.

Need for Social Science

That brings me to a second thing that we are learning to recognize: The *kind* of science we will need in



View of the Hayman Fire on June 18, 2002. The largest fire in Colorado history, Hayman burned through many areas of overgrown ponderosa pine forest in or near the wildland/urban interface. Photo: Cindy Nowak, USDA Forest Service, Klamath National Forest, Klamath Falls, OR, 2002.

Fire protection in the WUI is not just about protecting houses—it's about protecting quality of life.

fire management is evolving. Although the physical sciences will remain essential for understanding ecosystems and fire behavior, we will need a deeper understanding of the social sciences to help us widen the decision space we will need for ensuring the health, resilience, productivity, and safety of fire-dependent ecosystems.

The reason is that altered fire regimes in our long-needle pine forests are increasing the fire danger to communities. In the 2000 census, the five fastest growing States were all in the Western United States. By 2020, our 20 fastest growing counties are all expected to be in the South and West (Cordell and Overdevest 2001). Our population is gradually shifting from the Northeast and Upper Midwest to the South and West.

Why? Because people are moving to places they value for a better quality of life. People value forested settings. They value places with water, mountains, and amenities, such as hunting or hiking on public land. People are moving to the West or South to find these places. These are also the regions dominated by long-needle pine ecosystems with altered fire regimes.

The result is often a dangerous mix. People are moving in record numbers into forests that are increasingly susceptible to crown fire. The very qualities that people value—dense forests that provide a sense of seclusion and screening from neighbors—these same qualities put people at risk. The risks are enormous, and they go way beyond individual homes. If their houses are saved but the surrounding landscape is blackened, then as far as

they're concerned, people in the WUI have lost the very values that brought them there.

Fire protection in the WUI is therefore not just about protecting houses—it's about protecting quality of life. The wildland fire community is expected to protect the entire landscape—not only communities, but also watersheds, viewsheds, recreational opportunities and other amenities, and forest health—everything people value in the WUI, everything they move there to find.

We will therefore need a better understanding of the social sciences. If we are going to protect quality of life in the WUI, then we have got to do more to understand people's motivations so we can better influence social attitudes and behaviors. We have to do a better job of addressing public biases and fears in connection with fuels management and fire use in our fire-dependent ecosystems. We also have to do a better job of addressing public preferences and lifestyles in the WUI. For that, we will need to take such fields as sociology, communications, community relations, and public administration more into account when we formulate policy for public lands.

Four Kinds of Fire

A third thing we are learning has to do with our suppression program in the context of the fuels and fire environment. Despite significant advances in our firefighting technology, budgets, and personal protective equipment, we are seeing an upward trend in the number of acres burned per acre protected. Also, again in spite of all the advances we've made, the number of entrapments and fatalities we're seeing remains a major concern.

We might argue that the extended-attack fire and the megafire are our two most important kinds of fire—one in terms of safety, the other in terms of cost.

Although accumulated fuels and drought predispose many of our forests to wildfires, we are coming to realize that there are four distinctly different kinds of fire. We have good suppression strategies for two of them. But there are two other kinds of fire for which we do not have good strategies, and it shows in our statistics.

These four kinds of fire occur along a spectrum of size and complexity. They range from the small initial-attack fire to the enormous and complex "megafire." We have sound approaches for dealing with the small initial-attack fire and with the large fire. We train, organize, and staff to address the unique characteristics of these two types of fire. But for the transition or extended-attack fire and the so-called megafire, we do not do this well. We tend to treat the extended-attack fire like we do the initial-attack fire, only we fight it harder. And we tend to treat the megafire like the large fire, only—believing more is better—we fight it with more people, more equipment, and more money.

We might argue that the extended-attack fire and the megafire are our two most important kinds of fire—one in terms of safety, the other in terms of cost. Some 70 percent of our fireline fatalities occur on transition fires, such as South Canyon in 1994 or Thirtymile in 2001. We get into trouble when we keep using initial-attack tactics on a fire that requires a shift in thinking about potential fire behavior—

when fire behavior has become too extreme for initial-attack tactics to be safe and effective.

Large fires and megafires are less than 1 percent of all of our fires, but they account for a disproportionately high percentage of our total suppression costs—about 80 percent—and of our total area burned—about 90 percent. The megafire accounts for the majority of these costs and acres burned, even though these fires probably only comprise one-tenth of 1 percent of all fires.

We've learned that we can't go toe-to-toe with these big fires under extreme burning conditions. We've got to back off and take a defensive posture. Megafires are qualitatively different from large fires and need a qualitatively different type of management, just as extended-attack fires need a qualitatively different type of management from initial attack. For both kinds of fire, we need to develop discrete strategies in terms of policy, procedures, and practices.

Many of us believe that the suppression fight against large fires and megafires will ultimately be won or lost on the fuels front, where we're using fire and mechanical fuels reduction tools to take a little heat out of the woods. Basically, we need to fight fire where we must but use fire where we can. We are getting megafires in long-needle pine forests because fire regimes there have been altered. The long-term solution is

to restore these forests to something more resembling their historical condition and then get the right kind of fire back into the ecosystem.

Perhaps one of our lessons in accelerating fuels reduction work involves learning to mobilize for fire use operations like we mobilize for fire suppression operations. Although we've made progress toward a more balanced wildland fire policy, we still have to work on overcoming the bias toward fire suppression that stems from a legacy of fire exclusion.

Next Big Step

The three things we are learning—the need for more fire use, for a better understanding of the social sciences, and for discrete strategies on the four kinds of fire—are all interconnected. In fact, our ability to make progress in one area depends on understanding all three. That brings me to what lies ahead: the next big challenge for wildland

fire policymakers in the United States.

Our objectives in wildland fire management are clear. Our aim is to protect values—to protect quality of life by restoring fire-dependent ecosystems such as long-needle

Many of us believe that the suppression fight against large fires and megafires will ultimately be won or lost on the fuels front.

pine. For that, we need to establish a total, balanced program of fire management where there is no longer any bias toward fire suppression or fire use.

Given these objectives, we have probably pushed our fire management policy about as far as we might effectively go. Today, our

policy provides for fire use, suppression, and prevention. But I am afraid it is not balanced enough. I'll explain by giving a little history.

In 1995, the five Federal agencies with fire management responsibility in the United States wrote a collective policy for fire management. In 2001, we updated the Federal fire policy. As part of the implementation process, we gave the revised fire policy to two outside panels for their review.

One panel was made up of fire experts. They were satisfied that our revised Federal fire policy reflected good science and sound fire management. The other team was made up of policy experts. They, too, were generally satisfied that we had provided a coherent fire policy.

But one of these reviewers, from the JFK School of Government at Harvard University, said our fire policy was missing something: a much larger public land policy debate. We were setting ourselves up for failure, he said, without a broad public debate—a debate that addresses all the *long-term* social, legal, and economic factors that drive how we manage our fire-dependent ecosystems. These factors go way beyond our fire policy per se.

In other words, a sound fire policy must be predicated on a public lands policy that is not only socially acceptable, but also ecologically appropriate and economically efficient over time. Our fire policy is somewhat “stuck” until we can do three things:



View of the Biscuit Fire on August 1, 2002, the largest fire in Oregon history. Large fires and megafires are less than 1 percent of all fires but account for 80 percent of total suppression costs and 90 percent of total area burned. Photo: Gary Percy, USDA Forest Service, Siskiyou National Forest, Gold Beach, OR, 2002.

- More effectively influence development or growth behaviors in the WUI;
- Better align regulatory controls for clean air, clean water, and endangered species with the disturbance processes that define our fire-dependent ecosystems; and
- More specifically tailor resource objectives to be consistent with the ecological dynamics of fire-prone forests and grasslands.

Let me give a few examples to illustrate what I mean about the importance of a public lands policy debate for the viability of a balanced wildland fire policy.

Technical solutions are not enough. We also need social, legal, and regulatory solutions that focus on the dynamics of fire-prone forests.

First, let's consider the social influence on wildland fire policy. We know that we need to thin overcrowded long-needle pine forests to reduce fire danger in the WUI. The result would be a forest that is very open, with maybe only a hundred trees per acre. But people move to the WUI partly because they value the sense of seclusion and "naturalness" they get from lots of trees. They are used to seeing thick forests, with thousands of trees per acre. It's what they *think* of as natural and healthy, even if it isn't *really* natural, healthy, or resilient.

So people often object to a thinning project. Some people might object in principle to cutting any trees at all—there are even counties with



A home in Clark County, WA, before (top) and after (bottom) removal of hazardous fuels through a State project funded by the National Fire Plan. Many people prefer secluded homes in densely forested settings and resist vegetation removal—a serious constraint to wildland fire management. Photo: Thomas Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2002.

ordinances against tree cutting. Other people might see it as affecting their quality of life if we remove most of the trees near where they live. In fact, our projects are often appealed and even litigated for just this reason.

Now let's look at the regulatory side of wildland fire policy. Under the Endangered Species Act, Federal land managers are legally bound to

protect habitat for threatened, endangered, and sensitive species. In the case of the northern spotted owl and Mexican spotted owl, we do that partly by managing for lateral stand conditions to maximize canopy cover.

But managing for closed canopies might keep us in some places from restoring the more open forests that existed historically. The regula-

tory context can actually put us at cross-purposes. In fact, two of the megafires we had last year—the Biscuit Fire in Oregon and the Rodeo–Chediski Fire in Arizona—burned partly in areas we were managing for late-seral stand conditions. Ironically, such fires not only consume the old-growth forest we are trying to protect, but also imperil the very species we are trying to sustain.

We are in some serious quandaries. Social and regulatory factors can freeze our ability to reduce fuels and restore long-term forest health. Here are some more examples:

- When we use fire, people sometimes object to the smoke. Under provisions of the Clean Air Act, prescribed fire emissions count as air pollution, whereas wildfire emissions do not—even though, over time, wildfire emissions have actually increased due to our attempts to exclude fire. People tend to focus on immediate impacts, not future benefits.
- When we mechanically thin trees, the reduction in vegetative cover can temporarily impair local water quality, which might trig-

Although today we use fire more, we still have to work on overcoming the bias toward fire suppression that stems from a legacy of fire exclusion.

ger a prohibition under the Clean Water Act. This is another example of a tradeoff between short-term environmental impacts and long-term environmental benefits.

- When we try to get people to be smarter about building houses and maintaining their property in the woods, they might see it as a States’ rights issue or as Federal meddling in private affairs. Local building codes often favor economic expansion and development, even though development in some cases puts people, businesses, and local communities at risk in fire-prone forests.

We think we have the ecological science to restore fire-dependent ecosystems and better protect the people we serve, and technically maybe we do. But technical solutions are not enough. We also need social, legal, and regulatory solutions that focus on the dynamics of fire-prone forests.

As wildland fire professionals, we need to prompt a larger public lands policy debate that deals with values and tradeoffs if we hope to redeem our fire protection mandate. And we need to do it in the context of the dynamics of fire-dependent ecosystems. That is the next big step in the evolution of wildland fire policy in the United States—and maybe in other countries as well.

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NEW INTERAGENCY FIRE PROGRAM ANALYSIS SYSTEM*



S.L. Robertson and H. Roose

The 2000 and 2001 fire seasons shook the wildland fire community in the United States. In May 2000, an escaped prescribed fire roared through parts of Los Alamos, NM. That was followed by one of the largest fire seasons in 50 years. The next summer brought the Thirtymile Fire, a tragedy fire in the State of Washington that entrapped 14 firefighters and took 4 lives.**

These events raised calls for more accountability in the Nation's wildland fire program. The five Federal agencies responsible for the program—the USDI Bureau of Indian Affairs, Bureau of Land Management, National Park Service, and U.S. Fish and Wildlife Service and the USDA Forest Service—are working together to develop a mutually compatible, performance-based system for analyzing the interagency fire program and budget (see the sidebar).

Sarah Robertson is the national interagency fire planner for the USDA Forest Service and USDI National Park Service; and Howard Roose is the Fire Program Analysis Business Team leader for the USDI Bureau of Land Management, National Interagency Fire Center, Boise, ID.

* Based on a paper presented at the 3rd International Wildland Fire Conference in October 2003 in Sidney, Australia.

** For more on these events, see Jim Paxon, "Remember Los Alamos: The Cerro Grande Fire," *Fire Management Today* 60(4) [Fall 2000]: 9-14; Mike Dombeck, "How Can We Reduce the Fire Danger in the Interior West?," *Fire Management Today* 61(1) [Winter 2001]: 5-13; and Hutch Brown, "Thirtymile Fire: Fire Behavior and Management Response," *Fire Management Today* 62(3) [Summer 2002]: 23-30.

The new Fire Program Analysis System will replace the budget and analysis systems currently in use.

The new Fire Program Analysis (FPA) System will replace the budget and analysis systems currently in use, such as the National Fire Management Analysis System,

FIREPRO, and Fire Base. The new system is scheduled for field testing in summer 2004, with release of the first module (preparedness) planned for October 1, 2004.

The System in a Nutshell

Features

The Fire Program Analysis (FPA) System is a strategic tool for helping managers move from measuring outputs to measuring results and outcomes. The system:

- Uses objectives in land and resource management plans and fire management plans as the cornerstone for planning;
- Provides a common approach to fire management program planning and budgeting for all five Federal wildland fire management agencies;
- At any given budget level, displays tradeoffs involved in meeting various fire management objectives, such as protecting natural and cultural resources as well as infrastructure and property;
- Helps quantify meaningful performance requirements under

the National Fire Plan and the Government Performance and Results Act of 1993; and

- Facilitates partnerships between Federal interagency fire planning units and tribal, State, and local governments.

Scope

When completed, the FPA System will address the full scope of fire management activities, including:

- Initial response for both wild-fire suppression and wildland fire use;
- Extended attack, large fire support, and national resources;
- Prescribed fire and fuels management;
- Wildland fire prevention and education; and
- Postfire emergency stabilization and rehabilitation.

Land Management Planning Framework

The FPA System focuses on the goals, strategies, and objectives identified in developing fire management plans (FMPs). FMPs are derived from broad land and resource management plans, which assess the landscape condition and define the desired future condition. Wildland fire specialists then determine the appropriate role of wildland fire management in achieving the desired condition, and they formulate FMPs accordingly.

The FMPs define fire management units—specific areas that are distinct from adjacent units in terms of fire regime, management objectives, topographic features, values to be protected, or other key factors. For each unit, the FMP:

- Formulates suppression goals and objectives that support the desired condition;
- Specifies programmatic approaches or strategies for managing fire;

The FPA System focuses on the goals, strategies, and objectives identified in developing fire management plans.

- Defines measures of accomplishment (fire management objectives) over time;
- Addresses public and firefighter safety; and
- Describes sensitive social, economic, and resource issues related to fire management strategies and objectives.

Fire management objectives are important triggers for the FPA system. For each fire management unit, the FPA system documents fire management objectives from the FMP and translates them into meaningful measures for the analysis model (fig. 1).

Weighted Objectives

Through an interdisciplinary and/or interagency process, the FPA System weights each fire management objective based on such factors as values to be protected from wildfire or enhanced through fire

use. Weighting takes into account such variables as time of year and fire intensity levels (fig. 1).

Weights relate to objectives in other fire management units. For example, fire suppression is more urgent in the wildland/urban interface (WUI) than in the backcountry, so the suppression objective has a greater weight in a WUI fire management unit than in a backcountry unit.

By assigning weights, the FPA System helps managers set priorities and budgets. For example, a planning unit might have several different fire management units, with strategies ranging from protecting communities in the WUI, to restoring the natural role of fire in wilderness, to protecting threatened species and restoring habitat. By weighting the associated objectives, the FPA System lets man-

Example: Suppression objectives

<i>Land management plan (General direction)</i>	<i>Resource management plan (More specific direction)</i>	<i>Fire management plan for a particular fire management unit (Fire management objective)</i>	<i>Fire Program Analysis System input (Damage threshold)</i>
Suppress all wildfires.*	Protect critical habitat for threatened and endangered (T&E) species from damage by wildfires, especially high-intensity fires.	Over the next 5 years, 100 percent of all wildfires in habitat for T&E species are controlled during initial attack.	Wildfires at or greater than fire intensity level 3 should be kept to less than 100 acres from April to June. Weight = 8 (high relative importance)

* A wildfire is an unwanted wildland fire.

Figure 1—Relationship of land and resource management planning through fire management plans to the Fire Program Analysis System for a sample fire management objective (wildfire suppression). The inputs are designed to be meaningful performance measures.

agers prioritize the needed work and set corresponding funding levels.

Formulating Measurable Objectives

In the past, accountability systems for Federal land management agencies have focused on outputs rather than outcomes. The reason was simple: Outputs were deemed more measurable.

However, under the Government Performance and Results Act of 1993, program activities must be directly linked to desired outcomes, and they must be measured for effectiveness in achieving those results (Robertson 1998). Traditional performance measures such as costs and number of acres treated reflected a program's efficiency but not its effectiveness. Such measures say nothing about whether results were achieved.

The FPA System addresses the problem by drawing on the fire management objectives specified in FMPs. FMPs are based on land and resource management plans, which focus on outcomes—on achieving desired conditions on the land. By deriving performance indicators from objectives designed to achieve the desired future condition, the FPA System helps managers evaluate not only the efficiency of a program, but also its effectiveness.

But that raises another problem. The greatest challenge ahead will be identifying fire management objectives and performance indicators that are both meaningful and measurable—that are both outcome based and useful for showing accountability.

For example, many outcomes from prescribed fire are very long term. Interim measurable objectives are therefore needed for short-term program accountability. Moreover, the National Fire Plan and the 10-Year Comprehensive Strategy Implementation Plan prescribe programs in the WUI with social and cultural outcomes that are extremely difficult to measure.

The key to successful performance measurement is knowing which program indicators have the most significant relationship to desired outcomes. Defining performance indicators is where science and art

By weighting each fire management objective, the FPA System helps managers set priorities and budgets.

come together as managers link the logic and rationale of policy and programs with the primary activities designed to produce results.

For every set of activities, there should be a set of indicators that test whether program logic and assumptions truly deliver intended results. Many indicators will be interdisciplinary ecological measures of resilient and sustainable ecosystems; others will be social and economic measures of fire protection for communities and the general public.

An additional challenge will be to ensure that the sum of the indicators at the national level translates into a defensible and coherent budget structure for Congress. The challenge in developing measurable

objectives is to ensure that indicators are meaningful to field-level fire managers and high-level decisionmakers alike.

A Big Step Forward

Implementing the FPA System will take time. Coming up with appropriate short-term indicators as interim measures for long-term wildland fire management outcomes will not be easy. Moreover, the new system cannot be expected to make the hard political choices for decisionmakers. Many factors in addition to performance must still go into final decisions on resource allocation.

In fact, the FPA System will only be as good as the process of land management planning it is based on. Stakeholders and the public must be meaningfully engaged to ensure that land and resource management plans reflect a full range of ecological, social, and economic values. Plans must also contain goals, desired conditions, and resource management objectives that support an appropriate role for wildland fire in the landscape.

However, the FPA System is an important step toward increased accountability in wildland fire management. It will move the Federal wildland fire program from reporting one-dimensional output data toward providing more meaningful information based on outcomes. Managers need such information to make decisions that will stand the test of time in the public service.

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A NEW TOOL FOR FIRE MANAGERS—AN ELECTRONIC DUFF MOISTURE METER



Peter R. Robichaud and Jim Bilskie

Prescribed fires are increasingly being used to reduce hazardous fuels, a major objective of the National Fire Plan. Despite advancing technology and ever-improving models, fire managers still find it challenging to determine the right time for a prescribed burn.

Measuring Duff Moisture Content

The effect of fire on the forest floor can vary from merely removing the litter to totally consuming the duff, which exposes the mineral soil and alters the surface soil structure. Fire managers often design prescribed fires to leave some of the duff to protect the mineral soil. Duff thickness and moisture content are the most important factors in determining duff consumption during fires.

In comparison to other woody fuels, duff has greater spatial and temporal variation in moisture content. Small precipitation events and heavy dew accumulations that have negligible effect on the moisture content of large fuels can significantly increase the moisture content of fine fuels and litter. And subsurface duff can lose moisture through evaporation much more quickly than the large woody fuels. Due to subtle differences in canopy

The DMM600, a duff moisture meter, provides reliable, real-time measurements of duff moisture content.

closure, slope, aspect, and microtopography, duff moisture levels can vary significantly across the landscape, even at the hillslope scale.

These variations make it important to use real-time duff moisture measurements to estimate duff consumption and, more importantly, to achieve desired postfire duff depths. Using a measured duff moisture content in models like FOFEM (Keane and others 2003), fire managers can better estimate the duff remaining after a burn.

In the past, the fire manager might pick up a bit of duff, squeeze it firmly, and check the moisture before giving approval to begin the burn. The fire manager used past experience, weather information, and a “feel” for the current conditions as a final check.

An additional tool is now available. The DMM600,* a duff moisture meter (fig. 1), provides reliable, real-time measurements of duff moisture content. The DMM600 was patented and developed

through a cooperative research effort by three of the USDA Forest Service’s research and development units—the Forestry Sciences Laboratory in Moscow, ID; and the Fire Sciences Laboratory and Missoula Technology and Development Center, both in Missoula, MT. The Forest Service collaborated with Campbell Scientific, Inc., in Logan, UT, for production and marketing.

How the Meter Works

The fire manager collects a sample from the portion of the duff layer just above the soil mineral horizon and pushes it through a #4 mesh sieve that fits in the opening of the sample chamber (fig. 2). Passing the duff through the sieve breaks



Figure 1—The duff moisture meter (DMM600).

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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*.

up large organic fragments and removes sticks and rocks, allowing for more uniform packing.

After the sieved material fills the chamber, the cap is put on and the compression knob turned until an audible indicator signals that the sample is properly compressed (at 15 pound-force [66 N]). The meter then automatically takes the measurement and displays it at the base of the instrument. Readings are displayed in real time only; measurements are not stored. Total time needed to sieve and measure each sample is about 30 seconds.

The tough, lightweight DMM600 is a portable, battery-powered sensor that was developed from frequency domain reflectometry technology. When proper pressure triggers a measurement, a high-frequency signal of 42 MHz is applied to the sensor electrodes at the base of the sample chamber, and the sensor electronics detect the change in frequency of the reflected signal (fig. 3) (Robichaud and others 1999, 2000). The frequency change depends on the dielectric constant of the medium adjacent to the sensor electrodes. Because the dielectric constant of the medium varies with moisture content, the frequency change can be easily related, through a simple calibration function, to provide moisture content. The unit's microprocessor uses a factory-supplied calibration to convert the frequency to a volumetric moisture content and displays the value in the LCD readout.

Air voids in the duff can reduce the apparent dielectric constant and/or create a poor contact between the duff and the sensor electrodes. Using the meter's compression feature on sieved duff ensures that

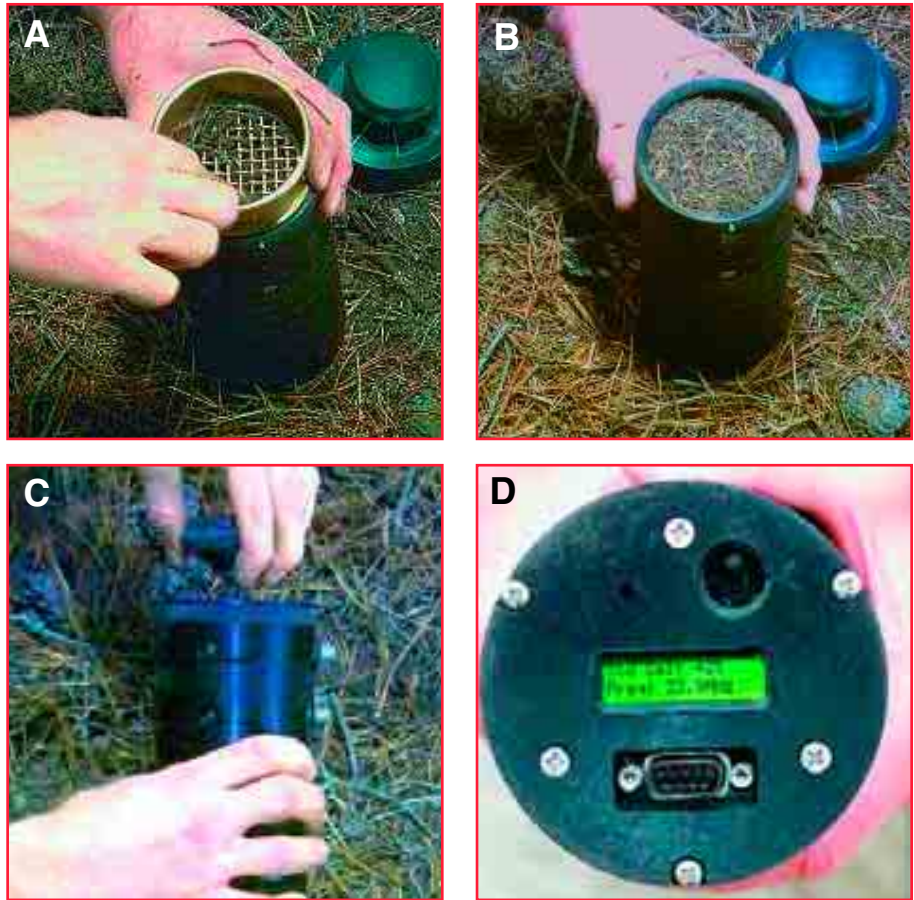


Figure 2—Using the duff moisture meter in the field is simple and fast. Toggle the power switch on and select the duff to be sampled—usually from the lower half of the duff layer. (a) Push the duff sample through the sieve into the chamber. (b) Fill the chamber with the duff. (c) Compress the sample using the hand-turn knob, stopping when the audible signal is sounded. (d) Read the moisture content from the display window at the base of the instrument.

each sample is pressed evenly against the sensor electrodes, which reduces measurement variability.

Calibration

The factory-supplied calibration for the DMM600 is derived from laboratory measurements of the volumetric moisture content of duff from eight different forested sites. Depending on elevation, the cover species included Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*). Because



Figure 3—The bottom of the sample chamber is a printed circuitboard containing two interlocking finger sensor electrodes attached to a movable piston.

Specifications

Physical

Dimensions: 3.5 inch (9 cm) diameter
10 inch (25 cm) length
Weight: 3.7 lbs. (1.7 kg)
Sieve: #4 mesh = 0.203 inch (5.16 mm)
3 inch (7.6 cm) diameter

Power

Battery: 9 V alkaline
Measurements per battery: > 2000

Performance

Accuracy: ± 5 percent for full scale range
Resolution: 1 percent volumetric moisture content

Included with the DMM600:

- CD containing (a) video instruction, (b) PCDMM software, (c) DMM600 Instruction Manual, and (d) Excel spreadsheet for calibrations.
- 6-foot (1.8-m), 9-pin serial cable.
- Soft-sided, padded carrying case with screwdriver and spare 9-volt battery.

the individual calibration curves were similar, the data were combined to develop a single, standard calibration curve (fig.4).

The error bars indicate that measurement accuracy decreases as moisture content increases. The accuracy is approximately ±4.0 per-

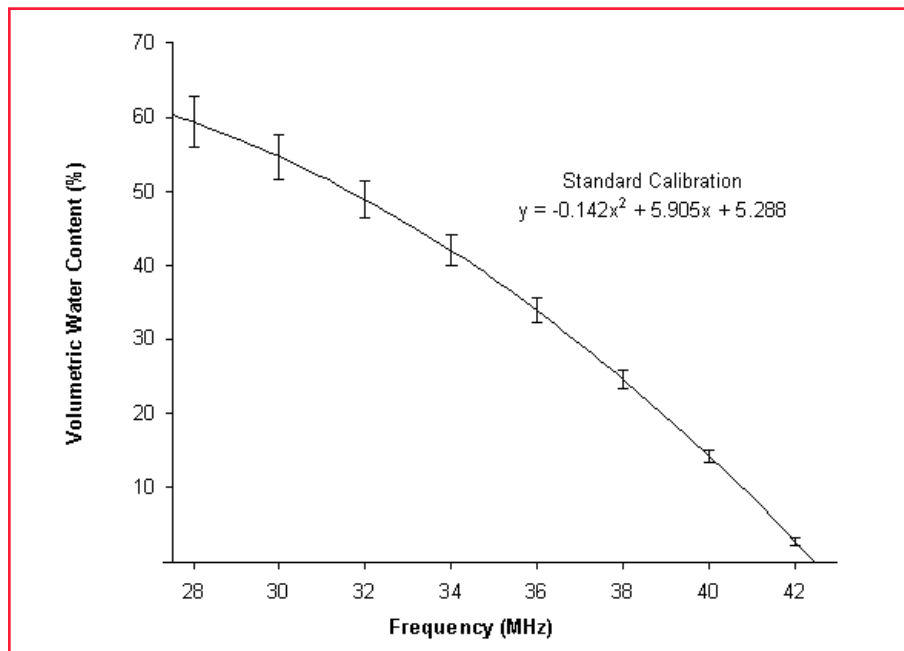


Figure 4—DMM600 standard calibration curve. The variability is smallest in the lower moisture/higher frequency area of the curve, where accuracy is most critical.

The standard calibration curve will likely meet the needs of most fire managers across a range of vegetation types.

cent at 60 percent volumetric moisture content and approximately ±1.5 percent at 30 percent volumetric moisture content. It is recommended that the average of samples from several nearby locations be used to reduce the effects of natural variability.

The meter's response to changing moisture content is best described with a quadratic calibration equation:

$$\text{Volumetric Water Content} = 5.288 + 5.905 \times \text{freq} - 0.142 \times \text{freq}^2,$$

where *freq* is the DMM600 readout frequency in MHz. User-derived calibrations can be determined using the laboratory procedures described in the *DMM600 Instruction Manual* and the *DMM600 calibration spreadsheet.xls* provided in the PCDMM software package (Campbell Scientific 2000). User-defined calibrations are entered into the PCDMM interface and loaded to the DMM600 through a serial port connection.

Studies done on eastern hardwood duff from Massachusetts show little deviation from the standard calibration curve. It is likely that the standard calibration curve will meet the needs of most fire managers across a range of vegetation types.

Gravimetric Moisture Content

The basic operation of the DMM600 gives the volumetric moisture content of the sampled duff. Using a simple calibration process, the gravimetric (“dry-weight-based”) moisture content—the measurement most commonly used by fire managers—can be added to the instrument readout.

A value for duff bulk density is needed for this calibration process. Fire managers may choose to use a known bulk density value or determine one from local conditions (*bulk density = dry weight ÷ volume*). Each coefficient in the standard calibration equation is divided by the bulk density. The three gravimetric coefficients are entered into the PCDMM software (fig. 5)



Figure 5—The PCDMM duff moisture meter interface software. A user-defined calibration curve, such as for gravimetric moisture content, can be added by setting the three calibration coefficients. The DMM600 display alternates between the standard volumetric moisture content and the user-defined calibration for each measurement.

Duff moisture content is critical information for fire managers making operational and planning decisions for prescribed burns.

and uploaded to the DMM600 through a serial port connection on the base.

Because duff bulk density is relatively constant, this calibration process can be completed before going to the field to make duff moisture measurements. When each field measurement is made, both the standard volumetric moisture content and the user-defined gravimetric moisture content are alternately displayed in the readout.

Critical Information

Duff moisture content is critical information for fire managers making operational and planning decisions for prescribed burns. The DMM600 provides dependable duff moisture content data, both in the field and for input in predictive modeling programs. For more information, contact Pete Robichaud at the Forestry Sciences Laboratory, Rocky Mountain Research Station, 1221 S. Main St., Moscow, ID 83843, tel. 208-883-2349, email: <probichaud@fs.fed.us>.

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Ordering Information

Ordering information can be obtained from the Campbell Scientific, Inc., Website at: <<http://www.campbellsci.com/duffmoisture.html>>

Campbell Scientific can also be reached at:

Campbell Scientific, Inc.
815 W. 1800 N.
Logan, UT 84321-1784
Tel. 435-753-2342
Fax 435-750-9540

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FUEL MAPPING FOR THE FUTURE



C.W. Woodall, G.R. Holden, and J.S. Vissage

The large wildland fires that raged during the 2000 and 2002 fire seasons highlighted the need for a nationwide strategic assessment of forest fuels. The lack of a nationally consistent and comprehensive inventory of forest fuels has hindered large-scale assessments—essential for effective fuel hazard management and monitoring reduction treatments. Data from the USDA Forest Service's enhanced Forest Inventory and Analysis (FIA) Program is key to creating fuel maps to improve large-scale assessments.

The Program

The enhanced FIA Program has three phases that contribute to fuel map synthesis.

Phase 1. Remotely sensed images help determine whether field crews can access potentially permanent FIA field plots. Forest and nonforest stratification data layers from phase 1 might both constrain fuel loading predictions in forested areas and facilitate certain analyses, such as locating fuels adjacent to wildland/urban interfaces.

Phase 2. Permanent FIA field plots are established (fig. 1), and standing live and dead trees are inventoried. The data from this phase provide information about tree species, crown ratio, and height. They are useful for estimating fuels in each plot's live and dead standing tree stands.

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The lack of a nationally consistent and comprehensive inventory of forest fuels has hindered large-scale assessments.

Phase 3. Subsets of the permanent FIA field plots are sampled for indicators of forest health. Down woody material (DWM)—duff, litter, and fine and coarse woody debris—is one indicator. Both planar intercept methodologies and fixed-radius plots are used to measure DWM. In addition, inventory data from indicators, such as soils and vegetative diversity, when combined with DWM data, help refine estimations of nonwoody fuels. When using the enhanced FIA Program, all three phases should be sampled annually

for a portion of all permanent plots to maintain current fuels data.

Seamless Dataset. When all phases of the FIA inventory program are integrated, the result is a seamless dataset connecting DWM inventories, traditional forest inventory data, and remotely sensed imagery. The resulting multidimensional fuel maps, developed using the most current data available, provide national fuel estimates from the duff layer to the top of the forest canopy (fig. 2).

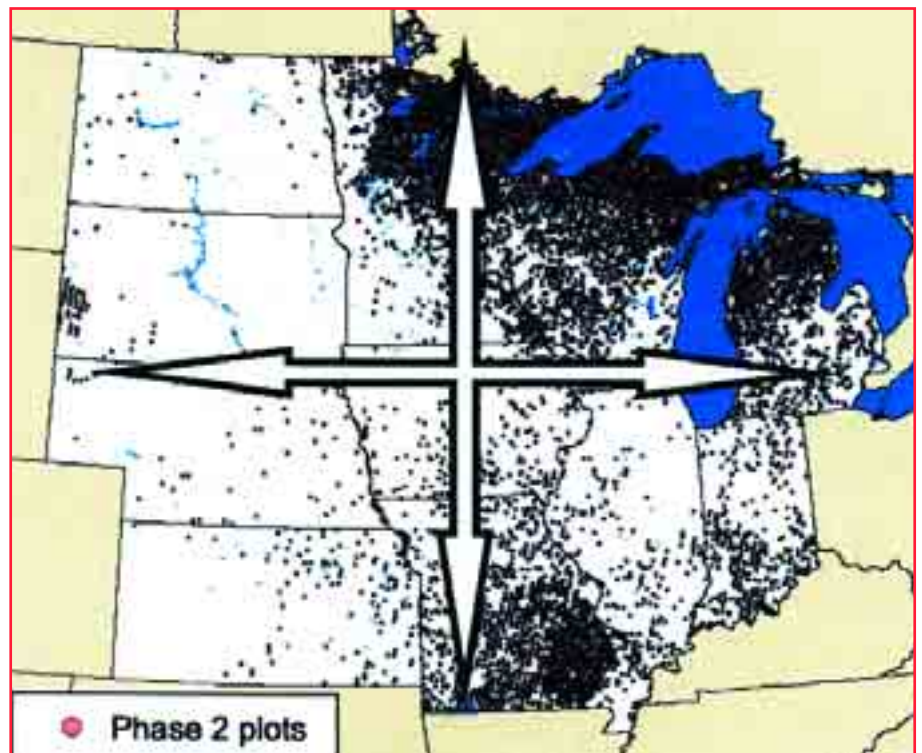


Figure 1—Annual forest inventory analysis phase-2 plots (forested condition) for the North-Central United States from 1999 to 2001. The plots allow for timely fuel hazard assessments at strategic scales.

Mapmaking

Modeling, interpolation, and ancillary stratification are methods for creating fuel maps using all phases of the enhanced FIA Program to satisfy a variety of needs. Selecting the appropriate fuel-mapping technique depends on the objectives, acceptable levels of error, regional DWM sampling intensity, and the proximity of the map region to international borders and large bodies of water.

A modeling approach is appropriate when fuel loads are predicted based on a DWM inventory from phase-2 plots. Another approach is to use

spatial interpolations to estimate fuel loadings for forests not directly sampled by DWM inventory. When combined with phase-1 forest and nonforest data layers, the fuel loading estimates can produce fuel

maps. A third way to create effective fuel maps is to use mean fuel loadings from an ancillary data layer, such as ecological units or forest type, combined with phase-1 forest and nonforest data layers.

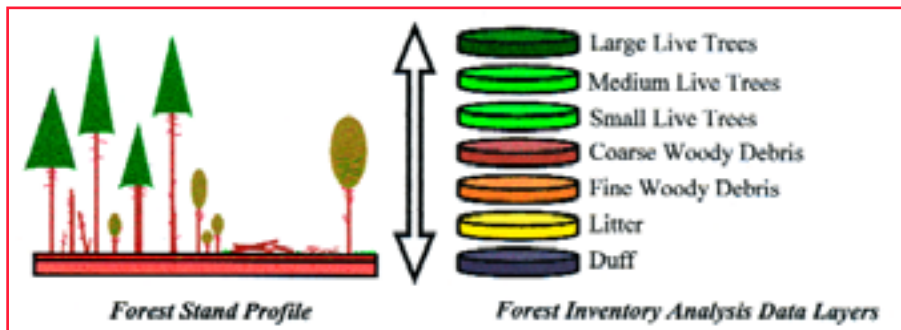


Figure 2—Components of forest fuels. Individual components were sampled during a comprehensive, vertical fuel hazard assessment.

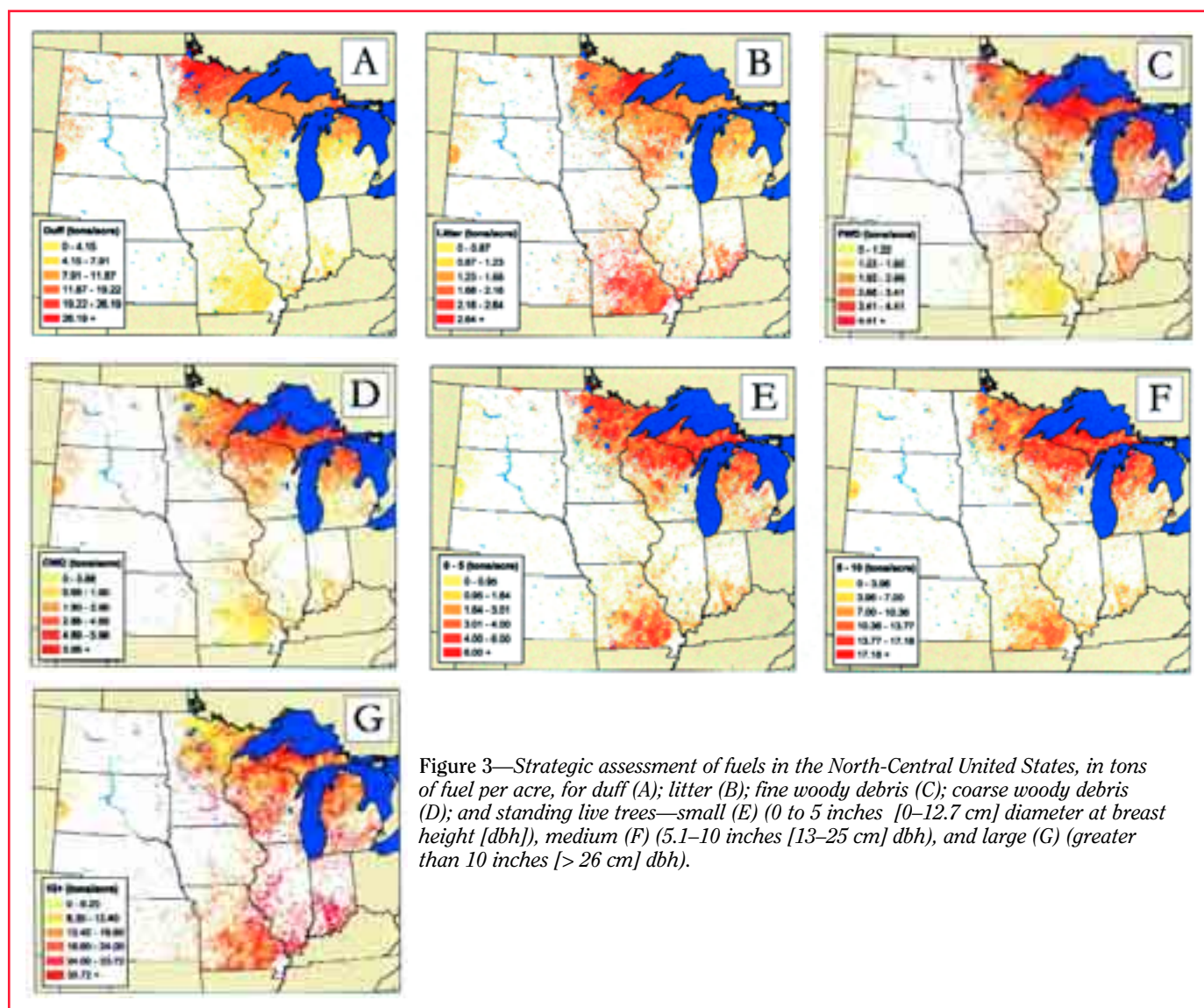


Figure 3—Strategic assessment of fuels in the North-Central United States, in tons of fuel per acre, for duff (A); litter (B); fine woody debris (C); coarse woody debris (D); and standing live trees—small (E) (0 to 5 inches [0–12.7 cm] diameter at breast height [dbh]), medium (F) (5.1–10 inches [13–25 cm] dbh), and large (G) (greater than 10 inches [> 26 cm] dbh).

When all phases of the inventory program are integrated, a seamless dataset connecting downed-wood material inventories, traditional forest inventory data, and remotely sensed imagery results.

For example, figure 3 shows seven regional maps for each of the seven fuel layers (duff, litter, two layers of woody debris, and three layers of standing live trees). We produced the maps by interpolating fuel loadings from DWM sample plot locations, combined with phase-1 forest and nonforest data layers. The maps were based on 8,569 phase-2 plots inventoried from 1999 to 2001 and 249 DWM plots inventoried in 2001.

Figure 4 shows a single map integrating all the data in figure 3. Fuel loadings for each individual map were scaled to a uniform data range (0 to 1), then combined and rescaled, yielding a comprehensive assessment of fuels on a strategic scale.

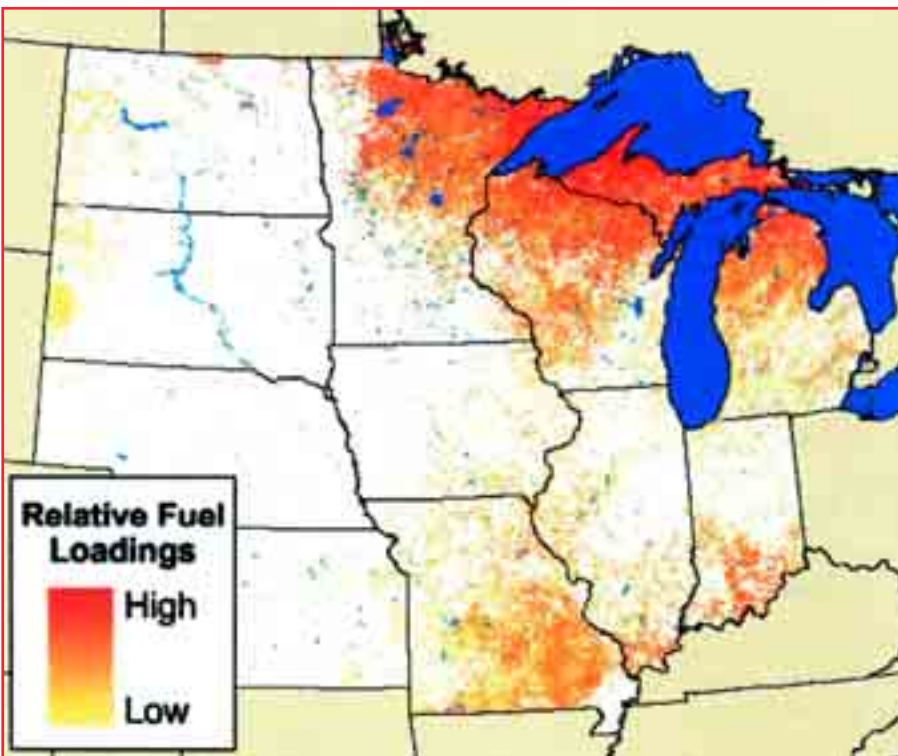


Figure 4—Relative fuel loadings (duff layer to canopy top) for the North-Central United States, based on combining scaled inventory maps for duff, litter, two layers of woody debris, and three layers of standing live trees.

Value of Fuel Mapping

Creating comprehensive and consistent national fuels maps is possible using the extensive forest inventory data available through the enhanced FIA program, coupled with new mapping and remote-sensing technologies. Based on the information provided in such maps, completing large-scale assessments, essential for managing and moni-

toring fuel hazards across forest ecosystems, might mitigate the potential for another devastating fire season.

For more information, contact Chris Woodall, USDA Forest Service, North Central Research Station, 1992 Folwell Ave., St. Paul, MN 55108, 651-649-5141 (tel.), cwoodall@fs.fed.us (e-mail). ■

DIVERSIFYING FUELS MANAGEMENT TO OFFSET UNCERTAINTY



John Hof

As the USDA Forest Service embarks on a campaign to reduce and better manage forest fuels, the outcomes are uncertain. How do we manage for uncertainty? One approach is to diversify management actions to reduce the chance of severe loss and to enhance adaptive management.

Risk, Uncertainty, and Ignorance

Ecosystems are stochastic (that is, subject to random variability), which renders our knowledge of them imperfect. There are three conditions of imperfection, each more difficult to deal with than the last:

- **Risk**, where we know both the probabilities of the possible outcomes and the effects that our alternative courses of action will have on those probabilities;
- **Uncertainty**, where we don't know the probabilities or the effects, but we do know possible outcomes; and
- **Ignorance**, where we don't even know what outcomes are possible.

Although analytical approaches are effective for managing risk, they typically fall short when uncertainty and ignorance are involved. For example, for stochastic programming and expert systems, we need information on outcome probabilities to manage randomness rigorously.

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Diversifying a land management portfolio helps reduce the chance of catastrophic loss.

Reducing uncertainty and ignorance through research or assessments is always good but takes time. Besides, the systems we manage are often inherently stochastic. In such systems, converting uncertainty and ignorance into risk is usually all we can hope to achieve. In the short term, we face considerable uncertainty or ignorance. Yet doing nothing while trying to learn is a gamble.

Eliminating randomness is impossible—all we can do is reduce the chance of making a really big mistake.

Short-Term Diversification

There is a solution: diversification. Diversifying land management activities is similar to a stock portfolio manager diversifying investments to reduce the chance of catastrophic loss. Like diversifying a stock portfolio, diversifying a land management “portfolio” reduces its overall variability.

For the short term, two principles of diversifying a land management portfolio are:

- Performing different land management activities in areas sub-

ject to the same random events so that the responses to the events are different; and

- Performing the same activities in different areas only when they are far enough apart so that they are not subject to the same random events.

In both cases, the object is to reduce the random variability of system response through diversification. We can do this without knowing the actual variances because we know that landscape independence increases with distance—the farther apart two landscapes are, the greater their independence from each other.

Long-Term Adaptive Management

Diversification is also a good basis for adaptive management, whereby we experiment with management actions to learn more about the systems we manage. By diversifying our approach to management, we learn more—and sooner. Of course, we must monitor the results to learn from the “management experiments” and adapt management strategy accordingly.

Let's take fuels management as an example. To prevent an unwanted stand-replacing fire, fuels managers often tend to look for Best Management Practices, assuming that in any given situation, there is always



Alternative methods of reducing hazardous fuels and restoring long-needle pine forest. Left, the sun shines through smoke and flames during a prescribed fire on the Colville National Forest in Washington. Right, a crew member limbs up a tree as part of a thinning project in the Jemez Mountains of northern New Mexico. Diversifying treatments can reduce the chance of unwanted outcomes. Photos: Thomas Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2001; and Kristen Honig, National Park Service, Los Alamos, NM, 2002.

a “best” thing to do. In reality, we are usually uncertain about the effectiveness of different fuels reduction methods, and we are also typically uncertain or ignorant about the effects of fuels reduction methods on the ecosystem.

Diversification means using a variety of fuels reduction methods in a given forest area and using the same method only in well-separated areas. That reduces risk: If a fuels reduction method harms the ecosystem, it affects only a small area; and if it fails to prevent a crown fire, the affected area is also limited. As we monitor the results,

When land management is diversified, we learn more, sooner.

we learn about the actual fire and ecosystem responses and can adapt our management strategies accordingly.

Facilitating Active Management

Land managers today face a difficult conundrum. High fuel loads and their associated hazards mean that we do not have the time to experiment in a few areas and wait

to see what happens. But because we can never eliminate randomness, we do not always know for sure what management activity is best in a given situation.

We can make the best of a bad situation by diversifying land management activities. By accepting the chance of making small mistakes, we can reduce the chance of making big ones. ■

PROBABILITY OF SPOT FIRES DURING PRESCRIBED BURNS



John R. Weir

Spot fires have always been a problem on prescribed burns. Just the possibility of a spot fire can cause mental and physical stress on burn bosses and crews. Actual spot fires can cause personal injury or even loss of life, as well as costly damages and loss of public support for prescribed fire programs.

Many private and public land managers in Oklahoma have told me that they avoid prescribed burning for fear of spot fires and escaped fires. Many have the resources needed to conduct prescribed fires, but lack the experience or knowledge to deal with spot fires. A simple guideline or rule-of-thumb might help.

Variables Affecting Fire Behavior

Weather factors are the main variables that burn bosses can use to predict and monitor prescribed fire behavior. In general, there are three main weather factors:

- **Relative humidity.** Burning when relative humidity exceeds 40 percent significantly slows rates of spread (Lindenmuth and Davis 1973) and reduces danger from firebrands (Green 1977).
- **Temperature.** Bunting and Wright (1974) found that danger from firebrands was lower if the

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If we can narrow spot fire causes down to a single main weather factor, burn bosses might focus on that variable, possibly reducing the chance of spot fires.

ambient air temperature is below 60 °F (15 °C) when burning.

- **Windspeed.** Windspeeds of at least 8 miles (13 km) per hour are needed to ignite and burn standing fuels (Britton and Wright 1971). However, windspeeds of more than 20 miles (32 km) per hour can create problems with firebrands and other blowing debris (Wright and Bailey 1982).

If we can narrow spot fire causes down to a single main weather factor, burn bosses might focus on

that variable, possibly reducing the chance of spot fires.

Key Variable

At the Oklahoma State University Research Range (OSURR), we conduct prescribed burns during different seasons all over Oklahoma. Fuels include tallgrass prairie (NFES fuel models 1 and 3—see Anderson 1982), post oak–blackjack oak (fuel models 3, 8, and 9), eroded mixed prairie (fuel models 1 and 3), sandsage grassland (fuel model 4), and oak–pine (fuel models 3, 8, 9, and 11). Since 1996, we have



Firewhirl on a prescribed fire in Oklahoma. Fuels were tallgrasses, sand sagebrush, and scattered eastern redcedar. About 20 feet (6 m) tall, the firewhirl left the burn unit and started two small spot fires that were quickly contained. Photo: John Weir, Oklahoma State University Research Range, Stillwater, OK, 2001

been keeping track of spot fires on our prescribed burns. We consider a spot fire to be any fire outside the burn unit, no matter what the size or cause.

The size of a spot fire depends on fuel loads outside of the burn unit, crew size, crew experience, equipment present, equipment dependability, firebreak type and size, and weather conditions. Our spot fires have ranged in size from less than one square foot (0.09 m²) to 120 acres (264 ha). Most of our spot fires were caused by firebrands from crowning eastern redcedar (*Juniperus virginiana*). The rest were usually caused by smoke, fire whirls, or flaming oak leaves or tallgrasses floating or blowing across the fireline.

When the OSURR crew conducts prescribed fires, we record weather data onsite before, during, and after the burn. We also note whether or not a spot fire occurred. When we reviewed the burn data, one weather variable stood out in association with spot fires: low relative humidity (fig. 1). From 1996 to 2002, we conducted 99 burns, 21 of which produced spot fires. All but two occurred when relative humidity was at or below 40 percent.

40-Percent Threshold

Research has shown that fine fuels ignite and burn easily when relative humidity is below 40 percent, whereas ignition slows when relative humidity is above that threshold (Britton and Wright 1971; Green 1977; Lindenmuth and Davis 1973). Our experience validates the research. A threshold value of 40-percent relative humidity might suggest an excellent rule-of-thumb for conducting prescribed burns.

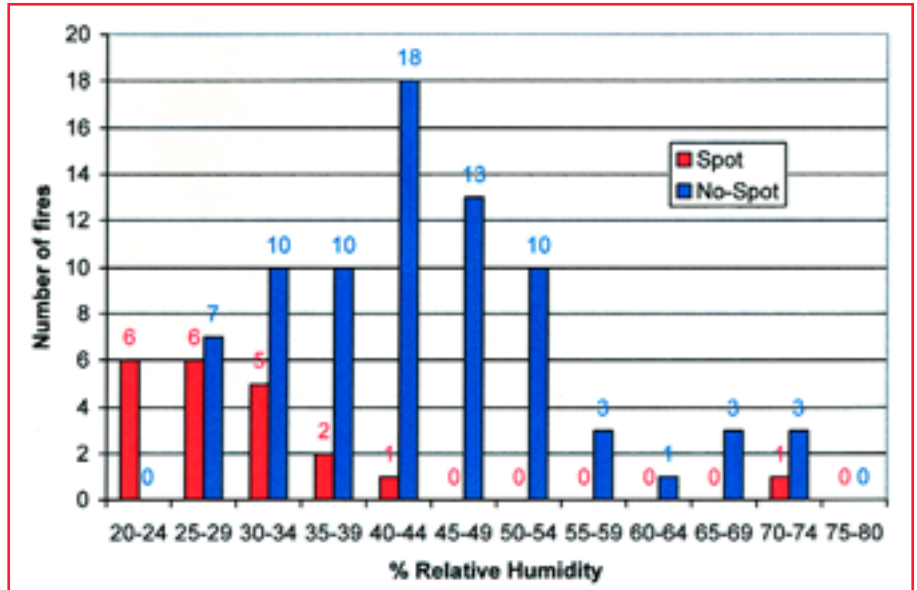


Figure 1—Spot fires on prescribed burns in relation to relative humidity. Twenty-one of 99 prescribed fires conducted across Oklahoma from 1996 to 2002 were associated with spot fires, but only two spot fires occurred when relative humidity was greater than 40 percent.

When we reviewed the burn data, one weather variable stood out in association with spot fires: low relative humidity.

That does not mean that managers should never prescribe-burn when relative humidity falls below 40 percent. Some parts of the United States and some particular burn units might require low relative humidity to achieve the goals and objectives of a prescribed burn.

But it should be etched into every burn boss's mind that a spot fire might well occur on a prescribed burn when relative humidity is below 40 percent. Of course, burn bosses should always be ready for spot fires on every prescribed burn, no matter what the relative humidity. We recorded one spot fire when the relative humidity was as high as 73 percent. It was caused by firebrands thrown by a crowning eastern redcedar into heavy fuels across the firebreak.

Spot Fire Probability

What is the probability that a spot fire will occur when relative humidity is below 40 percent—or, for that matter, at any level? Knowing spot fire probability can be vital in preparing and safely conducting prescribed burns.

We used the information from our 99 prescribed burns to develop a set of spot fire probabilities at various levels of relative humidity. We used the following formula (based on Steele and Torrie 1980):

$$P = SF \div PF,$$

where P is the probability of a spot fire occurring, SF is the number of spot fires, and PF is the number of prescribed fires.

Our data showed a 21.2-percent probability of a spot fire occurring on a prescribed burn when relative humidity was between 20 and 80 percent, or about one out of five burns. For the 40-percent relative humidity threshold, the probability of a spot fire was 41.3 percent when relative humidity was below the threshold and only 3.8 percent when it was above the threshold—a substantial difference.

The data also showed that, below the 40-percent threshold, spot fire probability rose with each 5-percent drop in relative humidity (fig. 2). At 25-percent relative humidity, there appears to be another threshold: Below this point, there was a 100-percent probability of a spot fire occurring. But in the 25- to 29-percent relative humidity range, spot fire probability dropped from 100 percent to just 46.2 percent; and in the 30- to 35-percent range, only one out of three burns was likely to produce a spot fire.

Lessons for Burn Bosses

What does all this mean for burn bosses? It does not mean that managers should never prescribe-burn when relative humidity falls below 40 percent. But managers should still take the 40-percent threshold into account, particularly when inexperienced personnel are conducting prescribed burns, when heavy fuel loads are adjacent to the burn unit, or when a fire escape could result in terrible publicity or even litigation.

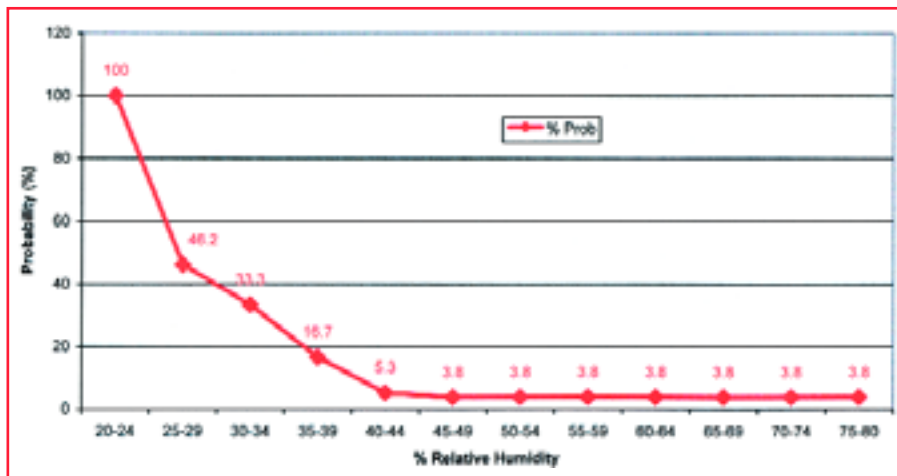


Figure 2—The probability of spot fires as a function of relative humidity, based on 99 prescribed fires conducted across Oklahoma from 1996 to 2002.

Within the range of 20- to 40-percent relative humidity, there is a large difference in the probability of a spot fire occurring. When relative humidity is below 25 percent, burn bosses should be prepared for a

of a crew's anxiety about spot fires on prescribed burns when relative humidity exceeds 40 percent. Best of all, it can help managers reduce risk and increase safety for their crews.

It should be etched into every burn boss's mind that a spot fire might well occur on a prescribed burn when relative humidity is below 40 percent.

100-percent probability of a spot fire. But they can cut the risk by about half with just a slight increase in relative humidity.

This information can help burn bosses determine spot fire potential when considering burn units or burn days. It can also help them determine crew size and equipment needed. It might help relieve some

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FIRES IN THE WILDLAND/URBAN INTERFACE: BEST COMMAND PRACTICES



Michael S. Rohde

I recently completed a study (Rohde 2002) providing insight into critical decisions by command officers on some of California's most notorious wildfires in the wildland/urban interface (WUI) (see the sidebar). My study focused on the first several hours of response to the fires, a period of time when organizational development and control can be as complex as the fire itself, and State or Federal incident management teams have not yet been mobilized. I consulted with experts with exceptional command experience on WUI fires.

The study shows the fire environment common to catastrophic WUI fires (see the sidebar). It also identifies best command practices that might be used by incident commanders and others responsible for leadership on such fires in the future. Some of the practices are summarized below. The practices are best utilized in a "systems fashion"—by integrating multiple concepts into a command methodology.

Prefire Planning

The study found that planning for wildfire risks in the WUI and in historical fire corridors is critically important. Planning might include:

- Conceiving strategies and tactics,
- Identifying values at risk,
- Planning deployments and evacuations,

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Within the ICS, experts prefer to organize initial response to a major WUI incident by branches rather than divisions.

- Calculating resource needs, and
- Projecting fire behavior and spread.

All experts consulted in the study had developed prefire plans for their respective areas of responsibility, and many had involved cooperating agencies, including law enforcement. Some had followed up on prefire planning with interagency tabletop exercises.

Incident Command System

Within the Incident Command System (ICS), most experts consulted in the study prefer to organize initial response to a major WUI incident by branches rather than divisions. They establish branches for each flank of the fire and possibly for structural protection, law enforcement and evacuation, or

Wildland/Urban Interface Fires Studied

The study focused on command complexities and key decisions on six notorious wildland/urban interface fires in California:

- The 1990 Paint Fire near Santa Barbara,
- The 1991 Tunnel/Berkeley Hills Fire in Oakland and Berkeley,
- The 1993 Old Topanga Fire in Malibu,
- The 1993 Kinneloa Fire near Altadena,
- The 1993 Laguna Fire in Orange County, and
- The 1996 Harmony Fire near Carlsbad.

Collectively, these six fires caused 30 fatalities, burned 4,907 structures and 52,422 acres (21,215 ha), and occurred in or immedi-

ately adjacent to heavily urbanized areas. On each fire, the vast majority of loss occurred during the first 12 hours.

Subject matter experts who commented on these and other fires included:

- Bill Teie, Bill Clayton, Tim Sappok, John Hawkins, and Chuck Manor from the California Department of Forestry and Fire Protection (CDF);
- Gary Nelson from the Los Angeles County Fire Department; and
- Mike Warren from the Corona Fire Department (formerly with the USDA Forest Service and CDF).

other specific needs. Operations branch directors may then establish divisions or groups as resource availability or situational needs dictate.

This organizational approach has several advantages. By establishing branches first, the incident commander (IC) can immediately organize the entire projected fire area, leaving no part of the fire unsupervised. Quick establishment

Experts suggested that the best way to overcome conflicting demands on the OSC's time early in a WUI incident is to delegate more authority to branch directors.

of a basic command framework can alleviate concerns about independent actions. ICs are also immediately able to place initially responding command officers into high-responsibility positions, thereby best using their local experience and knowledge while capitalizing on the preexisting basis of trust they are likely to have.

Role of the Operations Section Chief

It is critical for the operations section chief (OSC) to communicate nearly constantly with the IC during early incident development. However, the OSC must also oversee suppression and related activities, demands that can interfere with communication between the IC and OSC. Physical collocation is not necessarily the solution.



The May 13, 2002, Antonio Fire threatened 500 Orange County homes and burned 1,500 acres. Photo: Orange County Fire Authority, Orange County, CA.

Experts consulted in the study suggested that the best way to overcome the conflicting demands on the OSC's time is to delegate more authority to branch directors for operations section management. With branch directors responsible for managing operations, the OSC can provide less direct oversight and devote more time to partnership with the IC. The OSC is also freer to interact in other necessary relationships and attend planning and strategy meetings as needed.

On the Harmony Fire, for example, the five branch directors assumed responsibility for a great deal of the operational leadership. The OSC was able to focus more exclusively on coordination and mobility of resources and on ensuring that resources were responding to what the fire might do rather than what it was already doing.

Strategy and Tactics

The ideal strategy is to provide both offensive perimeter control and defensive structural protection simultaneously. Abandoning

perimeter control in favor of structural protection risks unabated fire expansion, increased structural risk, and difficulty of control. In some situations, perimeter control might have to be abandoned for a period of time, but it must be reestablished as soon as possible.

Crews, dozers, air tankers, and some engines are best assigned to perimeter control, whereas type 1 or 2 engines are ideally assigned to structure protection, supported by helicopters capable of working close to the ground in heavy smoke. A common strategy is to “pinch the flanks” through perimeter control to limit the width of the fire's head as it enters areas with structures.

Experts consulted in the study acknowledged the difficulty of sorting out the key issues from all the minutiae on a WUI fire. They recommended that ICs be careful to focus on key issues such as:

- Protecting lives and property,
- Supporting effective operations with additional resources,

- Taking advantage of containment opportunities, and
- Holding line.

Experts recommended allocating resources to structural areas partially damaged by fire to prevent additional loss from residual fires after the main fire has passed.

Command Post Staff

Without timely logistical support, key firefighting needs go unmet, such as drinking water, food, or fuel. Unless command staff development—including logistics—matches resource commitment, it risks falling hopelessly behind. To assist in command staff development, firefighters are generally assigned to initial logistics functions, such as situation and resource status tracking, until they can be relieved by fully qualified ICS staff.

One expert suggested having responding resources report to one of at least two staging areas on opposite sides of the fire for assignment. The IC would communicate potential assignments directly to the staging area manager, who would fill the requests through face-to-face contact with available resources and report the action to the IC. In this manner, the IC could ensure check-in of resources and reduce radio traffic.

Ordering Resources

California has a well-developed mutual aid system, allowing more than 900 engines to be assigned to two of the fires studied. However, that was more than could possibly

A common strategy is to “pinch the flanks” through perimeter control to limit the width of the fire’s head as it enters areas with structures.

be managed. Of the 900 engines assigned to the Old Topanga Fire, only 20 percent were actually committed. Fire apparatus on the Pacific Coast Highway was backed up for miles.

Experts agreed that overordering has become a serious problem. Most could not visualize an incident requiring more than 300 engines. Prefire planning was suggested as key to effective resource ordering and deployment. One expert suggested preestablishing resource orders that can be placed when fires reach certain benchmarks, perhaps shown on fire projection maps with time ellipses at hourly intervals. Past fire history can also guide resource needs assessment and planning.

Risk Acceptance and Mitigation

Experts recommended allowing operations involving elevated risk only under very specific circumstances—generally, only when civilian lives are directly at risk and then only with strong planning and support. Under other circumstances, operational risk must be addressed on a continuing basis for all line assignments and mitigated as much as possible through aircraft support, construction or identification of safety zones, communications and lookouts, varied tactical approaches, and other means.

Many experts suggested that medical personnel be prepositioned for firefighter support, and that additional resources for technical rescue and extraction be placed at their immediate disposal. In one case, a burnover involving two firefighter fatalities and two serious injuries required hours for personnel extraction due to difficult terrain. Accident scenes should be quickly designated as “incidents within incidents,” with separate command, communications, and resources.

Unified Command

On the six fires studied, the most successful incident commands immediately organized a unified command and ordering point. This helped reduce independent actions, increase command cohesiveness, and concentrate available firefighting resources on the most significant needs.

Incidents that included law enforcement in the unified command were highly successful in mounting evacuations. On the Laguna Fire, for example, 26,000 people were evacuated from Laguna Beach and the surrounding area in 2 hours. The evacuation included planning for fire service access and separate civilian egress. In contrast, lack of effective traffic management during the Berkeley Hills/Tunnel Fire contributed directly to loss of life.

It is essential to assign an information officer to deal with the media on wildland fires in the WUI. Commands that utilized the media to

Experts agreed that overordering has become a serious problem and that prefire planning is the solution.

Catastrophic WUI Fires: Common Factors

Forty-seven factors were common to all six WUI fires studied in California. Some are summarized below.

General Factors

All fires occurred during critical fire weather patterns, involving Santa Ana or other foehn winds. They occurred during seasonal drought, with critical live and dead fuel moistures, following a wet winter preceded by multiple years of drought. They generally occurred in steep mountainous terrain with a history of wind-driven wildfire and structural loss.

Native chaparral fuels were abundant in the fire areas. The fires exhibited conflagration behavior immediately following mass structural involvement, including extreme burning intensity, fire whirls, long-range heavy spotting, mass ignition, high energy release, and rapid rates of spread.

Community-Related Factors

Affected communities were largely constructed of nonfire-resistant materials, including wood shake roofs. Many properties lacked adequate fuel modification or brush

clearance, and some had concentrations of combustible landscaping adjacent to structures. In each case, the presence of threatened or endangered species was an obstacle to presuppression activities.

Water systems were often unable to provide adequate fire flow or failed during the fires, and arterial road access and egress were generally limited. Many burned structures were isolated and served by substandard or hazardous roads or bridges. In some areas, dense structural spacing aided conflagration development.

Emergency Response

Each fire caused significant injury, and half cost lives. Available regional fire resources were overwhelmed by the initial fire problem, and massive structural loss occurred during the first 12 hours on each incident. Firefighters practiced structural triage to select defensible homes, and a period of independent action by firefighting resources occurred on each of the fires. Regional commitments to multiple fires compromised availability of aircraft, hand crews, and dozers. Communications centers and fire radio systems were overwhelmed.

Situation-driven tactics compromised and elevated firefighter risk, as did the need to effect rescues and civilian evacuations. Coordination with police agencies for traffic control and evacuation was difficult, as was acquiring accurate information on the situation and status of resources. Inability to provide adequate and timely logistical support, including water and fuel, compromised firefighting. Loss of momentum occurred in perimeter control activities as a result of concurrent structural protection demands. Effective command organizational development was hindered by lack of qualified staff and the rapidly changing fire conditions.

Initial command post locations were generally inadequate, with command posts burned over on three of the six studied fires. After resources were initially deployed, incident commanders had difficulty mobilizing them to address new and evolving threats. Despite California's well-developed Fire and Rescue Mutual Aid System, mobilization of mutual-aid resources was slow; problems were exacerbated by overordering resources on some incidents. Initial use of multiple resource ordering points com-

get out their messages succeeded in communicating information about evacuations and other fire-related matters. On incidents where the media were not engaged, misinformation ensued, including misdirection of civilians in the fire area.

Improving Command

In fall 2003, more than 10 large fires ringed urban centers in south-

On the six fires studied, the most successful incident commands immediately organized a unified command and ordering point.

ern California, burning more than a quarter of a million acres and destroying thousands of homes. Such fires are common in California and spreading across the Nation. All six of the fires I studied confounded the best cooperative efforts of local, State, and Federal firefighters, who shared responsibility for initial response.

licated organizational and command activities. Limited communications and interaction between fires and governmental emergency operations centers contributed to confusion and support inadequacies.

Human Factors

On all six fires, firefighters and fire management officers acknowledged stress associated with high-risk, high-consequence decisionmaking. Many seemed frustrated by the large structural losses. Public fear and panic also affected firefighters, as did stress associated with fatalities, entrapments, missing-person reports and searches, and concern for civilians defending their properties.

On all fires, public volunteerism proved unmanageable and an impediment to firefighting operations. Firefighters used recognition-primed decisionmaking, for better or worse, in exercising tactics and strategy, emphasizing the need for high-quality training and experience. Demands for fire service involvement in postfire recovery and political events exceeded all expectations.

Command decisions and actions can and should be preplanned for such incidents, partly for firefighter safety and efficiency. Decisions must be rapidly made and implemented on such rapidly evolving incidents, often in the absence of organized management teams and with the best local capability available.

Independent Action

Particularly problematic during the early periods of firefighting was independent action by firefighting resources. In fact, independent action was so prevalent that it might be seen as typical during the initial phases of a major WUI fire.

Independent action occurred either through intentional delegation by command or through unselected organizational evolution. What drove it were overwhelming and dangerous fire conditions during the first hours on an incident. Often, an incipient command organization saw no other choice.

Independent action did achieve some tactical benefits where individual crews were well trained and highly motivated. One expert consulted during the study conceded that independent action yielded “a lot of productivity,” but noted that the incident commander might not know or be able to direct “what that productivity is.”

All of the experts consulted during the study viewed independent action as a “strategy of last resort.” Independent action raises serious issues and concerns:

I hope that my findings will help fire management officers achieve superior leadership and command for future incidents in the WUI. For a more detailed summary of my study, please contact Michael S. Rohde; Battalion Chief; Orange County, CA, Fire Authority; 21 Aloysia, Rancho Santa Margarita,

- On all six incidents, independent action contributed to situations where safety and efficiency were compromised or organizational control and resource accountability lost.
- During several of the studied fires, high-risk firing operations with low probability of success resulted from independent action. Some succeeded, but others directly contributed to structural loss.
- Firefighter entrapments resulted from independent action, including 20 separate entrapments on the Old Topanga Fire.
- Independent action made it difficult for command organizations to deploy resources to new threats and to coordinate searches and evacuations.

In general, the command approach to independent action is to end it as quickly as possible by consolidating command and developing field supervisory positions, but this takes time and resources. Although experts have recommended ways of overcoming some of the negative aspects of independent action, its prevalence during the early phases of major WUI fires—desired or not—suggests the need for specific training in such operations.

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FIRE REGIMES IN THE NORTHERN ROCKIES*

Stephen W. Barrett

Land managers today recognize the importance of understanding natural disturbance regimes for maintaining sustainable ecosystems (USDA 1999, 2000a, 2000b). Ecosystem-based plans require information on long-term disturbance history (Cissel and others 1999; Morgan and others 1994; Quigley and others 1996), because most terrestrial and aquatic systems in the Northern Rockies are disturbance adapted.

Fire regimes classifications describe in a general way the periodicity, severity, sizes, and patterns of fire disturbance (Brown 2000), largely at the stand scale (Arno and Peterson 1983). To date, most classifications have been largely theoretical. Such systems are useful at a broad conceptual level but lack precision and usefulness for fine- to mid-scale management planning (see the sidebar). In contrast, I developed an empirically based classification for forested landscapes in the northern Rocky Mountains.

Six Fire Regimes

I reviewed all published and unpublished fire history studies in the Northern Rockies to establish a database containing 1,440 plot samples from 95 studies (fig. 1). Mean fire intervals (MFIs) from about 1600 to the present suggest that there are six different fire regimes in the Northern Rockies (table 1),

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* The article is distilled from a contract final report (Barrett 2002) prepared for a USDA Forest Service landscape modeling project (Jones and others 2002).

Knowing the current status of the historical fire regimes is critical for land management planning.

including one nonlethal (NL) type, three mixed-severity (MS) types, and two stand replacement (SR) types. All six are described below.

NL (< 25-year MFI). During the presettlement era, stands in the NL fire regime (also known as “frequent surface fire regime” [Brown 2000]) experienced frequent understory fires that promoted lightly stocked, uneven-aged structures (Arno 2000). Brown (2000) defines NL fires as those killing less than 20 percent of the mature trees in a

stand (fig. 2). In dry ponderosa pine stands, fire-scarred veterans often contain from 10 to 20 scars per tree (Arno 1976; Arno and others 1995; Barrett 1988; Heyerdahl 1997). I classified about 30 percent of the database as NL, where MFIs ranged from about 10 to 26 years long and averaged 17 years.

The NL fire regime occurs largely in relatively dry forest types, for example, in the ponderosa pine, dry Douglas-fir, and dry grand fir potential climax types. Most of the

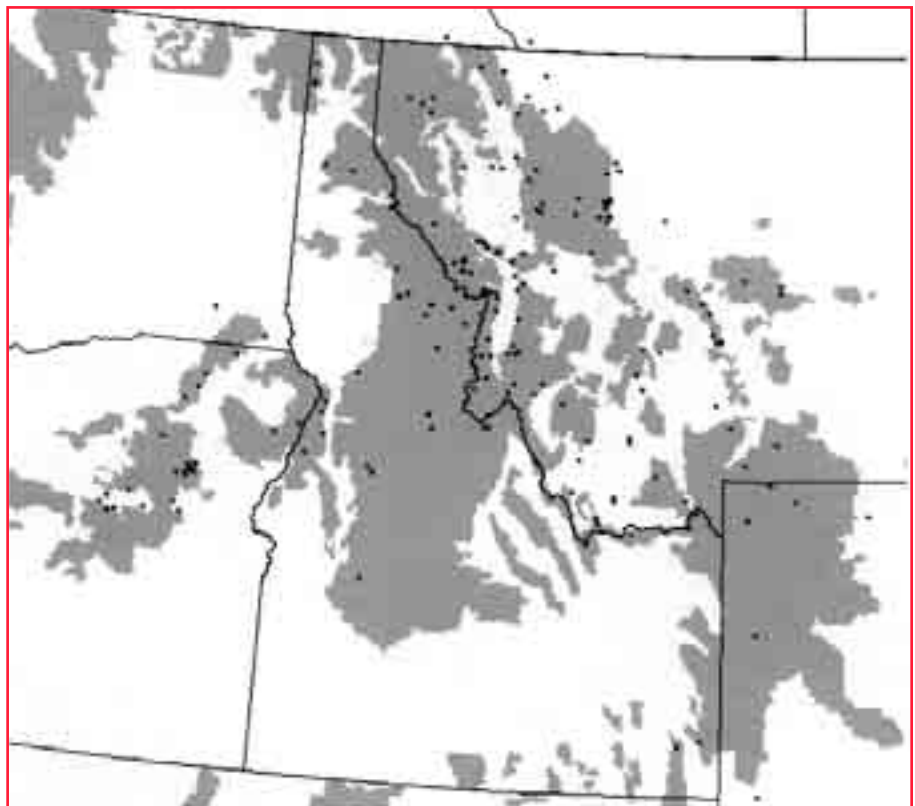


Figure 1—Study area in the northern Rocky Mountains. The fire regimes database contains 1,440 plot samples from 95 fire history studies, each represented by a dot. Shading depicts national forest land.

The National Classification: How Does It Compare?

Schmidt and others (2002) developed a national fire regimes classification used by the USDA Forest Service and other agencies. Their system is useful for assessing landscape condition in terms of vegetation composition and structure, potential fire severity, and other variables. They identified five different fire regimes:

- Fire regime I: 0- to 35-year mean fire interval (MFI), low-severity fires.
- Fire regime II: 0- to 35-year MFI, stand-replacement fires.
- Fire regime III: 35- to 100-year MFI or greater, mixed-severity fires.

- Fire regime IV: 35- to 100-year MFI or greater, stand-replacement fires.
- Fire regime V: 200-year MFI or greater, stand-replacement fires.

Schmidt and others (2002) developed a broad classification in order to make assessments on a national scale. By contrast, my classification is tailored to a regional scale—specifically, to the Northern Rockies. Differences therefore exist between our classifications:

- Fire regime II is found primarily in grass- and shrublands (Schmidt and others 2002) and is thus not covered by my Northern Rockies classification for forests.

- Fire regimes I and III do not show the relatively fine gradations found in the Northern Rockies from nonlethal to mixed-severity fire regimes. I used the more refined NL, MS1, and MS2 fire regimes to reflect those gradations.
- Similarly, fire regimes III, IV, and V are too broad to adequately reflect natural variation at higher elevations in the Northern Rockies, especially near upper treeline. I defined the MS3, SR1, and SR2 fire regimes to reflect those conditions.

data are from ponderosa-pine-dominated stands, for example, in eastern Oregon (Heyerdahl 1997), central Idaho (Barrett 1988, 2000), and west-central Montana (Arno 1976; Arno and others 1995; Gruell and others 1982). East of the Continental Divide, the NL regime also occurs in open-grown Douglas-fir stands bordering intermountain valleys (Arno and Gruell 1986; Bakeman 1983; Barrett 1997).

MS1 (25- to 40-year MFI). The MS1 fire regime essentially is a variant of the NL regime, but with longer fire intervals that occasionally promote locally severe burning (Arno and others 1997; Barrett and others 1991). For example, such fires might kill up to 30 percent of the overstory trees, in a highly patchy pattern (fig. 2) (Arno and others 1997; Barrett and others 1991). The oldest trees generally have from 3 to 10 fire scars each, and the stands often contain small

Table 1—Northern Rockies database: number of plot samples and descriptive statistics for historical fire frequency, by fire regime type.

Fire regime ^a	Number ^b	Median fire interval	Mean fire interval	Standard error	10th percentile	90th percentile
		years				
NL	407	16.00	17.11	0.31	10	26
MS1	216	32.50	32.13	0.49	23	41
MS2	334	65.50	73.22	1.46	43	117
MS3	36	122.00	135.22	13.82	47	275
SR1	288	129.00	133.41	2.00	96	180
SR2	159	220.00	244.19	4.11	200	325

a. NL = nonlethal; MS1 = short-interval mixed severity; MS2 = moderate- to long-interval mixed severity; MS3 = variable-interval mixed severity; SR1 = moderate- to long-interval stand replacement; SR2 = long-interval stand replacement.

b. Out of a total of 1,440 plot samples from 95 fire histories (fig. 1).

even-aged patches (unlike the primarily uneven-aged NL stands). I classified about 15 percent of the database as MS1, where MFIs ranged from about 25 to 40 years long and averaged 32 years.

The MS1 regime contains nearly twice as many potential vegetation

types as the NL regime, and stand structures and species composition are much more variable. West of the Continental Divide, MS1 occurs on relatively productive montane sites, usually in warm-dry forests such as dry Douglas-fir and dry grand fir. Such stands often are codominated by various combina-

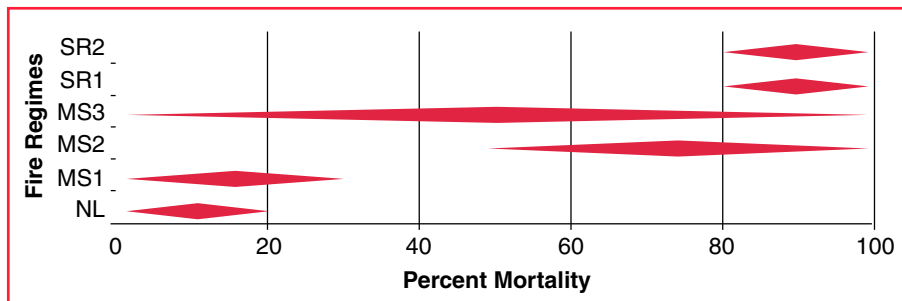


Figure 2—Hypothesized postfire stand mortality by fire regime type. NL = nonlethal; MS1 = short-interval mixed severity; MS2 = moderate- to long-interval mixed severity; MS3 = variable-interval mixed severity; SR1 = moderate- to long-interval stand replacement; SR2 = long-interval stand replacement.

tions of ponderosa pine, western larch, Douglas-fir, and lodgepole pine (Arno 2000; Arno and others 1997; Barrett and others 1991). Lethal fire severity locally has usually produced multiple seral cohorts, generating even-aged patches less than 2.5 acres (1 ha) in size (Arno and others 1997; Barrett and others 1991).

MS fires also are common east of the Continental Divide and in eastern Idaho. Such burning occurs on cool-dry montane sites and on adjacent cold-dry sites in the lower subalpine zone, where stands have widely varying fire resistance. For example, the MS1 regime occurs in stands dominated by Douglas-fir and lodgepole pine bordering the northern Great Plains and intermountain valleys (Arno and Gruell 1983; Barrett 1996; Houston 1973). As with the NL regime, MS1 stands often occur in areas that might have been frequently burned by Indians (Barrett and Arno 1982; Gruell 1985) (see the sidebar on page 35).

MS2 (40- to 120-year MFI). The MS2 fire regime contains substantially longer fire intervals and generally more severe fires than the MS1 regime. Such fires often kill from 50 to 100 percent of the stand (fig. 2) (Arno and others 1993; Barrett and others 1991) but can

Over the past century, forested area with low-severity fire potential has declined by more than 80 percent.

also burn at low severities. Old trees rarely have more than three fire scars each. I classified about 25 percent of the samples as MS2, where MFIs generally ranged from 40 to 120 years long and averaged 73 years.

The MS2 fire regime can promote more diverse age class mosaics than the MS1 or SR types (Arno and others 1993; Barrett and others 1991). Stands usually contain from one to three seral cohorts, often in well-defined patches ranging from 5 to 100 acres (2–40 ha) in size (Arno and others 1993; Barrett and others 1991). Most stands occur on relatively productive or steep sites in forest types of varying fire sensitivity (e.g., western redcedar–western hemlock, moist grand fir, moist Douglas-fir, and subalpine fir). The MS2 regime also includes many mixed-conifer stands, such as in northern Idaho’s upland western redcedar and grand fir habitat types (Barrett 1982; Brown and others 1994; Zack and Morgan 1994).

East of the Continental Divide and in eastern Idaho, the MS2 fire regime often is found on moderately productive or steep terrain dominated by Douglas-fir or lodgepole pine (Arno and Gruell 1986; Barrett 1997, 1999; Pierce 1995) in the montane and lower subalpine zones.

MS3 Fire Regime (50- to 275-year MFI). The MS3 fire regime occurs near upper treeline (i.e., in the upper subalpine zone), where stands typically are dominated by whitebark pine, subalpine fir, and alpine larch. Historical fire frequency, sizes, severities, and spread patterns vary widely (fig. 2) (Barrett 1996; Keane and others 1990; Morgan and Bunting 1990). High variability in the MS3 regime evidently results from such factors as widely varying fuel loads and spatial arrangements, extensive fire barriers such as rocklands and wet meadows, and highly variable fire weather.

Interpreting fire frequency near upper treeline is inherently difficult, and the data from the few studies to date are sparse. The database contains only 36 plots, and the estimated fire intervals ranged from about 50 to 275 years long (mean: 135 years). However, the concept of “stand fire frequency” has only limited meaning because fires often involve just one or two trees (Fischer and Clayton 1983; Morgan and Bunting 1990). So perhaps the best way to characterize MS3 fire patterns is with the admittedly vague term “highly variable.”

SR1 Fire Regime (100- to 180-year MFI). Stand-replacing fires typically kill most trees in a stand (fig. 2) (Brown 2000). Such fires also tend to be larger and spread more uniformly than in the MS regimes

(Barrett 1996; Barrett and others 1991). As a result, stands usually are dominated by a single seral cohort, fire-scarred trees are uncommon, and patch sizes often exceed 1,000 acres (400 ha) (Arno 2000).

The data suggested two SR fire regimes for the Northern Rockies. For example, I classified about 20 percent of the samples as occurring in the moderately long-interval SR regime (SR1), where fire intervals ranged from about 100 to 180 years long and averaged 133 years.

SR fire regimes often occur on productive or steep terrain. Eighty percent of the samples classified as SR1 were in the lower and upper subalpine forest zones, where stands usually are dominated by trees with moderate to high fire sensitivity (such as lodgepole pine, subalpine fir, and Engelmann spruce). Biophysical differences between SR1 stands and the long-interval SR2 stands (see below) are not always readily apparent. However, many SR1 stands are juxtaposed with stands in the MS regimes, whereas SR2 stands generally are not (Barrett and others 1991; Brown and others 1994; Hawkes 1979).

SR2 Fire Regime (200- to 325-year MFI). The SR2 regime exhibits substantially longer fire intervals than SR1, but other fire characteristics are similar, including fire sizes, spread patterns, and postfire mortality levels (fig. 2). I classified about 10 percent of the samples as the SR2 fire regime, where stand MFIs ranged from about 200 to 325 years long and averaged 244 years.

The SR2 regime often occurs on highly productive terrain, for example in wet western redcedar–west-

Case Study: Indian-Influenced Fire Regimes

Fire regimes can be difficult to differentiate. For example, evidence of a “stand-replacing” fire might simply reflect locally heavy mortality during the last mixed-severity fire. Other factors that can hinder classification include sparse or skewed data; sampling errors; natural or topographical variation; and anthropogenic influences, such as fire use by American Indians (Arno and others 1997; Barrett and Arno 1982; Gruell 1985).

An example of the latter occurred in a moist subalpine fir habitat (potential climax) type at Girard

Grove near Seeley Lake, MT. My Northern Rockies database suggested that such habitat types generally are dominated by relatively severe fire regimes (e.g., > 100-year fire return intervals). Conversely, Arno and others (1997) found frequent low-severity fires at the site, with a mean fire interval of just 24 years. That primeval Indian campsite and adjacent travel corridor evidently had been heavily used and repeatedly burned for centuries (Ayres 1901; Barrett and Arno 1982)—indirect evidence of human-altered landscapes and fire regimes in an earlier era.

During the presettlement era, stands in the nonlethal fire regime experienced frequent understory fires that promoted lightly stocked, uneven-aged structures.

ern hemlock (Arno and Davis 1980; Barrett 1993) and moist subalpine fir forest (Barrett 1994; Barrett and others 1991; Tande 1979). Conversely, evidence of the SR2 regime has also been found on highly unproductive terrain, such as in climax lodgepole pine stands on the Yellowstone Plateau (Romme 1982), where long fire-free intervals might be necessary to develop sufficient fuel for stand-replacing fires.

Stands in the SR2 regime often are juxtaposed with SR1 stands rather than with more frequently burned terrain. For instance, the lodgepole pine stands on the Yellowstone Plateau (Romme 1982) adjoin seral lodgepole pine stands in the steep Absaroka Mountains (Barrett 1994).

In those areas, site MFIs average about 350 years and 200 years, respectively.

Management Implications

Fire regimes classifications by Brown (2000) and Hardy and others (1998) are useful for national-scale work, whereas this article presents a more refined, empirically based system for the Northern Rockies. This system helped support terrain modeling of historical and current fire regimes for land management planning (Jones and others 2002). Specifically, the modeling results suggested that low-severity fire regimes (NL and MS1) occupied about 35 percent, moderate-severity fire regimes (MS2 and MS3) occu-

pied about 40 percent, and high-severity fire regimes (SR1 and SR2) occupied about 25 percent of the forested terrain (fig. 3).

Over the past century, forested area with low-severity fire potential has declined by more than 80 percent due to long-term fire exclusion, inappropriate logging, and other activities. These results generally agree with the Interior Columbia Basin Ecosystem Management Project interpretations for Northern Rockies forests (Morgan and others 1998; Quigley and others 1996).

Knowing the current status of fire regimes is critical for planning. For example, fire regimes models can be used in conjunction with other data in a geographic information system to help design and prioritize strategies for forest restoration, wildland fire planning, and habitat protection for threatened and endangered species. Legislators, policymakers, and forest managers might also use such information in developing funding priorities for Federal lands and management units.

Land managers are increasingly focusing on ecosystems rather than on individual stands. Therefore, fire regimes sampling at multiple scales would foster a better understanding of the varying roles of disturbance (Lertzman and others 1998; Morgan and others 2001). Landscape-scale research, particularly in areas dominated by the inherently complex MS fire regimes (Agee 1998; Arno and others 2000; Rollins and others 2001), would further refine our understanding of fire regimes by revealing the influence of macroclimate, microclimate, topography, anthropogenic activi-

The mixed-severity fire regimes contain more potential vegetation types than the nonlethal regime, and stand structures as well as species composition are much more variable.

ties, and other factors (Morgan and others 2001). Given the complexity of forested ecosystems, management decisions at all scales, from national-level planning to site-specific treatments, require such detailed information.

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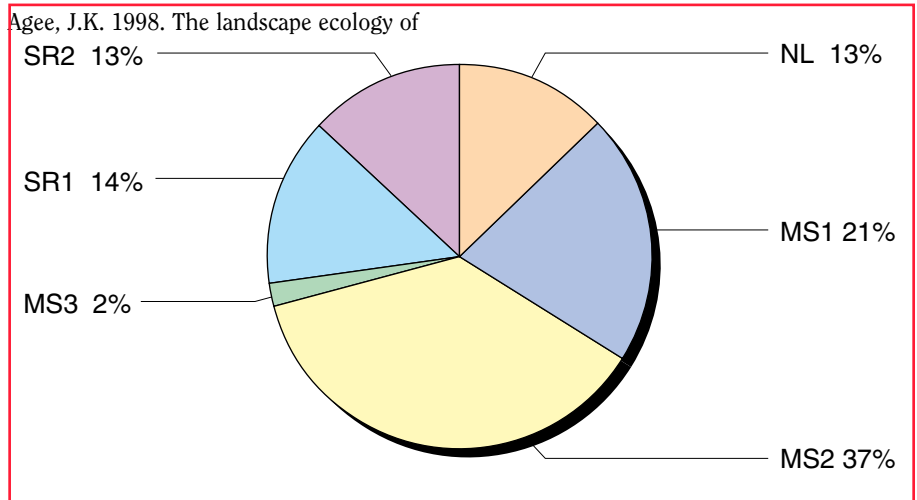


Figure 3—Percent of forested terrain by fire regime type in the general study area (Jones and others 2002). NL = nonlethal; MS1 = short-interval mixed severity; MS2 = moderate-to long-interval mixed severity; MS3 = variable-interval mixed severity; SR1 = moderate-to long-interval stand replacement; SR2 = long-interval stand replacement.

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WEBSITES ON FIRE*

Fire Consortia for Advanced Modeling of Meteorology and Smoke

In support of the National Fire Plan, Federal and State land management agencies have created a national framework of regional modeling consortia. Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) members include the National Oceanic and Atmospheric Administration, the National Weather Service, the

Environmental Protection Agency, and universities. Located in East Lansing, MI; Athens, GA; Fort Collins, CO; Riverside, CA; and Seattle, WA, each consortium is conducting research on fire/atmosphere interactions and developing improved predictive models and decision support tools for the fire management community. The FCAMMS Website displays a national map that links to the consortium sites where you can learn about their research and development objectives, relevant meetings and presentations, and current projects and products.

The Eastern Area Modeling Consortium (EAMC), in East Lansing, MI, one of the five consortium sites, addresses fire weather, fire behavior, and smoke transport issues for the north-central and

northeastern regions of the United States. Participants—the USDA Forest Service's North Central and Northeastern Research Stations, the Eastern Region of the National Forest System, the Forest Service's Northeastern Area State and Private Forestry, and the Interagency Eastern Area Coordination Center—work together to address the need for better predictions and decision support tools for fire and air quality management. Site visitors can quickly view real-time fire weather model maps for the contiguous United States, the North-Central and Northeastern States, New England, and the Lake States.

Found at
<<http://www.fcamms.org>>

* Occasionally, *Fire Management Today* briefly describes Websites brought to our attention by the wildland fire community. Readers should not construe the description of these sites as in any way exhaustive or as an official endorsement by the USDA Forest Service. To have a Website described, contact the managing editor, Hutch Brown, at USDA Forest Service, 202-205-0878 (tel.), hutchbrown@fs.fed.us (e-mail).

KEETCH-BYRAM DROUGHT INDEX: CAN IT HELP PREDICT WILDLAND FIRES?



Daniel W. Chan, James T. Paul, and Alan Dozier

The Georgia Forestry Commission uses the Keetch–Byram Drought Index (KBDI) (Keetch and Byram 1968) to determine potential wildland fire hazards. (For an overview of KBDI, see the sidebar.) The objectives of our study were to better understand the relationship between KBDI and fire activities in Georgia and to evaluate KBDI computed from National Weather Service (NWS) observational data compared with KBDI computed from fire weather observations.

What We Did

Traditionally, fire weather observations for determining wildland fire hazards are recorded at 1 p.m. daily. This means that the maximum temperature recorded at this time usually occurs during the previous day's afternoon hours. Likewise, the 24-hour precipitation recorded is from 1 p.m. on the previous day until 1 p.m. on the present day. By contrast, the NWS reports maximum temperature and 24-hour precipitation for the 24-hour period ending at midnight.

To compare NWS data to traditional fire weather data, we used NWS hourly data from Athens Municipal

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Georgia's typical fire season from 1957 to 2000 ran from February through April—when the Keetch–Byram Drought Index was lowest.

Airport, Macon Regional Airport, and Savannah International Airport from 1957 to 1995. From these data, we constructed a fire-weather-type observation for both 1 p.m. and midnight. Then we used the data to calculate a KBDI for the two defined observation times.

Daily records for the 24-hour period ending at 1 p.m. and daily records ending at midnight can yield different maximum temperature and rainfall data for the previous 24-hour period. If a heavy rain incident occurred after 1 p.m., the KBDI numbers from 1 p.m. and

What is the Keetch–Byram Drought Index?

According to Melton (1989), the Keetch–Byram Drought Index (KBDI) is an index based “on a measurement of 8 inches (0.2 m) of available moisture in the upper soil layers that can be used by vegetation for evapotranspiration.

The index measure is in hundredths of an inch of water and has a range of 0 to 800, with 0 being saturated and 800 representing the worst drought condition. The index indicates deficit inches of available water in the soil. A K/B reading of 250 means there is a deficit of 2.5 inches (6.4 cm) of ground water available to the vegetation. As drought progresses, there is more available fuel that can contribute to fire intensity.”

If a location has been dry during the previous 24 hours, the KBDI will increase, depending on the maximum temperature in the previous 24 hours, the previous day's index, and the annual rainfall amount at that location. Generally, high temperature and a low KBDI mean big increments.

When an area has received rain during the previous 24 hours, the index changes, depending on the rain-adjusted KBDI—for each 0.01 inches (0.03 cm) of net rainfall, one point is subtracted from the previous day's index—the maximum temperature, and annual rainfall amount at that location.

In Georgia, the Keetch–Byram Drought Index alone is not a good indicator for fire activity.

midnight could yield a difference of a hundred points or more. Although KBDI computed from 1 p.m. averaged higher than KBDI computed from the midnight data, we decided that the midnight KBDI is a good approximation of the 1 p.m. KBDI (fig. 1).

After determining that the midnight and 1 p.m. indexes were comparable, we obtained daily weather data from selected NWS cooperative weather stations in Georgia between 1950 and 2001 through Georgia’s State Climatologist Office. These cooperative daily stations record data once each day for maximum and minimum temperatures and 24-hour precipitation. Although observation times vary at these stations, our analysis of the NWS hourly data indicated minimal differences between a 1 p.m. and midnight observation time. Based on this analysis, we assumed that the differences due to varying observations at the cooperative stations would also be minimal, and we chose 14 stations across Georgia (fig. 2).

What We Found

Average quarterly temperatures from 1961 to 1990 at the stations we sampled are shown in figure 3. The hottest months were June, July, and August at all stations. The stations in northern Georgia had lower temperatures than those in the south. The temperature difference between the hottest and the coolest stations was less than 10 °F (5.5 °C).

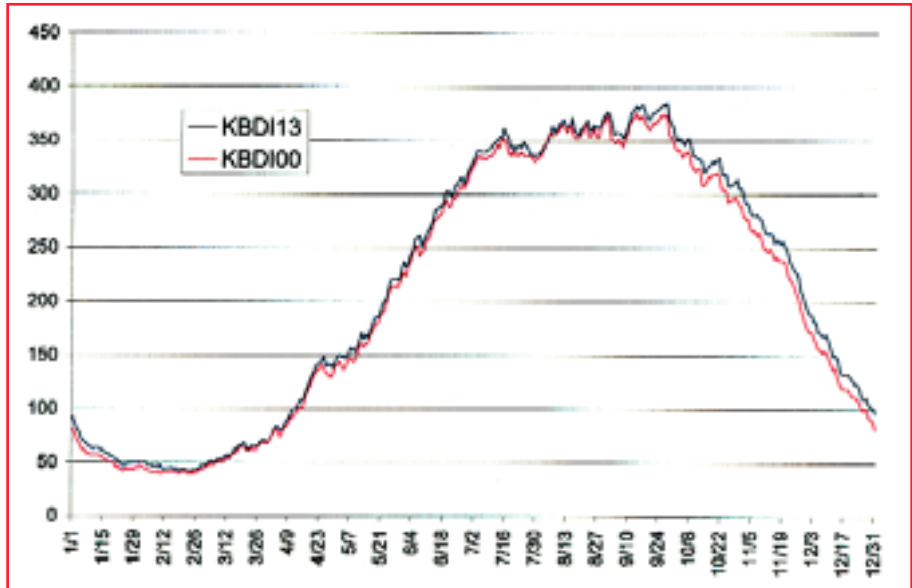


Figure 1—Average Keetch–Byram Drought Index (KBDI) climatology at Athens, GA, for midnight (KBDI100) and 1 p.m. (KBDI13), 1957–95. There is no significant difference.

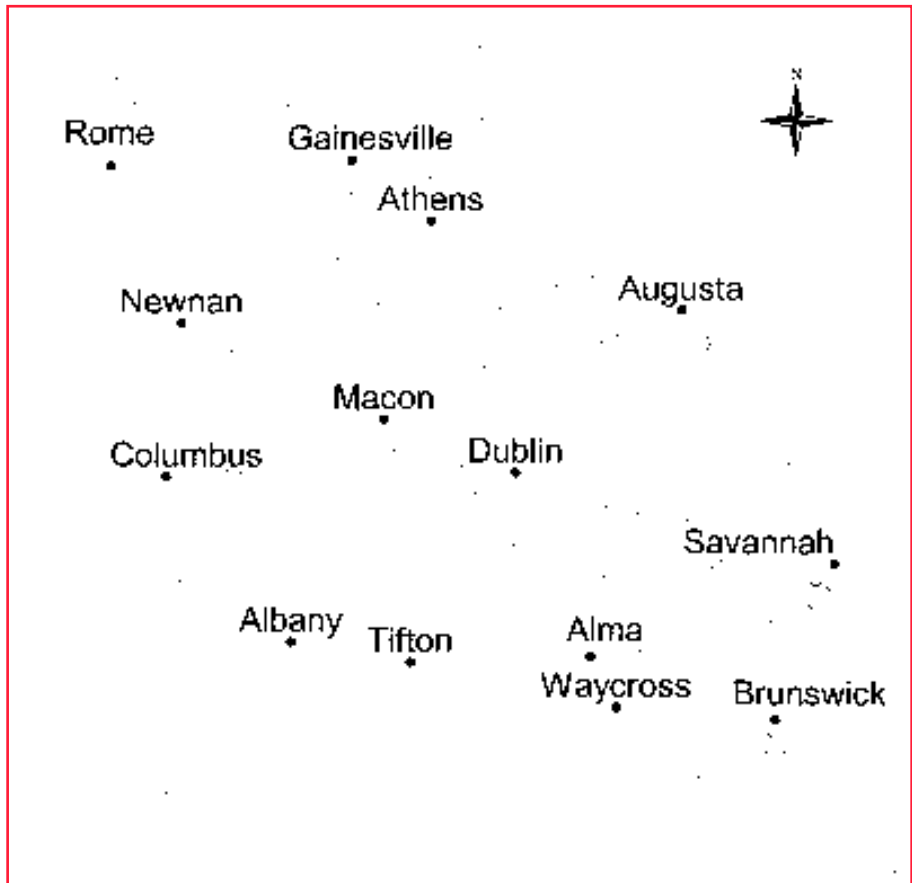


Figure 2—The 14 National Weather Service cooperative weather stations chosen for the KBDI study, located across Georgia.

Average quarterly rainfall from 1961 to 1990 for the selected stations is shown in figure 4. At stations in northern and central Georgia, January, February, and

March are the rainy season. But at stations near the coast, such as Savannah, Waycross, Brunswick, and Alma, the rainy months are June, July, and August. We found

Wildland fire incidents in Georgia followed the burn seasons of spring and fall rather than the high Keetch–Byram Drought Index months of summer.

that KBDI was low at coastal stations during June, July, and August due to high rainfall levels in this region. Conversely, when rainfall was low at coastal stations during January, February, and March, KBDI was higher. Therefore, the seasonal range of KBDI at coastal stations was smaller than at stations located elsewhere (fig. 5).

In Georgia, KBDI is typically lowest in February or March and highest in August. However, the number of fires and acres burned from 1957 to 2000 suggested just the opposite (fig. 6). Georgia’s typical fire season for those years ran from February through April, when KBDI was lowest. Fire activities then dropped off gradually from May through September and picked up again in October as KBDI began to drop. Obviously, other factors besides KBDI were influencing the fire episodes.

According to fire reports collected by the Georgia Forestry Commission, we found that human activities caused 95 percent of wildland fires in Georgia from 1957 to 2000 (fig. 7). Almost half of the fires were caused by outdoor burning, which is mostly done in spring and autumn. Therefore, wildland fire incidents corresponded to the burning seasons—especially spring—rather than the high KBDI months of summer.

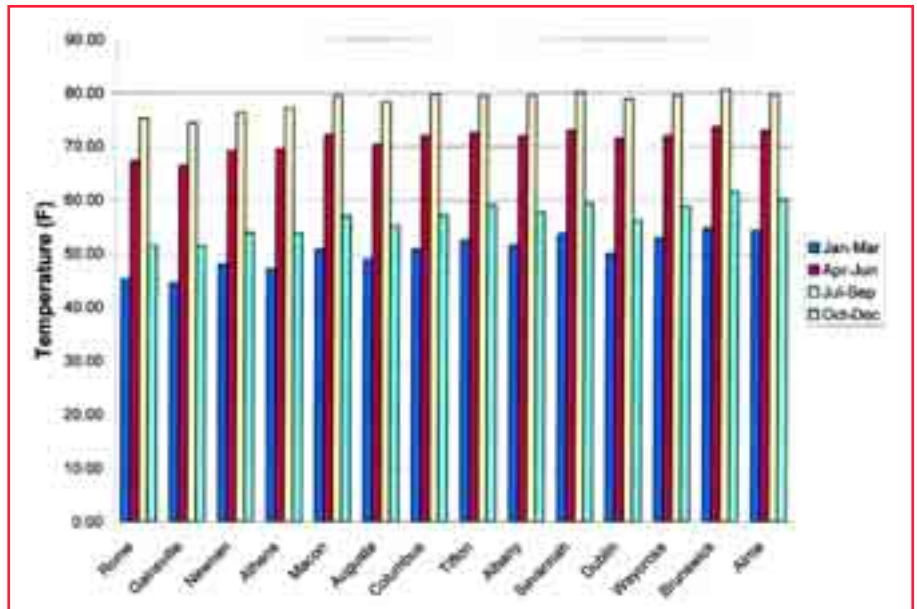


Figure 3—Average quarterly temperature at 14 National Weather Service cooperative weather stations, 1961–90.

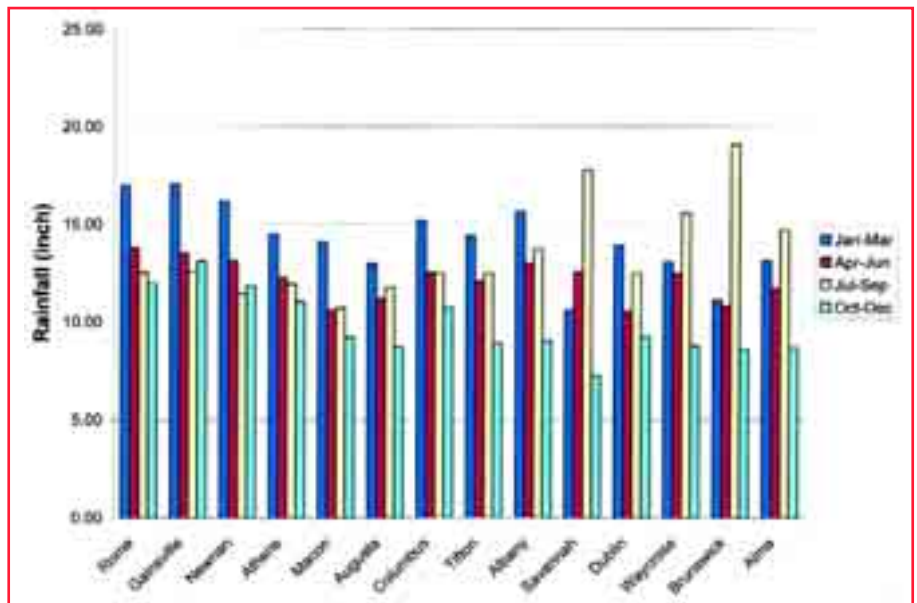


Figure 4—Average quarterly rainfall at 14 National Weather Service cooperative weather stations, 1961–90.

There were exceptions to a low KBDI during the spring. In 2001, KBDI at Waycross in southeastern Georgia rose steadily from 100 in April to more than 600 by the end of May (fig. 8), which is more than 150 points above normal. This finding suggests that fuels were very dry and fires could be difficult to control—which was exactly what happened. In late May, severe fire

activities in southeastern Georgia burned almost 16,000 acres (6,500 ha). More than 360 people were involved in the firefighting effort, and about \$1 million was spent to control the dangerous fires.

What We Think

All this information helped us to conclude that KBDI alone is not a good indicator for fire activities. It

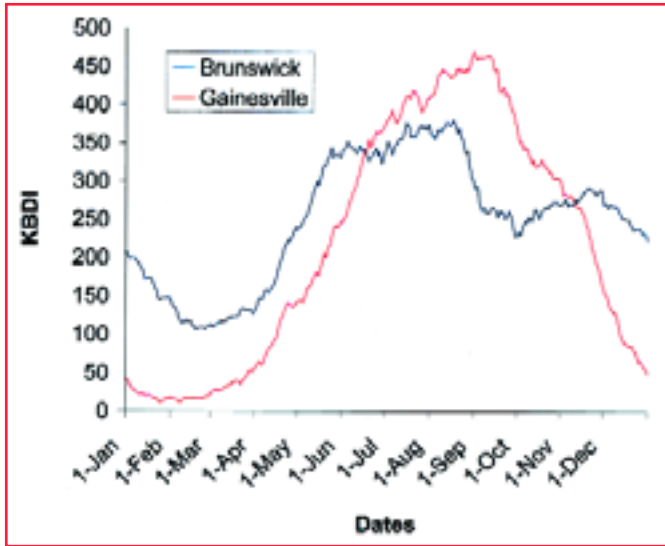


Figure 5—Average KBDI climatology at Georgia stations on the coast (Brunswick) and inland (Gainesville), 1957–95. The seasonal range of KBDI is smaller on the coast.

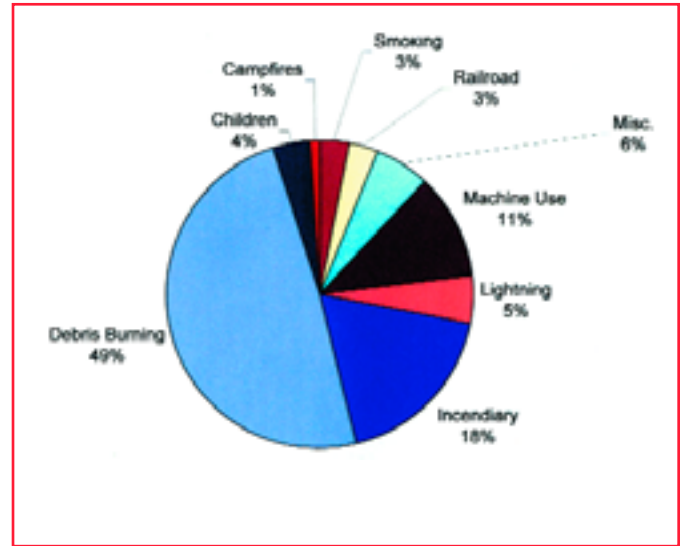


Figure 7—Causes of wildland fires in Georgia, 1992–2001.

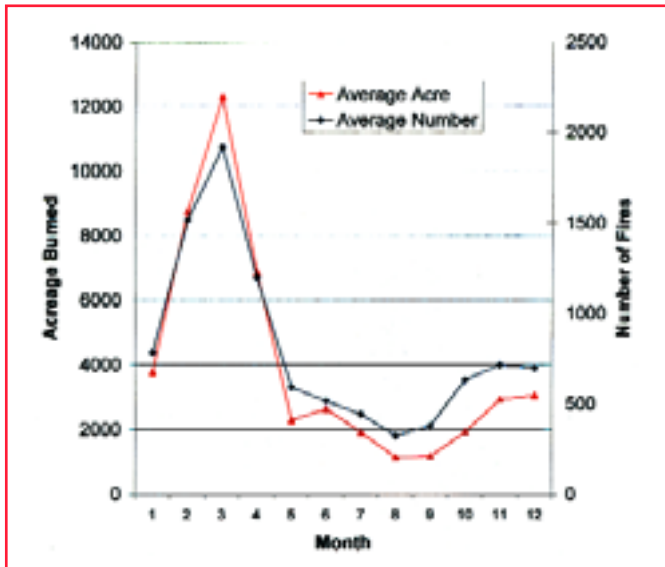


Figure 6—Average number of wildland fires and acres burned in Georgia by month, from January (1) to December (12), 1957–2000.

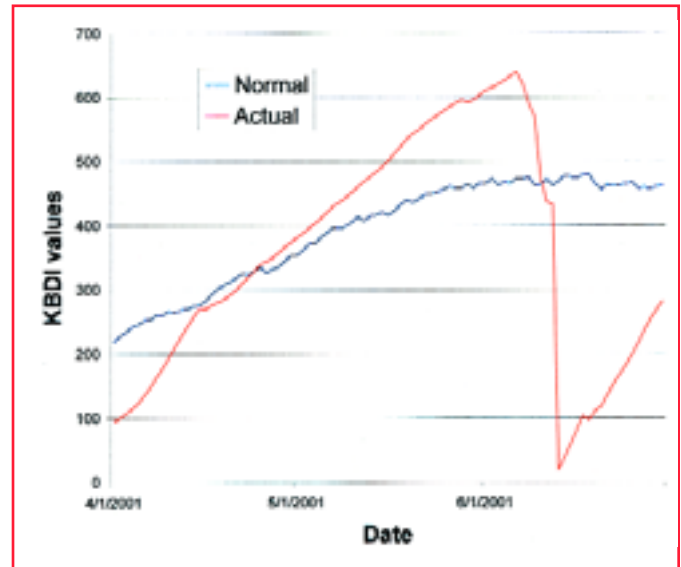


Figure 8—KBDI values for Waycross, GA, from April to June 2001 differed greatly from normal, suggesting that fuels were much drier than usual and fires could be more difficult to control.

should be used only in conjunction with other reliable sources of information to predict wildland fires. However, a higher-than-normal index or a sustained rise in the index could mean that the potential for wildland fire is high.

Knowing how KBDI varied across Georgia could be helpful to fire managers when planning resource allocation. Managers should be alert to a potential fire hazard when KBDI is higher than normal during summer.

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FIRE PREVENTION TEAM SHOWS ITS WORTH IN GEORGIA



James T. Paul, Daniel Chan, and Alan Dozier

Smoke Bear's familiar message, "Only you can prevent wildland fires," comes from one of the oldest fire prevention programs in the nation. Most forestry organizations have active fire prevention programs, largely centered around long-term education. Less common are short-term efforts to get out fire prevention messages through the media when fire potential is high. Such efforts can make people more cautious by making them aware that the situation is critical.

In 1999 and 2000, the group of Fire Chiefs in the Southern States promoted the formation of specially trained wildland fire prevention teams.* Joining the effort, Georgia trained 10 people in wildland fire prevention.

Put to the Test

In fall 2001, fire potential was increasing in northern Georgia and adjacent states due to a continuing drought and severe burning conditions. Districts administered by the Georgia Forestry Commission (GFC) were cautiously issuing permits for debris burning on a case-by-case basis. A debris fire is "any fire intentionally set for any purpose other than campfire or incendiary [burn] such as land

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* For more on Cooperative Wildland Fire Prevention/Education Teams, see Judith W. Kissinger, "Interagency Teams Prevent Fires From Alaska to Florida," *Fire Management Notes* 59(4): 13-17.

Short-term intensive fire prevention efforts during times of high fire danger can make people more cautious if they become aware that the situation is critical.

clearing, burning brush, weeds, grass, trash, garbage, etc." (GFC Fire Staff 1996).

Finally, on November 11, 2001, the GFC announced a ban on all outdoor burning. It was an unusual move; the GFC seldom bans burning, in part due to the beneficial uses of prescribed fire (Moorman 2001; Wade and Lunsford 1989).

The GFC also decided, for the first time in its history, to put a fire prevention team to the test. The Rome District (district 1) in Georgia's northwestern corner (fig. 1) was chosen as the site due to its historically high number of escaped debris-burning fires (table 1). The team was dispatched to the Rome District on November 9, 2001.

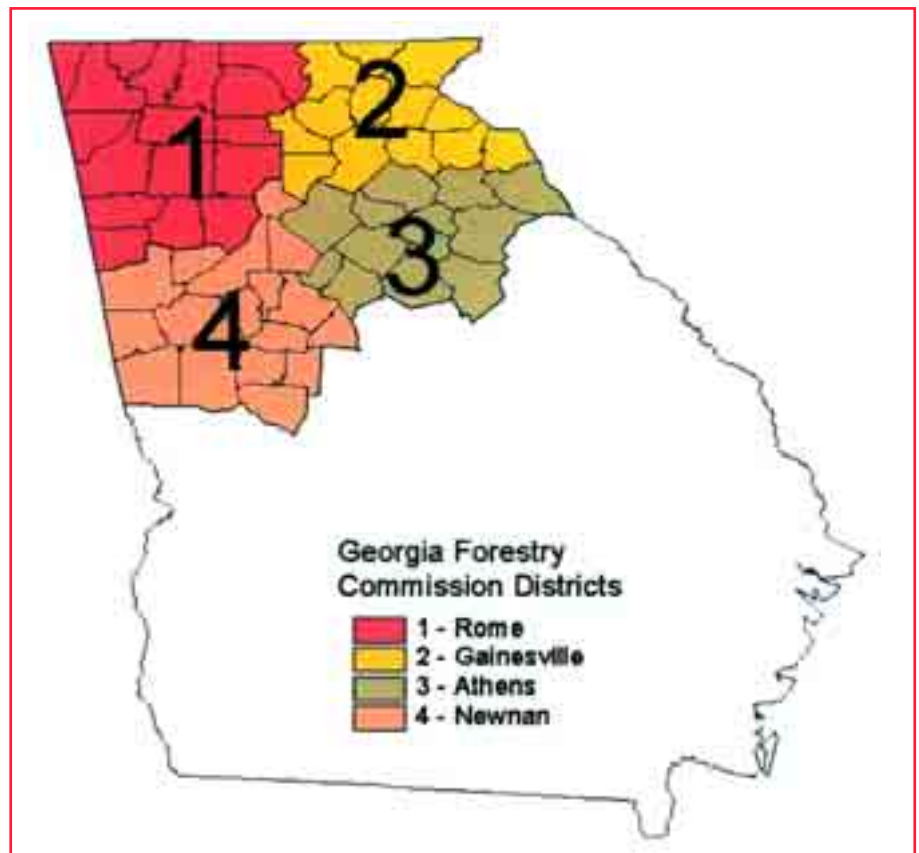


Figure 1—Districts administered by the Georgia Forestry Commission.

- dispatchers to help in handling callers;
- Visits to 38 radio stations, including—
 - 30 contacts,
 - 9 interviews, and
 - 1 on-air 20-minute program in Spanish;
- Visits to 25 newspapers, including—
 - 22 contacts,
 - 13 interviews, and
 - 1 interview with a Spanish-language newspaper;
- Visits to three television stations, including four contacts and three interviews; and
- Visits to three visitor centers in Bartow, Floyd, and Whitfield Counties.

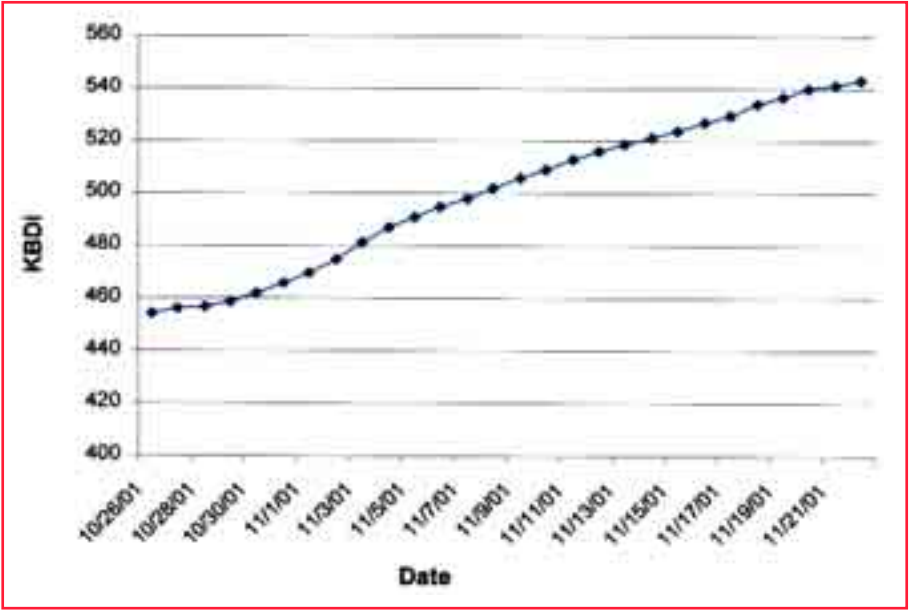


Figure 3—Keetch-Byram Drought Index at Dallas, GA, from October 26 to November 22, 2001.

Effectiveness Analysis

How well did the team do? One way to tell is to compare the number of escaped debris-burning fires and acres burned before and after the team arrived. We looked at the 14 days before and the 14 days after the team arrived, focusing primarily on district 1 (the Rome District) and using districts 2-4 (the adjacent districts) for comparison.

The entire evaluation period had severe burning conditions, with the Keetch-Byram Drought Index (KBDI) at 454 on October 26 and increasing to 545 by November 23

If one assumes the same level of fire activity before and after the team was in place, the drop in fire activity can be attributed to the burn ban plus the team’s work.

(fig. 3). According to Melton (1997), fires burning when the KBDI is in the range of 400 to 600 can be very intense. “Under these levels, most of the duff and associated organic layers will be sufficiently dry to ignite and contribute to the fire intensity and will actively burn,” noted Melton (1997). “The intensity can be expected to increase at an almost exponential rate from the

lower to the upper ends of this range.” Both the acres burned and the number of fires declined sharply after the burn ban was announced (table 2, fig. 4). If one assumes the same level of fire activity before and after the team was in place, the drop in fire activity can be attributed to the burn ban in districts

Table 2—Occurrence of escaped debris-burning fires on the 14 days before and the 14 days after the arrival of a wildland fire prevention team in Rome District, GA.

Data	District 1 ^a			Districts 2-4 ^a			Total
	Before ^b	After ^b	Total	Before ^b	After ^b	Total	
Number of fires	128	74	202	52	39	91	293
Percent of total	63	37	100	57	43	100	100
Acres burned	412	126	538	109	43	152	690
Percent of total	77	23	100	72	28	100	100

a. District 1 = Rome District; districts 2-4 = Athens, Gainesville, and Newnan Districts (fig. 1).
 b. Before = 10/26/01 to 11/8/01; after = 11/9/01 to 11/22/01.

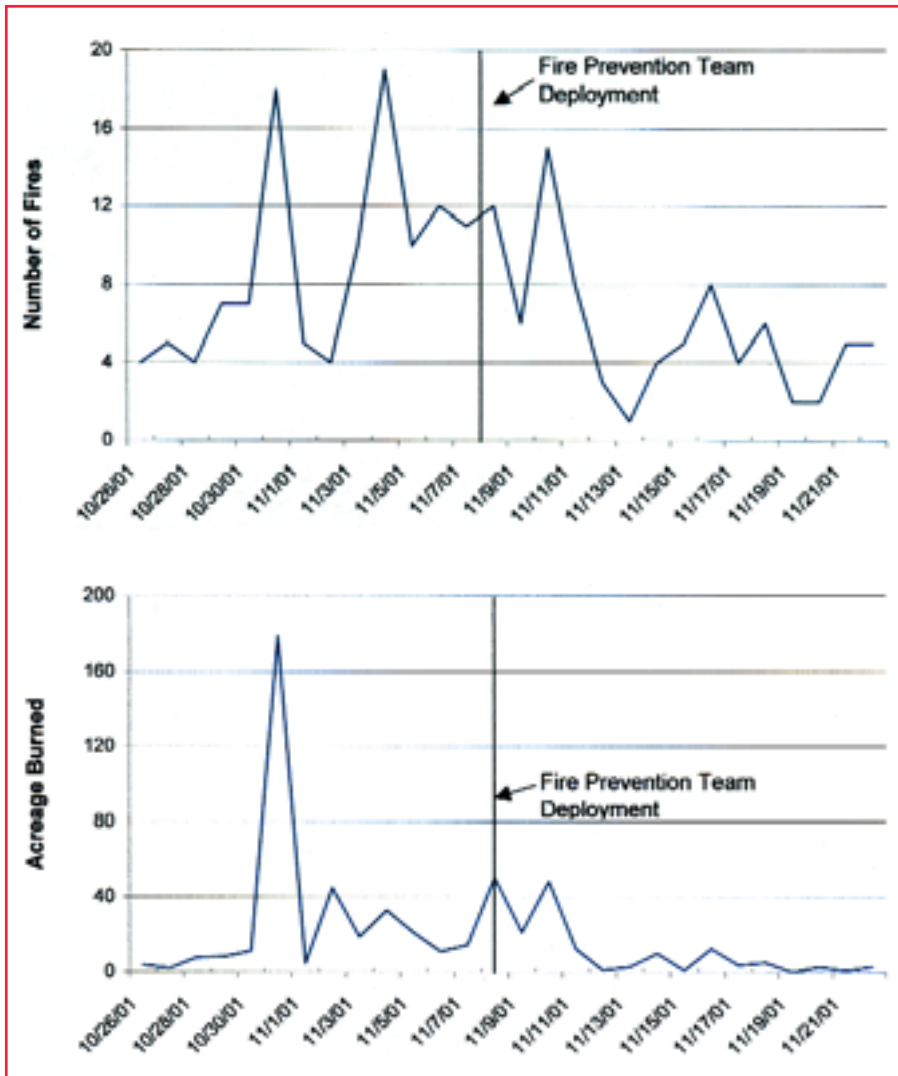


Figure 4—The number of escaped debris-burning fires (top) and acres burned (bottom) in the Rome District before and after a wildland fire prevention team was deployed.

2–4. In the Rome District, the drop can be attributed to the burn ban plus the work of the fire prevention team.

Cost/Benefit Analysis

Can a dollar value be assigned to the team’s effectiveness?

In Georgia, we estimate the total cost of suppressing fire on 1 acre (0.4 ha) to be about \$500, based on the average number of acres burned annually and the total annual GFC fire budget. This is higher than the actual on-the-ground cost for an individual fire, because the \$500 includes all organizational costs.

Based on table 2 and an estimated suppression cost of about \$500 per acre, savings due to the burn ban in districts 2–4 can be calculated as:

$$[(109 \text{ acres burned before} - 43 \text{ acres burned after}) \times 3] \times \$500 \cong \$99,000$$

In district 1 (the Rome District), total savings due to both the burn ban and the fire prevention team can similarly be calculated as:

$$(412 \text{ acres burned before} - 126 \text{ acres burned after}) \times \$500 \cong \$143,000$$

If burn ban effectiveness is assumed to be constant across all four dis-

The fire prevention team prevented 18 fires and kept 34 acres from burning, for a net savings of \$10,400.

tricts, then the substantially greater savings for the Rome District are at least partly attributable to the effectiveness of the fire prevention team.

Just how many fires did the team actually prevent? Table 2 shows that:

- 293 debris-burning fires escaped during the entire 28-day period evaluated, burning a total of 690 acres; and
- 6 percent fewer fires escaped in district 1 than in districts 2–4 after the fire prevention team arrived, burning 5 percent fewer acres.

If we therefore assume that the number of fires prevented by the team is 6 percent of the total number of fires and that 5 percent fewer acres burned, then the team prevented 18 fires and saved 34 acres from burning.

Now we can calculate cost savings. If the team kept 34 acres from burning at a suppression cost of \$500 per acre, then the team saved \$17,000 in suppression costs. The team itself cost \$6,600, so net savings are \$10,400.

In summary, the fire prevention team’s activities:

- Reduced the number of fires by 18,
- Reduced the number of acres burned by 34, and
- Produced a net savings of \$10,400.

Of course, there are important caveats. Our data set was small, and more extensive analysis might show different results, although the general pattern is likely to be similar. Moreover, parts of the Newnan and Gainesville Districts were probably influenced by the fire prevention effort in the Rome District through the reach of radio, television, and newspapers across districts. Consequently, the fire prevention team might have been even more effective than calculated.

Positive Balance

The benefits of fire prevention are often difficult to measure and therefore intuitive at best. But the fire prevention team in the Rome District did produce measurable results. The estimate of \$10,400 produced in savings is likely repre-

All things considered, it seems quite reasonable to say that the fire prevention team contributed measurably to reducing fire activity in the Rome District.

sentative of the savings actually realized by the team.

All things considered, it seems quite reasonable to say that the fire prevention team contributed measurably to reducing fire activity in the Rome District. The work of the team was considered a success—an incentive to deploy similar teams in the future.

Acknowledgments

The authors wish to thank Dr. James A. Pharo, a forest economist, for his helpful suggestions in the cost/benefit analysis for this article.

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BUILDING GROUP COHESION IN TYPE 2 FIRE CREWS



Bill Lee

Much of the training for wildland firefighters, from smokejumpers to ground pounders, centers on fire behavior, weather, fuels, fireline construction, safety, physical conditioning, and equipment use. The training is extensive and thorough, yet one element might not always receive enough attention at the local or national level—and it can mean the difference between life and death.

That element is group cohesion of a fire crew. Group cohesion affects group communication, decision-making, and survivability. In a 12-year study of USDA Forest Service fire crews, Driessen (1990) discovered an inverse correlation between crew cohesion and accident rates. In his report on the collapse of decisionmaking and organizational structure on the 1994 South Canyon Fire, Putnam (1995a) pointed out that too little training time for firefighters is spent on improving thinking, leadership, and crew interactions.

Driessen (2002) offered a basis for increasing the level of cohesion on a type 2 crew as quickly as possible. This article takes Jon Driessen's report on crew cohesion and provides specific steps to increase cohesion in type 2 crews.

Bill Lee is a school social worker in Lander, WY, during the school year; and a seasonal recreational specialist/firefighter since 1979 for the USDA Forest Service, Shoshone National Forest, Washakie Ranger District, Lander, WY.

Group cohesion can mean the difference between life and death.

Before Fire Season

Type 2 crews usually include personnel from different units (such as ranger districts or national forests) or agencies (such as the Forest Service, USDI Bureau of Land Management, or State fire divisions). Different affiliations among crew members make it difficult for a crew boss to build a cohesive unit (Putnam 1995b). Right when a type 2 crew is first mobilized, the crew boss should openly acknowledge group cohesion as a crew weakness.

Crew members not knowing each other can hamper communication, trust, and leadership, all key to a cohesive crew (fig. 1). If crew members are to better communicate, make better decisions based on group input, and watch out for each other, then crew bosses must speed up the process of building group cohesion.

One way is through gatherings of crew members in neighboring ranger districts before fire season begins. For example, the Washakie Ranger District on the Shoshone National Forest has an orientation campout with the neighboring ranger district at the beginning of summer to get people better acquainted with each other for coming work projects and fire duty.

Such socializing builds group cohesion. The purpose should be explic-

it—the district ranger needs to say, “Besides learning policy, procedures, and programs, we want you to get to know each other better so that when we move into our fire season, we can pull together more effectively.” Such prefire experiences will improve communication on a fire.

During Staging

This approach works well with adjoining units for local fire suppression. But crews are often formed from people from around a State or across a region. How do we build cohesion in such crews?

Again, we look for prefire opportunities to help crew members get better acquainted and understand each other's strengths. In the staging phase on the way to a fire, crew members typically meet at a predetermined location and caravan to

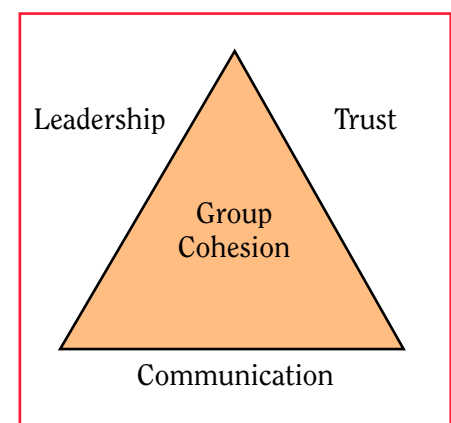


Figure 1—Three key elements make up the group cohesion triangle.

the fire. During this phase, the crew boss should assemble the crew and acknowledge the need for crew members to get to know each other better. Crew members can connect with each other, building cohesion within the crew, through a formal discussion on crew cohesion. For example, crew members might:

- Introduce themselves,
- Explain the special skills they bring to the fireline,
- Say something personal about themselves,
- Discuss what they can contribute to a more cohesive crew, and
- Add anything else they want.

Afterwards, the crew members should be assigned to travel in groups other than the groups they arrived with. Travel and conversation with unfamiliar people can help break down communication barriers and build alliances. Such mixing can break up cliques and foster group cohesion.

When a crew arrives on a fire, it is best to assemble crew members into squads by the groups they originally arrived with for mobilization. The time spent split apart for travel will still enhance communication between squads, encourage squads to look out for each other on the fireline, and make it easier for crew members from different squads to further get to know each other during break times and in fire camp.

When on Standby

Under the severe fire conditions of recent years, some fire management officers have ordered type 2 crews to stand by for potential fires. The standby strategy can allow more time for a crew to become more cohesive through project

Right when a type 2 crew is first mobilized, the crew boss should openly acknowledge group cohesion as a weakness.

work as crew members wait to be dispatched.

Throughout a crew's assignment, from standby to actual fire duty, crew bosses should work to build group cohesion (see the sidebar below). At the beginning or end of each shift, crew bosses can discuss observed examples of good communication and teamwork. They can also ask the crew to share their own observations of good communication and teamwork. Finally, the crew needs to talk about what things are helping the crew become more cohesive.

The toughest and most important position on a fire is the crew boss. He or she must carry out plans from overhead, look out for the

safety of the crew, and make decisions that can have life-or-death implications. Type 2 crews require a crew boss who is skilled at:

- Fostering good communication,
- Communicating clear expectations,
- Briefing crews well,
- Understanding the strengths and limitations of each crew member, and
- Creating an atmosphere in which crew members look out for each other.

In short, we need type 2 crew bosses who can build group cohesion.

Through Training

The wildland fire community knows the importance of group

Sample Training Card

The words below are printed on a business card I hand out at crew boss training. It can help trainees remember steps to follow in developing group cohesion with the type 2 crews.

Type 2 Wildland Fire Crew

- Good decisions occur by promoting crew cohesion.
- Acknowledge the need for crew members to get to know each other better.
- Encourage input from all crewmembers. Express contradictory observations in a respectful manner.
- Brief/debrief often.
- Reassign to traveling groups.
- Know strengths/limitations of each crew member.
- Model behavior you want from the crew.

At Staging Area

- Crew members introduce themselves.
- Explain skills/experiences they bring to the fire crew.
- Share something personal about themselves.
- Explain what they can contribute to better a cohesive crew.

Training Opportunities for Building Group Cohesion

The National Wildfire Coordinating Group offers several courses on group cohesion. Though not mandatory, they are widely used within the wildland fire community, including the USDA Forest Service.

- **Human Factors on the Fireline (L-180):** This entry-level course, intended for all firefighters, addresses basic situational awareness and communications skills, along with the challenges of integrating into an effective team operating in a high-risk environment.
- **Followership to Leadership (L-280):** Intended for aspiring crew bosses, this course addresses the decisionmaking and teambuilding skills needed to lead other firefighters.
- **Fireline Leadership (L-380):** This course for fire crew leaders is a rigorous weeklong training application of critical leadership skills—such as situational awareness, communications, teambuilding, and decision-

making—in field simulations. It allows fire crew leaders to practice crew cohesion-building techniques, such as providing vision, establishing standards, conducting after-action reviews, mitigating stress, and resolving conflict.

Two more courses are currently under development, one for those stepping up to the Division Supervisor or IC Type 3 level (L-381), the other a seminar for incident management team candidates (L-480/580).

In addition, a Web-based self-study resource (<<http://www.fireleadership.gov/>>) supports the formal leadership curriculum. It provides fire crew leaders with a number of tools, some with direct bearing on crew cohesion, including a guide for conducting after-action reviews, a guide for improving briefing skills, and a reference for assessing a crew's level of cohesion.

We should use prefire opportunities to help crew members get better acquainted and understand each other's strengths.

6 weeks that it typically takes to develop a cohesive type 2 crew. Type 2 crews can benefit from very purposeful training prior to the fire season to enhance group cohesion. Additional training can improve communication, decisionmaking, and survivability.

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cohesion (Driessen 2002), and training opportunities exist for building it (see the sidebar above). Individual units should use these opportunities to develop leadership skills in our crew bosses for build-

ing group cohesion in our type 2 fire crews.

Well-trained crew bosses can speed up the process of building group cohesion, thereby reducing the

WILDLAND FIRE EDUCATION: GOING THE DISTANCE IN ALASKA



Sandi Sturm and Matt Weaver

Reaching educators in rural Alaska is not easy. A mid-sized rural district, Iditarod, is about the same size as the State of Ohio. Anchorage and Barrow, AK, are about 800 air miles (1,300 km) apart. Many rural communities are in roadless areas and rely on air or water travel most of the year.

Very few opportunities for additional training exist in the home communities of rural educators. The alternative is to travel to “the city” for training. However, a weekend workshop can cost \$2,000 or more, not to mention the inconvenience of leaving the classroom for up to 4 days. Extreme weather can extend such trips indefinitely.

In spite of these obstacles, it is more critical than ever for Alaskan educators to get exciting interdisciplinary fire education materials. In 2002, Alaska had its fifth largest wildland fire season on record, with 539 fires burning more than 2.2 million acres (880,000 ha).

Most of these fires were human caused, and several threatened villages and towns, recreational areas, and cultural and historic sites. The answer is more fire education statewide. Because teachers can't always come to us, we must find a way to get to them.

Sandi Sturm is the online learning designer with Creative Conservation, Wasilla, AK; and Matt Weaver is the Alaska Project Learning Tree coordinator, Alaska Department of Natural Resources, Anchorage, AK.

Communicating with educators in rural Alaska is hard, but it is critical that Alaskan educators have access to exciting, interdisciplinary fire education materials.

Face-to-Face Workshops

Fire crosses all boundaries—and so does Project Learning Tree (PLT). In partnership with the U.S. Department of the Interior (USDI) Bureau of Land Management and in cooperation with the National Interagency Fire Center, PLT delivers annual fire education workshops to hundreds of teachers in about 20 States.

With support from agencies, organizations, and colleagues, Alaska PLT developed a fire education program called Fire! In Alaska. The program is designed to help educators learn about wildland fire ecology, behavior, and prevention (see the sidebar on page 52). Alaska PLT used a variety of established curricula—such

as the USDI U.S. Fish and Wildlife Service's Role of Fire in Alaska, the USDA Forest Service's FireWorks, and the national FireWise program—and contributions from Alaskan agency fire experts to build a program that addresses the unique needs of Alaskan educators.

More than 100 educators have completed the 2- to 3-day Fire! In Alaska face-to-face workshop. The first workshop was in Homer, a town nestled between the boundary of Alaska's coastal rain forest and the interior boreal forest on Alaska's south-central coast—often called the “end of the road.” Homer, the epicenter of a decade-long spruce bark beetle epidemic that has affected more than a million acres (400,000 ha), was the perfect



Alaska Division of Forestry Fire Manager Joe Stam and Alaska teachers evaluate a property within beetle-killed spruce in Homer, AK, using FireWise evaluation sheets. Photo: Matt Weaver, Alaska Department of Natural Resources, Division of Forestry, Anchorage, AK, 2002.

Fire! In Alaska Course Objectives

Alaska Project Learning Tree developed a program for educators in rural Alaska called Fire! In Alaska. The 2- to 3-day workshop is designed to help teachers do the following:

Fire Ecology

- Locate and describe three major Alaska biomes.
 - Explain how variables such as temperature, rainfall, soils, and topography influence biota.
- Apply anatomical similarities and differences to taxonomy.
 - Use a dichotomous key.
 - Name major Alaskan trees by sight.
- List how boreal forest fire history is studied and explain how/why fire affects the biotic and abiotic features of the forest.

- Define, understand, model, and predict primary and secondary succession in the boreal forest.
- Provide examples of how biota are adapted to fire-dependent ecosystems.
- Understand the Alaska Wildland Fire Coordinating Group suppression plan for Alaska.

Fire Behavior

- Explain the chemical nature of combustion.
 - Compare combustion to photosynthesis and cellular respiration.
- Design and conduct new experiments that explain how the parts of the fire triangle interact.
- Identify, explain, and model how fuels, weather, and topography influence the behavior of wildland fire.

- Use the fire triangle and fire experiments to explain how fire is used safely in prescribed burning and fire suppression.
- Define, describe, and model how controlled burning influences ecosystems and people in the wildland/urban interface.
- Define, describe, and model the three main types of wildland fire and the variables that influence them.

Fire Prevention/Fuels Mitigation

- Understand and apply precepts of defensible space to hypothetical and real situations.
 - Use the FireWise defensible space checklists to evaluate their own homes.
- Design a FireWise house.
- Plan and conduct a simulated prescribed burn to safely mitigate fuel loads near subdivisions.

backdrop for a field trip after participants learned about fire ecology and conducted fire behavior experiments.

On the field trip, teachers evaluated private homes in the wildland/urban interface threatened by the dry, heavy fuels left behind by marauding beetles. Although the workshops have been a great success—we trained about 100 teachers in 2003, who will reach an estimated 2,000 students and households—they are not easily accessible to teachers working in rural Alaskan communities.

Fire! In Alaska Online

One answer was online training. In 2000, Alaska PLT enlisted support from a PLT facilitator to develop a distance learning course on wildland fire. After months of research-

Distance education is an excellent tool to help reach wildland fire ecology, behavior, and prevention goals.

ing connectivity issues and overcoming numerous obstacles, the first distance PLT course was available in May 2002.

By April 2004, five online courses had reached 75 teachers in rural and remote villages, who in turn reach 1,500 students per year or more. Even before the online courses ended, the teachers were already using the materials.

Alaska PLT and the professional facilitator followed up by developing an 8-week Fire! In Alaska course, to be delivered through distance education. In October 2003,

fire experts from several agencies—the Alaska Department of Natural Resources, Division of Forestry; and the USDI Bureau of Land Management and National Park Service—joined educators in piloting the program and fine-tuning its content.

The term “online course” might be deceiving. The course uses a variety of methods and technologies. Rather than a “sit-and-click” kind of experience, the course is fully facilitated and very interactive, bringing in local fire experts for a local twist.

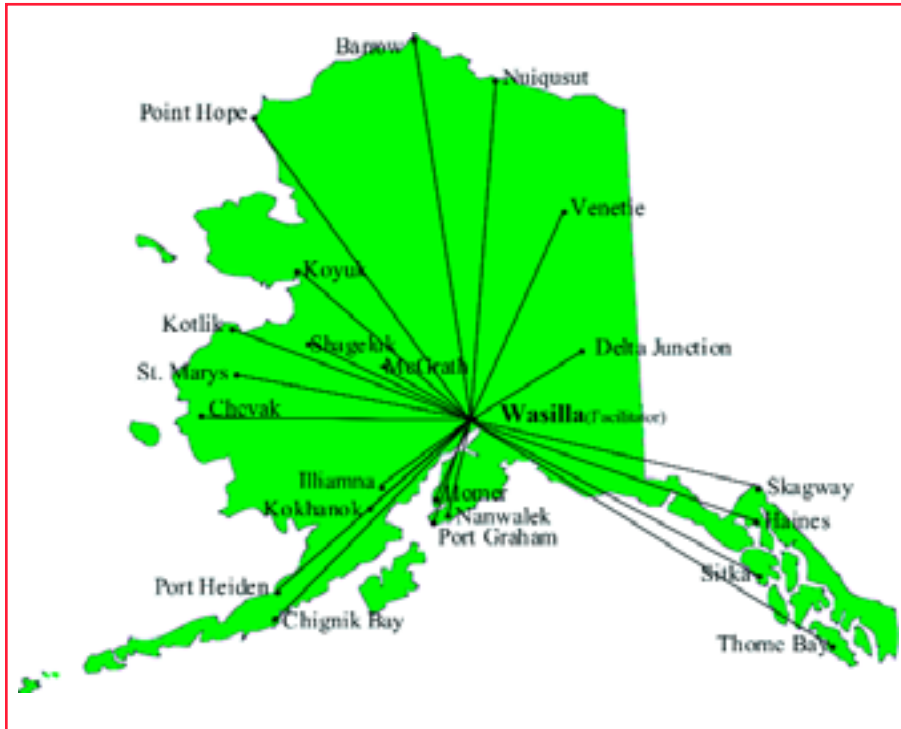


Figure 1—Since May 2002, 47 educators from across Alaska have taken an online Project Learning Tree workshop.

Fire! In Alaska Online focuses on the same three areas as the face-to-face workshop (see the sidebar). Teleconferencing, compact discs, and the Internet are incorporated throughout the course. Participants share local cultures and interact with their individual communities while working on fire ecology, behavior, and prevention projects and experiments. One advantage is the interaction among the many far-flung cultures of Alaska. Educators share stories and build new friendships with people who share similar experiences.

The 8-week course is scheduled to be delivered twice per year, in the fall and spring of the school year. Teachers are currently on a waiting list for the fall 2004 offering. Several times per year, face-to-face workshops are still offered to educators living in more urban areas.

Future Training

Distance education can play a vital role in Alaska's wildland fire management, according to Joe Stam, Chief of Fire and Aviation in the Alaska Division of Forestry. Stam believes that the Fire! In Alaska dis-

Alaska Project Learning Tree teaches teachers about fire ecology, behavior, and prevention through a large national network of State coordinators and volunteer facilitators.

tance education initiative offers the most effective long-term solution for reducing the number of new fire starts, informing the public about wildland management, and preventing catastrophic loss in remote communities due to wildland fire.

Research has already begun to take the program to other regions of the country. Sponsors are coming forward to develop a regional or national Fire! Online course and a train-the-trainer program to build a force of online facilitators. PLT is committed to offering the opportunity to its more than 3,000 coordinators and facilitators nationwide.

For more information about distance-delivered wildland fire education, contact Sandi Sturm at <www.creative-conservation.com> or Matt Weaver at <matt_weaver@dnr.state.ak.us>. ■

CANADIAN FOREST FIRE WEATHER INDEX SYSTEM: TRAINING NOW AVAILABLE ON CD-ROM

Paul St. John and Martin E. Alexander

“Understanding the Fire Weather Index (FWI) System” is the latest CD-ROM-based wildland fire training course produced by Alberta’s Hinton Training Centre in concert with Christie Communications* to utilize interactive multimedia technology (Alexander and others 2002). The course, completed in August 2002, also involved the Canadian Interagency Forest Fire Centre’s National Training Working Group and was produced in association with the Canadian Forest Service.

Course Content

The course offers a comprehensive introduction to the Canadian Forest Fire Weather Index (FWI) System, one of the major subsystems or modules of the Canadian Forest Fire Danger Rating System. The FWI System consists of three fuel moisture codes and three fire behavior indexes that provide relative numerical ratings for six aspects of wildland fire potential—ignition, duff consumed, smolder-

Paul St. John is a fire management instructor with Alberta Sustainable Resource Development, Hinton Training Centre, Hinton, Alberta, Canada; and Marty Alexander is a senior fire behavior research officer with the Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta, Canada.

* 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*.

The course offers a comprehensive introduction to the Canadian Forest Fire Weather Index System, a major subsystem or module of the Canadian Forest Fire Danger Rating System.

ing/persistence, spread rate, total fuel consumption, and intensity—based on four weather observations.

“Understanding the Fire Weather Index (FWI) System” contains:

- 14 video clips, 219 audio clips, and 656 graphics/photos;
- Online help and a glossary;
- An SI-to-imperial-unit conversion calculator;



The CD-ROM training course “Understanding the Fire Weather Index (FWI) System” encapsulates more than three decades of knowledge and experience with the FWI System in Canada. Photo: M.E. Alexander, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB, 2002.

The course was developed and reviewed by a national team of fire danger rating specialists representing research, operations, and training.

- The “FWI Calculator,” which allows for the calculation of the six standard components of the FWI System for two broad regions in both the northern and the southern hemispheres; and
- A calculator allowing for the overwinter adjustment to the spring starting value of the Drought Code component of the FWI System.

The course was developed and reviewed by a national team of fire danger rating specialists representing research, operations, and training. The four main sections (Overview, Fuel Moisture Codes, Fire Behavior Indexes, and Applications) are each followed by a test in preparation for a final exam that is tracked by the computer. User success on the section tests is shown by lit matches: For each correct answer, a match goes out; for each incorrect answer, a match rekindles. When all the matches are out, the user has finished the test.

Time Commitment and System Requirements

“Understanding the Fire Weather Index (FWI) System” takes approximately 6 hours to complete. Users can take the course in installments using the bookmarking feature that allows them to return where they have left off.



A training session in progress using the “Understanding the Fire Weather Index (FWI) System” CD-ROM. Photo: N. Merrifield, Alberta Sustainable Resource Development, Hinton Training Centre, Hinton, AB, 2003.

The course can be run on a stand-alone computer or over a network. Minimum system requirements include:

- A Pentium 133 MHz processor (with Windows 95) or greater, to run under Windows 95, Windows 98, Windows NT, Windows 2000, or Windows Millennium;
- 32 MB of total RAM memory and 100 MB of free hard drive space (4 MB actually required for the software);
- Color SVGA monitor (set for 800 x 600, 16 bit color);
- 16-bit sound card (SoundBlaster);
- 16X or greater CD-ROM; and
- A mouse, as the primary means of input.

For a copy of this and other wildland fire training CD-ROMs (Alexander and Thorburn 2001; Thorburn and others 2003), visit

the Hinton Training Centre Website at <http://www3.gov.ab.ca/srd/forests/resedu/etc/mmp.html>.

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“BREWER FIRE MYSTERY” DISCUSSION

Editor's note: Occasionally, Fire Management Today publishes comments from readers on topics of concern, offering authors a chance to respond. To have your comments considered for publication, write to Managing Editor Hutch Brown at USDA Forest Service, Office of the Chief, Yates Bldg., 4th Floor NW, 201 14th St., SW, Washington, DC 20024, tel. 202-205-0878, fax 202-205-1765, e-mail: hutchbrown@fs.fed.us.

Reader Comment: “Brewer Fire Mystery” Not So Mysterious

Stephen A. Eckert

An article in the Fall 2002 issue of *Fire Management Today* mentions a blowup on the 1988 Brewer Fire in Montana that forced shelter deployment by the Wyoming Interagency Hotshot Crew.* The article states that “that there has never been an explanation for what triggered the Brewer Fire blowup.”

But what happened on the Brewer Fire is no mystery.

From 1982 to 1990, I was the fire control officer for the Bureau of Land Management, Miles City Field Office, Miles City, MT. From the outset of the Brewer Fire, I was the air attack supervisor. I also ordered the overhead team on the evening the fire started, and I was a member of the fire investigation team that later explored and reported on the shelter deployment incident.

In 1988, the drought in eastern

Steve Eckert is the assistant fire management officer for the Bureau of Land Management, Wyoming State Office, Cheyenne, WY.

* See Martin E. Alexander, “The Staff Ride Approach to Wildland Fire Behavior and Firefighter Safety Awareness Training: A Commentary,” *Fire Management Today* 62(4) [Fall 2002]: 25–30.

Montana was even more severe than during the Dustbowl. The recorded moisture was 3.35 inches (8.49 cm), compared to 5.11 inches (12.98 cm) per year in the 1930s. Normally, surface fires in open dry ponderosa pine forest stay on the ground; but in summer 1988, had you touched a lighted match to the pine duff, the flame would have easily crawled all the way up even the biggest yellow pine. Throughout that summer, winds that ranged from southwest to northwest were consistently and unusually strong, both during the day and in the evening.

So conditions were ripe for extreme fire behavior. They included record drought, record low fuel moistures, erratic and strong winds, extreme temperatures, and very low relative humidities. Under these conditions, the fire quickly went from a surface fire to a running crown fire. The hotshot crew was flanking the fire, building fireline. Had a lookout been posted in the meadow where the deployment took place, the crew would have had more time for escape or shelter deployment.

Under the severe burning conditions at the time, what happened on the Brewer Fire is no mystery. Instead, it was entirely predictable. Obviously, weather factors created an explosive environment. No other explanation is needed.

Author Response: What Triggered the Brewer Fire Blowup Remains the Mystery

Martin E. Alexander

First of all, I wish to state for the record that my mention of the Brewer Fire in my article (Alexander 2002) was in no way meant to criticize the people involved in fire suppression or the subsequent investigation into the shelter deployment incident. However, I do believe that Mr. Eckert has missed the point as to what “mystery” I was referring to in my article. I hope this response will clarify matters, and I appreciate the opportunity to elaborate on my initial thoughts concerning the Brewer Fire blowup.

My article was not intended to serve as a case study of the Brewer Fire. My sole purpose was to show how fire investigations are often rushed and the root causes of an incident on a fire (e.g., a fatality or near-miss) are often inadequately explored due to more pressing issues, in this case a rapidly escalating fire season in the Western United States. I wanted to support my call for creating wildland fire behavior research units.

Marty Alexander is a senior fire behavior research officer with the Canadian Forest Service at the Northern Forestry Centre, Edmonton, Alberta.

It is absolutely true that the critical level of dryness in live and dead fuels contributed to extreme fire behavior on the Brewer Fire. But the real question is this: What actually *triggered* the temporary escalation in extreme fire behavior on that particular evening in late June 1988?

We simply don't know. That is the mystery, not the fire as a whole, which is readily explainable. Certainly, other fires have burned under similar critically dry fuel situations over the years, and yet we haven't always seen events like those reported on the Brewer Fire.

I am a strong believer in not attributing unusual fire behavior to an "act of God." So I speculated that perhaps a heat burst (HB) was responsible for causing (i.e., triggering) the blowup or flareup that forced the Wyoming Interagency Hotshot Crew (IHC) to move away from the fire to a clearing and deploy fire shelters.

An HB is a recognized meteorological phenomenon (Bernstein and Johnson 1994; Johnson 1983). Perhaps HBs happen a lot more often than we think. We think we have studied our fire environments really well, but the truth of the matter is that we haven't—we just think we have. In the late 1950s, Mark Schroeder and Clive Countryman conducted a series of "fireclimate surveys" to begin collecting case histories or studies from which generalizations about the dynamics of mesoscale phe-

nomena could be made (Schroeder and Countryman 1960). A lot more work is needed. The meteorological conditions associated with the 1953 Rattlesnake Fire in California, which involved 15 firefighter fatalities, are a specific case in point (Maclean 2003).

The whole point of my bringing up the Brewer Fire was the need for thorough followup, because investigations are often rushed and we don't necessarily learn as much about what influenced a fire's behavior as we should or could have. As a result, we set ourselves up for the possibility of repeating the same scenario sometime in the future—perhaps with a fatal outcome.

I believe that mesoscale phenomena such as an HB should be looked into as a possible factor in the blowup of the Brewer Fire. An HB would seem to explain what happened. Associated with nocturnal thunderstorms, HBs are characterized by a sudden and dramatic localized increase in air temperature and a drop in relative humidity, coupled with strong, gusty winds. If we were to find that the Brewer Fire blowup was in fact triggered by an HB, we might in the future be able to use a sudden increase in air temperature—like the one reported by the Wyoming IHC foreman just before the blowup—as an "early warning system."

The possibility that an HB ultimately triggered (not set up) the Brewer Fire shelter deployment incident should, in my opinion, be

examined by a fire weather meteorologist using all the available data from both synoptic and mesoscale standpoints (e.g., upper air data, satellite and radar imagery, and hourly airport observations). Simply examining the data collected at a single remote automatic weather station might not necessarily suffice to detect an HB, because existing research suggests that HBs are so localized that they are not picked up at a single observation point on the landscape.

In closing, if extreme fire behavior was really so predictable on the Brewer Fire, then I must ask, with all due respect: Why was the Wyoming IHC allowed to be in such a dangerous position? To my knowledge, neither the fire weather forecast nor the fire behavior forecast mentioned the possibility of what transpired.

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GUIDELINES FOR CONTRIBUTORS

Editorial Policy

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

Submission Guidelines

Submit manuscripts to either the general manager or the managing editor at:

USDA Forest Service
Attn: April J. Baily, F&AM Staff
Mail Stop 1107
1400 Independence Avenue, SW
Washington, DC 20250-1107
tel. 202-205-0891, fax 202-205-1272
e-mail: abaily@fs.fed.us

USDA Forest Service
Attn: Hutch Brown, Office of the Chief
Yates Bldg., 4th Floor NW
1400 Independence Avenue, SW
Washington, DC 20024
tel. 202-205-0878, fax 202-205-1765
e-mail: hutchbrown@fs.fed.us

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

USDA Forest Service
Attn: Hutch Brown, 2CEN Yates
201 14th Street, SW
Washington, DC 20024

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

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

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

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

Photos and Illustrations. Figures, illustrations, overhead transparencies (originals are preferable), and clear photographs (color slides or glossy color prints are preferable) are often essential to the understanding of articles. Clearly label all photos and illustrations (figure 1, 2, 3,

etc.; photograph A, B, C, etc.). At the end of the manuscript, include clear, thorough figure and photo captions labeled in the same way as the corresponding material (figure 1, 2, 3; photograph A, B, C; etc.). Captions should make photos and illustrations understandable without reading the text. For photos, indicate the name and affiliation of the photographer and the year the photo was taken.

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

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

Contributors Wanted

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

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

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

PHOTO CONTEST ANNOUNCEMENT

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

Awards

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

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

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 from any place or time; but for each photo, you must indicate only one competition category. To ensure fair evaluation, we reserve the right to change the competition category for your photo.
- An original color slide is preferred; however, we will accept high-quality color prints, as long as they are accompanied by negatives. Digitally shot slides (preferred) or prints will be accepted if they are scanned at 300 lines per inch or equivalent. Digital images will be accepted if you used a camera with at least 2.5 megapixels and the image is shot at the highest resolution or in a TIFF format.
- You must have the right to grant the Forest Service unlimited use of the image, and you must agree that the image will become public domain. Moreover, the image must not have been previously published.
- For every photo you submit, you must give a detailed caption (including, for example, name, location, and date of the fire; names of any people and/or their

job descriptions; and descriptions of any vegetation and/or wildlife).

- You must complete and sign a statement granting rights to use your photo(s) to the USDA Forest Service (see sample statement below). Include your full name, agency or institutional affiliation (if any), address, and telephone number.
- Photos are eliminated from competition if they have date stamps; show unsafe firefighting practices (unless that is their express purpose); or are of low technical quality (for example, have soft focus or show camera movement). (Duplicates—including most overlays and other composites—have soft focus and will be eliminated.)
- Photos are judged by a photography professional whose decision is final.

Postmark Deadline

First Friday in March

Send submissions to:

Madelyn Dillon
CAT Publishing Arts
2150 Centre Avenue
Building A, Suite 361
Fort Collins, CO 80526

Sample Photo Release Statement

Enclosed is/are _____ (*number*) slide(s) for publication by the USDA Forest Service. For each slide submitted, the contest category is indicated and a detailed caption is enclosed. I have the right to grant the Forest Service unlimited use of the image, and I agree that the image will become public domain. Moreover, the image has not been previously published.

Signature _____ Date _____

