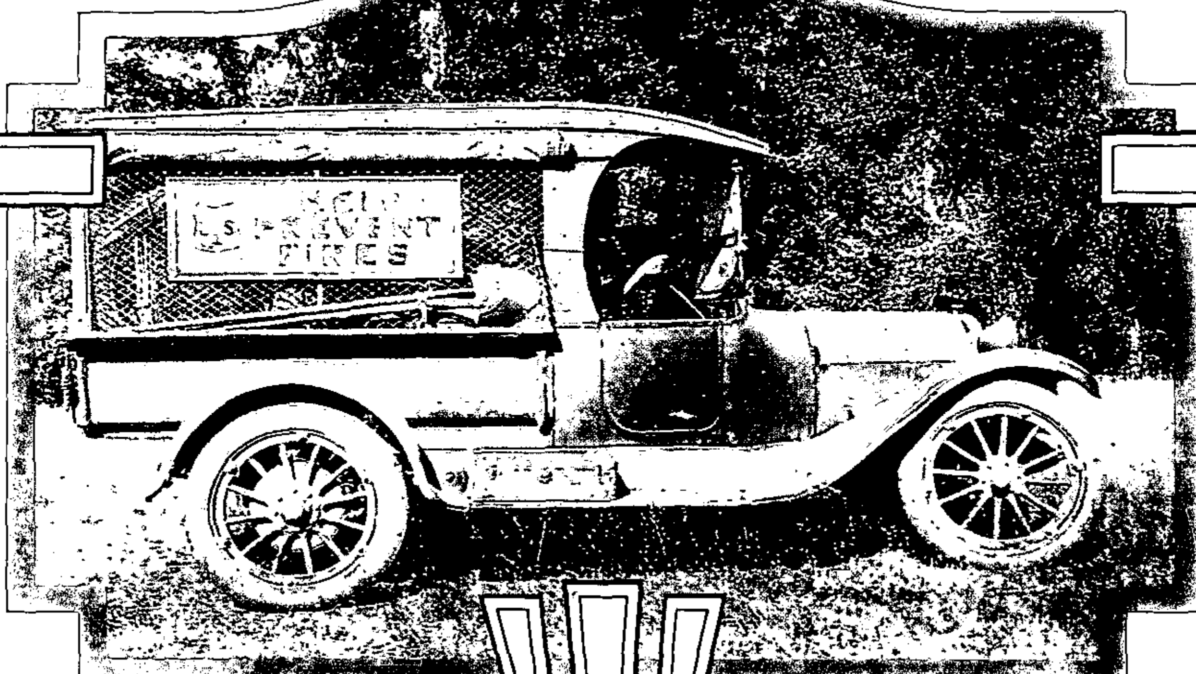
FIRE MANAGEMENT NOTES



50TH ANNIVERSARY

Fire Management Notes

An international quarterly periodical devoted to forest fire management

United States Department of Agriculture

Forest Service

Volume 50, No. 1
1989

Contents

Short Features

Special Features

Front cover:
A fire truck used on the Mendocino National Forest in 1923.

Back cover:
With this Smokey Bear poster, *Fire Control Notes* published its first piece of Smokey Bear art on the back cover of its April 1952 issue.

Overwhelmed—and We Love It!

For the first issue of its 50th volume of publication, *Fire Management Notes* was overwhelmed with articles and news items. Your response was encouraging to all who work on the publication to keep the wildfire protection community and its interested public informed about important fire management issues and concerns. Materials submitted but not published in this issue will be used in later issues of this important anniversary year, a half-century milestone in sharing research, policy development, equipment and supplies, delivery systems, and experiences in fire protection. We will use your important contributions and celebrate your enthusiasm throughout the year!

Doris N. Celarier, *editor*
Public Affairs Office, Forest Service, Washington, DC

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Send suggestions and articles to Chief, Forest Service (Attn: Fire Management Notes), P.O. Box 96090, U.S. Department of Agriculture, Washington, DC 20090-6090.

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Thank You, *Fire Management Notes*

As a former District Fire Management Officer, District Ranger, Forest Supervisor, and Director of Fire Aviation and Management Staff, I have seen *Fire Management Notes* mature in service to the wildfire community. Over the years, although some of the issues confronting the fire protection community have changed, the focus of *Fire Management Notes* has always been on strengthening the wildfire protection effort and preventing the loss of lives and natural resources.

Allan J. West

Fire Management Notes, initially known as *Fire Control Notes,* was first published in 1936 and has been published continuously since then, except for the war years of 1943 to 1945. The name *Fire Management Notes* was first used in 1973 when the Division of Fire Control was changed to the Division of Fire Management. With this anniversary issue, we begin the second half century of information sharing.

Fire Management Notes serves as a forum in which new developments, equipment modifications, and other matters of interest to the national and international fire community are discussed. *Fire Management Notes* is also a respected medium through which the Forest Service carries out some of its technology transfer responsibilities by sharing information with the international wildfire community. Keep up the good work!

The challenging fire seasons of the past few years remind us how cooperative and dependable the wildfire community really is and of our continuing need to share information and other resources. *Fire Management Notes* has been there for the past 50-plus years, a tried and trusted tool, to help us meet our many fire protection challenges.

I am deeply appreciative of *Fire Management Notes'* long service to the wildfire community. I extend my gratitude and encouragement to those managers, writers, and editors whose efforts have made its publication possible. I also take this opportunity to remind you, the reader, that this is your publication. Take the time to document your findings and experiences and share them with others. *Fire Management Notes* is a reflection of your interests and contributions! Your continued support will help start us on another 50 years.

ALLAN J. WEST
Deputy Chief
State and Private Forestry

Fire Management: Strength Through Diversity

Harry Croft

Budget coordinator, USDA Forest Service, Fire and Aviation Management, Washington, DC

The fire community has a new look! Today, we find women in many nontraditional jobs such as smokejumpers, lead plane pilots, division supervisors, and engine operators. Similarly, minorities are assuming greater roles in fire management as the need for qualified people transcends racial and sexual barriers. Through the Forest Service vision statement the Chief says it most clearly and succinctly: "We will have a workforce that better reflects the national diversity."

Fire technology, terminology, and organizational structure have changed in the last 80 years; similarly the composition of firefighters and other personnel involved in fire protection activities has also undergone significant change. The workforce—its values, and composition—have changed and continue to change as the number of women and minorities become an integral part of the fire management family (fig. 1). Change is not new to fire management. C.P. Cockrell stirred up plenty of controversy when she became the first woman fire lookout in 1920.

Fire and Aviation Management (F&AM) organization has traditionally been white male dominated. While we all can see progress in assimilating women and minorities, the organization still has a long way to go to achieve the Forest Service vision. Nearly a year ago, a major effort, directed by Allan J. West, Deputy Chief for State and Private Forestry, was initiated to formulate and implement tangible results that would change the composition of F&AM by 1995.

What's Different?

Why is this effort different from ongoing agencywide activities? Deputy Chief West knows that affirmative action measures have not always gotten the grassroots support needed to bring about effective change. He also knows fire people have a "can do" reputation, so his strategy focused on fire people achieving diversity in the workforce through their own program. More than 38 people are working on implementation strategies to accomplish the action items identified in the "Model for Workforce Diversity." Nearly all regions are represented with personnel from a wide variety of fire management backgrounds. All these people share a desire to design workable actions increasing the diversity of the F&AM workforce.

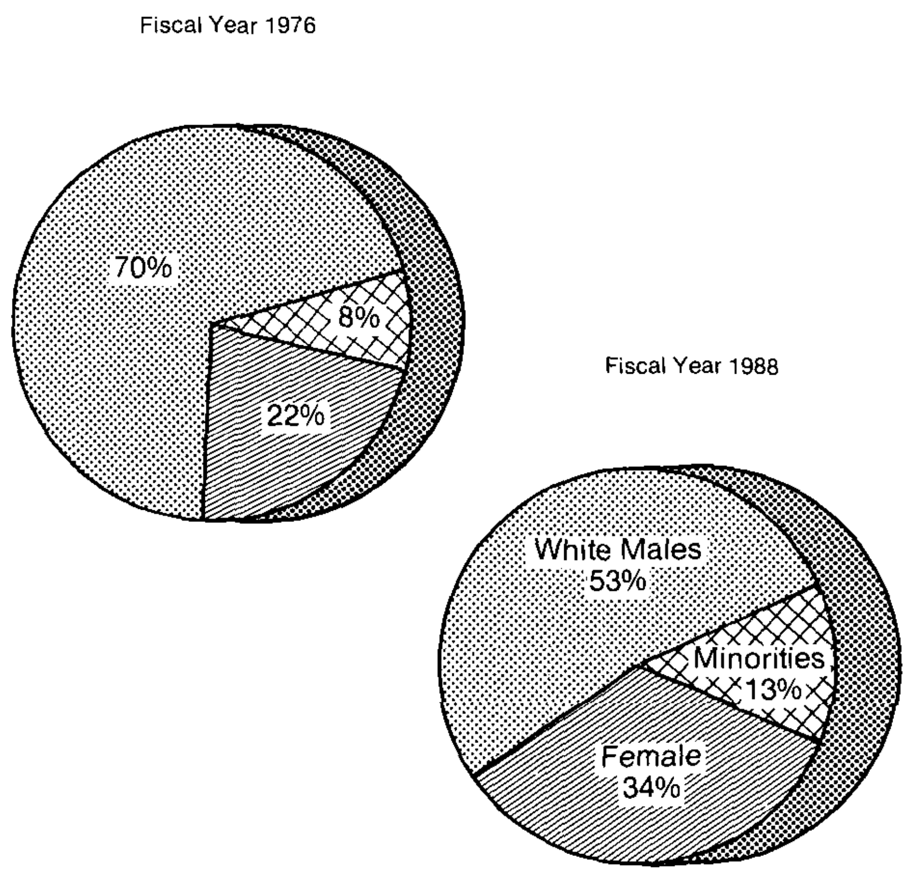


Figure 1—*A changing Forest Service workforce.**

*Data contain all and only permanent General Service and General Merit employees. Female minority employees are counted in both the female and minority categories.

"We will have a workforce that better reflects the national diversity."

—The USDA Forest Service—Caring for the Land and Serving People.

Native Americans continue to be among the best wildland firefighters.

The "Model"

Five primary issues are addressed by the "Model for Workforce Diversity": recruitment, Washington Office funding, hiring goals, development of opportunities and skills, and inappropriate behavior. Planned products growing out of these issues include:

- Recruitment—A handbook for supervisors on how to recruit, a cross-training program to recruit women and minorities internally into F&AM, and an expanded detailer program for interagency handcrews.
- Washington Office funding—Creation of a special affirmative action fund along with a recognition program specific to fire accomplishments in affirmative action.
- Hiring goals—Definitive hiring targets to accomplish the overall goal of reaching population parity by 1995 and a program to monitor fire's progress in achieving the goal.
- Development of opportunities and skills—Elimination of barriers within the Incident Command System/National Interagency Incident Management System (ICS/NIIMS); methods of eliminating bottlenecks in the fire organizational structure; proactive training linked to preplanned mobilization; emphasis on diversity in training, emphasis on and training for mentoring; and in the spring of 1989 a national conference on diversity in F&AM.
- Inappropriate behavior—Training lessons in all supervisory training courses, tracking and publicizing inappropriate behavior, a human resource specialist at large fire incidents to counsel staff and coordinate activities, and increased emphasis on the rating of fire teams for their Equal Employment Opportunities/Civil Rights (EEO/CR) actions.

What's Already Underway

Some of the planned actions have already been initiated. For the first time, posters are displayed at large fire bases providing information for those who need help. Some Incident Commanders (IC) have designated an EEO specialist who coordinates with the local forest and region on a variety of human rights issues. Gordon Reinhart, IC of a national fire team, has added a training specialist to

Regular U.S. Army personnel take a break with USDA firefighters.

his team who also has human resource management responsibilities. On the Shady Beach Fire, 50 percent of the training assignments involved women and minorities as the result of his proactive role. Region 1 dispatched an EEO counselor to one of the Greater Yellowstone Area fires. A sampling of fires revealed nearly all had someone designated as available for handling EEO-related issues. Many IC's included EEO issues in their daily briefing sessions. Region 6 deliberately took time to brief incoming crews, including the U.S. Army and casuals; unit leaders provided comprehensive briefings on a variety of topics, including positive guidelines for appropriate behavior. At the Fire Directors' annual meeting and at the national IC's meeting, L.A. (Mic) Amicarella, National Fire Director, emphasized the need to address cases of inappropriate behavior actively and gave direction on how to do that. During the height of intense fire activity, IC's sent individuals and entire crews home for documented instances of sexual harassment or other inappropriate behavior.

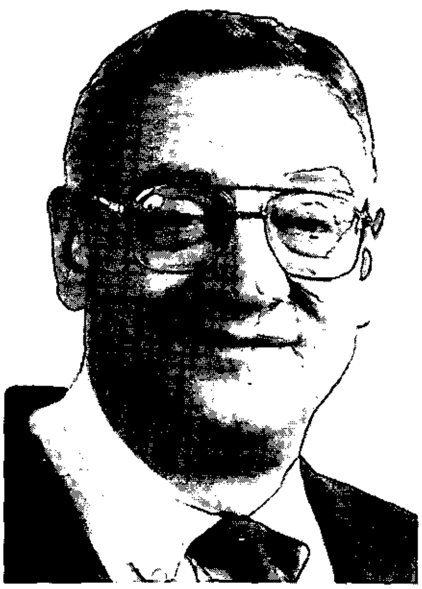
Supervisory responsibilities are drafted for inclusion in the Fireline Handbook (FSH 5109.32), and a quality video to help us all understand the nature of sexual harassment is being prepared for national distribution. EEO/CR issues are now part of crew briefings and are part of an IC's performance rating.

Fortunately, the number of positive experiences and the overall success of the 1988 fire season far outnumber the negative cases. The national TV show, "High Risk," highlighted the courage and hard work of the Redding Interagency Hotshot Crew and captured the spirit of the entire fire community. One could not miss the presence of women and minorities on that crew and their contribution to the total suppression effort. We've come a long way from the C.P. Cockrell days!

A changing workforce is inevitable. The "model" sets a course of action to bring about the change in a positive and constructive manner.

Utilizing all our resources, human and natural, is the key to maintaining a strong and responsive organization. F&AM is a leader in this and many other areas. The plan is simple: Foster a constructive, proactive work environment for women and minorities in the short term, and everyone benefits in the long term. Just as C.P. Cockrell encountered resistance in 1920, resistance to change in 1988 and beyond is inevitable. Our success will depend on the positive attitude of fire managers in carrying out the Chief's vision. The Deputy Chief and the National Fire Director both have exercised leadership in F&AM efforts to take affirmative action. They are committed to diversity in the workforce and are convinced F&AM will be better for everyone once parity is reached. They are intolerant of inappropriate behavior. They need your support. ■

Women are playing an expanding role in all phases of fire management.



L.A. Amicarella

Workforce Diversity—What We Can Do!

Over the last 50 years of *Fire Management Notes'* publication, a wide variety of topics has been discussed for the overall benefit of Fire and Aviation Management (F&AM) personnel across the country. Only recently have we begun to address the issue of workforce diversity. Nothing is so important as the management of our personnel and of the many people from other agencies and groups who help us accomplish our mission. After all, that's what it's all about, accomplishing our mission.

Fire management people have accomplished seemingly impossible tasks dealing with emergency situations. I can think of no other agency that has the track record that we have. Who else can rapidly mobilize 25,000 or more firefighters in a week? Who else can manage the aviation operations, the logistics, the planning, or the suppression efforts over the last 2 years as effectively as we have? I feel the same way about how we can achieve workforce diversity. Our reputation is on the line. Every fire supervisor, every fire management officer, every section chief—from crewleaders to the Incident Commander—has a personal responsibility to accomplish the goals and objectives of workforce diversity. This effort is not a one-time shot. The effort must be continuous and proactive.

Success in fire management goes beyond putting wildfires out. Success in fire management includes aggressive "initial attack" for integrating women and minorities throughout our organization—at all levels, grades, and positions. Our overall success as an organization will depend on the extent we all participate in this effort and achieve its goals. F&AM has a "can do" reputation. I personally take pride in our attitude and capability to diversify the F&AM workforce. If we all take a "can do" attitude, I have no doubt about the continued success of F&AM. ■

L.A. Amicarella
Director, Fire and Aviation Management

Moving, Anyone? Would You Tell Us About It?

If you have moved recently or are about to do so, please send us your address change or a copy of your new mailing label. Our address is as follows:

Fire Management Notes
P.O. Box 96090
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Major Transitions in Firefighting: 1950 to 1990

Jack F. Wilson

Director, Boise Interagency Fire Center, Boise, ID

In the decades from 1950 to the present, quantum leaps in wildland firefighting effectiveness have been made. Wildland firefighting has historically been a part of this country's culture since it was first settled. At first, this effort was in the hands of private landowners and the States, but in August of 1886, when the Secretary of the Interior requested the Secretary of the Army to protect the newly created National Parks from wildfire, it also became a Federal responsibility.

Today, as in 1886, fires are still suppressed in some of the same ways—by smothering them with dirt or by wetting them to the point of extinguishment. The firefighter still uses a shovel or axe or wetting device—be it hose, backpack pump, or something similar. From the earliest days, wildland firefighting was an experience in neighborly togetherness, ranchers and farmers working with Government officials and forest landowners. Even though some things remain the same, from those early beginnings, and later through cooperation of multi-Federal agencies, State agencies, and private individuals and companies, enormous advances have been made in how we fight wildland fire.

Advances in Cooperative Firefighting

During these decades, the major innovation in wildland firefighting probably is the growth in cooperation between Federal and State agencies to coordinate their firefighting efforts. This has led to an extremely efficient system of mobility and rapid deployment. Key to these cooperative efforts was the development of the interagency fire center concept. In 1965, the Boise Interagency Fire Center (BIFC) was established, and in 1974, the National Wildfire Coordinating Group (NWCG).

It was within this environment of cooperative effort that a significant development in training could take place. The fire training process became an interagency effort, bringing together the expertise of all fire agencies. The effort resulted in a structured professional curriculum, standardized course material, a responsive distribution system, and a qualification and certification system that included a physical conditioning standard and a system for evaluating experience.

The methodology that grew out of the training program did much to establish the way fires are fought today. This training and qualification effort known as the National Interagency Fire Qualification System (NIFQS) was directed by NWCG. In the early 1970's, a fire management system was developed in southern California that became known as the Incident Command System (ICS). This system was broader based than NIFQS in that it was viewed as an all-risk system that could be used to manage any kind of an emergency. In the early 1980's, the two systems were merged into a new system known as the National Interagency Incident Management System (NIIMS). Now the course material used to teach the earlier systems is being reworked to better fit the concepts of today.

Today, even the makeup of the group of people who fight fires has become diverse. Firefighters from many ethnic groups make up the firefighting crews. No longer are there only firemen, but firewomen as well.

Advances in Technology, Equipment, and Technique

Important advances in technology, equipment, and technique during these decades contributed significantly to effective firefighting. One of those advances having the greatest impact came in the area of fire behavior research. The understanding of fuel loads, burning characteristics, fire behavior, and prediction capability greatly enhanced the sophistication of firefighting. Most of the research was done in the Northern Forest Fire Laboratory in Missoula, MT, during the 1960's and early 1970's. The National Fire Danger Rating System (NFDRS) and its allied delivery system, the Administrative and Forest Fire Information Retrieval Management System (AFFIRMS), have become benchmarks in the management of firefighting and provided the scientific base to enter the era of prescribed fire use.

Most of the technologies, equipment, and techniques that came of age during the 1950 to 1990 period began in the 1920's and 1930's—reconnaissance aircraft in 1919, air cargo delivery in 1928, retardant

During these decades, the major innovation in wildland firefighting probably is the growth in cooperation between Federal and State agencies to coordinate their firefighting efforts.

dropping (firebombing) in 1931, smoke jumping in 1939. Many of these technologies, it is interesting to note, arise out of either the war efforts or some major project like the "man-on-the-moon" space program. The emergence of aircraft use in fire suppression closely followed the introduction of aircraft used in the two World Wars—the reconnaissance plane of World War I and the bomber and helicopter of World War II. The explosion in the use of electronics in fire programs followed the technology of the manned space programs.

The use of this equipment and its accompanying technology was not the only change taking place. With each new piece of equipment or technology, a specialized crew was needed to operate the equipment. To use the technological advances to their fullest, the organizations were created to institutionalize the technology: provide the required training, certify skills, integrate the systems, and evaluate the results. With each new technological step, a similar sequence followed.

Consider some of the events that occurred in these years. In the early 1950's, the DC-3 aircraft came on the scene in a big way to move crews rapidly. It was at this time that the first professional fire crews were organized. These trained, managed, and equipped firefighters originally were in components of 25 persons including 4 squads each with a squad boss and a crew boss. The first record of such a crew was a Southwest Indian crew (Mescalero Tribe) from New Mexico in 1952 (Larkin 1987). In 1968, larger transport aircraft became available—DC-4 and the Lockheed Electra. The crews were downsized to 19-person crews to allow 4 crews to fit into the aircraft. Today, there are 58 Category I or Federal professional crews and about 375 Category II crews or trained crews, like the original Mescalero, that move in jet transport aircraft.

The use of helicopters moved from the early beginnings in 1943 through successive stages, with the development of the turbine-powered helicopter, from the small single-place Bell G-2's and G-3's, which carried 1 or 2 people, mainly for reconnaissance, to the multirotored Boeing Chinook, the giant Sikorsky Sky Crane, or the S-62 or S-68 logging helicopter, which could carry 1,000 gallons of retardant or 20 people. The workhorse, however, was the Bell Jet Ranger or the Hughes 500, which usually carried three to four people and 150 gallons of retardant.

With the accidental salvo of water from a prototype DC-7 aircraft over the runway at Palm Springs, CA, in 1953, the program of "water bombing" revived. It rapidly evolved from the small, World War II training aircraft, the Stearman, and the N3N, which carried from 200- to 400-gallons, to larger aircraft. The real impetus to use water came with the securing of eight surplus TBM (U.S. Navy torpedo bombers) by the Forest Service in 1956 (Wilson 1978). These aircraft could carry 600 gallons. By 1965, the 4-engine B-17 ushered in the era of the large air tanker that could carry 2,000 gallons. Also the skilled air attack pilot and air attack boss came into the picture. Today, a fleet of approximately 80 air tankers, which consists of outdated commercial airline aircraft (DC-4, DC-6, and DC-7), improved World War II bombers (PB4Y2, P2V, and S2F), and 8 military C-130 Hercules aircraft capable of carrying 3,000 gallons.

It is clear that without the coordination of efforts of Federal agencies, States, and others the effective use of our technology would have been diminished. Mobilization before 1950 was usually by road vehicle; today it is by jet aircraft. In scale, instead of moving hundreds in firefighting operations, thousands are moved. For instance, during the fire siege of 1987, the entire national wildland fire suppression capability was mobilized in just 4 days. This consisted of about 28,000 people and all the hardware, subsistence and management capability that was possible.

Today's Direction

Today, we are rapidly moving into the technology of the information age. Pioneeer systems like the lightning detection system, remote automated weather systems (RAWS), infrared applications, and the danger-rating predictive systems are the forerunners. The development of computer-based information and data systems, satellite transmitted communications systems, tracking systems (Geostar), Automated Resource Ordering System (AROS), satellite network in fire camps (INCINET), and a host of other space age technologies are already being developed and tested. The development of sophisticated foams to replace water, and the delivery systems are just coming on. Truly, transitions in these decades have been productive and exciting, and we are only beginning. ■

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Wilson, Carl C. 1978. A brief history of the use of aircraft in forest firefighting: report to Chief, USDA Forest Service. Unpublished.

The Fire Equipment Working Team

The Fire Equipment Working Team (FEWT) was established in 1976 by the National Wildfire Coordinating Group (NWCG). NWCG's purpose is to coordinate programs and projects of mutual concern to the wildland fire protection community in the United States. To support that objective, FEWT works to inform Federal and State firefighting agencies about new fire equipment and fire chemicals and advise them on its use. For the benefit and convenience of the fire protection community, FEWT publishes the following guides to equipment and supplies:

Water Handling Equipment Guide (NFES 1275)	$ 3.00
National Fire Danger Rating System User's Guide (NFES 1522)	5.33
Spark Arrester Guide (NFES 1363)	4.24
Airtanker Base Planning Guide (NFES 1259)	0.95
Field Quality Control of Fire Retardant (NFES 1245)	40.90

These guides can be ordered from the Boise Interagency Fire Center (BIFC) at the following address:

BIFC
3905 Vista Avenue
Boise, ID 83705

Foam Applications for Wildland & Urban Fire Management, a newsletter prepared by the NWCG Fire Equipment Working Team's Task Group of International/Interagency Foams and Applications System, can be obtained through Paul Hill, advisor to FEWT. His address is as follows:

San Dimas Technology and Development Center
444 East Bonita Avenue
San Dimas, CA 91773
(818) 332-6231 or FTS 793-8000

The team has recently completed a brochure describing FEWT activities and listing members. The brochure is also available from Paul Hill or from Bill Shenk, Chairperson of FEWT, and other team members. Bill Shenk's address is as follows:

USDA Forest Service
P.O. Box 96090
Washington, DC 20090-6090

William Shenk, *fire equipment and chemicals specialist, Fire and Aviation Management, Forest Service, Washington, DC*

A Look at the Next 50 Years

John R. Warren

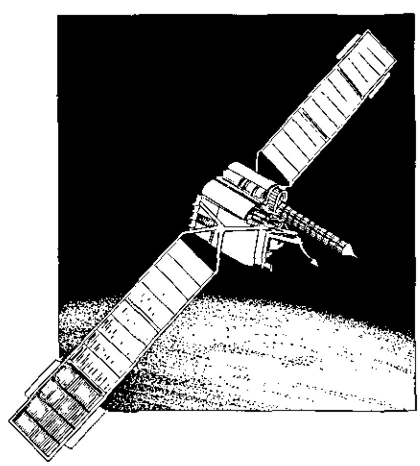
Advanced electronics group leader, USDA Forest Service, Boise Interagency Fire Center, Boise, ID

Information Storage, Retrieval, and Viewing

The year is 2038. I just electronically "paged" through the latest *Fire Management Notes* on my 36-inch extended high definition TV (EHDTV) monitor hanging on the wall. I stopped to read an article entitled "Supplemental Intelligence on Minicards" written by Frank Russ. (Fran Russ, Frank's grandpa, was managing editor of *Fire Management Notes* when I was working as an electronics engineer at the Boise Interagency Fire Center (BIFC) 50 years ago.) I could not help but compare this article to one written by Don Latham in the early artificial intelligence days and reflect on how far research had taken us in this area. I stored this article, along with two others, on a video minicard and made a full-color printout of another. As a retired but full-time Forest Service volunteer, I still like to keep up-to-date on the latest changes in electronics and its effects on fire management.

Back in 2008, many were predicting that paper copies would gradually vanish. Some people still use them, but most of us use the minicard. The minicards are the size of business cards and can store the equivalent of the *Encyclopedia Brittanica*, the unabridged *Webster's Dictionary*, and a few other lengthy reference books. Alternatively, they can store 20 hours of EHDTV programing with stereo sound or 12 hours of 3D-TV. Playback can be on your fold-out 5-inch color wrist monitor or on any TV set, either EHDTV or the old HDTV, which became popular before the turn of the century in the 1990's.

The video minicard recorder (VMR) is all electronic and about the size of a deck of playing cards. It doesn't need to be connected by wires, it simply uses a low-power infrared (IR) transmitter to communicate with the TV receiver. All receivers have the worldwide standard remote capability, sort of a take-off from the old remote control units that were once used for such simple tasks as turning TV sets on and off, changing channels, and adjusting the volume. We do all that now by just telling the TV set to turn on or off, to change channels, and to make other adjustments. Voice control has greatly reduced TV and stereo theft. A set responds only to "its master's voice," and can't be operated by anyone else. The voice prints are burned in when you first buy your set and can only be altered with your permission. This was originally a method to provide parental supervision over channel selection. Parents program the channels that can be accessed by their children's voices at specified hours. With 120 channels available from worldwide sources over the fiber optic Integrated Services System (ISS) to nearly all the homes in the country, there is every conceivable type of programing available. Much of the programing is stored and can be selected by the consumer over the ISS. To use the ISS requires videophones and EHDTV. The system provides stereo sound and access to general and special purpose computer data bases. The ISS evolved from the old Integrated Services Digital Network (ISDN). All signals are transmitted digitally now.



Space systems in communications are limited only by the imagination.

Fire Detection and Mapping

Supplemental intelligence (SI) coupled with Remote Sensing Spacecraft (RSS) data has made fire occurrence about 95 percent predictable. That other 5 percent that develops unpredictably can be embarrassing sometimes. For example, last year when a rainstorm, usually predictable 8 days in advance, veered off at the last minute, the worst fires in the Greater Yellowstone Area in nearly 50 years resulted. And some of the best fire behavior people of that era, including Richard Rothermel, thought that wouldn't happen again in 100 years. Of course, with the new Cool-It foams, no structures were lost this time, and the

"I believe spending a certain amount of time looking toward the future is a necessity, not a luxury."

—Former Chief R. Max Peterson in speech at the College of Environmental Science and Forestry, Syracuse, NY, 1986.

"50-year-growth" timber, started after the 1988 fires, was protected. With the new foams delivered by Remote Automatic Vehicles (RAV's), the Highly Accurate Prescribed Predictable Yield (HAPPY) fires rarely cause harm and are sometimes even steered into desired areas and patterns.

With the fourth generation Landsats and SPOT and third generation China-view RSS constellations in low-earth orbit (LEO) and their multispectral, automatically selected, microband spectrometers, virtually all small fires are detected and correlated with the Automatic Lightning Detection System (ALDS-IV) data. The microband spectrometers with ultra high speed integrated circuits (UHSIC) are able to combine numerous narrow spectral bands similarly to how Ralph Wilson, once a Forest Service physicist, combined the two wide IR bands many years ago to optimize hot spot detection. Ralph, as well as Dale Gable, electronics technician at BIFC, would certainly appreciate the added amount of intelligence that can be derived by combining so many narrow bands of the spectrum now. The Fire And Smoke Termination (FAST) teams are dispatched in minutes to parachute or otherwise get to the scene fast and take appropriate action on the fires as recommended by the SI computers, with concurrence from the fire staff.

Fire Management

For larger prescribed or the occasional escaped fire, fire behavior videos are viewed by the Multi-Agency Committee of Experts (MACE) team, while the various combinations of weather, fuels, values, and suppression resources are processed by the SI computer. The range of possible fire spread, probable costs and losses, and recommended suppression action are all displayed with other pertinent data. The LEO satellites provide an accurate update every 30 minutes of the fire location via the Very Speedy Acquisition Terminals (VSAT's). Applied and available suppression resources are also displayed continuously on the 60-inch (152.4 cm) graphics/EHDTV monitors on the wall. The MACE team members no longer meet together at a central location as they did until about 2018. All of them can view the same displays and talk to each other via wall monitors in their own offices. With the exception of an occasional unpredicted weather change and a few fires picked up by Santa Ana-type winds each year, all other fires burn only under prescribed conditions, monitored by satellites, and displayed on the large wall monitors in agencies' fire staff offices.

The fourth generation airborne IR Advanced Starring Array (ASA) systems were phased out after the LEO satellite constellations were put in orbit by the Orient Express II a few years ago. The China-view satellites are quite advanced and would no doubt be amazing to me, Patricia Andrews, and Fred Fuchs, who all visited China about 50 years ago (ca. 1987, 88) to start helping the Chinese apply modern technology to their fire management problems. Fred Fuchs' article on his China trip was published in *Fire Management Notes* in 1988. It is stored on my video library minicard.

Individual Instruments and Communications

The only IR devices used now (besides those on the satellites) are the zoom flashlight-sized starring array units. These are handheld or mounted on the RAV's. They can locate the hot spots occasionally missed by the satellites because they are under foliage and are useful for mop-up and special purpose operations. The satellite location data are only accurate to 20 feet (6.1 m), so the small units come in handy.

Fire crew members now always know their location to within 2 feet (0.6 m) by using the pocket Advanced Global Positioning System (AGPS) receivers in use. Their locations are transmitted via satellite for display on the large wall monitors. The SI computer automatically monitors their positions and the fire status and location, and tells them, their crew chief, and the safety observer at agency headquarters when a dangerous situation is developing. There hasn't been a fire line death or fire shelter deployment for 12 years. The shelter folds into handkerchief size and when used releases a special formulation of Cool-It foam that covers and surrounds the shelter.

All communications are via the Personal Satellite Systems (PSS), which replaced the Mobile Satellite System (MSS II). The capacity is adequate so there is never any waiting. If your line is busy and another call comes in, your pocket phone will let you know who's calling and store the voice or data message which you can listen to or read when you're ready. Fire personnel are all connected through Instanet.

BIFC and the Phoenix

I saw another interesting notice in this 99th volume of *Fire Management Notes*. Since large-screen video teleconferencing is now universally used and the new Data International General (DIG) Automatic Dispatch System (ADS) does not require a centralized facility, the Boise Interagency Fire Center (BIFC) (they never did get that name changed) will be disbanded. Coincident with that, my former colleague, the Bureau of Land Management Director of BIFC, Jack Wilson, announced he will retire. Jack said he'd been thinking about it since his 102d birthday and felt this would be a good time. He will join me, Fran Russ, and many other "phoenix" who have arisen out of fire to a new life as retired volunteers.

In Looking Forward, a Look Back

To continue the tradition I started 50 years ago, maybe I'll write an article for the 100th anniversary volume of *Fire Management Notes*. What are the significant electronic advances that have changed how we manage firefighting? In my earlier article, I listed 50 years of those events (see next page). That list will need an update. It is good to know where you've been to understand how far you've come and where you might be heading. ■

Smokejumper Reunion—June 1989

Like the distant roar of a Ford Tri-Motor churning its props into airworthy rpms, a rendezvous call goes out to all those who intimately knew that hardy "smokejumper plane" and to those who know its successors. A half century of smokejumping will be celebrated in Boise, ID, this June.

Though initially considered a dangerous and impractical means of firefighting by the USDA Forest Service, the agency put the idea of smokejumping to the test in 1939. The following 50 years of history have confirmed its relative safety and effectiveness.

The smokejumper reunion committee invites all who have rigged or relied upon the Eagle or Derry round-canopy parachute, jumpers who use the square Ram-air chutes, as well as pilots and other people who have supported smokejumping, to attend this 50th year reunion.

The 3-day festival, June 16–18, 1989, begins Friday afternoon with sign-in, followed by an outdoor buffet and photography session. Saturday's activities include exhibition jumps and tours of the national Boise Interagency Fire Center, nearby Idaho City, and the Snake River Birds of Prey Natural Area. There will also be a golf and tennis tournament and a 10-kilometer run. Children will have a chance to play at the local water slide park. A nondenominational memorial service will be held Sunday morning. The service will be followed by a closing brunch.

The reunion committee anticipates attendance of over 3,000, three times the number that attended the first smokejumper reunion held in Missoula, MT, in 1984. It is in the process of updating its mailing list and encourages response from all who wish to attend or who can offer help in organizing the reunion. The committee also would appreciate those reading this article to pass the word along to others who are or who have been involved with smokejumping. For further information, contact:

Smokejumper Reunion
P.O. Box 5759
Boise, ID 83705-0757■

Janice Eberhardt, *Writer, Public Affairs Office, Bureau of Land Management, Boise Interagency Fire Center, Boise, ID*

A Chronology of Some Electronic Advances: 1938 to 1987

- **1938**—The klystron was developed.
- **1939**—William Hewlett and David Packard started a small company in Packard's garage.
- **1940-1945**—The development of loran and radar rapidly advanced during World War II.
- **1945**—Arthur C. Clarke proposes the geostationary orbit for communications.
- **1946**—First all-electronic computer (Electronic Numerical Integrator and Calculator (ENIAC)), using 18,000 vacuum tubes, was built.
- **1947**—Transistor was invented at Bell Telephone Laboratories by John Bardeen, Walter H. Brattain, and William Shockley.
- **1948**—Claude Shannon published his classic information theory paper, "A Mathematical Theory of Communication."
- **1953**—First digital voltmeter built by Non-Linear Systems.
- **1956**—First video tape recorder built by Ampex Corporation.
- **1957**—The U.S.S.R. orbited first artificial satellite (Sputnik).
- **1958**—First integrated circuit was developed by Texas Instruments Incorporated (TI).
- **1960**—Laser action was first demonstrated.
- **1963**—First successful geostationary satellite was launched (Syncom 2).
- **1963**—First touch-tone telephone was developed.
- **1964**—The abbreviation cycles per second (cps) was replaced by hertz (Hz); Forest Service first used infrared (IR) operationally.
- **1965**—First commercial communications satellite was launched, Intelsat I (Early Bird).
- **1966**—Charles Kao published his paper on fiber optics.
- **1969**—Apollo 11 landed on the moon.
- **1970**—First digital watch produced by Hamilton Watch Company.
- **1971**—The microprocessor was introduced by Integrated Electronics (Intel) Corp.
- **1972**—The first handheld scientific calculator (HP 35) was marketed by TI.
  —First domestic communications satellite (Anik 1) was launched by Canada.
- **1975**—Home video disks were introduced by Radio Corporation of America (RCA); Sony Corporation introduced Betamax.
- **1976**—Forest Service and Communications Satellite Corporation (Comsat) laboratories demonstrated remote-site satellite communication.
- **1978**—First operational Remote Automated Weather Stations (RAWS) were developed and fielded by the Forest Service and the Bureau of Land Management.
- **1979**—First handheld forward looking IR (FLIR) was used by Forest Service.
- **1981**—International Business Machines Corp. (IBM) enters the personal computer market.
- **1982**—American Telephone and Telegraph (AT&T) Company agreed to divestiture settlement.
- **1987**—Superconductivity was achieved at 77K (liquid nitrogen temperature). ■

Warm Springs Hotshots

Holly M. Gill

Volunteer, USDI, Bureau of Indian Affairs, Warm Springs, OR

Warm Springs Interagency Hotshots.

Now in their fourth year as an organized firefighting crew, the Warm Springs Interagency Hotshot Crew can claim two special distinctions: They are one of two nationally recognized all-Indian hotshot crews in the United States, and they are the Nation's only self-supporting hotshot crew of any kind.

In June 1987, the 20-member team became the first Indian crew in the Northwest to be recognized by the USDA Forest Service as an Interagency Hotshot Crew. The Boise Interagency Fire Center gave national acceptance in 1988 by listing them on the national roster. The "Type I" hotshot status indicates that a crew is well trained and experienced. Before the Warm Springs crew earned that recognition, the only other all-Indian hotshot crews were from the Fort Apache Indian Reservation, Whiteriver, AZ, and Flathead Indian Reservation, Mission Valley, MT. Those crews, like all other hotshot crews, are made up of Federal employees.

"We think it is a real success story," said Bob C. Harned of Ronan, MT, who recently retired from his position as Forest Manager for the Bureau of Indian Affairs (BIA) at the Warm Springs office and is currently a consultant for the Warm Springs hotshot crew. "This crew contracts for all of its jobs and earns all its own money."

Of the $315,000 budgeted by the crew for 1988, only about $15,000 in training funds was received from the Federal Government. "To subsidize a regular Interagency Hotshot Crew costs the government an estimated $150,000," reported Mike A. Gomez, field operations liaison officer for the Confederated Tribes of Warm Springs. Gomez has been involved with training, organizing, and supervising the crew since its inception.

According to Gomez, the crew got its start in 1983 when the tribes used extra Federal money to hire a crew to do forestry-related work. "Production and interest was good, so they decided to make the crew more professional—able to fight fires as an organized crew," he said. "In 1984, with over $200,000 budgeted for them by the tribes, they became a firefighting crew. Our goal was to become self-sufficient in 3 years," Gomez added. "We surpassed that goal, and the following year met our second goal of becoming an Interagency Hotshot Crew."

By obtaining BIA, Forest Service, and private contracts for planting seedlings, constructing firelines on clearcuts, and prescribed burning, the crew was able to make nearly all the money needed to support themselves in 1986, a year ahead of schedule. "We've come a long way from the idea to the organized crew," Gomez said.

The crew, made up of 17 men and 3 women, works out of the Warm Springs BIA Fire Management Office from March 1 through November 30 of each year and then is furloughed for 3 months. "If they want to keep working the full 9 months, they have to get contracts and get work done on time," Gomez said.

"In order to get contracts, bids

They are one of two nationally recognized all-Indian hotshot crews and . . . the Nation's only self-supporting hotshot crew . . . .

Crew superintendent Michael Gomez discusses chainsaw maintenance with sawyer, Vernon Tias.

must be competitive with other contractors," Harned stressed. "Even for work on their own reservation," he continued, "they have to go through the bidding process. If they are too far off, they don't get the bid."

A commercial forest, such as the Warm Springs Indian Reservation, requires a lot of labor-intensive contract work, according to Gomez. "Most of the contracting crews are based in the Willamette Valley. Since we don't have the travel and lodging costs that they do, we can bid less for most of the contracts and still make money. Also, we have a genuine interest in what we are doing because we are taking care of our reservation," he said.

Jim Surface, a squad boss for the crew, noted that the ways in which they "take care of" the reservation are varied. He explained, "In the spring and fall we plant seedlings. We also spray herbicides for brush reduction and help in the tree improvement program by putting squirrel guards around superior trees and pole-stepping trees for cone collection."

The off-season for firefighting can also be a time for first-hand experience with fires. "We learn a lot by prescribed burning of clearcut blocks. The fire behavior that we learn there carries over to wildfires," Gomez said.

From the first of April, the Warm Springs crew accepts firefighting assignments. "We tell the crews to pack so they can be gone comfortably for 2 weeks. We may be gone a minimum of 2 weeks to a maximum of 45 days," said Gomez. "The crew must be dedicated to their jobs." After achieving "hotshot" status in 1987, the crew was dispatched to several fires in Oregon and northern California. This year, they have been dispatched to fires in Ontario, Canada; Rapid City, SD; and most recently, Jackson Hole, WY.

"Being an Interagency Hotshot Crew is giving us more experience and opportunities to fight fires in other countries and different States. The crew really enjoys seeing a different country and working with different crews. For the month of July, the crew was only home for 3 days, then gone again," said Gomez.

While they are performing their firefighting duties this year, they are also taking part in an experiment. "The Boise Interagency Fire Center, the forest firefighting headquarters for the United States, has selected the crew to perform in a national experiment to evaluate the use of firefighting foam in backpack pumps," said Harned. "For the remainder of the year," he added, "they will turn in evaluations and suggestions for improvements."

This year they were selected for a national experiment; only last year, they were still struggling to become an Interagency Hotshot Crew. "It has not been easy gaining status as a hotshot crew," said Jim Steele, fire management officer for the Warm Springs BIA, who oversees the crew. "Crew performance is only one criterion." Steele explained that there are regional and national limits on the number of such crews that can be formed. The limits are "tied to funding and fire occurrence throughout the country by region and fire season," he said.

According to Steele, decisions on the number of Interagency Hotshot Crews to be allowed are made as a result of a National Crew Study. In the past, these studies assumed that federally funded crews would be the sole source for Interagency Hotshot Crews. "It helped the Warm Springs crew to be sponsored by the BIA and to have identified their desire to become an Interagency Hotshot Crew when the National Crew Study was being revised," Steele explained.

The Forest Service set the standard for Type I crews, Steele reported, and as a result, in the past, it has been difficult for other crews to gain acceptance, although it has been done by federally funded crews, such as those from the National Park Service and the BIA. Steele noted, "The Warm Springs crew helped change things in two ways: They've been accepted nationally, and they've now been accepted based on their performance. They're not Federal employees. They have set a precedent. Contract crews can be Type I."

To attain Type I status, crew members must pass basic firefighting courses and physical requirements and have firefighting experience. Gomez is quick to credit the tribes for helping with another important requirement: The crew must be self-equipped. The tribes have purchased two crew cabs with canopies and one eight-passenger van for the crew. He added, "This year they're going to buy the crew a 3,500-gallon water-tender. That will help us to compete better on our burning contracts."

"The tribes have a lot of pride in the crew because they're doing a tremendous job," Gomez said. "The crew is one of the few organizations on the reservation that is trying to survive on its own." Their success has attracted attention from other Indian reservations. "I've had a lot of calls from other reservations to find out how to get started. They want to get people working." Two other reservations—the Shoshone-Bannock Indian Reservation in Pocatello, ID, and the Blackfeet Indian Reservation in Browning, MT—are currently forming crews using the same guidelines and organization used by the Warm Springs group, he said.

"We're real proud of them," commented Zane Jackson, Chairman of the Warm Springs Tribal Council. "The crew members are role models for our young people." ■

NWCG's Publication Management System: A Progress Report

In 1983, the National Wildfire Coordinating Group (NWCG) established the Publications Management System (PMS) Unit. Initially, PMS was developed as a way to make National Interagency Incident Management System materials available to users. NWCG later expanded the role of the PMS to include all wildland fire materials endorsed for use by the NWCG. There are currently over 300 NWCG-sponsored items in the system including forms, guides, signs, handbooks, and training course materials.

The PMS Unit is made up of representatives from each Federal wildland agency. All the representatives are based at the Boise Interagency Fire Center (BIFC).

The PMS Unit has several functions:

- Maintain an inventory of all current publications approved by NWCG.
- Assign publication and form numbers.
- Provide camera-ready masters to designated distribution points.
- Make recommendations to NWCG on minimal format and publication standards.

The PMS Unit recognizes four distribution points for handling these NWCG materials. Most PMS items are available through the U.S. Department of the Interior (USDI) Bureau of Land Management (BLM) Warehouse at BIFC. An annual publication catalog of these materials is available by ordering NFES 3362. There is a charge for the catalog. The other three distribution points are as follows: the National AudioVisual Center, the National Fire Protection Association, and, the International Fire Service Training Association. Each of these distribution points distributes catalogs.

The demand for NWCG material is steadily increasing. During 1987, nearly 1.2 million copies of materials were ordered from BIFC alone; in 1988, that figure increased to just over 1.5 million.

For further information about PMS, please write to the following:

Publications Management System
Boise Interagency Fire Center
3905 Vista Avenue
Boise, ID 83705.■

Mike Munkres, *chief, Branch of Technical Development, Division of Training, Bureau of Land Management, Boise Interagency Fire Center, Boise, ID.*

Wildfire Law Enforcement—Virginia Style

John N. Graff

Chief, Fire Management, Virginia Department of Forestry, Charlottesville, VA

In Virginia, law enforcement continues to be an important part of the Department of Forestry's fire prevention program, although it cannot do the job by itself. The 3 E's, education, enforcement, and engineering, are the pillars of fire prevention. Commitment to all of the E's is essential if fire occurrence numbers are to be reduced.

Law enforcement for the Virginia Department of Forestry has been ongoing for many years. The Department will celebrate its 75th anniversary in 1989. Law enforcement as part of the Department's program is not quite that old, but it is close.

Suppression Costs—Who Pays?

Soon after the creation of the Department of Forestry in 1914, the Governor commissioned forestry personnel to act as forest wardens. Today, all field personnel including professional foresters act in the capacity of forest wardens, regularly enforcing the fire laws and collecting payment for suppression costs. The earliest statute requiring the State Forester to recover the costs of firefighting was enacted in 1919.

Suppression costs are collected by the forest wardens and may be collected at the fire scene after the fire is controlled. The wardens carry rate sheets showing pay, mileage, and equipment rates. On small fires, if there is no violation of the law, they can compute the suppression cost, collect it from the person responsible for starting the fire, give them a prenumbered receipt, and go on their way.

The misdemeanor that has the greatest impact on wildfire occurrence in Virginia is the violation of the 4:00 p.m. burning law. This law simply states that no open burning will be done from March 1 to May 15 each year, except between the hours of 4:00 p.m. and midnight. The penalty has been a maximum fine of $100 and court costs. In 1988, the maximum fine was increased to $500. Smoke detected before 4:00 p.m. in the spring usually stems from a wildfire or a law violation.

Other statutes effective in preventing fire include those assessing penalties for leaving a fire unattended and consequently damaging or jeopardizing property belonging to another person.

The Juvenile Firesetter

Juvenile firesetters present special problems. The Virginia judicial system provides for at least one juvenile intake officer in each local jurisdiction, available to help Department personnel with juveniles who have set fires. Several options are available to the parent or guardian of a juvenile firesetter:

- The parent or guardian can voluntarily pay the suppression cost for the juvenile.
- In some instances, the juvenile intake officer takes part in the matter and conducts an off-the-record informal hearing with the parent or guardian and the juvenile.
- If the matter cannot be resolved informally, the parent or guardian can be required to pay up to $750 suppression costs through civil action brought through the General District Court.
- As a last resort, the matter may be taken to juvenile court.

During the first 6 months of 1988 out of approximately 45 cases, 30 juvenile cases were resolved.

Table—*Fire data and law enforcement accomplishments*

		Cases						
		Escaped Fires					Nonescaped fires	
			Court cases				Court cases	
Year	Acres burned	No. of fires	Won	Lost	Suppression cost collected	Won* (percent)	Won	Lost
1943	102,251	2,526	114	15	437	21.1	124	8
1953	32,763	2,461	91	7	694	31.9	269	13
1963	44,823	3,300	237	15	1,147	42.1	356	19
1973	3,291	914	24	3	431	50.0	165	1
1983	3,098	885	58	2	316	49.0	198	4
1984	2,755	949	73	0	317	49.0	230	9
1985	12,722	2,470	216	17	820	49.0	411	12
1986	13,833	2,091	181	7	612	39.0	459	15
1987	20,393	1,326	148	9	385	42.0	549	9

* Refers to those cases successfully prosecuted or cases in which the State was able to collect for suppression without going to court.

Law enforcement in a forestry organization requires commitment at the leadership level, dedication at the field level, and good cooperation with other agencies.

Incendiary Fire

A growing problem in Virginia and in many other States is woods arson or incendiary fires. Incendiary fires have steadily increased for at least 22 years to the point where 25 percent of the wildfires were attributed to this cause in 1987, (fig. 1). Arson cases are much more complex than those resulting from other causes and require talented, well-trained, and experienced officers to investigate.

The Department of Forestry has a Chief Fire Investigator, Milton Morris, whose primary responsibility is to train forest wardens in arson investigation as he works with them on cases. One additional fire investigator works in the southwestern portion of the State.

Some progress is being made in incendiary fire prosecutions. During 1986, seven persons were prosecuted for intentionally setting fires, with varying degrees of penalties. In 1987, 12 persons were successfully prosecuted. During 1988, 10 persons were prosecuted with more cases pending in court.

A bloodhound program was initiated in 1987 in southwest Virginia with moderate success. Firesetters who leave the scene on foot can now be tracked and apprehended. The prevention value of this resource is significant.

Railroad fire prevention has improved dramatically in the past several years with the advent of a new statute in 1984 (fig. 2). Department of Forestry people

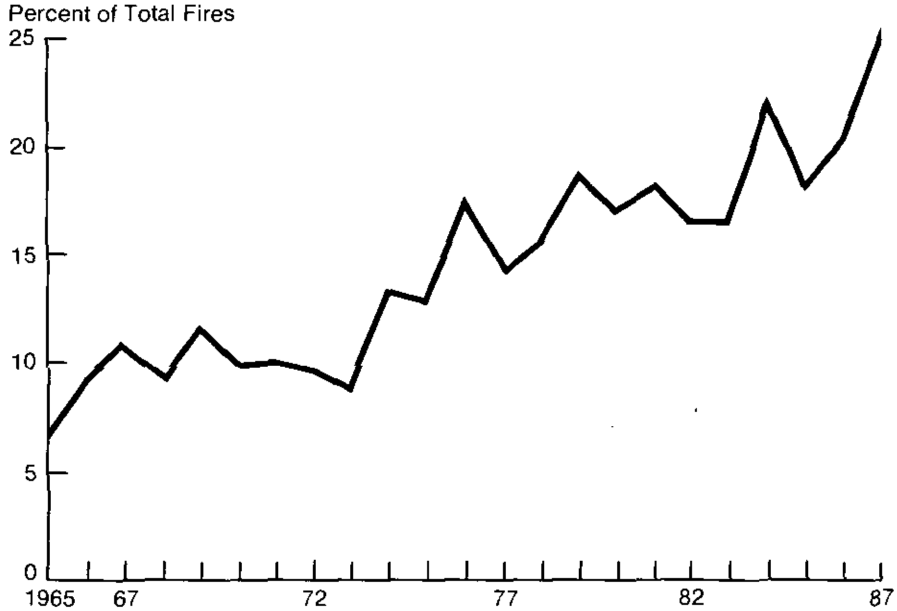


Figure 1—*Arson-caused wildfires in Virginia, 1965–1987.*

identify, on railroad track charts, the hazardous areas adjacent to the rights-of-way. These areas must be cleared of flammable material prior to the spring fire season. The penalty for noncompliance is a temporary injunction against that railroad brought by the Attorney General in any circuit court of his or her choice.

A Cost Efficient Program

The USDA Forest Service provided the following information to the Virginia State Forester in a July 1987 report:

- The Virginia Department of Forestry is one of the two States in the South with a cost efficient fire management program that includes a prevention program.
- Prevention programs have a direct effect on reducing wildfire occurrence in Virginia.
- The current Virginia Department of Forestry fire management program, as a whole, is the best effort possible at the current funding level in the effective use of taxpayers' dollars.
- Based on comparisons of firefighting costs with neighbor States, Virginia's fire prevention program is saving State taxpayers $1,431,208 in fire suppression costs annually.

The 1987 USDA Forest Service report measured the success of the Virginia Fire Prevention and Law

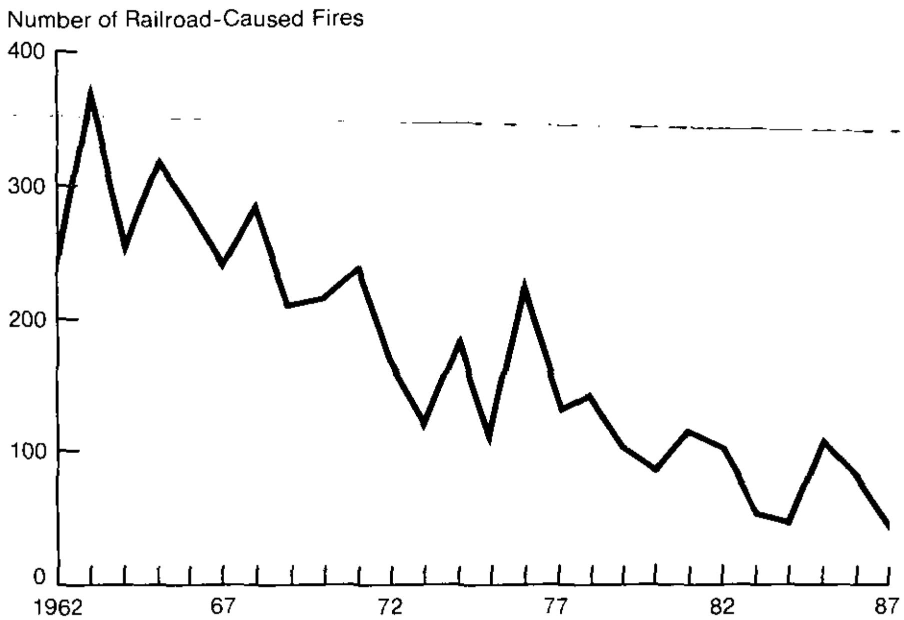


Figure 2—*Railroad-caused wildfires in Virginia, 1962–1987.*

Enforcement Program. The report confirmed the importance of fire prevention and law enforcement to a forestry agency charged with wildfire responsibility. It also provided an insight into the vision of early forestry officials in Virginia such as former State Foresters George Dean and W.F. Custard and Forestry Relations Chief Ed Rodger. The present State Forester James Garner continues to fully support these programs.

Law enforcement in a forestry organization requires commitment at the leadership level, dedication at the field level, and good cooperation with other agencies. When good law enforcement is combined with other elements of fire prevention and greater public awareness of the importance of fire prevention efforts, an impact can and will be made on wildfire occurrence. ■

Fire Management in the Berkeley Hills

Carol L. Rice

Consultant, Wildland Resources Management, Walnut Creek, CA

The hills above the University of California at Berkeley campus include a remarkably large expanse of wildlands, mixed with custom-built homes, research installations such as the Lawrence Hall of Science, the Space Sciences Laboratory, the Mathematical Science Research Institute, and areas of high recreational usage. Resource values are high and, until recently, at some risk due to heavy fuel loadings.

The problems of this hillside area are a microcosm of those across the country in the urban-wildland interface: steep slopes, wooden building materials, lack of clearance around structures, poor access, and jurisdictional conflict. Vegetation suffers through California's summer drought, and a mix of plant species and ages combine to make a fuel arrangement that is optimal for great heat buildup and explosive rates of fire spread.

Fire Hazard Reduction Program

The Office of Environmental Health and Safety recognized the problem and initiated a 5-year program in 1986 that prescribes and schedules activities to reduce this fire hazard. Management activities either change the vegetation type or reduce the fuel volume within a vegetation type by the following:

- Reducing the total amount of material to burn.
- Designing spacing of the vegetation (both horizontally and vertically).

Goats used to modify vegetation in the Berkeley Hills.

- Reducing flammability of the fuels. A mixture of these methods is often used. The most dramatic improvement in fire safety results from the removal of large eucalyptus sprouts. Five of the last six fires in the hill area have burned in eucalyptus.

The highest priority areas to treat are those on University borders and those adjacent to high-value facilities. Vegetation modification is directed first at those flammable fuels that pose the greatest risk. The methods used to make this modification include hand labor, goat grazing, cutting, chemical treatment of stumps of the most flammable vegetation (eucalyptus), and prescribed burning. A schedule has been developed to gradually decrease fuel loading to an acceptable level, reducing flame length by 50 percent.

While all prescribed activities incorporate concerns for fire safety and cost efficiency, precautions are taken to minimize environmental impact. Forty percent of the program costs result from these precautions. In addition, a wildlife refuge has been established in the area where no manipulations will occur.

The fire hazard reduction activities will restore native grasslands to areas now invaded by brush or planted with eucalyptus. Because this area, which at one time encompassed two dairy farms, is now an Ecological Study Area, the ecosystem restoration aspects are

The problems of this hillside area are a microcosm of those across the country in the urban-wildland interface . . . .

being highlighted through magazine features, news articles, and participation in field trips to other communities.

The Fire Prevention Committee

A Fire Prevention Committee guides the implementation of this fire management program. This committee has a diverse population, representing many viewpoints. Membership in this committee includes homeowners, officials from local fire departments, and staff from the University of California operating (Facilities Management, Campus Planning, and Environmental Health and Safety) and academic (Zoology and Forestry and Resource Management) departments. Environmental concerns have been identified and resolved. Efforts have not been without opposition and delay (after all, this is Berkeley).

Program Status

Cooperation is integral to the program. Cooperation of worried neighbors, wary Bay Area Air Quality Management District administrators and inspectors, and skeptical fire department officers has been noteworthy—all have responded to early notification of planned activities. Further, concern over smoke, changed vistas, and fenced goats has been minimal. Faculty and students realize increased research opportunity to analyze a greater diversity of vegetation ages and treatments. Students have benefited by taking part in operations, planning, patrol, and mop-up. Areas made inaccessible by brush and poison oak will be more open to recreationists.

The first years of the program are proceeding well. Approximately 100,000 hours of hand labor have been donated to this program by the California Conservation Corps, who prune and thin forest stands and build firelines, all in anticipation of prescribed burns. The program has conducted six prescribed burns and contracted a goatherd (500 goats) to graze in areas of dense brush where other manipulation is not feasible. So far, almost 100 of the 350 acres (40.5 of the 141.7 ha) targeted for manipulation have been treated through these means.

Perhaps other areas will want to respond to local problems through joint action. Other examples of cooperative programs include the Wildfire Strikes Home Initiative and Project Phoenix. Both involve private organizations and public agencies on the Federal, State, and local level. Cooperative programs can be a source of help and support to those who live or work in the urban-wildland interface. The University of California and groups and individuals in the community surrounding it are seeing the benefits of a cooperative effort. They are pleased to share experiences with others.

For more information, contact the University of California. The address and telephone number are as follows:

Office of Environmental Health and Safety
2223 Fulton Street
Berkeley, CA 94720
(415) 642-4400. ■

Light-Hand Suppression Tactics—a Fire Management Challenge

Francis Mohr

Assistant fire management officer, USDA Forest Service, Wallowa-Whitman National Forest, Baker, OR

Fire Control to Fire Management

Fire management is more than just a name change for what was once called fire control. Rather, the change reflects a change in firefighting approach. Traditional thinking that all fires need to be put out immediately and the only safe wildfire is a fire without a trace of smoke is no longer the sole approach to fire suppression action. Fire management challenges land managers to make unique decisions with each fire start. There are situations when the decision involves suppressing fire "with time" in contrast to "against time." This is a major change from the era of the 10 a.m. policy that prevailed before 1978. The fire suppression decision process involves assessment of land management objectives, resource values, and consideration of minimum cost and resource damage.

Environmental Impact of Suppression Tactics

Whether the appropriate suppression response is prompt control at the smallest acreage possible or confinement of a fire to specific drainage, the tactical approach to achieve that objective can have a major effect on the natural resources of the area. Determination of appropriate tactics that achieve suppression objectives without unnecessary environmental impact is part of the inherited change that came with the move from fire control to fire management. It involves not just the firefighter, but all levels of management as well. Firefighters, fire managers, and land managers need to assess the effect of tactics used during fire suppression just as the effect of any proposed project is assessed using the environmental assessment process.

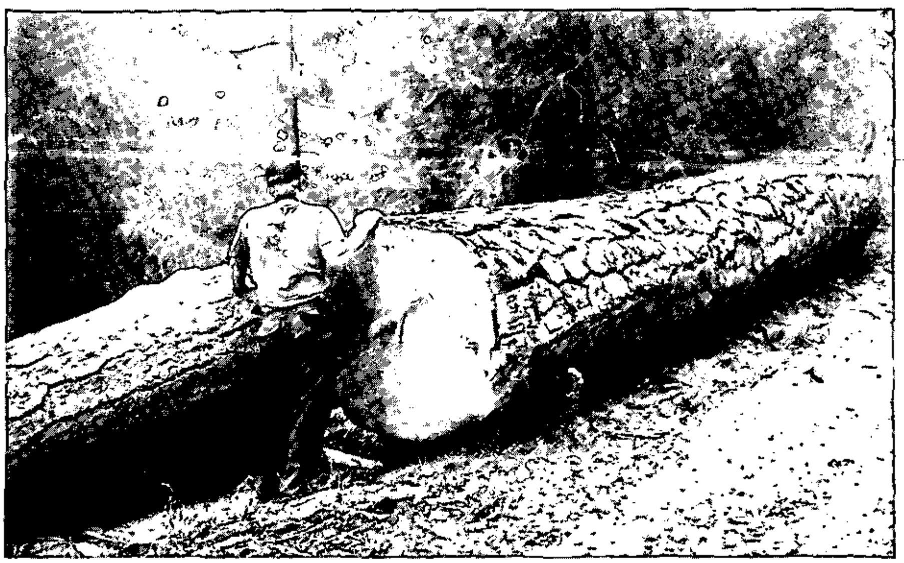
Portable weather station with automatic recording capability, used on prescribed-burn areas.

Suppression Tactics—Some Examples

Firelines. Awareness of tactics and concern for the land has increased; however, a survey of several fires during the last 3 years indicates that application of fire management concepts with concern for the land is still in a pioneering stage. One clearly visible impact is the tactical choice of firelining. There are examples where cattle trails, in grass fuels on a 30 percent slope, were used as fireline and as the anchoring point for burnout. On the other hand, parallel, blade-wide dozerlines were constructed through sparse grass and rocky scab areas. On some easily accessible ground, engines drove along the fire's perimeter, using water as the tactic to hold and extinguish firespread—not a clump of sod was removed. In other areas on similar ground of grass and scattered trees, dozerlines were constructed parallel to a major forest access road that could have served as an adequate fireline. On another forest where burnout was planned, a four-blade-wide dozerline was constructed along an open grassy ridge.

Tree Cutting. Another impact that can be long-term and even a direct resource loss is tree cutting. Tree cutting occurs during both the firelining and mop-up phase. In some situations, 300 yards (274.32 m) inside the fire perimeter, live ponderosa pines with minimum fire in the base were cut. Because of the natural tolerance to fire of this species, a small amount of water from a backpack or a few shovelfuls of soil instead could have been the means of extinguishing the fire. Diameters of cut trees ranged from 10 inches to 5 feet (25.4 cm to 1.5 m)—a direct valuable resource loss. (The observed cut trees were "solid" at the base and posed no safety hazard threat.) Similar actions occurred with other species

The fire suppression decision process involves assessment of land management objectives, resource values, and consideration of minimum cost and resource damage.



Five-foot diameter pine, felled during suppression activity, had fire only in portion of base.

as well. The question needs to be asked, "Even if a tree is on fire and may eventually die, does it need to be cut?" In a forest management environment, dead, standing trees are acknowledged as a resource that achieves specific management objectives.

Question Guide for Selecting Appropriate Tactics

Land managers, fire managers, and firefighters are challenged to select tactics appropriate to achieve fire suppression objectives, without causing unnecessary scars on the landscape. In this selection process, managers and firefighters need to ask the following questions:

- Are suppression and mop-up tactics commensurate with the fire's potential to spread or escape and cause resource damage?
- Which tactics are effective in light of existing or potential fire behavior?
- What is the objective of a constructed fireline—to burn out from or to halt advancing fire spread?
- Are our tactics causing unnecessary long-term adverse impact on the land?

Although choice of tactics in some situations left little to no impact on the land, tactics implemented on some burned areas left a greater impact than did the fire! Tactics that may have been acceptable during an era of staunch fire control policy may no longer be a part of today's fire management actions. Times have changed and so have attitudes and concern for the land. Just as resource management activities are directed by an approved environmental assessment document, our actions during suppression of a fire must include *responsibility for the land.* Techniques and fire behavior principles learned and used during prescribed burning activities can be utilized effectively during fire suppression activities.

Recommendations

Change is imperative. Increased awareness and understanding of the problem and development of a "light-hand-on-the-land" attitude can be achieved through a conscientious, assertive effort. Some initial recommendations are as follows:

- The national forests and Government agencies concerned with fire management should include the topic of "light-hand-on-the-land tactics" during future management meetings and seminars. (See box for list of suggested training aids pertaining to light-hand tactics.)
- Forest Service regional training offices should schedule or promote use of light-hand tactics training aids at their annual basic and refresher sessions for Incident Management Teams, Interagency Hotshot Crews, and smokejumpers and at fire management-related conferences and symposiums. The national forests and Government agencies, likewise, should review and discuss this topic at their local, annual fire training sessions.
- Government agency managers and resource advisors should request that working documents such as "Escaped Fire Situation

Analysis," "Fire Behavior Analyst Forecast," and the "Incident Shift Plan" address and evaluate specific suppression and mop-up tactics.

- The national forests and Government agencies should preselect resource advisors before the fire season, considering such criteria as a broad resource background, knowledge of District resources (including locations of cultural sites), familiarity with the Incident Command System, and experience with wildfire suppression or use of prescribed fire.
- All fire training courses should be reviewed and edited on the national level. (Some inappropriate or adverse impact tactics are still suggested in course content.)

Light-Hand Tactics—Defined Further

Light-hand tactics does not mean "no action" or non-aggressive suppression action. Light-hand tactics means that the suppression action taken is effective and necessary to counteract a fire's existing or potential behavior and threat to resource values. It means a one-to-four-blade-wide dozerline (fireline) isn't constructed when the fire is only generating 1- to 2-foot (30.5- to 61-cm) flame lengths and can be halted by burning out with a 1- to 2-foot (30.5- to 61-cm) wide fireline or extinguished with a spray of water. It means burned trees are not cut unless they pose a threat of additional fire spread or are a safety hazard for crews. It means fire effects on the vegetation and resource values of the area are important factors in selecting a tactical approach in suppressing a fire. It means fire behavior knowledge is applied and the factors influencing fire behavior are evaluated on a case-by-case basis.

Summary

The light-hand-on-the-land concept is intended to raise the level of environmental consciousness among firefighters in order to avoid unnecessary adverse impact on natural resources from suppression actions. Accomplishment of light-hand tactics originates with instructions that are understandable, stated in measurable terms, and communicated both verbally and in writing. Monitoring tactics during the suppression effort and a follow-up evaluation of their effects will increase the understanding and achievement of professional stewardship and good land ethics during fire suppression activities without compromising fire suppression objectives. ■

Training Aids in Light-Hand Tactics

Concern over suppression strategies and tactics that leave long-lasting scars on forest resources over the years prompted a small group of individuals in the Pacific Northwest to identify a variety of suppression, mop-up, and rehabilitation techniques to meet light-hand objectives. As a result, they produced a video entitled "Light-Hand Tactics—Strategies and Tactics" to demonstrate these techniques.

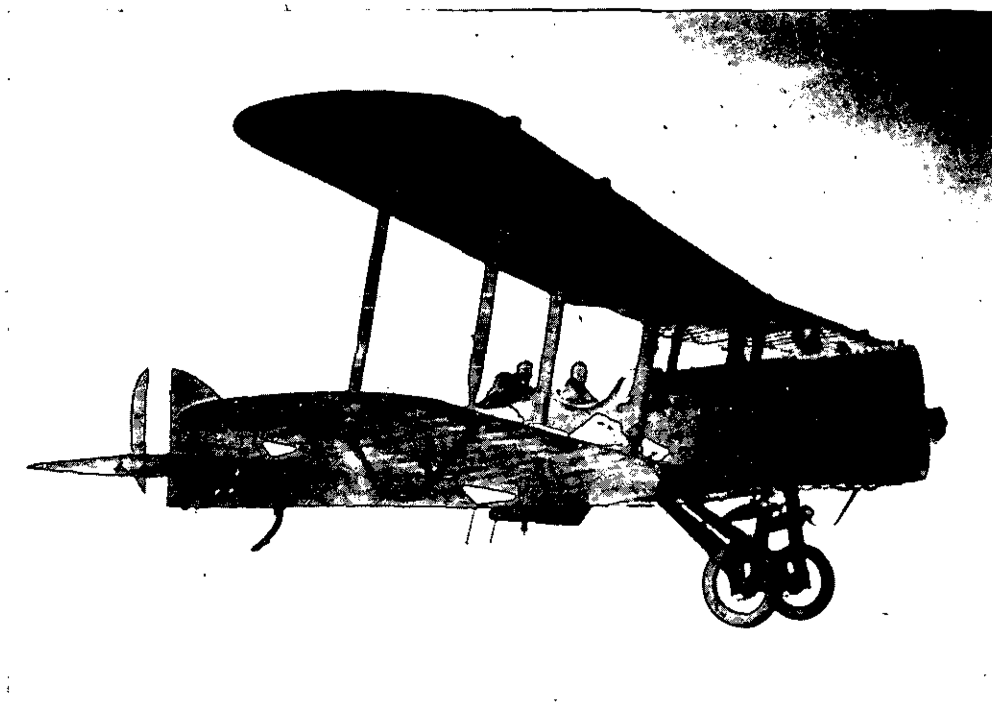
Early in 1988, a similar concern caused the Redmond Training Center and the Training Division of the Boise Interagency Fire Center to produce a video of a presentation on fire suppression tactics made at a regional Forest Service fire manager's conference. This video focuses on tactics used during suppression and mop-up and the process used in managing fire in confinement strategy. The title of the video is "Fire Management Concepts in Suppression and Mop-Up."

In addition to the video, the Redmond Training Center published a pocket-sized field guide entitled "Light-Hand Tactics." Its intent is to assist land managers, incident teams, and firefighters in selecting tactics that meet appropriate suppression response objectives, yet leave minimal impact on the land.

Master copies of both video tapes have been loaned to Teknifilm, Inc., in Portland, OR, for duplicating purposes. Copies of both video tapes can be acquired from Teknifilm, Inc., at a reasonable rate. The address and telephone number are as follows: 909 19th Avenue NW, Portland, OR 97209, (503) 224-3835. Copies of the pocket-sized guide can be acquired by contacting the Redmond Training Center, USDA Forest Service, 1740 SE Ochoco Way, Redmond, OR 97756, (503) 548-5071. ■

The way we were . . . in fire detection, on the line and in camp, in radio and telephone communication, and in transportation and support operations

Helen Dowe in Devil's Head Fire Lookout, Pike National Forest (F.E. Colburn, 1919).

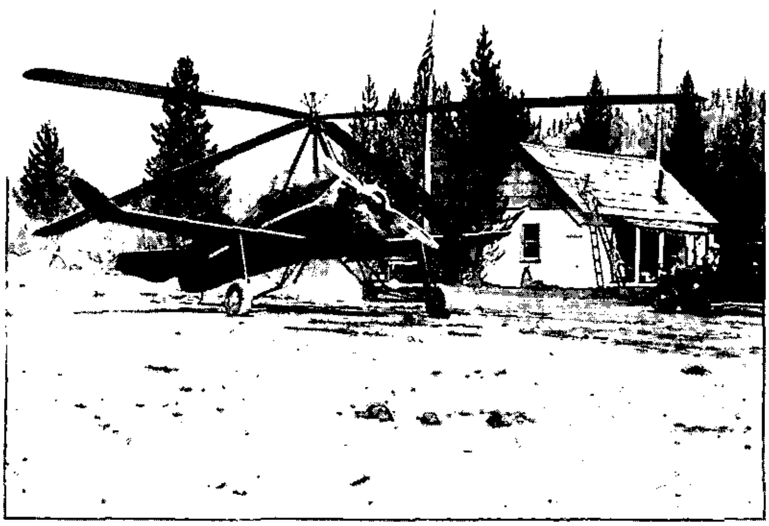


Forest patrol airplane, Olympic Air Patrol, Olympic National Forest, (W.J. Paeth, 1921).

Pilots of the Olympic Airplane Patrol at Humptulips, WA, Olympic National Forest (W.J. Paeth 1921).

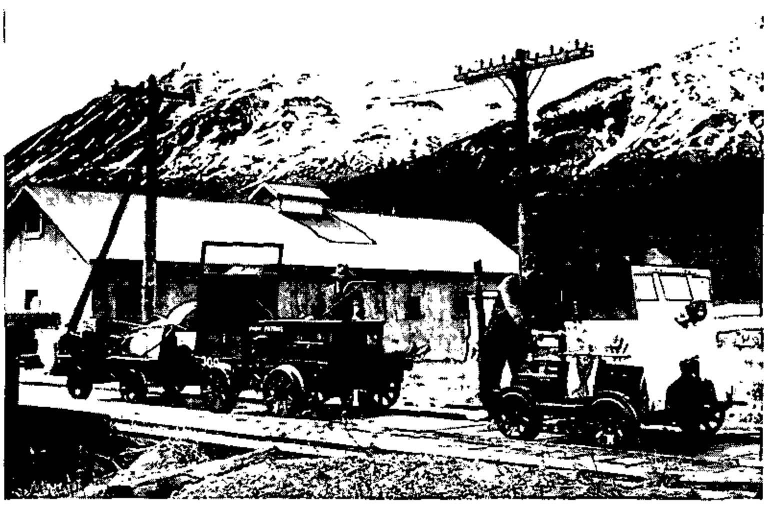
Photographs:
Courtesy of National Agricultural Library, Forest Service Photo Collection

Getting ready to start on fire patrol in pony blimp, Angeles National Forest (W.I. Hutchinson, 1921).

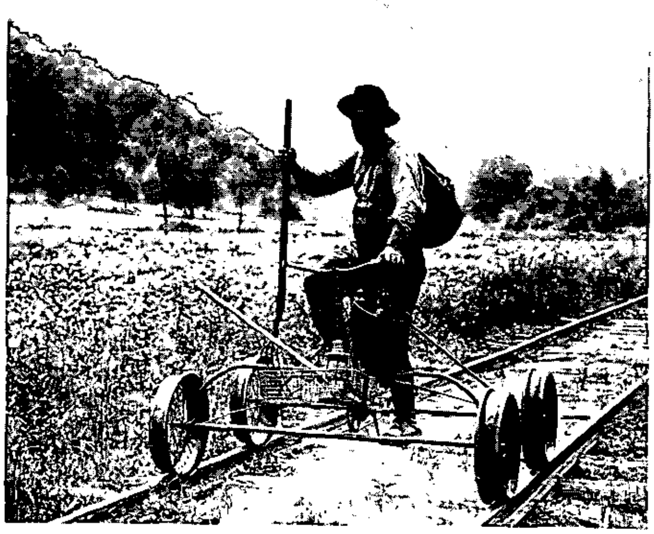


Autogyro at Summit Meadows, Mt. Hood National Forest (Roy Headley, 1932).

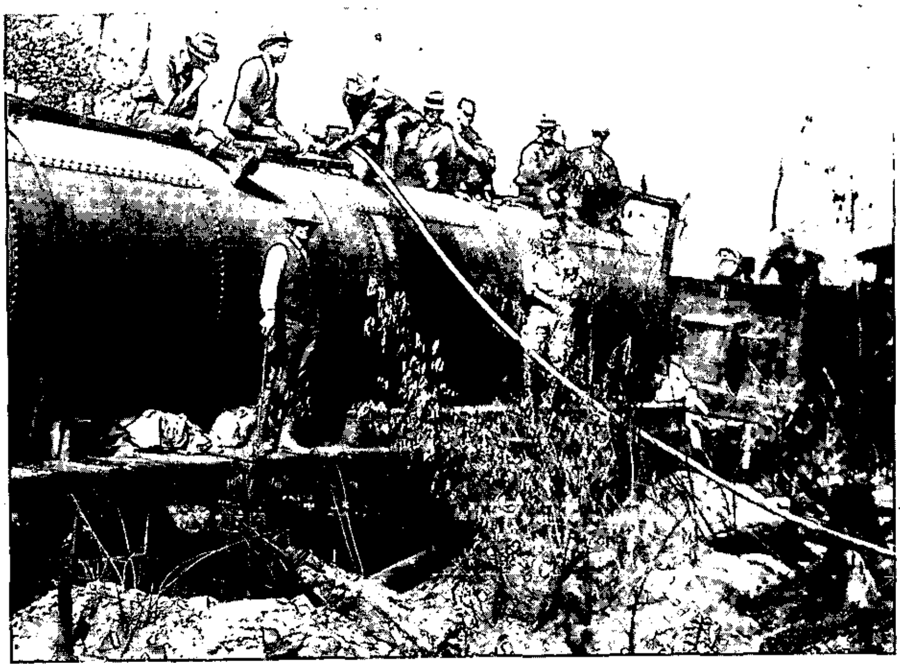
Helen Dowe climbing stairway to Devil's Head Fire Lookout in the Pike National Forest (1919).



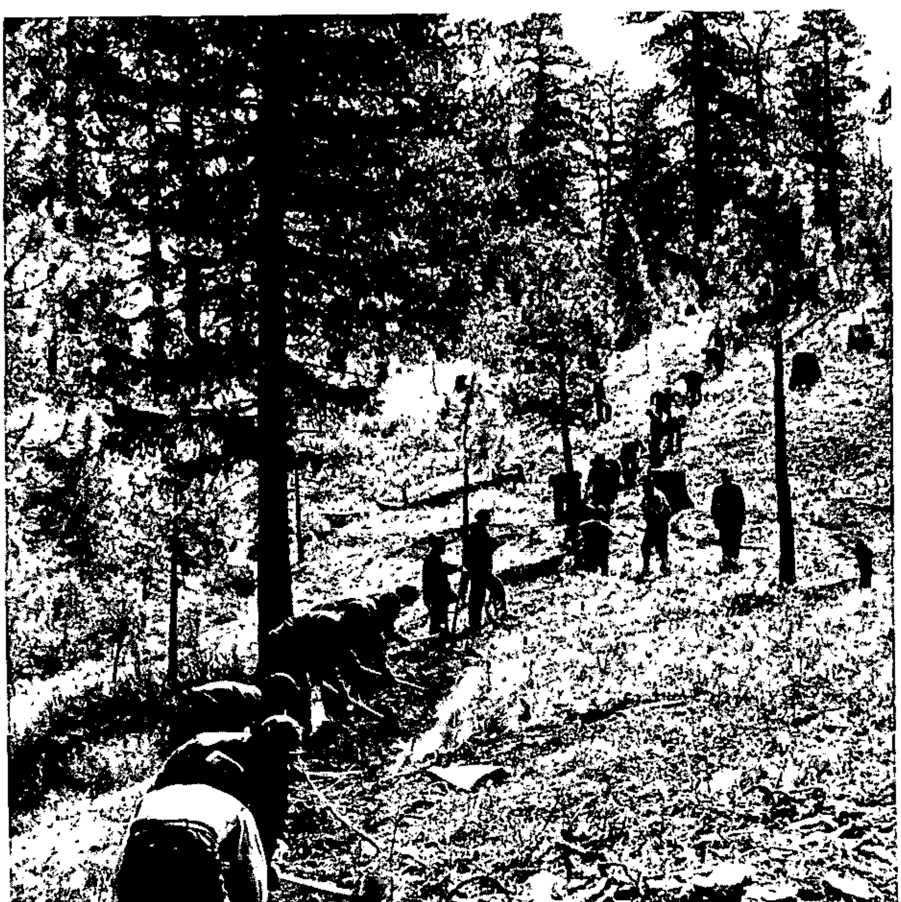
Railroad fire patrol, Kanai Lake Ranger Station, Chugach National Forest (Harry Sperling, 1947).



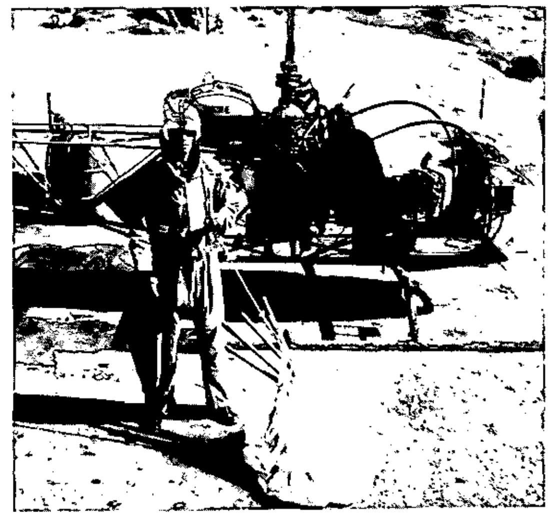
Perry Davis, forest guard, Davidson River District, patrolling on his leg-powered, rail speeder, Pisgah National Forest (E.S. Shipp, 1923).



Pumping out of railroad tank car during mop-up work on the Three Forks Fire, Monongahela National Forest (1936).

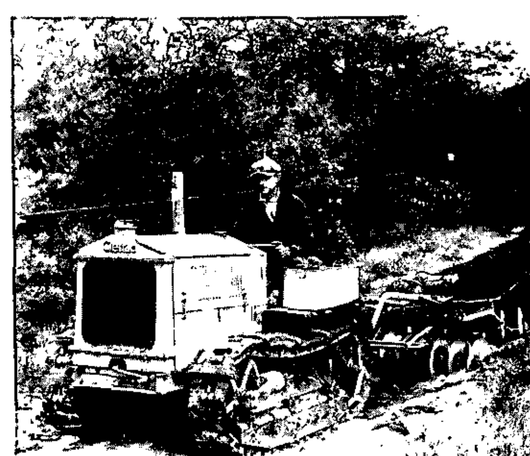


Civilian Conservation Corps enrollees being trained in fire line construction near Idaho City, ID (Paul S. Bieler, 1941).

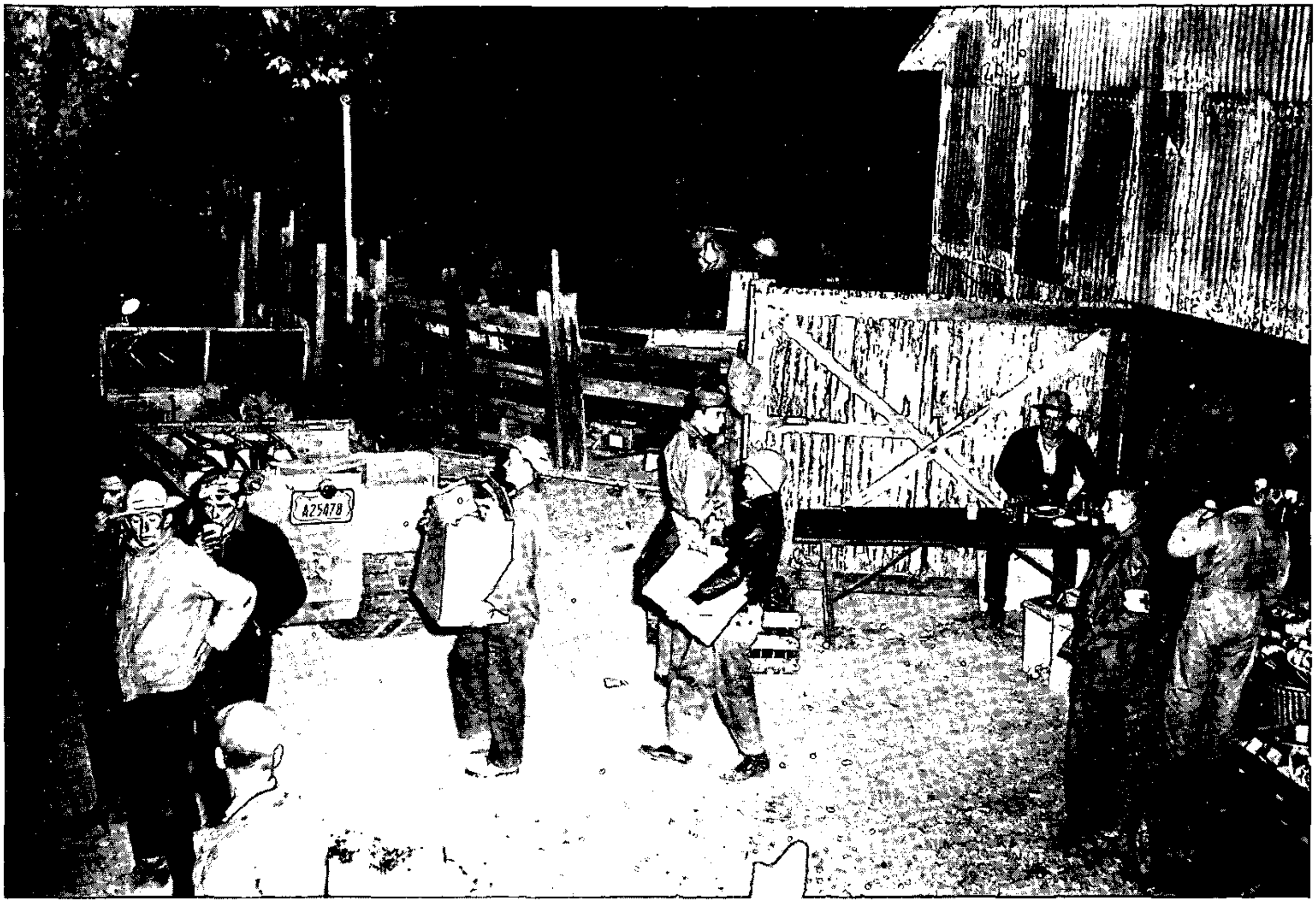


Helicopter project—complete attack equipment—ready for drop. Assistant District Ranger Lynn Biddison wearing smokejumper's suit (R.F. Johnson, 1954).

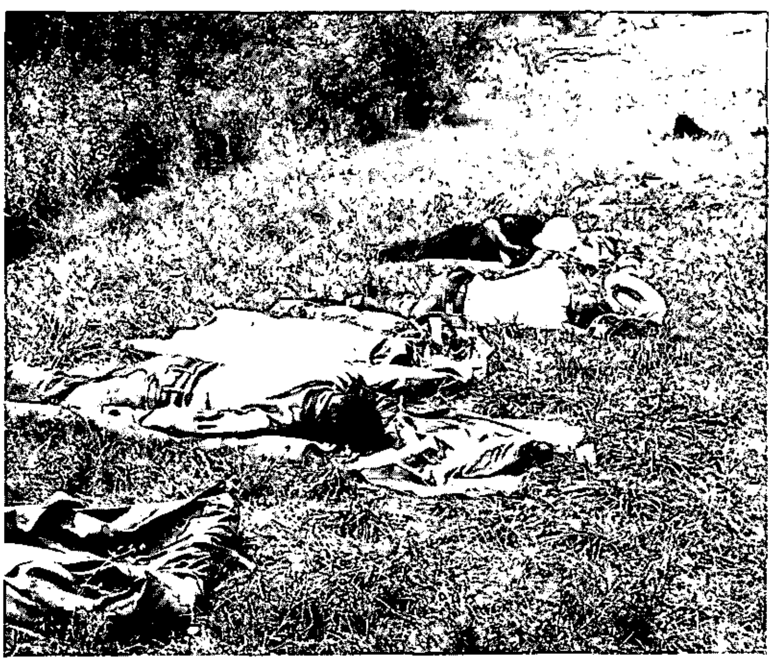
Washing up at fire camp on O'Brien Creek Fire, Lolo National Forest (Virgil Andrews, 1940).



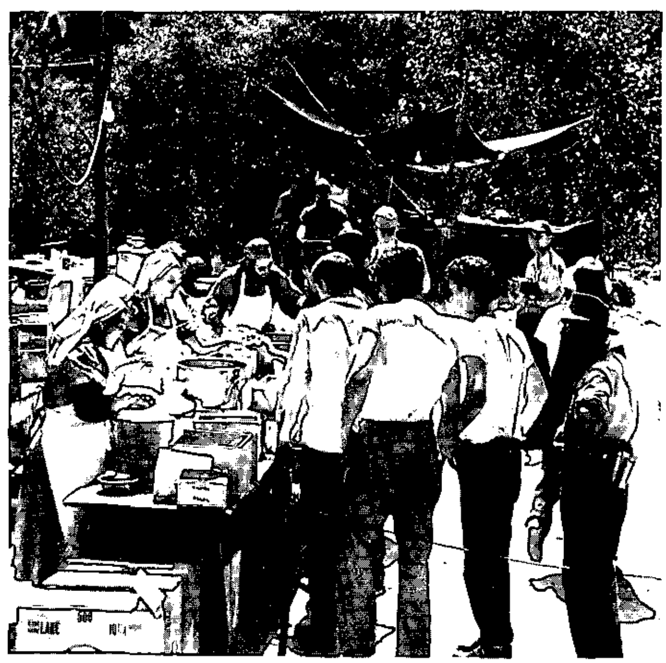
Disking plowed fire lines with tractor and 7-foot disk harrow, Huron National Forest (E.S. Shipp, 1929).



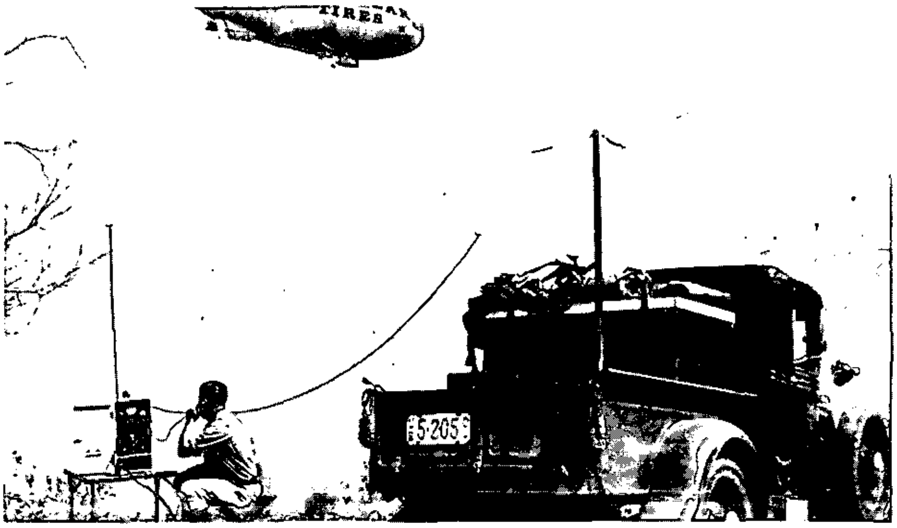
Fire camp at Green River Fire, Cleveland National Forest (Don Downie, 1948).



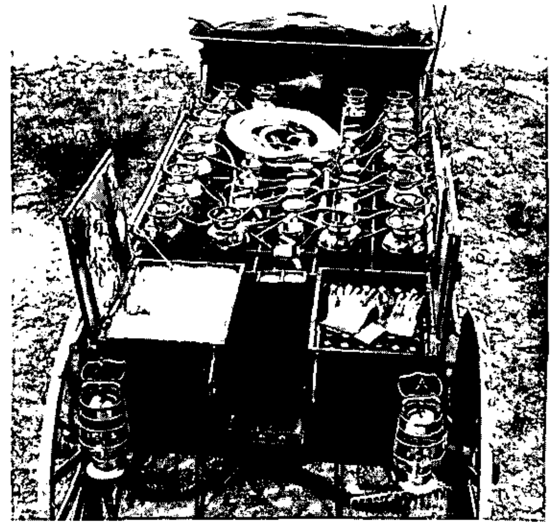
Firefighters who worked on the night fire line catch sleep at Daggett Creek Fire camp (Bluford W. Muir, 1955).



W.K.F.L. (Work, Knowledge, Faith, Love) Fountain of the World serving dinner at fire camp—Fish Fork Fire, Angeles National Forest (Jack Rottiar, 1953).

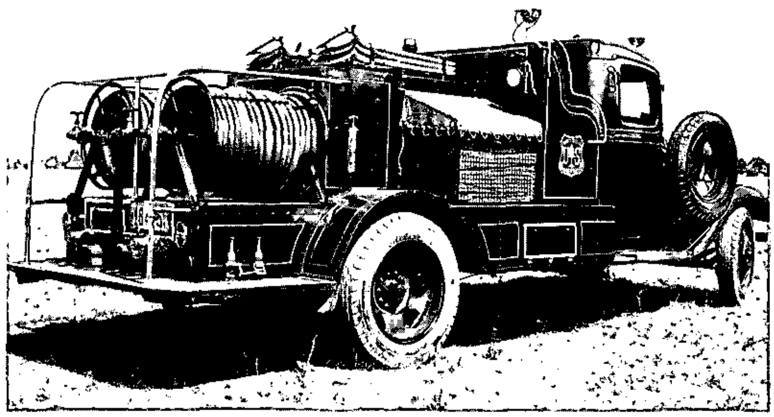


Composite photo-radio communication between ground and blimp for fire control, Los Padres National Forest (Paul Fair, 1943).

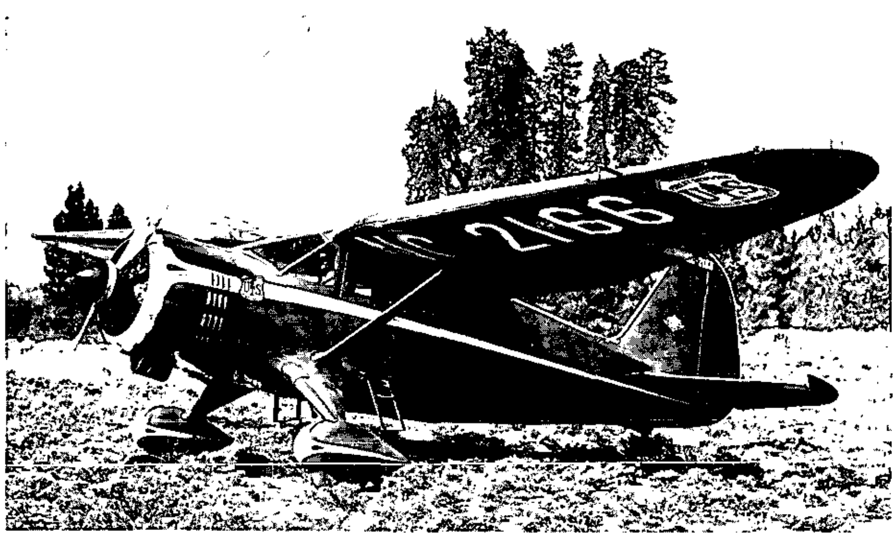


Equipped fire wagon (Massachusetts) (T.F. Borst, 1904).

Message center at Barley Flats Fire, CA (George W.E. Petersen, 1936).



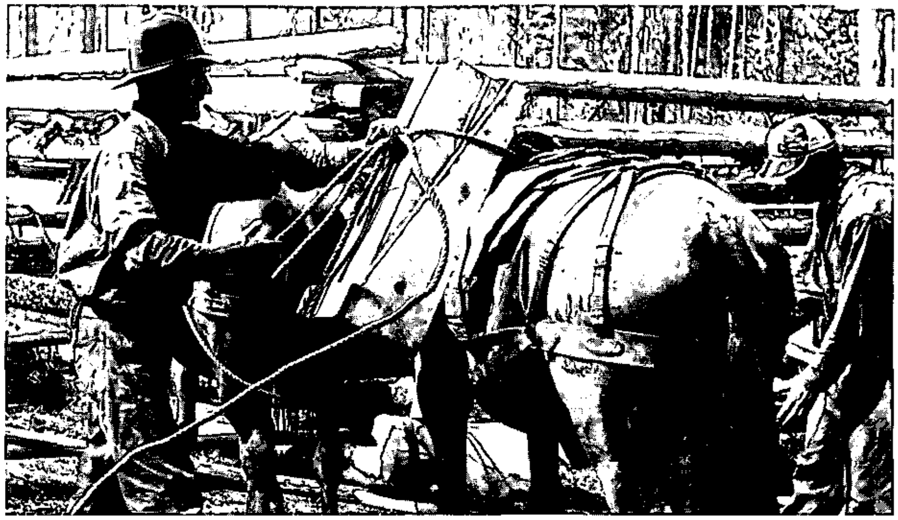
Forest Service fire truck used in Region 1 (K.D. Swan, 1936).



Forest Service fire control research airplane, Shasta National Forest (Fred W. Funke, 1938).

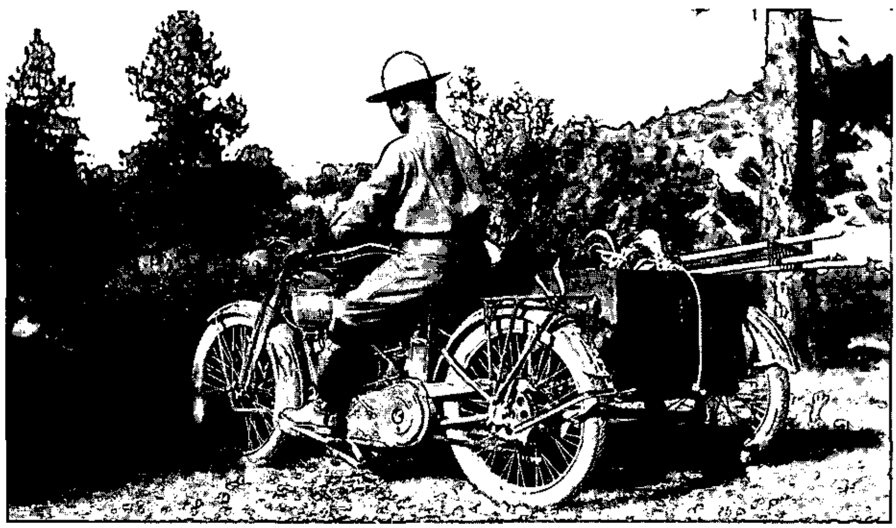
Lookout man on Black Butte, CA, using heliograph. (Two mirrors are in use and the shutter is being held open with a buckskin thong.) (D.P. Godwin, 1912).

Fire truck at Waterville Garage, ready with equipment for 50 men to respond to fire call, White Mountain National Forest (1931).



Packing water on mule (20 gallons to a mule) from base camp to another camp nearer fire line where water was not available, Kootenai National Forest (K.D. Swan, 1940).

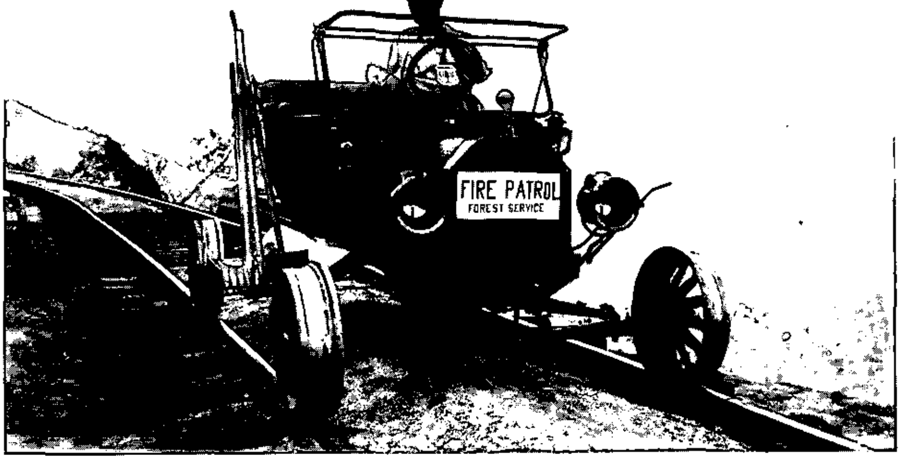
Forest ranger radio broadcasting measurements of fire danger, ID (K.D. Swan, 1935).



Motorcycle van for transporting fire equipment, Gila National Forest (1917).

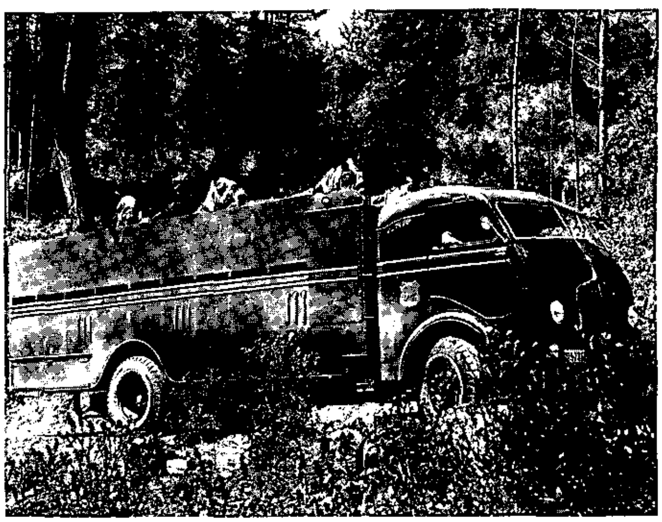
Loading Forest Service radio equipment on airplane at Missoula, MT, for transportation to back country, Lolo National Forest (K.D. Swan, 1935).

Forest patrol reporting forest fire by portable telephone from top of King Doodle Peak, Ouachita National Forest (1924).

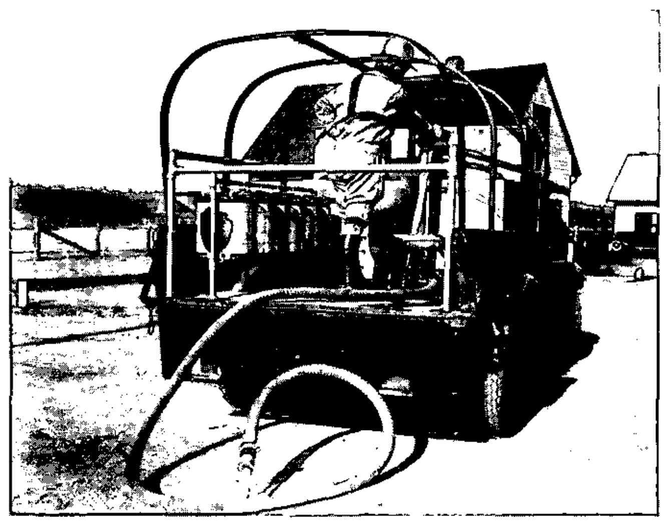


Ranger Jordan in car converted to rail patrol, Sierra National Forest (1914).

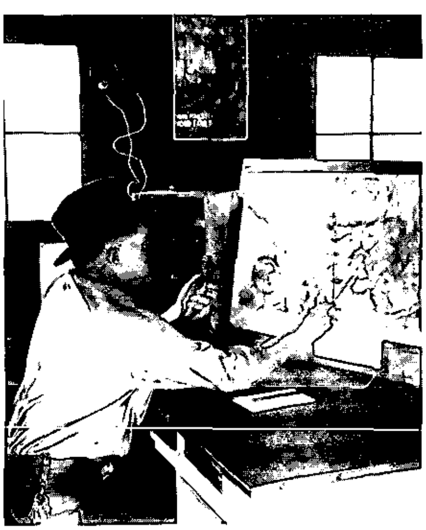
Radio experiment: crystal control transmitter and 2-volt station cell, Klamath National Forest (Capt. Daniel Sheehan, 1933).



Truck loaded with mules enroute to a fire (Montana) (Ruth Ambrose Ogg, 1937).



Fire truck with suction hose and pump and backpack pump fastenings attached to fastenings welded to pipe rack, Ozark National Forest (April, 1937).



Fire dispatcher, Churchport, Camp Jefferson National Forest (W.H. Morin, 1937).

Forest fire patrol truck with load of firefighters, Shasta National Forest (1926).

Lightning Fires in Saskatchewan Forests

C.J. Ogilvie

Fire research technician, Canadian Forestry Service, Northern Forestry Centre, Edmonton, AL

Canadian Forestry Service | Service canadien des forêts

Lightning is responsible for igniting more than 3,000 forest fires in Canada per year, (*1*) yet there is surprisingly very little formal documentation available on the initial stages of such fires, except the general information contained in individual forest fire report forms. Data on the type and condition of fuel where the fire originated and the time interval between ignition and arrival are needed for constructing models to predict the occurrence of lightning fires, including an evaluation of holdover potential. These data, however, are rather difficult to obtain because the pertinent information must be gathered very soon after ignition before the evidence is subsequently obliterated.

In 1982, the author made arrangements with the Saskatchewan Department of Parks and Renewable Resources to accompany an initial attack (IA) crew to the scene of recently reported lightning fires near La Ronge in the northern part of the province (lat. 55°06′ N., long. 105°07′W). These four-member crews are charged with actioning fires as quickly as possible and, depending on a fire's status, extinguishing or holding it until a larger suppression crew arrives. They are then returned to their base for dispatching to the next reported fire. The IA crew is transported in a S-55 or S-58 Sikorsky helicopter. These helicopters are large enough to permit room for an observer and his or her equipment.

Upon reaching the fire location, the first priority was to take representative fuel moisture and bulk density samples as close as possible to the point of ignition and in any other fuels in which the fire was burning. Moisture content samples were taken from the top 2-inch (5-cm) segment and the 2- to 4-inch (5- to 10-cm) and 6- to 8-inch (15- to 20-cm), segments from the organic component of the forest floor. If the fire was candling, moisture samples were taken of whatever fuel was responsible for carrying the fire upwards (usually bark flakes or arboreal lichens). The bulk density layer samples measured 4 by 4 by 2 inches (10 × 10 × 5 cm) in size, giving a gross volume of 32 inches^3 (500 cm^3). A record was completed on every fire investigated. This included details on the nature of the strike point (tree species, height, diameter at breast height, and condition). In addition, notes were made on the fire's general behavior, fuel complex characteristics in the area, and any unusual occurrences. All aspects of the incipient lightning fire were photographed with a 35-mm camera, with particular emphasis on the tree struck by the lightning (if found) and the fuel complex.

The distance and direction to the two closest fire weather network stations and the fire danger indexes at those two stations was noted later. The lightning locator system (*2*) data for up to 5 days before the fire's occurrence was examined in relation to the fire's exact known location.

Eleven lightning fires were documented between 1982 and 1985.

Figure 1—*Tree destroyed by lightning that started Fire No. 9.*

Although no firm conclusions can be drawn from the results obtained to date, some interim observations on the natural history of lightning fires in the boreal forest are in order:

- Living trees acted as the initial "ground terminal" in at least five of seven cases (figs. 1 and 2).
- Ten of the eleven fires propagated themselves in the deep organic matter near the base of trees (if present). The moisture content of the organic layers was extremely variable with the top 2-inch (5-cm) layer ranging from 8.6 to 148 percent between different fires and from 8.6 to 69.8 percent on the same fire with the dry sample taken from an exposed area and the other from within the forest stand. Bulk densities of the top 2-inch (5-cm)

During wildfires, suppression personnel are often in the best position to make fire behavior observations.

Figure 2—*Scar left by lightning that ignited Fire No. 4.*

organic layer ranged from 0.499 pound per foot^3 (0.0089/cm^3) to 1.62 pounds per foot^3 (0.0269/cm^3). The bridge fuels such as bark flakes were much more uniform ranging only from 9 to 14 percent moisture content. Of interest here is that the only fire presenting a real control problem was the one where the bridge fuels were at 9 percent moisture content.

- One fire did occur on a treeless muskeg plain.
- A live black spruce, 10 inches (25 cm) diameter at breast height, exhibited a lightning-caused bole scar that ended 8 inches (20 cm) above the tree base (fig. 3).
- Another fire was started at a location where at least three tree boles exhibited older lightning scars with one individual stem possessing two scars.
- Most of the fires were ignited by relatively isolated lightning, probably because high-density lightning storms are usually accompanied by heavy rain.

As further data are accrued, a clearer picture of the relationships between the lightning fire ignition process and forest fuel characteristics should emerge. ■

Literature Cited

Ramsey, G.E.; Higgins, D.G. 1986. Canadian forest fire statistics: 1981, 1982, 1983. Inf. Rep. PI-X-49 E/F. Chalk River, ON: Government of Canada, Canadian Forestry Service, Petawawa National Forestry Institute. 148 p.

Krider, E.P.; Noggle, R.C.; Pifer, A.E.; Vance, D.L. 1980. Lightning direction finding systems for forest fire detection. Bulletin of the American Meteorological Society. 61(9):980–986.

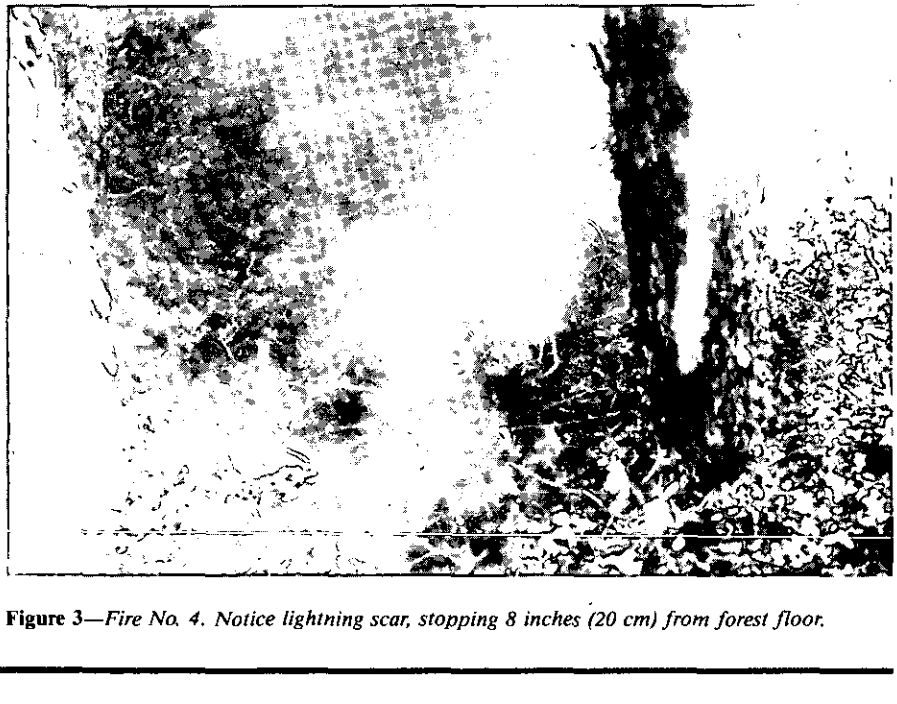
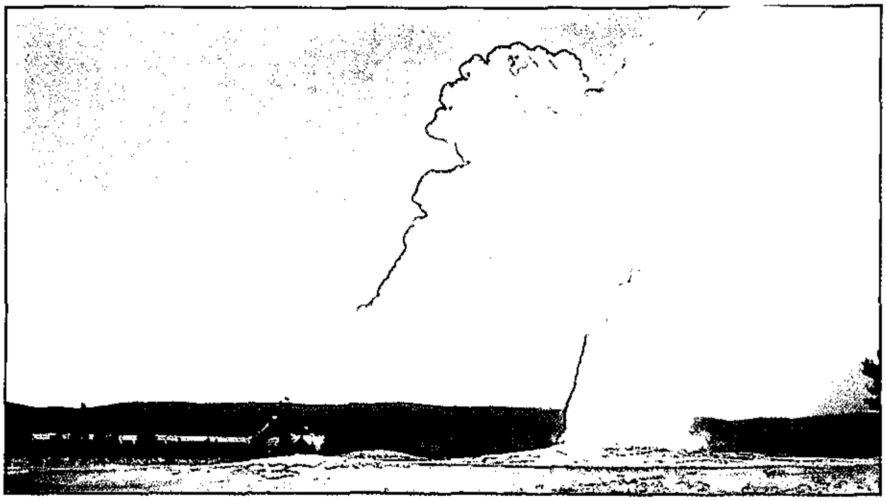
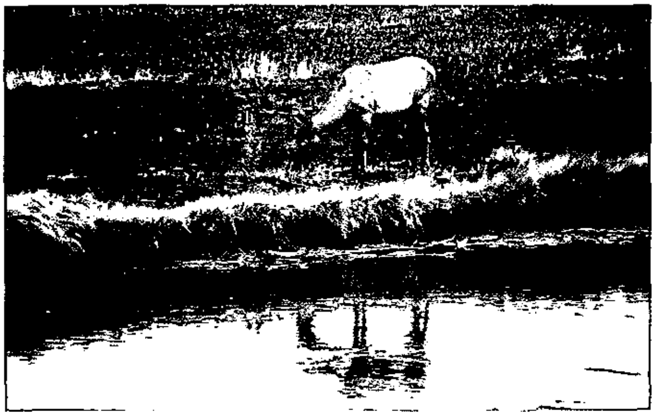


Figure 3—*Fire No. 4. Notice lightning scar, stopping 8 inches (20 cm) from forest floor.*

The 1988 Greater Yellowstone Area Fires—Along with Many Others—We Were There

Undaunted by fire blow-ups on the North Fork, Old Faithful, with its own special show of force, erupts on schedule for tourists. Smoke billows in the background, a byproduct of another ancient element. In seeming tranquility, swans swim near the shore; an elk browses on grass along the edge of the burned area.





Firefighters—25,000 of them in the 1988 season—came from around the country and Canada. As many as 9,500 roughed it in fire camps and took on the bone-weary work of fighting fires at the fire season's peak. After driving all night, Minnesota firefighters catnap on the grass before assignment. Even soldiers of the U.S. Sixth Army, after a crash course in firefighting, march to fireline assignments to relieve trained firefighters for specialized tasks.

Working in time-honored ways, firefighters battled 249 fires in the Greater Yellowstone Area in 1988, using pulaskis, McCleods, axes, and shovels in the hard labor demanded in the building of a fireline or extinguishing hotspots. For the firefighter detailed to pulaski sharpening, there was no shortage of supply.

Firefighters also relied, as they have since World War II, on airborne equipment for attacking major fireruns and reaching difficult-to-access areas. In the struggle to protect structures, they frost buildings with snowy-looking foam-water retardants. Helicopters alone dropped about 1.4 million gallons of fire retardant and 10 million gallons of water in the assault on the Yellowstone fires.

GSA—a Partner in Wildfire Protection

Larry Camp

Fire coordinator, General Services Administration, Federal Supply Service, Fort Worth, TX

The 1988 fire season is one to be remembered for a long time, especially by those in the supply support area, as the system was stretched to its limit. General Services Administration (GSA) took orders for and shipped a total of 34 million dollars' worth of fire supplies during fiscal year 1988. The bulk was ordered and shipped during August and September. This represents a 30-percent increase over any previous fire year.

Responsibilities

The GSA's Federal Supply Service (FSS) is responsible for procuring, stocking, and shipping over 300 items used in the wildfire protection efforts. This support is mandated by a written agreement between GSA, the U.S. Department of Agriculture (USDA) Forest Service, and the U.S. Department of the Interior (USDI) bureaus and services involved in wildland firefighting. The various State firefighting groups also purchase supplies from FSS by virtue of their individual agreements with the USDA Forest Service or the USDI agencies.

New or improved equipment and supplies enter the GSA system after development at one of the two USDA Forest Service Technology and Development Centers (San Dimas, CA, and Missoula, MT) or through the USDI Bureau of Land Management development activity in Boise, ID. The members of those staffs work closely with the GSA engineering representative located in Fort Worth, TX, to see that the newly developed equipment and other products meet requirements and specifications.

Location and Shipment Routes

GSA's support personnel are located in the FSS's General Products Commodity Center, Fort Worth, TX. The program was transferred from Denver, CO, in 1986 and all procurement, inventory management, and requisition processing activities are centered in Fort Worth. The major stocking point for fire support items is the GSA Western Distribution Center (WDC), located in Stockton, CA. During fire alerts, the Stockton personnel are on call 24 hours per day, 7 days per week. During July, August, and September, the WDC shipped 295 trailer loads (2,446 tons) of fire supplies. Most of the supplies were sent to the major caches supplying the Greater Yellowstone Area fires, with other shipments going to Denver, CO, and Redmond, OR. Many smaller shipments were dispatched to locations throughout the Western United States.

GSA is increasing inventory levels and working to improve the ordering process to better serve its customers.

Future Role

GSA anticipates that the wildfire support program will continue to grow as the States and other Federal agencies such as the Department of Defense increase their participation. Increased use of items offered by GSA will improve firefighters' readiness and response time when needed in other parts of the United States by insuring that the firefighters are properly outfitted upon arrival at the incident.

Field input and user feedback are considered to be key components of the ongoing success of the wildfire supply support function. One avenue of input from the users comes from participation in the annual "National Wildfire Protection Equipment Conference" held each year in November. This conference is sponsored jointly by the USDA Forest Service, USDI Bureau of Land Management, and GSA. Input from the 1988 meeting has now been evaluated. Based on that review, changes have been made to products and the delivery operations. Attendance at this meeting is open to any government entity that is involved in wildfire protection activities.

GSA looks to the future and its challenges with a renewed commitment to meet the needs of and improve service to its many wildland fire management customers. GSA is increasing inventory levels and working to improve the ordering process to better serve its customers. For information on GSA support or questions regarding any fire item furnished by GSA, contact Larry Camp, GSA Fire Coordinator. His address and telephone number are as follows:

GSA Region 7 (7FXER)
819 Taylor Street
Fort Worth, TX 76102
(817) 334-8637 or
FTS 334-8637 ■

Predicting Fire Potential

Thomas J. Rios

Intelligence section chief, USDA Forest Service, Boise Interagency Fire Center, Boise, ID

For many years, fire managers have looked for ways to predict where wildfires would occur and how intense they would be. However, it was not until recent years that the need to plan for severe fire activity became a necessity within the agencies' fire management programs. With decreasing budgets and increasing competition for resources, managers had a need for both short- and long-range predictions for planning purposes. With a prediction system to provide guidance, managers could better utilize existing resources by being able to separate low fire potential areas from high potential areas.

Rating Methods and Their Usefulness in Planning

The National Fire Danger Rating System (NFDRS) (*1*) provides a consistent method for rating the relative fire potential of areas with homogeneous fuels, topography, and climate. However, the indexes produced were limited to actual information for the current day and a forecast for the next day. This provides good information; however, it lacks long-range projections that are needed for planning purposes such as budget requests for additional resources, both add-on and pre-positioned.

In 1984, Robert E. Burgan, a research forester at the Southeast Forest Experimental Station in Macon, GA, and Roberta A. Hartford, a physical sciences technician at the Intermountain Research Station in Missoula, MT, prepared a computer program that generated a map of the United States (*3*). With this mapping program, the actual forecasted Burning Index (BI), Energy Release Component (ERC), and the 1000-Hour Timelag Fuels (THTLF) could be displayed using information retrieved from the Administrative and Forest Fire Information and Retrieval Management System (*4*). This program was used during the 1985 fire season, but only provided "today and tomorrow" information. Another problem was its reliance on hard numbers. The weakness in a program that identifies fire problems based on actual values is the difference in applicability to varying geographic areas. For example, a BI of 40 is not as big a fire problem in California as it is in Florida.

Improving Information Gathering

In 1985, the Fire and Aviation Management Staff in the USDA Forest Service Washington Office identified a need to improve information used in a fire severity forecasting system. An interdisciplinary group met at Boise, ID, to develop a process to be used by the Boise Interagency Fire Center's (BIFC) Intelligence Section in the preparation of a severity mapping process.

Decision	Strategic plans		Preparedness activity		Implementation (Dynamic models)	
	Seasonal[a] (4x/yr)	30-15 days[a] (2x/mo)	6-10 days[a] (2x/wk)	3-5 days[a] (Daily)	3-1 days[b] (2x/d)	<1 day[b] (2x/d)
Staffing and support (BIFC)		X[c]		X		
Severity (Fund requests)	X	X				
Pre-position national resources Identify and locate resource	X	X	X			
Alert			X			
Staging level I			X	X		
Staging level II					X	
Deployment					X	X

Figure 1—*Decision matrix: relation of forecast periods and decision strategy.*

Note: The longer the range of the forecast the more heavily dependent that forecast is on climatology (historical weather patterns/averages). Few if any decisions that involve high costs are made on the basis of long-range forecasts. The more costly staging and deployment decisions are not made until dynamic models based on actual information can be constructed.
[a]Temperature and precipitation departing from norm.
[b]All weather information.
[c]Long-term and seasonal employees.

With the current 30-day predicted fire potential map and severity potential narrative, fire managers now have a system that can be used for planning purposes.

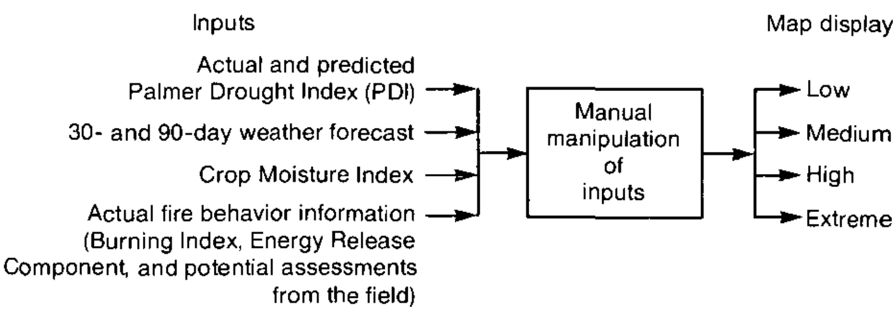


Figure 2—*Flowchart of information needed to prepare map.*

The group prepared a matrix (fig. 1) that identified the decisions that needed to be made, timeframes for making those decisions, and some of the products available to base forecasts on. This provided some guidance for the development of the process. The group also prepared a flowchart of information needed to prepare the map (fig. 2).

When the input information necessary to develop the severity mapping was identified, it was decided that the actual information (BI, ERC, and THTLF) needed to be more complete. This was accomplished by identifying NFDRS weather stations that had sufficient historical information (6 to 10 years) archived at the National Weather Data Library at the Fort Collins Computer Center. After the raw weather information was gathered for these stations, the BI and ERC were computed for the fuel model selected for the polygon (60 percent or more of the fuel type within the polygon). This was used to create a historical database to compare with current information. In other words, ranges could be derived and given labels such as "normal," "above normal," or "below normal" to describe a current situation in a convenient but useful way. Also with the historical database, a map could be generated anytime showing the climatological normal for the polygons on any given day of the year.

Developing Fire Potential Maps

The identified items and the available information accurately describing the current conditions allowed the Intelligence Section to begin preparing a 30-day predicted fire potential map and a severity potential narrative. Although there is no way to predict the exact location where fires will start, areas with high probabilities of sustaining ignitions and potential for these fires to become large or troublesome can be identified.

As the fire community is aware, there is no universal indicator of fire problems. The formats of information used to determine the

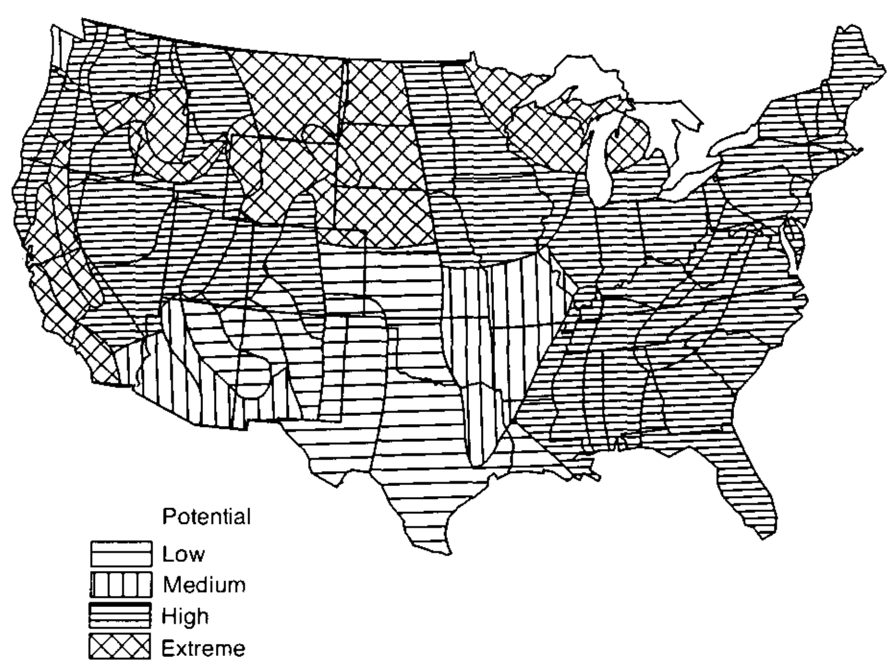


Figure 3—*Predicted fire potential for period, August 5, 1988, to September 9, 1988. (Drought conditions were still affecting 80 percent of the country. Recent rain in the East and Southeast had only provided short-term relief.) (Intelligence Section of Boise Interagency Fire Center.)*

extent of a fire problem range from narrative field reports to map displays. This has been the major obstacle in the efforts made toward fire forecasting and has prevented the creation of a fully automated process. Although a fully automated system would be the easiest for the user, it lacks "on-the-ground observation." On the other hand, by not being fully automated the need to convert the data manually allows for seasonal and geographic adjustments based on experience. Once the data has been interpreted and entered, fire potential is displayed with a uniform map and narrative for the continental United States (fig. 3).

The information collected through NFDRS inputs (fig. 2) are plotted on a map at BIFC to display areas of high fire danger in the 11 western States for national planning. However, this proved to be a difficult task on a daily basis due to the high number of weather station files that an individual was required to review. In 1979, John E. Deeming (retired, USDA Forest Service), Clyde A. O'Dell (retired, National Weather Service), and Ernie V. Anderson (retired, USDA Forest Service) divided the Western United States into polygons. These polygons represented areas that were of similar fuel types, topography, and climate. Within each polygon, anywhere from one to six stations that were representative of the polygon were used to provide an average fire danger rating for the polygon. However, even when the number of weather stations used was reduced, this method was still difficult to use due to the amount of time an individual had to spend preparing a display. The display prepared by BIFC's Intelligence Section was a map of the Western United States that was divided into the polygons and was handcolored.

At the same time BIFC's Intelligence Section was producing the handcolored map of the Western United States, it also prepared a map that displayed the Palmer Drought Index (*2*) (an index of meteorlogical drought or moisture excess indicating prolonged abnormal conditions affecting water-sensitive economics). This was done on a monthly basis along with a narrative that discussed the current situation and gave a brief forecast of what could be expected for the next 30 days. Although this provided helpful guidance, it was time-consuming to prepare. Another problem with this map and narrative was its reliance on the Palmer Drought Index and 30-day weather forecasts as the main inputs.

Distribution and Use of Mapping Displays

The current severity mapping and daily mapping displays of fire-danger indexes provide information that is being used for planning and operational decisions. The F&AM is using the 30-day severity potential map to support requests for additional funds during severe conditions within specific geographic areas. These maps have also grown popular for media use. *USA Today* has been publishing the maps on a monthly basis for the past few years. The Cable Network News weather channel in Atlanta, GA, has aired a modified version of the maps showing fire danger predictions through the weekend. These predictions are incorporated with recreation reports and fire prevention messages.

Currently, the maps are distributed through normal mail and electronically through the Forest Service Data General (DG) computer system. The Forest Service's coordination centers receive the maps and narrative via the DG on a monthly basis. They can also retrieve the daily maps that display "actual" and "forecast" maps generated at BIFC. The Bureau of Land Management (BLM) users have the ability to receive the 30-day severity potential narrative and to view the 30-day predicted fire potential map for the Western half of the United States using the BLM Initial Attack Management computer system.

Currently, the Pacific Southwest Forest and Range Experimental Station in Riverside, CA, is working on a project to enhance the use of the short-range (30-day) weather forecast information provided by the National Weather Service. The station expects to be able to provide this information by next year. This will provide additional guidance in the preparation of the 30-day mapping displays. In addition, the existing polygons of the map itself will undergo some modification. These changes will include moving some boundary lines and creating new polygons as well as switching from some of the weather stations now used to other stations.

One of the biggest obstacles faced in the use of the current mapping and narrative system is the lack of high quality, consistent weather information. Data that is needed to prepare daily and historical information for periods of high-fire activity is often missing. Also, Remote Automated Weather Stations (RAWS) are replacing many manual stations, leaving gaps in the available historical data. Within the next few years, it is hoped that RAWS databases will have sufficient data to replace the manual stations' databases.

With the current 30-day predicted fire potential map and severity potential narrative, fire managers now have a system that can be used for planning purposes. Other uses for the system such as determining the feasibility of a prescribed burn could be considered as well. ■

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Fire prevention promotion, "Carry a can for canning Camels." U.S. Army fire patrolman explaining to visitor the need to be careful with lighted cigarettes (1924).

Wildfire 1988—a Year To Remember

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Persistent drought in many parts of the country was a key factor in the conditions that led to an unprecedentedly severe 1988 fire season in the United States. Drought continuing from 1987 and, in some parts of the Nation, 1986 and 1985, contributed to record-low snowpacks and fuel moistures. When the lightning and wind came, the fuels were ready, and the resulting fire season will be remembered for many years to come.

Weather and Fuel Conditions

A month-to-month breakdown of weather and fuel conditions across the United States starts with a cold, wet, and snowy January in the Northeast and Southeast United States. Temperatures were moderating there by the end of January, but February saw cold, dry conditions prevailing over the Great Basin and the North Central States. Drought conditions present at the end of the 1987 fire season persisted in many parts of the country. Only minor fire activity occurred in the Southeast. High winds triggered fire activity in Texas in March and led to the activation of the Southern Compact and the declaration of a Federal Emergency Management Agency (FEMA) emergency. By late March, fire activity had spread into the southern Appalachians. This led to the dispatch of 20 fire crews from the West and Northeast, along with two airtankers and a Type II Incident Management Team. Fire activity continued to increase during April and May, with most April activity taking place east of the Mississippi. Eleven western crews were mobilized for suppression duties in the Northeast. Drought conditions prevented normal green-up in most of the Eastern United States, and fire activity continued into May, with six more western crews mobilized to the Northeast and six to the Southeast. Minnesota had to deal with fires spread rapidly by persistent high winds and above normal temperatures.

By June, hot, dry weather prevailed over most of the Nation. Fires in the Southwest necessitated the dispatch of 23 crews from other regions of the country. Ten percent of the air tanker fleet remained east of the Mississippi later than normal, and 11 additional crews were sent to the East. Canada's severe fire conditions led their fire managers to call for help. The Boise Interagency Fire Center (BIFC) responded by dispatching 7 Type I crews, 2 Type II crews, 1 Type I Incident Management Team, 195 pump kits, 3,200 lengths of hose, and radio equipment. It took three large air transport flights to move the crews and four to move the equipment. Drought conditions in southwestern Montana and northwestern South Dakota led to a run of fire activity that called for the activation of two Type I Incident Management Teams.

July saw record-breaking 100-plus degree temperatures occurring over most of the country. Substantial rainfall brought short-term relief to some of the drought-stricken regions of the East. High temperatures and plentiful dry lightning triggered major fire activity in Alaska. The Montana and South Dakota fires continued and two more Type I Incident Management Teams were mobilized for those States. During July, 246 crews were mobilized through BIFC for fires in Alaska, Colorado, Idaho, Nevada, Montana, South Dakota, Tennessee, Utah, Wisconsin, and Wyoming. Seventeen Type I Incident Management Teams were assigned to fires in the western United States. Alaska developed 52 large fires that consumed 2.2 million acres (890,340 ha) and required outside support that included 8 fire crews and 73 smokejumpers. Fires that ignited in and around Yellowstone National Park in late June and early July were exhibiting unusual fire behavior that required aggressive suppression action.

August saw some relief in the East, but windy conditions aggravated the situation in the West. Problem fires occurred in the western third of Wyoming and the western third of Montana, as well as Idaho, Oregon, and Washington. Mobilization of resources increased dramatically. In addition to local resources, 576 of 579 crews mobilized during August were sent to fires in the Greater Yellowstone Area and Montana. Fire activity continued to increase during the month, and many of the fires in the Greater Yellowstone Area burned together. Civilian firefighting resources were soon depleted and, on August 19, the Sixth U.S. Army was asked for help. Their

When the lightning and wind came, the fuels were ready, and the resulting fire season will be remembered for many years to come.

support included 6 Army and 2 Marine battalions to be used as hand crews; 23 Type I and 22 Type II helicopters for crew transport; and 2 infrared aircraft. A total of 5,595 military personnel were involved in this effort. Eight Modular Airborne Firefighting Systems (MAFFS) in National Guard C-130's were mobilized to drop retardant on fires in Montana. These aircraft flew 646 missions from August 20 to September 14 and dropped a total of 1,917,000 gallons (7,263,130 l) of retardant on fires in Montana, Oregon, and Washington. On August 26, the Forest Service issued a recruitment notice to hire and train Emergency Firefighters (EFF) to supplement existing firefighting crews.

September saw dry weather and record heat in the Pacific States, while ample rainfall brought relief to drought-parched central and eastern portions of the country. The need for firefighting resources in the Greater Yellowstone Area continued, and on September 8, Canadian resources were mobilized. People and equipment included 125 helicopter support personnel, 12 air tankers, 8 lead planes, 1 infrared aircraft, 4 5-person water-handling teams, 200 Mark III pumps, and 3,895 Pulaskis. On September 9, the total number of personnel on project fires peaked at 24,188. By late September, increased precipitation and decreasing winds and temperatures allowed many of the major fires to be contained. Some of the larger fires in and around Yellowstone National Park were expected to continue to burn until major snows fell. As of October 20, 1988, BIFC had received reports of 72,479 fires for 4,321,340 acres (1,748,846 ha) burned for the year. In comparing this year with last year, we see that by October 20, 1987, BIFC had reports of 57,003 fires for 2,106,745 acres (852,599.7 ha) burned.

Logistics Were More Than Just a Challenge

It is sometimes difficult to get a true picture of the magnitude of the situation from statistics, but the numbers for 1988 were impressive. BIFC's Logistic Support Office (LSO) processed 12,768 requests for assistance in support of 738 fires. The previous record was 6,000 resource requests, in 1985. In a typical year, the LSO processes 2,000 resource requests. In addition, 3,041 supply orders were processed by the Equipment Desk through the National Fire Equipment System. The LSO utilizes the closest National Cache to the ordering office to fill the order.

The Forest Service and the Department of the Interior maintain the National Incident Radio Support Cache (NIRSC) at BIFC as a national, interagency resource. NIRSC provides multichannel radio equipment for complex incident communications. Command/

The Boise Interagency Fire Center logistics office operated on a 24-hour basis for most of the summer of 1988.

Firefighters were kept supplied through the Boise Interagency Fire Center.

tactical and logistical radio nets can be dispatched to meet incident communications needs in a wide variety of situations. NIRSC fielded its 32 systems in response to 999 requests for communications assistance in 1988.

The LSO received and processed 629 orders for engines during this fire season. A total of 217 requests for light, medium, and heavy helicopters were also processed.

Other aviation resources supplied included 222 flights of light, fixed-wing aircraft, carrying 126,004 pounds (57,156 kg) of supplies and 316 passengers. The large transport aircraft, including the BLM 727, Forest Service Convair 580's, and other chartered large air transports, made 289 flights in the process of mobilizing 20,880 firefighters. During demobilization, the same mix of aircraft made 219 flights carrying 15,335 firefighters. Large cargo aircraft made 21 flights carrying 560,000 pounds (254,016 kg) of supplies to firefighters. A total of 258 air tanker orders were processed, along with 497 requests for infrared overflights.

A lot of people were mobilized to fight the 1988 fires, including 7,740 overhead personnel and a record 1,336 crews (26,720 firefighters). Type I team assignments totaled 60, with 1,560 personnel included in that figure. Type II team assignments totaled 15, and 765 smokejumper orders were filled.

BIFC was a busy place internally in 1988. The BIFC Fire Cache filled 14,000 orders with a value of $25.4 million and received 4,600 returns valued at $9.1 million. BIFC drivers made 634 trips and traveled 507,277 miles, carrying supplies to fires. BIFC Support Services processed 5,570 fire crew and overhead personnel through the center, feeding them 9,084 meals. This office issued 1,593 emergency firefighter paychecks with a value approaching $1 million. The tool shop repaired, refurbished, and returned to the field 35,000 handtools such as Pulaskis, shovels, and McLeods.

The 1988 fire season is history, but what are the prospects for 1989? As of this writing, the 90-day weather forecast for November 1988 through January 1989 has just been released. It indicates near normal precipitation for much of the country with pockets of slightly below normal for sections of the Northwest, the Upper Midwest, and the South. But forecasters say it will take much above normal precipitation over much of the country to eradicate stubborn pockets of drought and bring fuel moistures back to normal. It's too early to be predicting fire potentials for 1989 but, barring record snowpack in many locations, the end of this story is yet to be told. ■

Documenting Wildfire Behavior: The 1988 Brereton Lake Fire, Manitoba

Canadian Forestry Service / Service canadien des forêts

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Introduction

The documented behavior of free-burning wildfires can be a valuable source of information for both fire researchers and operational staff. For example, in an active fire situation, fire behavior observations provide a basis for suppression personnel to take action and advise personnel. Such information allows them to do the following:

- On a timely basis, inform and update district, regional, and provincial staff of the fire's status.
- Provide information that can be used to brief both the media and the public.
- Ensure the safety of firefighting personnel by directing them away from potentially dangerous situations.
- Make immediate comparisons between actual and predicted fire behavior.

Also, future benefits can be gained from formally recording the influences of weather, fuels, and topography on a fire's behavior. That information can then be used as an effective training tool for suppression staff since individuals relate well to recent real-life experiences in which they may have been involved.

From a fire research perspective, observations of extreme fire behavior can supplement or verify the data presently used in the development of the Canadian Forest Fire Behavior Prediction (FBP) System. The FBP System database currently consists of 245 experimental and operational prescribed fires and 45 documented wildfires (Lawson et al. 1985). Presently, most of the information regarding fire behavior under extreme fire weather conditions is collected from wildfires since it is difficult to arrange and conduct experimental fires successfully under such conditions. A detailed example of a documented wildfire in the Northwest Territories is provided by Alexander and Lanoville (1987).

This note summarizes the information needed to document wildfire spread rates and illustrates that this is not a complicated process but merely one that requires a few key observations. An example, taken from the information recorded by the suppression staff at the 1988 Brereton Lake Fire in southeastern Manitoba, has also been included.

Information Requirements

A summary of the information required to document accurately wildfire spread rates is given below. The FBP System user guide provides a more detailed account of the information needed (Alexander et al. 1984: 61–62).

Forward rates of spread. The position of the head fire at various times during a major run needs to be recorded. Observations can be made easily if landmarks such as roads, creeks, and hydro lines are used to plot the progression of the fire on a topographic map, forest inventory map, or recent aerial photograph.

Position of the flanks. Mapping or noting the positions of the fire's flanks (along with that of the head fire) permits the length-to-breadth ratio of the fire to be calculated.

Other fire behavior observations. Other observations not directly required to document the rate of spread but which can be useful in understanding other aspects of fire behavior are as follows:

- Type of fire (surface fire, torching, crown fire).
- Fire whirl development, occurrence of spot fires, and associated distances.
- Flame lengths or flame heights.
- Smoke column characteristics such as height of column and angle of tilt.
- Suppression effectiveness. (For example, hand-constructed fire guards are challenged but waterbombers are effective.)
- Depth of burn.
- Mop-up difficulty.
- Post-fire evidence such as narrow "streets" of unburned trees associated with horizontal roll vortices.

It is worth noting that a photograph can be an exceptionally useful tool in documenting many aspects of a fire's behavior. A photograph is especially valuable if the time it was taken is also recorded. This may be done manually or a camera with a "databack" attachment can be used.

Fire weather observations and fire danger indexes. The most sig-

[1] The author thanks the many Manitoba Natural Resources staff members who provided information regarding the events of the Brereton Lake Fire, with special thanks to Blair Bastian, Bob Enns, and Don Jacobs for their assistance and cooperation.

During wildfires, suppression personnel are often in the best position to make fire behavior observations.

nificant fire weather parameter to measure during a major fire run is wind speed and direction. Hourly observations of the wind, along with temperature and relative humidity, if possible, should be made at a weather station near the fire. However, if this is not possible, then estimate these parameters at the fire site by using, for instance, the Beaufort Scale to estimate wind speed. The information could also be obtained from a nearby fire weather station or Atmospheric Environment Service (AES) station. Inclusion of the daily fire weather observations that preceded the fire is important for calculating the values of the Canadian Forest Fire Weather Index (FWI) System and for possible future analysis.

Topography and fuel-type characteristics. For documentation purposes, details on the topography and fuel-type mosaic in the fire area can often be described after the fire has occurred. This may consist of information from 1:50 000 NTS topographic maps, FBP System fuel-type maps prepared from Landsat imagery or forest inventory data. However, observations of the fire's behavior in the various fuel types and on different topographic features should be noted.

The 1988 Brereton Lake Fire: A Case Study of Documentation

Observations of the fire behavior at the 1988 Brereton Lake Fire were made by a number of Manitoba Natural Resources staff members who were coordinating the fire sup-

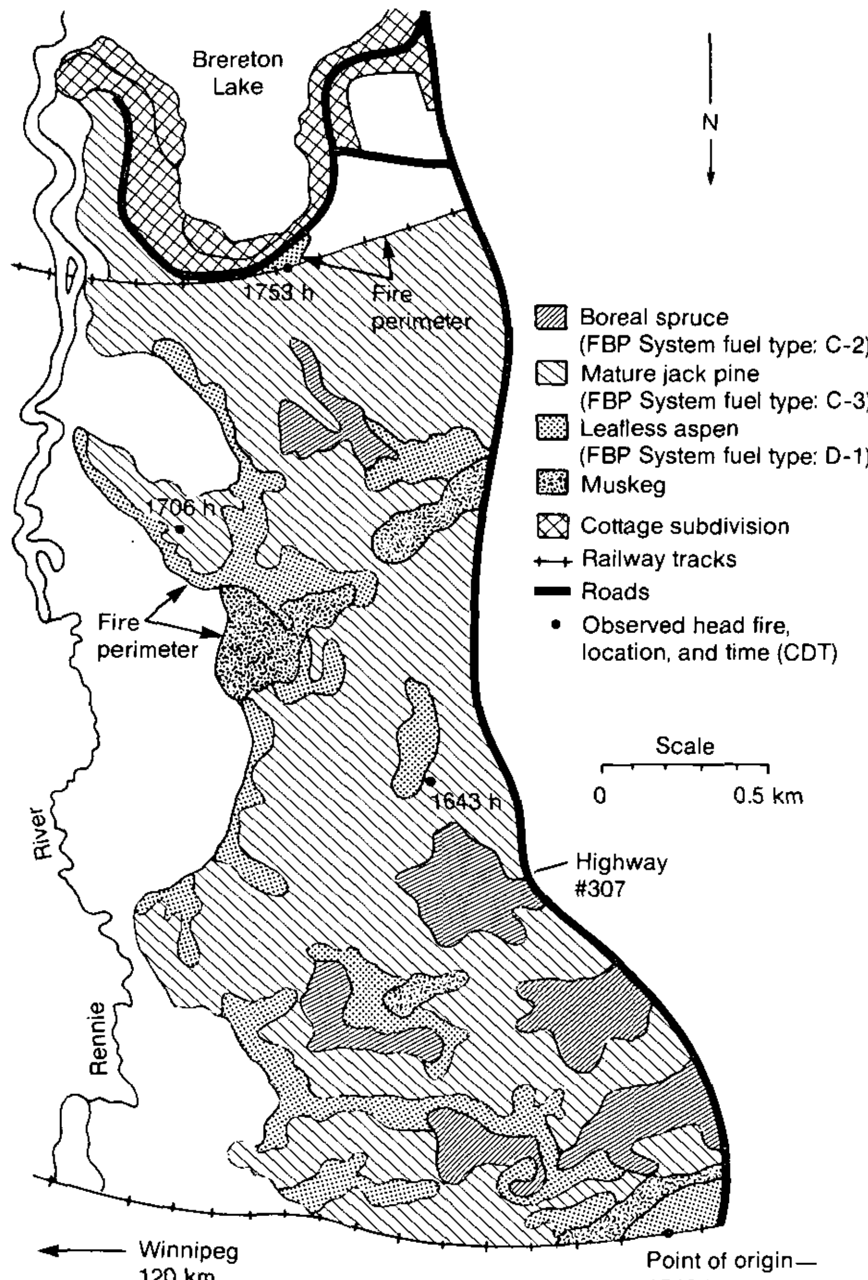

Figure 1—*Fire Behavior Prediction System fuel-type and fire-progress map for the Brereton Lake Fire, May 1, 1988.*

pression activities and positioned primarily in helicopters. This information was recorded verbally on tape and also onto the district radio logs. Given below is a summary of the recorded fire behavior at various times during the major run on May 1 (fig. 1) and how it relates to the information required for documentation.[2]

Forward rates of spread.

- 1540 hours—The fire was detected and reported to the Manitoba Natural Resources office in Rennie. It was located just west of the south railway crossing on Highway No. 307 and was less than 0.25 acres (0.1 ha) in size.
- 1550 hours—The fire crowned almost immediately and was heading northward towards the Brereton Lake subdivision.
- 1634 hours—The head fire was estimated to be approximately halfway to Brereton Lake, a distance of 0.9 miles (1.5 km) from the point of ignition.
- 1706 hours—The fire was on the last ridge before the swamp, a distance of 1.5 miles (2.4 km) from the point of ignition.
- 1753 hours—The head fire crossed the north tracks near the subdivision, approximately 1.9 miles (3.1 km) from the point of ignition.

In summary, the fire spread 1.9 miles (3.1 km) in 2 hours and 13 minutes (133 minutes) for a rate of spread of 76.4 feet per minute (23.3 m/min) or 0.88 miles per hour (1.4 km/h).

Position of the flanks.

- 1746 hours—The fire is now spreading at the back.
- 1806 hours—The west side of fire is crowning in black spruce and spreading rapidly.
- 1924 hours—A small spot fire is just east of Highway No. 307.

Other fire behavior observations.

- 1734 hours—The head fire is too intense for crews to work in front of fire so suppression efforts are restricted to the flanks.
- 1920 hours—The first cottage is lost to the fire.

It was also noted that the fire was not continuously crowning; that is, some torching was occurring but spread was not sustained through the tree crowns. The fire spread primarily on the jack pine ridges and only occasionally burned through the black spruce stands. Also, some mop-up difficulty was experienced in areas with a southern exposure; however, this was not the case on north-facing sites due to the presence of ground frost at or near the surface.

By the evening of May 1, crews were able to secure a fireline completely around the fire using both natural fuelbreaks and constructed fireguards. A major suppression effort on May 2, which included the use of three CL-215 waterbombers, prevented any further flare-ups from occurring and effectively brought the fire under control.

Fire weather observations and fire danger indexes. Fire weather information was not available from the Manitoba Natural Resources office at Rennie but a number of other sources were used to establish the conditions that existed before (table 1) and during the fire run on May 1. This included the 1300-hour observations from the fire weather stations at West Hawk Lake and Nutimik Lake; the hourly readings on May 1 from the AES stations at Kenora, Winnipeg, and Sprague, MB; and estimates of the conditions by the suppression staff at the fire. At 1700 hours, during a major fire run at the Brereton Lake Fire on May 1, 1988, the fire-weather and fire-danger condition observations provided in table 2 were made by fire suppression personnel and substantiated with data from the AES weather stations.

Topography and fuel-type characteristics. The fire area is situated at an elevation of 1,082 feet (330 m) above mean sea level (m.s.l.). The terrain is gently undulating and had a minimal effect on the fire's behavior.

The fuel types in this area were primarily mature jack pine (FBP System Fuel Type: C-3) with some small stands of boreal spruce (C-2) and trembling aspen prior to leaf flush (D-1). The forest inventory information for the area within the perimeter of the fire has been broadly categorized according to the FBP System fuel-type classification. A map depicting these fuel types is shown in figure 1.

Concluding Remarks

During wildfires, suppression personnel are often in the best

[2] Time is central daylight time (c.d.t.).

Table 1—*Fire weather and fire danger conditions which preceded the occurrence of the 1988 Brereton Lake Fire*

Date	1300 hr weather observations [1]							FWI System components [2]					
	Temperature		Relative humidity	Wind		Rain		FFMC	DMC	DC	ISI	BUI	FWI
	(°C)	(°F)	(%)	(km/h)	(mph)	(mm)	(in)						
04/21	2.0	36	73	12.5	7.8	0	0	83	30	236	3.1	46	9
04/22	3.5	38	72	1.5	0.9	0	0	83	31	238	1.7	46	5
04/23	6.0	43	49	7.0	4.3	0	0	84	31	240	2.7	47	8
04/24	9.5	49	47	12.5	7.8	0	0	86	33	243	4.3	49	12
04/25	3.5	38	86	13.0	8.1	4.7	0.19	44	22	235	0.1	35	0
04/26	5.5	42	45	9.0	5.6	0.1	0.01	65	23	237	0.8	36	1
04/27	10.0	50	33	14.5	9.0	0	0	81	24	239	2.5	39	6
04/28	18.0	64	19	16.5	10.3	0	0	91	28	244	11.3	44	23
04/29	22.0	72	18	12.5	7.8	0	0	94	33	249	13.6	49	27
04/30	22.0	72	32	16.0	9.9	0	0	93	36	254	14.4	54	30
05/01	22.5	73	40	27.5	17.1	0	0	91	40	260	20.9	58	39

[1] Observations from the West Hawk Lake (1,085 ft or 331 m m.s.l.) and Nutimik Lake (991 ft or 302 m m.s.l.) fire weather stations were averaged to obtain the values for the Brereton Lake area. Note: these stations are operated by Manitoba Natural Resources and located approximately 19 miles (30 km) southeast and north of the fire area, respectively.
[2] FWI System calculations began on April 21 with the following moisture-code starting values: FFMC-85, DMC-30, and DC-235. Key to acronyms: Fine Fuel Moisture Code (FFMC), Duff Moisture Code (DMC), Drought Code (DC), Initial Spread Index (ISI), Buildup Index (BUI), and Fire Weather Index (FWI).

Table 2—*Fire-weather and fire-danger conditions during a major fire run at the Brereton Lake Fire on May 1, 1988*

1700 hr fire weather observations [1]	
Temperature	79°F (26.0°C)
Relative humidity	21%
Wind	SSE 19 mi/h (30 km/h)
Days since rain [2]	6
Adjusted Fire Weather Index System values	
Fire Fuel Moisture Code	91
Initial Spread Index	22.4
Fire Weather Index	42

[1] Estimates were made by fire suppression personnel and substantiated with data from the AES weather stations at Kenora, 47 mi (75 km) east, 1,348 ft (411 m) m.s.l.; Winnipeg, 75 miles (120 km) west, 784 ft (239 m) m.s.l.; and Sprague, 56 mi (90 km) south, 1,079 ft (329 m) m.s.l.
[2] Greater than 0.6 mm (0.02 in.).

position to make fire behavior observations. This was true at the Brereton Lake Fire. The efforts of the suppression staff resulted in the collection of useful data. Information of this type serves many purposes such as use at post-fire boards of review and verification of the FBP System relationships. Operational staff should be encouraged to make similar observations in the future. ■

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Fire Observation Exercises—a Valuable Part of Fire Behavior Training

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Fire observation exercises have proven to be a valuable part of fire behavior training at the National Advanced Resource Technology Center (NARTC). The exercise was originally developed for the S-590 (Fire Behavior Analyst) course in 1977 and has since been used in the courses, Fire Behavior for Managers and Fire and Resource Management. Trainees record observations of flame length and rate of spread as the fire burns across constructed 50-foot (15-m) fuelbeds (fig. 1). In this article, we discuss the need for a fire observation exercise in fire behavior training courses and tell how to conduct such an exercise.

Much of fire behavior training is devoted to predicting fire behavior using tables, graphs, calculators, and computers (*1,2*). A live fire exercise provides a touch of reality as well as a break from classroom work. The computer may predict flame length of 4.2 feet (1.3 m). However, a person cannot estimate flame length to that precision.

Figure 1—*Trainees record observations of flame length and rate of spread as the fire burns across a constructed logging-slash fuelbed.*

There are reasons other than to smell smoke and escape from the classroom to justify the time and expense involved in setting up a fire exercise. Although S-590 trainees are all task force or strike team leader qualified, many have not spent much time observing fire behavior. There is a difference between merely seeing fire and observing its behavior. Eighty-six percent of the class of 1985 had 10 or more years of fire experience, but only 16 percent had been observing fire behavior for 10 or more years. For example, an individual who had 27 years of fire experience indicated that he had been observing fire behavior for 6 years. Only one person indicated that he had been observing fire behavior for his whole career. People seemed to have no trouble in identifying the point in their career when they really started observing fire behavior.

Need for Fire Observations

Fire behavior is observed by people at various levels in the organization for various purposes. In some cases, special equipment can be used to measure behavior (*3,4,5*), but often the judgment of the observer is the only means of measurement.

In the S-590 course, the exercise has been included in the lesson that instructs fire behavior analysts to verify predictions by comparing predicted and observed fire behavior (*6*). People on the fireline are sometimes asked to observe fire behavior and relay data to a fire behavior analyst. A strike team leader may radio the dispatch center the observed fire behavior at initial attack. The Forest Service fire report form requires an estimate of flame length on initial attack (*7*).

Fire managers are likely to be involved with recording observed fire behavior on prescribed fires. A major duty of a monitor on a "wilderness fire" is to periodically record fire behavior. Fire behavior observations taken on prescribed fires can be later correlated to fire effects. In addition, the associated weather and fuel moisture conditions, predicted fire behavior, and observed fire behavior can be used to refine prescription windows of acceptable burning conditions (*8*).

Program managers and line officers are not likely to be responsible for recording fire behavior themselves. Nevertheless, the fire exercise can help them make better management decisions. They can better understand and interpret fire behavior predictions. Perhaps even more important, they will recognize the implications of sending untrained people to record fire behavior.

Methods of developing custom fuel models depend on having observed fire behavior and associated weather and fuel moisture conditions (*9*). Fuel model parameters are adjusted until predictions match observations. A person should have the best possible observations and should also recognize the inherent variability in those observations.

There are reasons other than to smell smoke and escape from the classroom to justify the time and expense involved in setting up a fire exercise.

The need to record observed fire behavior properly became evident during an evaluation of the National Fire Danger Rating System (NFDRS) in North Carolina (*10*). An attempt was made to correlate NFDRS indexes to observed fire behavior recorded on historical fire reports of the North Carolina Forest Service. Because the results were not as expected, a survey was conducted to determine how individuals measured flame lengths. According to Williams (*10*), "The results showed that only 4 percent of those surveyed knew how to measure flame lengths and none of 15-foot (4.5-m) flames. Think about the implications of these observations being used in a decision involving level of suppression action to be taken.

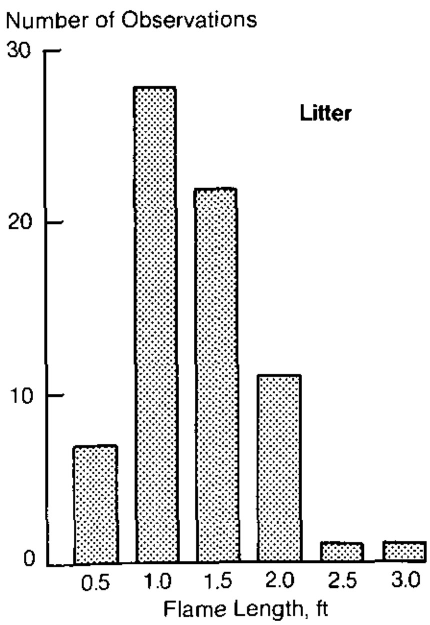

Figure 2—*Observed flame lengths at a single stake in the litter fuelbed. (From NARTC course, Fire and Resource Management, 1986.)*

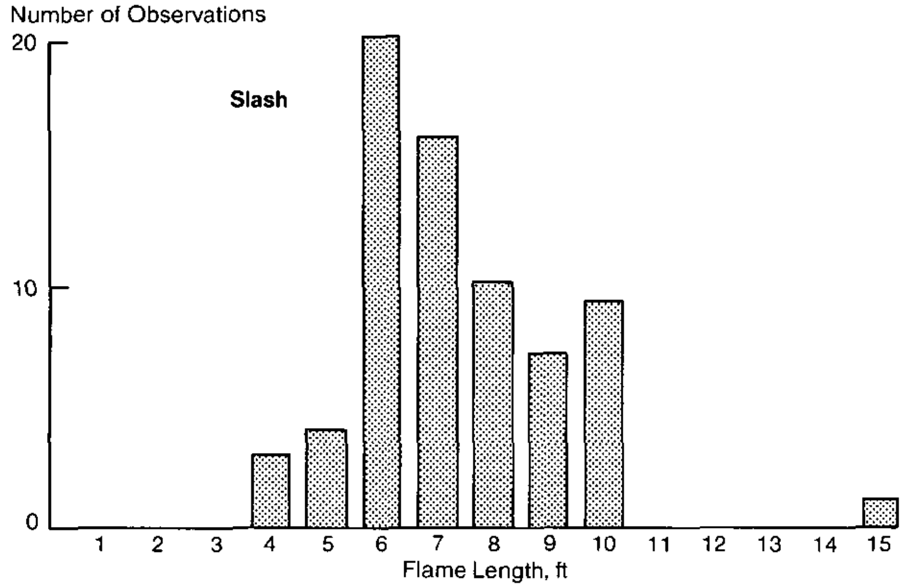

Figure 3—*Observed flame lengths at a single stake in the slash fuelbed. (From NARTC course, Fire and Resource Management, 1986.)*

We would expect less variation in the observations a second time around. It would be ideal to have these had the responsibility for filling out the fire reports that this study was dependent on."

Example Observations from an Exercise

Figures 2 and 3 summarize some of the flame-length observations recorded by the 72 members of the Fire and Resource Management class of 1986. These trainees came from a variety of disciplines and management levels, and their fire experience covered a wide range. Figure 2 is for a fire in needle litter; figure 3 is for logging slash. In each case the observations were recorded at a single stake in the fuelbed. Variability between figure 2 and figure 3 is due to differences in fuel. Variability within each figure is due to differences in the observers.

Although the computer gives a seemingly definitive prediction of flame length to the nearest 0.1 foot (0.1 m), there is much variability in actual flames. It is not expected that everyone in the class would record the same observed value. In this case, most observers estimated flame length 1 to 2 feet (0.3 to 0.6 m) in litter and 6 to 9 feet (2 to 3 m) in slash. Even with the variability in observations, the difference in fire behavior between the two fuel types is clear. It is important that two fuel types be included in the exercise.

To some extent, flame length is in the eye of the beholder. Note that at the same stake in the fuelbed, three people saw 4-foot (1.2-m) flames and one person saw the fires, discuss the results, look at videos of the fires, and conduct similar burns.

Setting up the Fire Exercise

At NARTC, two fuelbeds are used for comparison. A needle litter bed is used to represent a low-intensity, relatively slow-moving fire; a logging slash fuelbed provides a high-intensity, relatively fast-moving fire. Ponderosa pine has been used at NARTC for both the litter and slash fuelbeds. Circular beds are used so that wind direction is not a problem at the time of burning.

The litter fuelbed is relatively easy to set up. Collecting clean, relatively fresh needles is the difficult part. Needle litter can be collected from permanent, mineral-soil firelines, making it easy to rake and bag material. Heavy duty, 4-mil plastic bags have proved satisfactory. A more tedious and time-consuming alternative is to rake fresh, top-layer needles from the forest floor. A 50-foot (15-m) diameter fuelbed requires about twenty, 3- by 4-foot (0.9- by 1.2-m) plastic bags of needles. Needles are spread by hand evenly over the circular plot.

Constructing the slash fuelbed requires cutting, loading, and hauling slash. A large amount of slash is required to build a fuelbed equivalent to a fuel model 11 or 12 (*11*). Slash must be hauled green (fresh) so that it can be packed in a trailer or truck. If gray, brown, or red slash is compacted, it will end up as a pile of twigs.

Thinning sapling stands is the easiest way to get good slash. Tops of small trees provide easy handling and pack well in the transport vehicle. Two 7- by 16-foot (2.1- by 4.8-m) trailers with slash compacted to 10 feet (3 m) high make a good 50-foot (15-m) diameter slash fuelbed. Slash fuel is arranged as uniformly as possible in depth and distribution.

The time between slash cutting and burning is critical. Enough time must be allowed for the new, green slash to dry. At NARTC, the Arizona desert environment dries material in 3 to 4 winter months. Other climates would require more time, depending on the season.

Once set up, the fuelbeds should be protected against disturbance. At NARTC, for example, a truck has been driven through the slashbed; slash has been collected for firewood; and a fuelbed has been burned by pranksters and by an untended trash fire. Fuelbeds should be flagged and posted to warn against deliberate or accidental disturbance.

A fuelbed is diagrammed in figure 4. Shortly before ignition, an instructor determines wind direction and sets guidestakes through the diameter of the fuelbeds, parallel to the wind direction. One-half-inch-diameter (1.3-cm) rebar stakes are placed at 10-foot (3-m) intervals, the first about 5 feet (1.5 m) from the edge. Alternating colors, painted at 1-foot (0.3-m) increments on 6-foot (1.8-m) stakes, aid students in estimating flame length. Timing the fire's spread from one stake to another provides estimates of rate of spread. In order to get a line of fire moving across the fuelbed, two instructors begin ignition with fusees in line with the posts and move along the edge in either direction.

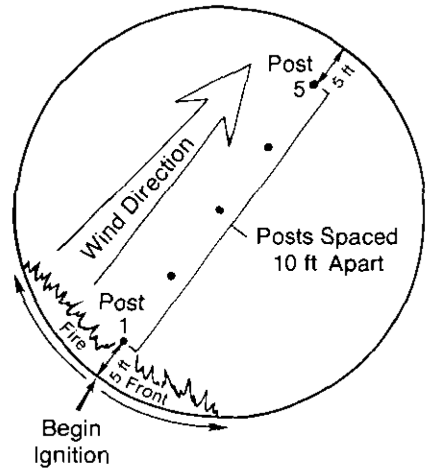

Figure 4—*Diagram of the fuelbed used in the fire exercises.*

The fire exercise begins with a classroom lecture that covers the worksheet and the information to be recorded. Slides are used to describe the estimation of flame

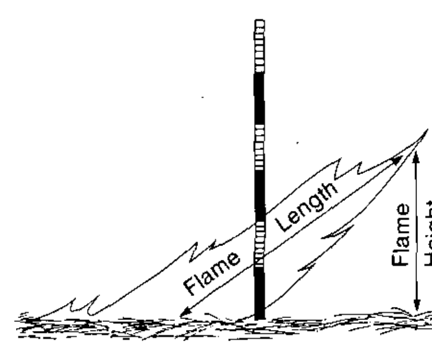

Figure 5—*Stakes painted alternate colors in 1-foot (0.3-m) increments facilitate estimation of flame length. The time that the base of the flame reaches the stake is recorded and used to calculate rate of spread.*

length and arrival of the fire at each stake. Figure 5 illustrates the relationship between flame length and flame height, which is measured directly by the stake. The arrival time at each stake is recorded when the base of the flame, rather than the flame tip, reaches the stake. Worksheets have spaces for flame length and time, which are recorded at each stake. Time lapse between stakes and rate of spread are calculated later.

If the exercise is part of a course that emphasizes methods of fire behavior prediction, as does S-590, trainees should be asked to do more than just record their fire behavior observations. Before the fire, they assign fuel models to each fuelbed, estimating the depth of the slash. An on-site weather station should be provided to determine temperature, humidity, and wind speed and direction. Fuel samples are collected and fuel moisture determined (*12*). After the fire, trainees calculate observed rates of spread from times between stakes. They then compute predicted flame length and rate of spread from fuel model, fuel moisture, and windspeed. Observed fire behavior is tabulated by an instructor and summarized in a form illustrated by figures 2 and 3. The results of the fire exercise are discussed the next day.

Recommendations

We recommend that a live-fire exercise be included in fire behavior training courses. The exercise has been shown to be worthwhile for people with little fire experience as well as anyone whose entire career has been devoted to managing fire. ■

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Forest Fire Simulation Video and Graphic System

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It's early spring in Virginia; a forest fire about 10 acres (4 ha) in size is spreading from a debris-burning operation toward a small woodland development. Virginia Department of Forestry personnel with fire trucks and tractor-transport units arrive on the scene. Suppression efforts have begun. Helicopter bucket drops are called in. From the air the fire head and flanks are visible, leaving behind blackened char. The smoke billows upward and drifts northeast. The progress of the fire lines and line firing begin to show up as the fire is controlled by one man sitting in front of a large projection screen with only a radio.

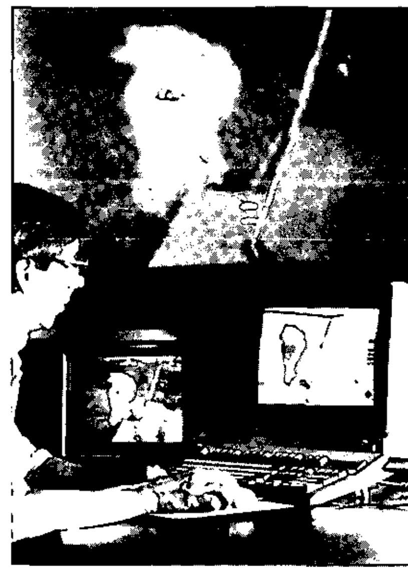
This scene could play on any spring day on Virginia's 15 million acres (6,070,500 ha) of timberland, but it is instead being generated by a computer located in one of the Virginia Department of Forestry's mobile tractor-trailer simulators.

Radical Changes in the Simulator System

For over 20 years, the Virginia Department of Forestry has operated a forest fire simulator to train firefighters. The old Scot simulator, now made by Technovate, has been retired in the face of newer and highly portable equipment. The new, complete computer system is also much more economical. State Forester, Jim Garner, states, "The new computer program for training incident commanders and other wildfire control specialists is so creative that only one's imagination will limit the system's capabilities."

The program was developed by V-Graph, Inc., of Westtown, PA, on a request for a proposal contract, using ideas suggested by the Virginia Department of Forestry personnel. V-Graph, Inc., in cooperation with the Department of Forestry, has designed and developed a software package for forest fire simulation. The package also has applications for hazardous chemical spills, structures, and plant fires. Incident Command System Simulator (ICSS) software allows bulky and expensive projection units to be replaced with a PC-based system. Benefits include increased productivity and flexibility and the reduction of set-up time from hours to minutes. The original ideas for this project occurred when Virginia Department of Forestry personnel watched a graphics simulation of a forest fire on January 16, 1987, in Washington, DC. A copy of the video showing new computer graphics capabilities was obtained and shown to the State Forester on January 19, 1987. State Forester Garner, immediately approved exploring the project. On May 6, 1988, the system was put into operation. To move this new revolutionary forest fire training system from idea to operation took only 16 months!

Basically, the simulations are created by instruction using digitized terrain maps. These maps can be created from slides, video tapes, topographic sheets, or relief maps. Various events such as fire, smoke, water, and fire breaks can be depicted over the terrain. Vehicles and equipment can be moved and



Larry Moody, forestry technician with the Virginia Department of Forestry, takes a turn at controlling a forest fire through the Computerized Fire Simulation System.

positioned. Helicopters can actually be flown through the scene. These elements are controlled interactively by the instructor, based on directions given over a simulated radio system by the student. The exercise can be recorded directly onto video tape for subsequent analysis and replay. Simulation can also be monitored in another room by another class. The simulation exercise is projected onto a large screen from the rear with a video projector.

Maynard Stoddard, Assistant Chief, Fire Management, in charge of the Virginia Department of Forestry simulator training says, "Computer graphics is the answer to many simulator problems. Now we can show equipment such as fire trucks and helicopters in addi-

"Computer graphics is the answer to many simulator problems . . . we can show equipment such as fire trucks and helicopters in addition to the fire scene and fire features . . . faster and with more precision."

tion to the fire scene and fire features, and we can do it faster and with more precision."

How the System Works

The basic equipment needed to run a simple simulation is an IBM-compatible personal computer with 640KB of RAM, a 20MB hard disk, and a monochrome monitor. (We use a Compaq II portable computer with a built-in monitor). An Image Capture Board (ICB) is installed in the computer, and a mouse is attached to the serial port. The Incident Command System Simulator (ICSS) program is loaded onto the hard disk and a color monitor is attached to the output of the ICB board.

The equipment is set up as shown in the accompanying photograph. The color monitor displays the ICB image. The ICB image is the initial realistic simulation scene and, as the simulation progresses, smoke, fire, and other overlays are placed on the initial scene. During an actual simulation session, the ICB image is also outputted to a large color monitor or video projector for viewing by the trainee or to a video cassette recorder for taping.

The monochrome monitor displays the PC image. This image is a graphic representation of the ICB image created by using the trace mode of the ICSS program. The PC image is the working model of the ICB image. The cursor appears on the PC image allowing the operator to position the overlay images of smoke, fire, water, and fire lines properly before these overlays appear on the ICB image. The monochrome monitor also displays the program menus and selection options. The density and size of each overlay image can be changed at any time by the operator. All these functions are selected using the mouse.

At any point during a simulation, the ICB or PC image can be saved to disk without interrupting the session. ICB images require 102K of storage; PC images, 17K. During a simulation, the operator continuously monitors both the ICB image and the PC image to be assured of proper position, density, and size of overlays.

The initial ICB image can be created from 35mm slides or negatives (via a slide digitizer) or direct input from a video camera or video cassette recorder. These images are digitized using True Vision Image Processing Software (TIPS) and saved to disk for later use. TIPS also allows the initial images to be modified to create more suitable scenes. For example, structures or vegetation can be added, deleted, or moved.

A unique feature of the ICSS program is that "window" images of firefighting equipment such as pickups, transports, and pumpers can be added to the ICB image. Aircraft can even be "flown" across the ICB image.

Equipment

The equipment and number of each piece required are as follows:

Item	Number
IBM PC XT/AT or compatible MS–DOS 640KB, 20MB hard drive, and 360KB drive PC	1
Monochrome monitor (can be built-in)	1
External color monitor	1
ICSS program with hardware key [1]	1
Microsoft mouse or compatible unit	1
Image Capture Board [2]	1

[1] Available from V-Graph, Inc., 1275 Westtown Road, Box 10, Westtown, PA 19395, (215) 399–1521.
[2] Available from Truevision, 7351 Shadeland Station, Suite 100, Indianapolis, IN 46256.

The following equipment is optional:

Item	Number
Truevision Image Processing Software (TIPS) [1]	1
35-mm slide/negative digitizer [2]	1
Image display device (color monitor, VCR, video projection unit, or 35-mm Polaroid recorder)	1

[1] Software for capturing images from video cameras or other composite video source. Available from Truevision. Highly desirable.
[2] "Photomaster" available from Howtek, 21 Park Avenue, Hudson, NH 03051.

To date, the Virginia Department of Forestry has three of these systems, two of which have replaced the old Scot simulators in the Department's fire simulator trailers. The third unit is used for training and can be sent ahead so that regional personnel can practice using simulation equipment before the fire simulator now in use arrives.

These two units are on the road constantly during the fall and winter months before the spring fire season. A dozen Department instructors have been trained in the use of the new computer simulator.

You actually have to see the simulation in operation to appreciate the capabilities of this system. Further details can be obtained by contacting the Department of Forestry, P.O. Box 3758, Charlottesville, VA 22903. The Department would be happy to arrange for visitors to view the new simulator system. ■

Federal Property—Fire Use Only USDA Forest Service

This unit of Federal Property is under the control of the USDA, Forest Service and was acquired for fire protection purposes only. It shall not be sold, traded, exchanged, or otherwise disposed of without the expressed written approval of the State Forester and the USDA, Forest Service.

No.

Identifying Federal Excess Personal Property

State Forestry agencies most commonly use one of two tags to identify Federal Excess Personal Property (FEPP) the USDA Forest Service has on loan to a State Forestry agency for use in fire protection (fig. 1). The identification information is the same on each tag, but one tag is made of plastic and the other of aluminum. Some States, however, have developed their own methods to identify FEPP as Federal property. An approved property identification method is required for all accountable FEPP. The "honest mistake" can be prevented by identifying properly all FEPP, other than consumable items. More information is available from your Cooperative Fire Protection representative in the USDA Forest Service regional or area office. ■

Francis R. Russ, *property management specialist, Fire and Aviation Management, Forest Service, Washington, DC*

Smoke Management Modeling in the Bureau of Land Management

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For the past 2 years, the Wyoming State Office (WSO) of the U.S. Department of the Interior's Bureau of Land Management (BLM) has been working on computer models of smoke dispersion from controlled burns. The initial model was programed in BASIC on a Sharp handheld calculator. This model has been reprogramed and incorporated in a modeling system called the Tiered Smoke and Air Resources System (TSARS). It presently consists of two FORTRAN programs plus operating system procedure files available for IBM PC compatible microcomputers and Data General (DG) minicomputers. This article provides information about the current capabilities, limitations, and availability of TSARS and our plans for additional development.

Responsibility

TSARS was developed by BLM personnel at the WSO. Its current smoke dispersion model was initially developed in 1985 in response to the Wyoming Department of Environmental Quality's (WDEQ) requirement that an air quality permit be obtained for a prescribed burn. WDEQ accepted the model, Simple Approach Smoke Estimation Model (SASEM), as a basis for determining air quality, and it is now used by Wyoming land managers for meeting the air quality analysis requirements to receive burning permits. The BLM later accepted it bureauwide as a means of assessing smoke impact from prescribed burns. The USDA Forest Service has also included it, as a recommended procedure, in its Air Resources Management Handbook (FSH 2509.19).

In 1986, the WSO and the Forest Service's Pacific Northwest Fire Laboratory entered into a formal agreement to link the SASEM model with an emissions model they had developed for Pacific Northwest fuel types. This model, the Emissions Production Model (EPM), was linked with SASEM in an interactive operating environment named TSARS.

Because of the relative ease of using the programs and since there are no formal requirements for its use except in Wyoming, no official training on TSARS is currently available. The programs have been and will be demonstrated (including hands-on sessions) at several BLM and interagency fire management courses.

Documentation

Because TSARS has been so recently developed, the documentation is not as comprehensive as BLM would like. Technical descriptions of each of the two current models, EPM (Sandberg and Peterson 1984) and SASEM (Riebau et al. 1988), are available in the open literature. A general overview and user's guide (Sestak and Riebau 1989) of the SASEM component of the system is in development as a BLM Technical Note (available soon through BLM's Denver Service Center).[1] An overall TSARS guide for fire managers is also expected to be developed in 1990—probably after some of the enhancements described later in this paper are incorporated in the guide.

Programs

The master copy of the TSARS program is maintained on a DG MV/4000DC at the Branch of Biological Resources, Division of Lands and Renewable Resources of the BLM Wyoming State Office in Cheyenne. The programs operating within the TSARS system are written in ANSI Standard *X*3.9-1978 FORTRAN. Executable versions are available for DG MV and desktop generation (such as Initial Attack Management System (IAMS)) minicomputers and IBM PC compatible microcomputers. Source code is available in several computer readable formats for other machines. Modification of the program to support other operating systems is primarily the responsibility of the user. However, tests should be made to ensure that the modified program system conforms in appearance and results to the master. It would be appreciated if all such modifications were reported to the authors so a log can be kept of versions and machines supported. TSARS currently consists of three parts: an operating system interface, EPM, and SASEM.

[1] All technical articles are available from the authors. The BLM Technical Notes are available from the authors and also through the National Technical Information Service (NTIS), Springfield, VA.

TSARS, BLM's current smoke dispersion model, was developed in response to the Wyoming Department of Environmental Quality requirement that an air quality permit be obtained for a prescribed burn.

The Operating System Interface. The operating system interface differs in actual implementation on each machine. It serves to provide a consistent and transparent connection to executing the model programs, printing results, and storing information in files.

SASEM. SASEM is a highly interactive program which calculates particulate emission and dispersion from simplified information about fuels, meteorology, and sensitive receptor locations such as towns, highways, and national parks. The concentrations calculated are compared with National Ambient Air Quality Standards, and potential violations are flagged. This model is intended for use as a regulatory screening tool; that is, the model is designed so it is more likely that it will over rather than under predict 24-hour ground-level concentrations. Thus, if no violations are flagged by the model, it is extremely unlikely any would occur under the actual circumstances. If a violation is predicted by the model, minor changes in the fire prescription will often eliminate the problem. The interactive nature of this model makes it easy to test such changes to facilitate smoke management planning. A more realistic model (such as the Forest Service/BLM Topographic Air Pollution Analysis System (TAPAS) (Riebau et al. 1986)) could also be used to demonstrate that the violation would not actually occur under the initially proposed conditions. Finally, the model provides a simple calculation of visual range at sensitive sites such as roads, housing developments, and Clean Air Act Class I areas. This is intended to provide information for at least an initial assessment of visibility impacts from smoke at such sites.

The EPM. The EPM was developed by the USDA Forest Service's Pacific Northwest Experiment Station researchers and provides a more accurate method than those previously used for calculating fire emissions, particularly for burning logging slash. From descriptions of fuel loading and moisture by size-class and ignition procedures, this model determines emissions of particulates, carbon monoxide, and heat as a function of time.

It accounts not only for the fuel-size and moisture effects, but also for the two phases (flaming and smoldering) of fire development. These emissions can be combined into total heat and particulates produced and transferred to SASEM for determination of the ambient particulate concentration under selected meteorological conditions.

At present, the entire executable version of the system fits comfortably on a single 360K IBM PC compatible floppy disk. It will run on any such machine (if somewhat slowly on an IBM XT compatible with no math coprocessor chip).

TSARS. All TSARS programs have the same general structure. When a user first enters a TSARS program, a program logo giving the program name, version number, and developing agency is displayed. Then, after a short pause, a list of the major input information required by the program is presented. At this point, the user can either quit without doing anything, request a detailed list of the required information to be printed, or continue on to execute the model. Input information is requested interactively, one value at a time. If the user does not know a suitable value for a variable, pressing the RETURN key (also labeled NEWLINE or ENTER on various machines) will enter a default value (also displayed on the screen). If the user is uncertain of the meaning of a question, entering a question mark will produce a more detailed description of what is required. After all the individual values have been entered, they will again be displayed on the screen, and the user will be given the chance to make any changes desired (to correct typographical errors or other inconsistencies). When the user has acknowledged that all values are correct, the model calculations begin. As the model computations are completed, they are displayed on the screen, printed, or displayed and printed as requested by the user. The user is then asked if more model runs are desired. If so, the process is repeated. The user also has the option of accepting the previously entered values and going immediately to the display where input corrections are requested. This allows for a few values to be changed quickly and then the calculations performed repeatedly for testing alternative fire prescriptions. When all the desired fire simulations have been made, the user can stop the program.

Upgrades

A major upgrade of TSARS is now in progress. This will consist of the addition of a ventilated valley box model (VALBOX) for calculation of ambient particulate concentrations. Using a box model approach to concentration calculation instead of the flat terrain gaussian approach of SASEM will allow stagnation episodes in mountain valleys to be considered. For the box model, emission information will be supplied either by the emission calculations from SASEM or EPM as desired. In addition, SASEM and EPM will be modified to calculate particulate matter of 10 microns or less (PM_{10} emissions). This upgrade and a user's manual covering all three components of the system are expected to be completed mid-1989. A list is being compiled of those currently using TSARS and the initial SASEM component. Listed users will be informed when the upgrade is available and how to obtain it. Anyone else who wishes to be placed on this list or wishes to receive a current copy of the smoke management programs should write to the authors. In particular, those desiring an IBM PC compatible version of the program should specify whether TSARS is to be run on an IBM XT or AT compatible system and send two 5 1/4-inch diskettes.

Additional Modeling Support

Currently, the BLM has operational capability to perform more advanced, complex terrain modeling analyses within the WSO using TAPAS. TAPAS is a system of interactive minicomputer/mainframe-based meteorological and dispersion models designed to support land management activities. This system can be used to supplement TSARS results in complex or extremely controversial burning situations.

Summary

TSARS is a set of FORTRAN programs for screening level assessment of impact on ambient particulate concentration and visibility resulting from prescribed burns. The system was developed by the BLM to determine whether air quality in Wyoming is such that a permit can be issued for a prescribed burn. It has also been approved for agency-wide use and is recommended in the USDA Forest Service Air Resources Management Handbook. New fine particulate and visibility standards promulgated at the national level will cause State air agencies administrators and Federal and other fire managers to demonstrate that they are using good smoke management practices. For more information on the TSARS programs, please contact: Allen R. Riebau and Michael L. Sestak, Bureau of Land Management, Wyoming State Office, 2515 Warren Avenue, P.O. Box 1828, Cheyenne, WY 82003. ■

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Smoke from Smoldering Fires—a Road Hazard[1]

Leonidas G. Lavdas

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In recent years, smoke management has focused increasingly on preventing visibility hazards on public roadways. Smoke from smoldering fuels contributes to this road hazard more often than other kinds of fire for the following reasons:

- The low-heat output from smoldering combustion produces little or no plume rise, so high concentrations of smoke are left near the ground.
- Smoldering can last a long time and may be mistakenly classed as inconsequential.
- Smoldering often continues into the night when visibility is low, when atmospheric dispersion usually is poor, and when the relative humidity is often high. High humidity increases the chances of producing smog, but the exact relationship is not known.

Paul, Lavdas, and Wells (1987) discuss the influence of weather on visibility in smoke more completely.

Information Needed

Two of the most pressing needs for information about the effect of smoke from smoldering fires are as follows:

- Predicting how much smoke will come from a fire during its entire lifetime on an hour-by-hour basis.
- Determining what effect the smoke will have on visibility during periods of high as well as low relative humidity.

Given the rudimentary state of knowledge, there is much to be gained by simply observing smoldering fires. This article summarizes my notes taken on an organic soil fire that may or may not be typical of such fires. I share these notes in the hope that others will also share their observations. Much new information is needed about smoke from smoldering fires and how it appears to be influenced by relative humidity.

Smoldering in a deep layer of organic soil may create the ultimate smoke management problem in forestry. The deep layer of peat "cooks" like a gigantic charcoal bed, glowing, smoldering, and occasionally flaring. The soil seems to melt away inch by inch over a period that may last for months. The fire can emit enough smoke to reduce air quality and raise the odds of traffic accidents over a wide area for many weeks.

Observations from a Burn Site

The site of my observations was part of an extensive land clearing operation near Shalotte, NC, in the Coastal Plain in the southeastern part of the State about 30 miles (48.3 km) west-northwest of Wilmington, NC. By August 12 and 13, 1987, when my observations were made, the burn had reached a fairly steady state after about 10 days of decreasing surface-combustion. I took no instrumentation readings, but made numerous notes from visual observations. An aerial photograph from 500 feet (152 m) of one of the more active areas of the burn site is shown in figure 1.

Figure 1—*Cluster of smoke sources in the organic site burn.*

[1] The author thanks the North Carolina Division of Forestry for their cooperation, particularly Dane Roten, John Sheppard, and Bill Miller for their help.

Can you help? More information will help us understand and manage the effects of smoke generated by smoldering fires.

Day 1. On the afternoon of August 12, the site was completely open and burned over. Access roads were actually at a higher elevation than the surrounding vegetation in the upwind direction for 2 miles (3.2 km). Since the vegetation was gone, the site was far windier than any forest fire weather station, and more closely comparable to the exposure of wind sensors at National Weather Service stations at airport locations. The organic soil was at least 4 feet (1.2 m) deep, judging from the appearance along access ditches. Whitish smoke rose from several isolated spots into a clear, well-ventilated atmosphere. One specific source of smoke was a mound of burning soil underneath a clump of live pocosin located 20 to 25 feet (6 to 7.6 m) upwind of the road (figure 2). About 20 to 30 percent of the mound seemed to be actively burning. The approximate dimensions of the mound were 8 by 12 feet (2.4 × 3.7 m).

Figure 2—*A clump of pocosin (within the circle) smolders near a road.*

Day 2. Just before sunrise on August 13, the appearance of smoke over the burn area was far different. A layer of smoke, haze, and fog was present within 30 feet (9.1 m) of the ground. The layer was particularly dense 1 mile (1.6 km) north of the clump near the extensive area of combustion shown in figure 1. Only within a few feet of the clump did any of the smoke have a convective appearance, but even this smoke stayed close to the ground in a fairly steady wind of about 6 knots. This windspeed created unusually good dispersion for summer nighttime hours in eastern North Carolina. At Wilmington, NC, windspeed was 7 knots. There was much dew; the Wilmington relative humidity was 93 percent, but locally, based on the presence of a heavy dew, it was probably at or very near 100 percent. We remained at the burn site for most of the morning.

Visibility through the smoke rapidly improved at and just after sunrise as the humidity dropped to the high 80's. The sun was partially hidden behind a deck of clouds for the first 90 minutes after sunrise, so warming and drying occurred slowly at first. After the sky cleared, warming and drying in direct sunlight was more rapid; the improvement in visibility continued during this time but seemed less dramatic despite the lower humidity and a windspeed increase to about 15 knots. By 10 a.m., the first thermal cumulus clouds appeared. These increased rapidly in number and size, indicating excellent vertical as well as horizontal mixing. The visibility in the smoke closely approached the favorable conditions of the prior afternoon well before the best dispersion conditions were established. In fact, the appearance of the smoke over the burn site as a whole seemed to be related more closely to the amount of dew remaining on the top of a parked vehicle than to any other phenomena noted. The humidity when the last of the dew evaporated was probably about 85 percent. The smoke from the clump maintained its convective appearance throughout the morning. As conditions dried and the wind increased, the smoke lifted to a height of 12 to 18 feet (3.7 to 5.5 m) as it traveled across the 30-foot (9.1-m) wide road. Much of the smoke was concentrated in sail-shaped wedges about a road's width apart. White smoke predominated when windspeeds were relatively light, but brown smoke appeared in puffs as the wind picked up. Bill Miller of the North Carolina Division of Forestry noted that this effect of windspeed on smoke color is typical of organic soil smoke.

We flew over the burn site at 500 feet (152.4 m) around noon. The smoke plume from the clump (barely visible in figure 2) was visible by eye for 1/4 mile (0.33 km) downwind. There was a similar clump 3/8 mile (0.6 km) to the

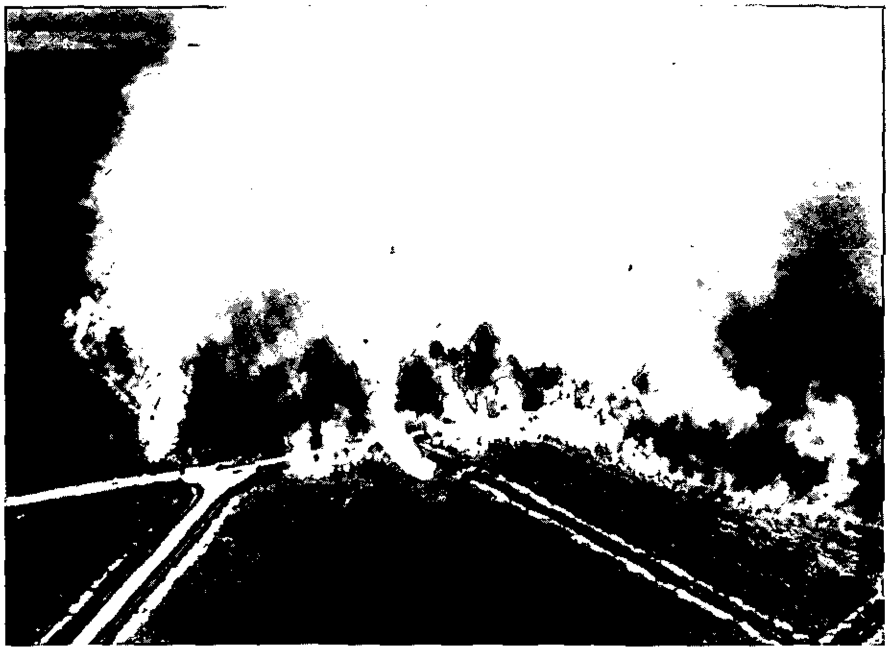

Figure 3—*A newly ignited land-clearing burn near the organic soil burn site.*

northwest that emitted a bit more smoke. The source of smoke 1 mile (1.6 km) to the north of the clump turned out to be a cluster of individual sources (shown in fig. 1) that appeared to emit at least 25 times as much smoke as the clump. This smoke was visible for 2 to 2.5 miles (3.2 to 4 km) downwind and probably accounted for 60 to 80 percent of the total smoke emitted from the burn site. An idea of the effect of the atmosphere on an active fire and its smoke column may be gained from examining figure 3, which shows a nearby land clearing fire ignited less than 1 hour previous to the photograph time. The smoke columns indicated an unstable atmosphere with moderately strong winds which veer about 25° with height. This indicates that the atmosphere's ability to disperse smoke was within the best or at least next to best category out of seven described by Lavdas (1986).

National Weather Service observations at Wilmington, NC, (table 1) were similar to conditions at the burn site. The wind directions and speeds estimated by watching and timing smoke movement were in very close agreement. The only significant difference is that Wilmington had more extensive cloud cover during the first few hours after sunrise on August 13. As a result, warming and drying at the burn site was more rapid. By 11:00 a.m., the temperature and humidity at the burn site were probably close to those reported in Wilmington for 2:00 p.m.

Impressions

The conclusions that can be drawn from these very limited observations are as follows:

- Visibility in smoke can be appre-

Table 1—*National Weather Service observations, Wilmington, NC, at 3-hour intervals*

Date (Aug. 1987)	Hour (EDT)	Sky cover (10ths)	Ceiling height (ft)	Visibility (mi)	Temperature (°F)	Relative humidity (percent)	Wind direction (degrees)	Wind speed (kn)
12	2 a.m.	5	Unlimited	10	73	87	050	8
12	5 a.m.	5	Unlimited	10	72	79	020	8
12	8 a.m.	10	9,000	7	73	87	010	12
12	11 a.m.	5	Unlimited	7	82	74	010	11
12	2 p.m.*	9	25,000	7	86	61	050	8
12	5 p.m.	6	12,000	12	85	63	080	12
12	8 p.m.	10	5,500	10	76	88	050	7
12	11 p.m.	5	Unlimited	15	75	87	040	7
13	2 a.m.	0	Unlimited	15	72	90	040	7
13	5 a.m.*	4	Unlimited	12	71	93	040	7
13	8 a.m.*	9	9,000	12	73	87	040	7
13	11 a.m.*	7	4,500	10	80	69	040	6
13	2 a.m.*	9	3,300	10	84	61	070	15
13	5 p.m.	5	Unlimited	10	83	61	080	13
13	8 p.m.	7	25,000	15	79	67	080	12
13	11 p.m.	0	Unlimited	15	73	82	030	8

* Denotes observations closest to the times of the notes at the fire site.

ciably lower when the relative humidity is near 100 percent than when it is around 80 percent, even though the wind is too strong for fog formation.

- A smoke source that looks unimpressive during the day can be a traffic hazard at night, particularly when relative humidity is high.
- Hygrometers, dew sensors, or similar instruments that can directly or indirectly monitor atmospheric moisture could be useful in monitoring the risk of low visibility in smoke.
- Although too few data are available to predict the exact visibility in smoke during high relative humidity, the potential for greatly reduced visibility appears to begin when the relative humidity reaches about 85 percent.

An Appeal for More Information

Data are too scarce to justify recommendations, but the safety hazards of smoke in high relative humidity are real. We need a storehouse of knowledge that includes results from test fires and the qualitative observations of experienced firefighters. I therefore would like very much to hear from people who have made (or wish to make) such observations on the effects of smoldering fires on visibility, particularly at high relative humidities. A complete copy of my notes taken at the organic burn site is also available. Those interested in my notes or in sharing their observations should contact:

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FTS 238-0204 ■

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Packing water from base camp for another camp nearer fire line where water was not available at Turner Mountain Fire, Kootenai National Forest (K.D. Swan, 1940).

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