# FIRE MANAGEMENT

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# FIRE MANAGEMENT

*An international quarterly periodical devoted to forest fire management*


## CONTENTS




Massive commitments of resources and manpower are necessary to control large fires. The risk is often high, but safety and lost control are paramount. The fire safety symbol on the cover depicts this control efforts with safety.


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John R. McGuire, *Chief, Forest Service*

Henry W. DeBruin, *Director, Division of Fire Management*

J. O. Baker, Jr., *Managing Editor*

# THE FIRE SAFETY CHIEF

***Jim Abbott***

It is some time in the future, but the picture is clear—2 months or more without measurable precipitation; hot days; humidity recovery at night poor; and people flocking to the forest to escape the heat of the city. A fire starts, and a massive control effort is instantly mobilized. Ultimately 2,000 men, 15 helicopters, 12 air tankers and related aircraft will be involved. Many tractors and tankers or engines, working along with a great array of equipment such as pumps, chain saws, and support items are used. Does this sound unusual? Of course not. The resources brought into use are readily available, and the situation is real enough.

Consider though, the complexity of the job and the multiple interfaces between all elements involved. These surely have changed in the past few years. MAFFS units (Modular Airborne Fire Fighting System) are 2 years old. Fireline explosives are still in the infancy stage. The use of heavy equipment has limitations, dictated by concerned land managers, that were not considered in the past. The list could go on, but the fact is that the tools available to the fire boss have expanded and have become more complex, sophisticated, and expensive.

### Complexity Will Increase

What is the point of this discussion? The point is that future fire suppression efforts are going to be vastly more complex than ever before. This means that organizations must adjust. The fire boss and his team members must be top flight managers and planners. Team effort is essential!

Past experience will often be an inadequate basis for determining future action, since we do not always perceive past experiences accurately. In this book, *Of Human Diversity*, Rene DuBos wrote, "At any given

**Continued on next page**

**Interface of men and equipment increases the complexity of the fire suppression effort.**

phase in our life, our perceptual environment is not identified with the internal environment; we deal with the past not through what it has actually been, but with the traces it has left in us." The fire suppression organization must meet the objectives established for the land while minimizing loss and providing for the safety of all people concerned. Prevention of human injury and death is the highest priority!

## Functional Role

In complex organizations a functional safety staff role must be assigned to provide this expertise.

The primary duty of the safety chief is to prevent loss, especially human loss. He is the member of the staff on the fire who works at this full time. He must see that specific operational objectives are met in a safe manner. His broad concern is loss control in the total operation.

Why have such a position? Isn't this really everyone's responsibility in his particular job? Beyond a doubt, it is—along with the mission objectives of suppressing the fire. However, in such a complex organization, people can process only so much information. Everyone cannot be an expert in everything. Like any job, safety demands certain specific skills and methods of operation which must be learned. For example, the line boss must carry out the plan on the fire line—a full time job—yet he is not expected to be a technical expert in every aspect.

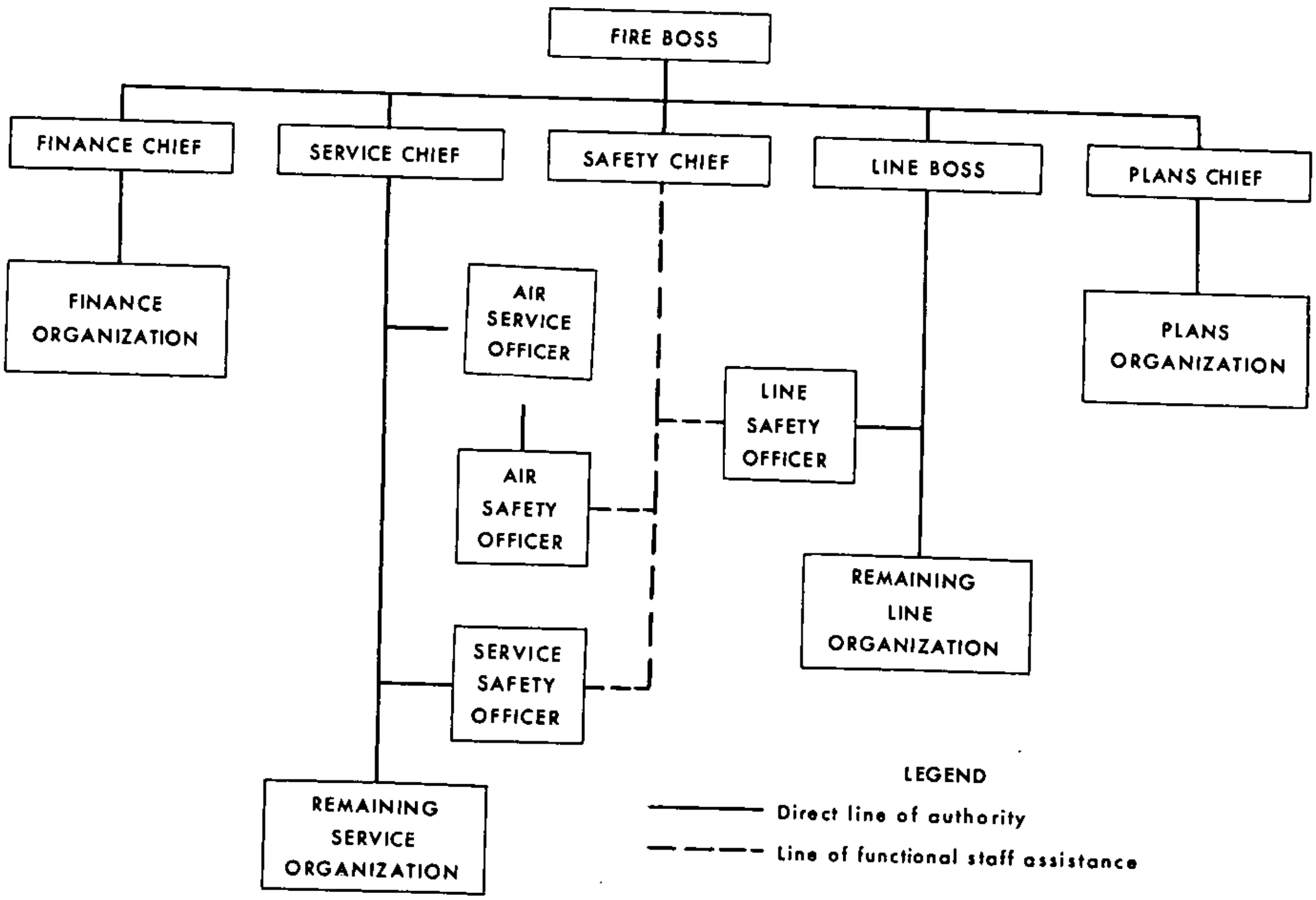
This, in an oversimplified form, is the job of the safety chief. His objectives are directly related to the organization's objectives. Pure safety objectives either do not exist or are suboptimized to organizational objectives. The skills he brings are unique, just as skills of the fire behavior officer are unique. Each person provides essential parts of the total job, especially in complex situations. The safety chief is one such person.

## Organization

Now that the broad role and reason for existence of the safety chief has been discussed, let's look at him in the organization and examine some key elements of his job.

The safety chief works for the fire boss on the same level as the plans chief, line boss, service chief, and finance chief. This is a change! He

COMPLEX FIRE ORGANIZATION INCLUDES SAFETY CHIEF



does not report to the plans chief In some situations, the person filling this position will provide the only safety expertise needed, but as the situation grows larger or more complex, his ability to cover all aspects of the situation will diminish. When this happens, additional safety expertise is needed in the critical areas of line, air, and service. Additional people with functional expertise and safety knowledge must then be assigned as needed. These individuals will report to the functional head (line boss, etc.), but will get technical safety direction from the safety chief.

The organization chart shows this function as a dotted line. The decision to place safety officers in the various functions must be made jointly by the safety chief and the functional head through the fire boss. The safety chief has a key role in identifying the need.

Coordination is necessary in all organizational directions. This functional staff assistance role is entirely appropriate for the safety function. The safety function works entirely to facilitate the accomplishment of the organization's objectives.

With all the change, a logical question is, "What does the safety chief do differently from the old safety officer?" Before describing the safety chief's job, let's talk about the old safety officer position. Often this position was assigned as an afterthought, something done automatically because "safety is good." Sometimes those selected for the job were not chosen on the basis of competence or safety expertise. The organization's expectations for them was only to hand out Band-Aids, fill out forms, run up and down firelines reminding people not to lean on their shovels, and ask sector bosses about escape routes. While some performed useful functions, few were really involved in the planning and execution of the operation.

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Two points expose the thrust of the safety chief's job. First, he serves as direct staff to the fire boss. He must assure that safety objectives are incorporated into all functional objectives through direct interaction with all members of the fire teams. Secondly, his job is predictive in that safety considerations are part of the planning process. He has responsibility for assessment of action. This assessment is primarily followup to the planning process. He is not responsible for first aid care, for sanitation, for line or aviation safety, for accident investigation, and he does not participate directly in meeting these needs.

## Program for Accomplishment

The key to how the safety chief performs lies in how he plans and approaches his job. At the Interagency Fire Safety Chief Training Sessions in 1975 and 1976, Trenton Crow discussed a total concept of safety from the safety professional's viewpoint. As in any job, a program and plan is necessary. The following 8-point program was presented by Crow as a model for safety chiefs:

- Analyze the operation for risks.
- Prioritize the risks.
- Analyze organization functions.
- Establish a performance (or safety) standard.
- Assess compliance with standards.
- Establish authority (if any) and penalties.
- Establish data and information systems.
- Reexamine each program element regularly.

The program is consequential, and it does not begin and end with the project fire. Safety chiefs must think through the program and develop a model which considers many situations. The conscious effort to explore possible actions and reactions must be made before the fire.

As discussed earlier, the qualifications of the old safety officer position were often less than other jobs demanded, perhaps commensurate with his role. The new role of safety *chief* is demanding. Let's discuss his qualifications now since he occupies a new spot in the organization and must play a role different from the safety officer.

First, the safety chief must be a competent fireman qualified at least at the division boss level. He must have working knowledge of all aspects of the fire operations. Secondly, he must understand the safety function. In addition to having training and experience, he must stay current in the field of safety. The reading of current safety literature and the continuing study of safety standards and revisions are also necessary.

## Safety Chief Has OSHA Role

His role as safety advisor to the fire boss is required by law under the Occupational Safety and Health Act (OSHA) and Executive Order 11809. These dictate that requirements of the law and all applicable agency standards must be followed.

It should be evident that safety chief assignments require dedication and commitment. The job cannot begin and end when the fire bell rings. It is so demanding that perhaps it should be an individual's exclusive assignment. It certainly is not an assignment for the inexperienced or for those unsuited for any other fire role.

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# Fighting Wildfire with Agricultural Pipeline

*Bill Turpin*

In recent years, a number of organizations and individuals have been experimenting with the use of agricultural irrigation pipeline as a tool for fighting wildfire. A field trial of an agricultural pipeline system was conducted on the Carmen Fire on the Tahoe and Plumas National Forests in August 1972, and on the Off Fire on the Klamath National Forest in July and August of 1973.

## Field Trials Conducted

On the Carmen Fire, water was lifted 1,200 feet through 18,000 feet of 3-inch aluminum pipe. The system used was an "open one" in which portable tanks were set at each pump to receive the water from the pump below and to provide a flooded suction for the pump at the tank.

A "closed system" was tested on the Off Fire. There the water was relayed from one pump to the next without being discharged into tanks. The closed system was easier to set up and took advantage of any pressure available from the pump below. On the Off Fire, water was lifted 920 feet through six pumps and 8,000 feet of latch-type quick-coupled aluminum irrigation pipe. Although the closed system required more coordination between pumps, some of the problems were alleviated by automatic devices such as no-return check valves, air intake and release valves, loss-of-prime kill switches, and loss-of-oil-pressure kill switches.

## Advantages Are Many

What are the advantages of using agricultural irrigation pipelines as a firefighting tool? If 1 mile of fireline one chain wide is sprinkled using the agricultural irrigation pipe, the effect is the same as irrigating only 8 acres of land. Present farm systems sprinkle hundreds of acres at one time. It is possible to encircle a large fire with a sprinkle line using present technology developed by agriculture. The challenge is to learn how to deploy irrigation pipeline fast enough for it to be useful in fire suppression.

Cost is a significant factor which in some cases favors the use of pipeline to fight wildfire. The Forest Service is spending up to $16 per foot of held line on its larger fires. By contrast, studies have shown that where pipeline can be used, a line held by a pipeline costs only a fraction of this price.

Capacity is another thing which often favors the agricultural pipeline system. A 4-inch aluminum pipe can easily carry 250 gallons of water per minute with a friction loss of only 2 pounds of pressure per 100 feet of pipe. It is possible to divert 250 gallons per minute from many streams, lakes, and ponds. Fire hydrants yield around 700 gallons per minute. Many irrigation wells produce more than 250 gallons per minute. An acre foot of water will last over 21 hours at the rate of 250 gallons per minute. This amount of

**On the Off Fire, water was lifted 920 feet through 8,000 feet of latch-type, quick-coupled aluminum irrigation pipe.**

water is generally available in forested areas within 3 miles of a random fire location.

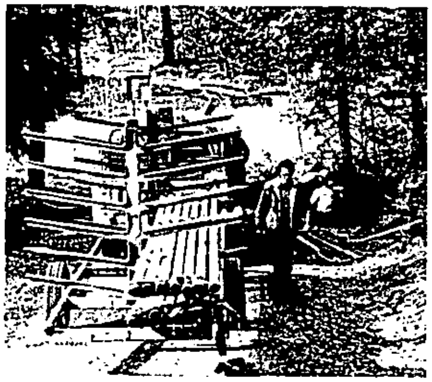
The objective, of course, is to get the water on the fireline in sufficient quantity as fast as possible.

The low pipe-friction loss mentioned above is required so that most of the pump pressure can be used to move water up steep mountains. It is possible to use pumps that develop pressures of 150 pounds per square inch. This is the working pressure of the best irrigation pipe.

## Handling Pipeline

What about the handling of agricultural pipeline? Again, field tests have shown that pipe can be pre-connected and dragged lengthwise in quarter-mile lengths if the drag line is fairly straight. Two men fitted with harnesses can carry six 30-foot lengths of pipe. Power saw winches can also be utilized to move pumps and pipe. With a rope and snatch block, a 10-man crew can pull a 1,000-pound pump on wheels up a steep grade without too much effort. Pumps and pipe trailers can be pulled behind trucks and tracked vehicles.

Water trucks, dumping into a portable pumping reservoir, may be a help on the lower end of a water delivery system. But trucking water for a pipeline does involve a lot of trucks and fast loading and unloading of the trucks. If 3,000-gallon



**Pipe trailers can be pulled behind trucks or tracked vehicles.**

**Most of the pump pressure is used to move the water since pipe friction is low.**

trucks can make a round trip in 3 hours, it takes 15 of them to keep up with the 250 gallons-per-minute requirement of a 4-inch pipeline, and one truck must be emptied every 12 minutes. Additionally, the fire boss may not want 15 tank trucks adding to the traffic on a road near the fire. With improvements in the portable pipeline technique, it should be possible to deliver water just as fast as the trucks, for less cost per gallon delivered, and still leave the road open for other traffic.

Many benefits can be attributed to using agricultural pipeline to distribute water on the fireline. One

**EDITOR'S NOTE**

**Bill Turpin died in a tragic swimming accident in June 1974, just 5 months after retiring. He was District Ranger of the Oroville District, Plumas National Forest for almost 25 years. During the latter part of his career, he became convinced that sprinkling systems could be adapted as a fire suppression tool. He had hoped to play a consulting role in the use of sprinklers after his retirement.**

**Ranger Turpin's friends submitted his manuscript for publication after his death. Myrtle Reichard, of the Forest Service Region 5 Fire Management Staff Group, and Arnold Hartigan, BLM—BIFC, spent considerable time reviewing and preparing Ranger Turpin's manuscript for publication at the request of the Editor.**

benefit is a more acceptable fire control operation from an ecological standpoint. More use of piped water means less use of dozers and other devices that disturb the soil. Another benefit is the lowering of temperature and the raising of humidity that accompanies the use of the sprinkler system. Still another is cost.

Costs of up to $16 per foot of held line can be equated to expenditures of approximately $100 per acre for the total fire acreage. Agricultural pipelines cannot provide all these benefits alone, but from a cost standpoint, water appears to be a most efficient tool when delivered by sprinklers.

## Pipeline and Efficiency

Agricultural pipelines can deliver the same materials to a fire that air tankers deliver, and pipelines deliver it in a continuous line over a wide front. During the night, during periods of turbulent air, to the bottoms of narrow canyons, under thick canopy, under power lines, in between buildings — there just isn't any wildfire that can't be reached with a pipeline.

Water is used in ground tankers and water-mixed retardant is used in aerial tankers. Agricultural pipelines can bridge the gap between these two widely used systems of water delivery and make wildfire fighting safer, more efficient, and less costly—to the ultimate benefit of the land, the resource, and the taxpayer.

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# Smokey Is Alive and Active on the Ozark National Forest

***Jack Kriesel and***
***Buddy M. Corbett***

Smokey Bear's fire prevention message has reached many millions of person in the past 30 years with Smokey becoming nationally known as the Fire Prevention Bear. In those 30 years the Nation has changed, the Forest Service has changed, and Smokey's campaign is actively keeping abreast of these changes. In many fields old methods have given way to new, and the same is true in fire prevention. An example can be found on the Ozark National Forest in Arkansas.

## Change

Two things brought about the change. First, rangers found themselves with increasing demands on their time that made them unable to conduct vigorous fire prevention campaigns. And secondly, the usual presentation—lecture, fire prevention movie, and an appearance by Smokey—was becoming less effective as a means of communicating ideas and concepts.

Jack Kriesel, a visitor information service technician on the Sylamore Ranger District, became acquainted with the California Division of Forestry presentation of fire prevention concepts to school children which differed from the usual lecture, fire prevention movie, and appearance by Smokey Bear. Kriesel suggested to the fire management staff that the Ozark National Forest cooperate with the Arkansas Forestry Commission and try a similar program in northwest Arkansas.

## New Program

The program instituted on the Ozark National Forest involves visiting each class in the elementary grades and leading the children in varied activities in a short period of time. The classes are divided into sub-groups, and a team member is assigned to each group of 6 to 10 students. During the next 8 to 10 minutes, the children are led to discuss such questions as:

- What things we use are made of wood?
- Who is Smokey Bear?
- Who is Woodsy Owl?
- Why should we prevent forest fires?
- Who causes pollution?
- Who can prevent pollution, forest fires, and vandalism?

Each child is encouraged by the group leader to take part in the discussion. The students each receive a litter bag containing fire prevention materials, a forest map, and anti-pollution literature.

The cooperative program between the Ozark National Forest and each district of the Arkansas Forestry Commission provides for pooling manpower, thus preventing any one organization from becoming overburdened. The fire prevention thrust is concentrated in the lower elementary grades in school, since the years children spend in these grades are important for developing and shaping attitudes and behavior.

Following group discussions, two short movies are shown. These discuss the value of forests and give the

**All the children seemed happy to be able to personally shake hands with Smokey Bear and Woodsy Owl.**

**The cooperative program between Ozark National Forest and the Arkansas Forestry Commission provides for pooling manpower, thus preventing either organization from becoming overburdened.**

students a look at Smokey's friends. Smokey and Woodsy make personal appearances after the movies and shake hands with each child.

### School Officials Impressed

Responses from school officials and teachers indicate a lot of satisfaction with the programs. School officials were especially impressed with the way each child was personally involved and was able to talk to and relate to a real "forest ranger." All the children seemed happy to be able to personally shake hands with Smokey Bear and Woodsy Owl.

A program of this type takes a lot of manpower but the pooling of resources keeps the impact from getting too big for any one unit.

In an 8-week period, 206 programs were presented to more than 17,000 school children. This effort should have a lasting effect on the school children and their teachers and should help clarify the role of the National Forests and State Forests, as well as instilling an understanding of the need to prevent forest fires.

Smokey's message is still being carried to school children on the Ozark National Forest, but with a new approach aimed at meeting the challenge of changing time—an approach that personally involves every student.

*Jack Kriesel is Visitor Information Specialist, Sylamore Ranger District, St. Francis National Forest. Buddy Corbett is Public Information Officer, Ozark–St. Francis National Forests, Russellville, Ark.*

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As the size and complexity of the fire organization increases, the need for additional safety expertise increases. Perhaps safety officers will be assigned to line, aviation, and service. If so, they will be assigned to the specific function with specific responsibility for safety.

The safety officers' qualifications are primarily as experts in the specific function with knowledge and skills in safety considerations for that function. Aviation safety is an example of a special skill needed. Line safety and sanitation are others, but special situations might identify different needs. A safety officer will fill the role of "safety specialist," and sometimes "inspector," under the terminology of OSHA. All of them would not necessarily be qualified at the division boss level, except in the case of line safety. They must understand the safety function and must work with the safety chief for technical direction in this field.

The safety chief and the safety officers in the organization can only provide the safety expertise. They are but one part of the team that must work together and share appropriately in meeting the total objective.

The new approach to safety in the time-tested fire organization is dictated by increasingly complex and high-risk situations. Change in the fire organization means that everyone must rethink their role on the fire team and reevaluate how they interact with other members of the team. The safety chief will be successful only if the organization to which he is assigned is successful, and this will happen only when all members of the team fully utilize the total expertise available. Reduced loss in the total sense—the goal of this program—is well worth the costs of change.

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# Is "Smoke-Free" Burning Possible?

**Hugh R. McLean**
**and Franklin R. Ward**

Forest managers are increasingly aware of the need for adequate disposal of concentrated forest residues. These accumulations of residues result from a variety of management activities, including forest road construction, utility rights-of-way clearing, land clearing projects, and timber harvesting activities. Unmerchantable material on timber harvest areas produced extensive volumes of residue that often require further treatment. If this material is not removed by operations specializing in utilization of low-grade material, the residue is commonly disposed of by open burning (Wilson 1970; Pierovich & Smith 1973).

Many problems of open burning—smoke, unsightly charred logs, possible soil damage, the need for control forces, perimeter firelines, mopup, and complete dependency on weather conditions—would be eliminated if an "incinerator" system could be used in the woods (Lambert 1972).

A debris disposal study was conducted in June 1975 near Portland, Oreg., on the Columbia Gorge Ranger District's Bull Run Watershed in two clearcut units that were logged in 1969. Large concentrations of unutilized material remained in the units and along a connecting spur road. The normal slash disposal method of open burning could not be used because of possible ash transfer to streams below the treated areas. Potential smoke management problems were also considered.

## Objective

The study objective was to determine if an air-curtain combustion device would provide an acceptable method for disposal of concentrated forest residues.

Important questions to be answered were:

1. What is the production rate in tons of dry residue consumed per hour?
2. What is the cost per dry ton of fuel consumed?
3. What environmental effects may be expected—visual smoke, spot fire potential, ash residues, soil damage?
4. What safety hazards are present?

This needed cleanup job provided an opportunity to test and evaluate an air-curtain combustion device (manufactured by Camran Corp., Seattle). A service contract for debris disposal, requiring the use of an air-curtain combustion device, was awarded to Trinco Incorporated, a Marysville, Calif., engineering firm. The research portions of the study were conducted by the Pacific Northwest Forest and Range Experiment Station's Forest Residues Program, with Ranger District personnel administering the contract requirements. A San Dimas Equipment Development Center representative monitored capability and performance of equipment.

## Description of Air-Curtain Combustion Device

The air-curtain combustion device is, in effect, a large boxlike incinerator mounted on wheels. The overall dimensions of this device are 24 by 12 by 11 feet, and it weighs approximately 90,000 pounds (fig. 1). The walls, constructed of heat-resistant refractory material, are air cooled to withstand extreme temperatures.

Debris for disposal is lifted into the compartment with a hydraulic knuckle boom, mounted at the rear of the device. Ashes, rocks, and soil drop through the grate to the ground beneath the unit.

A large diesel-powered fan provides a high-velocity "air curtain" across the top of the burner. The fan also provides forced air for combustion and cooling air within the walls. This "over-fire" air curtain combined with the forced air from below results in almost complete combustion and greatly reduces emissions.

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*Hugh R. McLean is currently with the Food and Agricultural Organization of the United Nations in Nairobi, Kenya. He was a Forester, Pacific Northwest Forest and Range Experiment Station, at the time this article was prepared. Franklin Ward is Forestry Technician, Pacific Northwest Forest and Range Experiment Station, Forest Service, USDA, Portland, Oreg.*

**Fig. 1.—Air-curtain combustion device in operation. Note size of the material being loaded and the small amount of smoke.**

## Description of Procedure

Originally the plan called for moving the trailer-mounted combustion device down the spur road, disposing of windrowed material on both sides as the device progressed. However, because of the rough surface and wet conditions on the spur road and proximity of green timber, it was decided to skid the debris to the burner.

The cubic feet and tons of material loaded into the burner were determined during 12 sample periods. Total production and hourly production rates were then calculated. The cost per ton of debris consumed was calculated from comparison of total production with total cost.

Opacity of visible smoke emissions was evaluated ocularly with a Ringlemann Smoke Chart during lightoff, normal operations, and burndown. Smoke emissions were also photographed using time-lapse photography, 16-mm movie footage, and black and white and color prints taken both during the day and at night.

Thermocouple probes were placed within the burner compartment at various locations to record temperatures.

Spot-fire potential was estimated from observations of the distribution of live embers during daylight hours and records of their dissemination at night through time-exposure photographs. Weather observations—temperature, relative humidity and wind—were recorded during each sampling period. General fire weather forecasts were also obtained.

Ashes below the burner grate were measured at the conclusion of the project to determine the volume remaining. Dry weight was determined by laboratory analysis. Ash production per unit of residue consumed and total ash output were calculated.

Extent of soil disturbance within the operating area was observed.

Safety hazards of the operation and suggested prevention measures were noted by observers throughout the project.

## Results

The total amount of material burned during this 68-hour project was 446 tons, air-dry weight. Measured volume totaled 31,000 cubic feet of material up to a 54-inch diameter and up to 20-foot lengths. Material 20 inches or larger in diameter made up 22 percent of the volume. Production averaged 6.5 tons or about 460 cubic feet per hour. The large size of this material plus the high moisture content—from 23 to 200 percent—affected the rate of consumption. Temperatures recorded by use of thermocouple probes ranged from 900° to 1900°F. Measurements showed that over 70 percent of the fuel was burning at temperatures above 1200°F.

The material had been cut and decked in 1969, 6 years before it was burned. The work was scheduled for early June to take advantage of residual winter moisture in adjacent areas to reduce the chance of spot fires (fig. 2).

Although some debris was yarded to the burner from as far as three-eighths of a mile, there were no problems in keeping the burner supplied with material during the

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Fig. 2.—Residue before it was burned. The pile contains large logs, stumps, and root wads.

Fig. 3.—Spur road after cleanup.

24-hour-day operation (fig. 3). No lost time resulted from breakdown of equipment during the project. Hydraulic lines ruptured twice from exposure to heat, but the contractor had anticipated this problem and made immediate on-the-spot repairs.

The direct cost of the combustion device with three men on this project was $16 per ton of residue burned. The auxiliary equipment, manpower, and moving costs increased the total cost to $30 per ton.

Considerable variation in the total cost of a burning project can be expected. Will special fire precautions be required? Fire tankers or other specialized equipment? Patrolmen? Will site preparation or rehabilitation work be needed? Move-in and move-out charges are a major factor in total cost and can vary greatly depending on distance traveled. These supplemental costs must be anticipated when any residue treatment job is planned.

## Environmental Effects

The air-curtain combustion device proved to be practically "smoke free" during this project (fig. 1). For approximately 15 minutes during startup, smoke density approached a Ringlemann rating of number 1 (equivalent to 20-percent opacity). Small amounts of smoke were visible at times during loading operations caused by ignition of fuel held in the grapple above the air curtain. Log ends, extending through the curtain, also produced wisps of smoke. At times, these pieces would burn off and drop to the cleared area next to the bin where they would smolder. These smoke sources presented no problems and could easily be eliminated.

The photographic record of the operation shows practically no smoke present. When time-lapse movies, filmed during this job, were compared with a similar film showing open burning of decked material, the difference was obvious. Smoke from the combustion device was minimal contrasted with emissions from open burning.

Some spot fires were started during the project. Many glowing embers were discharged, particularly when the curtain of air was broken during the loading operation or when burning debris extended through the curtain. This problem could be reduced if precautions were taken at the time of loading.

Close monitoring of fire weather forecasts was necessary because of spot fire potential. Burning continued, but loading was stopped on this job during a period when strong east winds were predicted.

Several spot fires were discovered in rotten wood (including one standing snag) and duff, some as far as 200 feet from the burner. Many airborne live embers were observed that did not result in actual fires because of high fuel moisture conditions adjacent to the work area. Precautions should be taken if burning is done under even moderate fire weather conditions, especially within a hazardous fuel area.

Burning embers, glowing charcoal, and ash continuously dropped through the grates could be a potential fire problem if the device is moved frequently. A surprisingly small amount of ash resulted from this burning job, a total of 1.3 tons or 6 pounds for each ton of residue burned. Only 0.4 percent of the fuel ended up as ash and a large portion of this material was actually soil and small rocks transported in stumps and root wads. The small amount of ash remaining can generally be disregarded where esthetics or possible movement to stream channels are considerations. However, fallout of entrained ash from the convection column could be a problem in locations sensitive to dust.

Under wet conditions this combustion device would disturb the soil to the same extent as a loaded logging truck. To minimize damage on this job the machine operated in only two locations, and debris was skidded and piled within reach of the knuckle boom.

## Safety Hazard Analysis

Safety hazards present on this project were similar to those encountered on any timber harvesting operation using heavy equipment for skidding and loading, plus some special hazards related directly to the burner. Normal precautions should be taken around skidding equipment, loading boom and grapple, chain saws, and other equipment. Hazards near the burner include material extending beyond the bin edge and dropping to the ground (hard hats are a must), hot embers discharged from burner (hard hats and fire resistant shirts are required), and intense heat above the top of the bin. Shields are installed to protect the boom operator, but he is still subjected to intense heat for short periods while loading is underway. The bin walls, with their cooling system and refractory-material construction, remained quite cool and presented no heat hazard to personnel.

## Conclusions

This study has shown that the air curtain combustion device does provide an environmentally acceptable technique for disposal of concentrated forest residues. The cost is higher than conventional burning methods, but environmental concern in specific locations may demand that special measures be taken in spite of the increased costs.

Its most efficient use is on projects where the burner can be transported to the debris and the knuckle boom loader used, rather than the debris being reyarded to a fixed burner location.

In situations where complete disposal of large-size residue is required—for example, root wads on a road construction job in a smoke sensitive airshed—this method provides a practical method of disposal.

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FIRE MANAGEMENT

# Hot Shot Crews Pay Big Dividends

*Jerry Ewart*

Wildland fires present a formidable challenge to the fire manager. Fast, effective initial attack can save millions of dollars in potential resource losses and suppression costs. The modern fire manager uses many tools to effect these savings. Air tankers, helitack crews, modern ground tankers, hot shot crews, more efficient prevention efforts, and intensive fuels management are some of the tools available. One of the most effective of these is the modern, hard hitting, 20-man hot shot crew.

### In the Beginning

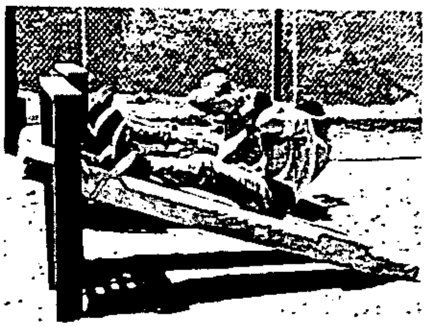
The Tonto National Forest in the Southwestern Region near Phoenix, Ariz., organized its first hot shot crew on the Payson Ranger District early in the spring of 1972. Since that time, two additional hot shot crews have been organized on the Forest, one on the Pleasant Valley Ranger District and one on the Globe Ranger District.

The Forest experiences an average of 300 fires each year. These crews have proved to be a valuable asset in the resulting suppression activities. Hot shot crews have long been thought by many as the most efficient and knowledgeable handline-construction crews in the field of wildland fire suppression. As part of proud organizations, the crew members feel a definite responsibility to do the best job possible, and they do. They are often called on for the toughest fire suppression assignments.

The initial hiring of crewmen for the hot shot crews on the Tonto proved to be somewhat difficult due to the relatively isolated locales and the demand for manpower early in the spring before schools were out for summer vacation. The job of finding enough competent people is getting easier each year, however, since many of the crewmen are returning for a second or a third season on the crew. They cite extended employment seasons and increased job satisfaction as their reasons for returning.

### Trained for Performance

Each spring these crews enter a rigorous training program geared to build their physical stamina, fire suppression knowledge, and ability to work together as a team under the toughest conditions. Regularly scheduled physical exercise is a must. Chinups, situps, pushups, and running all help condition the body for the strenuous firefighting work. Each member must pass the Step Test at a level of at least 45 and maintain this ability throughout the fire season.



**The "Torture Rack" toughens stomach, leg, and back muscles.**

Use of hand tools and principles of handline construction, chainsaw use, fire weather, fire behavior, helicopter safety, equipment maintenance, housekeeping, and fire organization are some of the subjects covered in training. Safety—an inherent part of all training and work assignments—is stressed constantly.

The primary mission of the hot shot crew is to provide professional initial attack and followup suppression action on wildfire assignments. Work supervisors take advantage of work situations to improve the crews' efficiency along these lines. Daily project work brings about countless opportunities to train men in work proficiency and safety. A well trained crew is a safe and productive crew, and a productive crew maintains a high level of morale and efficiency.

Once the initial training is complete, the crews are assigned various work projects, such as fuel break and firebreak construction, helispot construction, hazard reduction and improvement maintenance. Regardless of the project, crews maintain themselves in a constant state of readiness for immediate fire dispatch.

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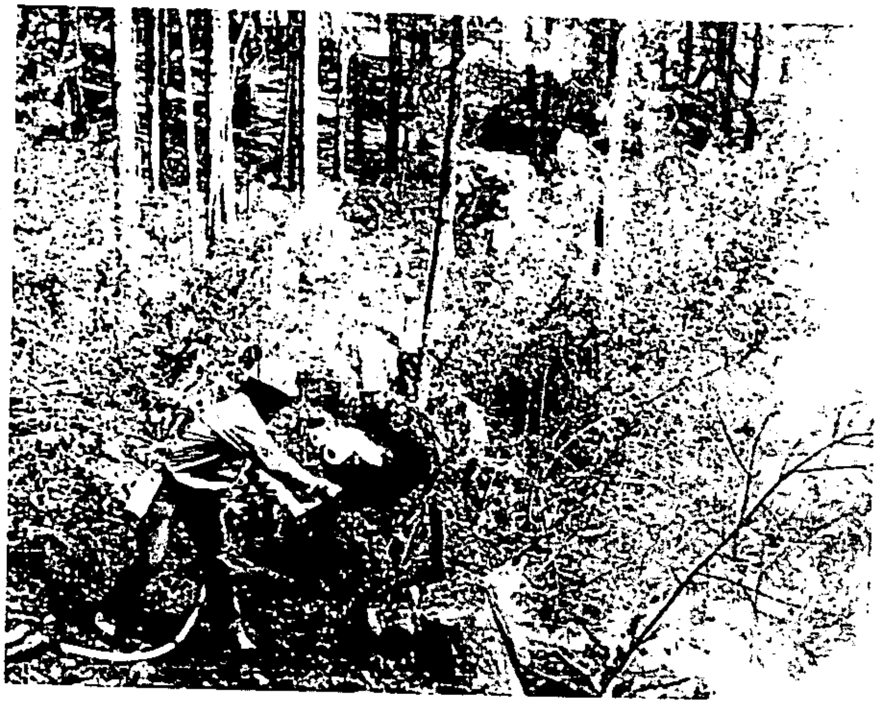

Training and physical fitness pay off when the chips are down.

## Before the Fires Start

Presuppression activities are important and must be planned and carried out in a systematic manner if crews are to be totally prepared for the suppression job. Fire tools and equipment have to be kept in excellent condition. Individual fire packs must be adequate and stored in the crew vehicles. Housing and station facilities must also be kept clean. Transportation must be kept in top-notch condition. Along with these requirements, safe work habits, suppression training, and physical fitness must be maintained currently.

Work supervisors have to have a thorough knowledge of successful hot shot crew organization and of what the crews can do. They also need extensive fire experience and the ability to lead people and command respect. Hot shot crew members have to work as a team, and supervisors have to become part of that team if they are to be effective.

## The Fire Season

Fire season on the Tonto National Forest starts early, normally beginning in early spring, and extends into late fall. During this season there are three somewhat different problems. Man-caused fires begin early and increase in number until the summer rains begin in July. Lightning fires then take over until the last of August when fuels dry out again in a combined man-caused and lightning-caused fire season which normally lasts through October. For these reasons the hot shot crew organization has to be flexible. Until the summer rains fall, the crew members are kept together as a unit for effective initial attack on the fast running fires that occur. Once the summer rain season is well established, there are many occasions when the crews are split into two- or three-man squads to handle small multiple lightning fires. There are also occasions when crews are split and placed in strategic locations depending on storm patterns.

Since the crews are often separated, it soon became apparent that at least two vehicles were needed for each crew. One-ton minibuses were tried and found to be almost ideal for the hot shot crews. Each minibus is capable of carrying 12 men with enough space for neat and readily accessible storage areas for tools, equipment, and personal gear.

## Fire Suppression

Fire managers on the Tonto National Forest are convinced that well trained and well prepared hot shot crews are a sound investment. Effective use of these crews on fires has saved the taxpayer many dollars in suppression costs and damage losses. For example, aggressive initial attack action by hot shot crews was a key factor in controlling three recent forest fires and minimizing losses.

The Seep Fire occurred on June 30, 1974, and was held to only 180 acres despite heavy fuels, steep topography, and adverse weather conditions (manning class V with winds gusting to 40 miles per hour at times). The fire occurred while the Forest was under a full fire closure in an extremely hazardous area. It began 8 miles from the nearest paved road at approximately 2:30 p.m. when a teenage boy started a signal fire to draw attention to himself and his companion who was injured in an accident. A helitack crew, a 16-man hand-tool crew, and the Payson Hot Shot Crew were dispatched on the initial attack along with air tankers. The fire was approximately 40 acres when first attacked. In the early stages of the operation, the helitack crew provided first aid care and hauled the injured man to the Payson Hospital. Effective work by the Payson "Hot Shots" on the northeast corner, plus some key retardant drops on the east flank, were the primary factors involved in holding the burned acreage to a

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Two heavy duty vans provide ideal transportation for the hot shot crews.

minimum under the existing conditions. Continuous heavy brush and rough topography made the area a prime target for a large project fire with a potential of at least 10,000 acres. Fire managers estimated that if the fire had not been held to 180 acres, the suppression costs could have reached as high as $1 million with resource damages as much as $15 million. As it was, suppression costs were only $65,000 and resource damage was only $315,000. This represents an estimated savings of over $15 million on a single fire.

The Pueblo Fire started at 2:00 p.m. on June 25, 1974, in heavy brush on the southeast slopes of the Sierra Ancha Range. The manning class for that day was 4 (very high). The topography was very rough and steep with many 100 percent and steeper slopes in the path of the fire. Fuels were heavy and continuous to the north and west. The fire was held to only 34 acres through fast initial attack action by the Pleasant Valley Helitack and Hot Shot Crews and two air tankers. The initial attack crews kept the fire from crossing Hinton Canyon to the south, while the air tankers delayed the fire's progress to the west and north until sufficient manpower could be transported to the fire.

This fire had the potential of burning 5,000 acres of prime watershed lands and of destroying one of the most scenic areas on the Forest. Suppression costs would easily have reached $500,000 and resource damages could have amounted to over $7 million. As it was, suppression costs were $26,000 and resource damage was held to only $25,000. Fire managers estimated that $7,450,000 were saved by the fast, effective initial attack.

The Go Fire also had the potential of becoming a large and costly one. It, too, burned in heavy fuels and in rough terrain.

Had the effective ground-air operation not succeeded, the Go Fire would have burned about 10,000 acres of watershed immediately above the Salt River Drainage and the three reservoirs that provide primary domestic water supply for the Phoenix Metropolitan area. Suppression costs might have run as high as $1 million and resource damage could have been in excess of $2,500,000. Actually, suppression costs were only $55,000 and resource damage was just a little over $23,000. This indicates a potential savings of $2,400,000.

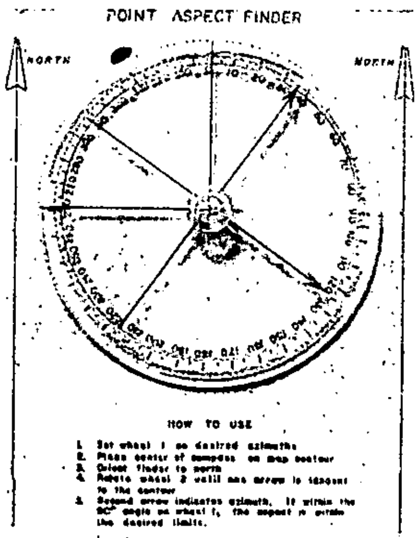
## The Result

The savings of over $25 million in suppression costs and resource damages were estimated for these three fires alone. The Tonto National Forest Hot Shot Crews were a key factor in their early control. Similar hot shot crews, strategically located throughout the West, are helping to protect parts of America's vast store of natural resources. As can be seen above, they are paying their way!

Handline construction is the hot shot crew specialty.

# New Map-Working Tool Designed

**_Lorraine Seger_**
**_and Clara Frobig_**




**The point-aspect finder.**

The point aspect finder (PAF) is a simple clear plexiglass tool designed to rapidly and accurately locate desired aspects, or positions of sloping land, on topographic maps.

## PAF Is Used In Colorado

In Colorado it is being used by technicians to delineate areas of south and southwest aspect. These aspects are components in wildfire-hazard area identification. The PAF is also being used in various resource inventories which require accurate aspect information for evaluation with other inventory data.

Finding an aspect accurately on a topographic map involves a little simple geometry—the perpendicular of a line which is tangent to a point on the curve (contour), etc. Some people determine aspect by ocular examination of a topographic map. Another technique commonly used to find aspects involves the use of an azimuth circle and a ruler. Positioning two instruments on a point on a map contour line is very tedious and time-consuming. Still another tool in use is the three-arm protractor.

The PAF works on the same geometric principle as these instruments but requires much less manipulation of separate parts. Thus, different workers with different levels of ability and patience can produce results of nearly identical accuracy. An accuracy of ±2° can be obtained, making the PAF about 25 percent more accurate than the other techniques.

Persons using the PAF can delineate aspects approximately twice as fast as when using other instruments. When aspects on numerous maps are being identified, the time saved translates into significant dollar savings.

## PAF Is Simple To Use

Anyone who can read a topographic map can use the PAF. It can be used in the office or in the field. The size of a small pocket compass, it is convenient to carry but large enough not to be easily lost. In the field, PAF readings from a map may be checked with ground truth.

Vegetation or solar radiation studies might employ aspect as a variable. The PAF is useful in such studies if accuracy is a must. Additionally, it can be used for any work in which a single angle from some axis is measured.

The point aspect finder was developed by the Colorado State Forest Service (CSFS). The CSFS is responsible for providing guidelines to the identity of wildfire hazard areas. Classification criteria and definitions are provided for wildfire hazard components, fuel, factors, topographic factors, and fire oc-

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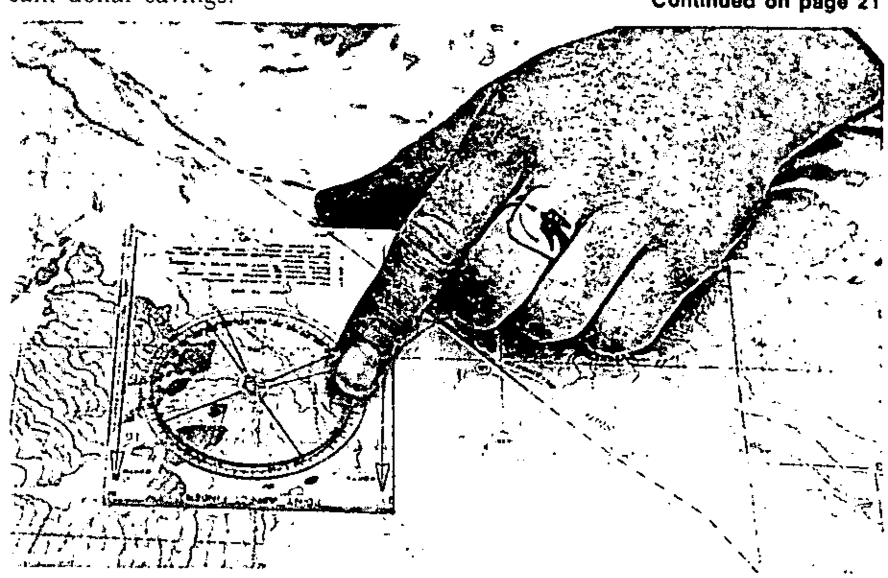

**The point-aspect finder aligned for use on a topographic map.**

*Lorraine Seger and Clara Frobig are Engineering Aids, Colorado State Forest Service, Fort Collins, Colo.*

# Fire Management in Everglades National Park

*Larry Bancroft*

**Before man, lightning fires created and maintained pine forests sand sawgrass glades (NPS photo).**

Fire is a natural factor of the Everglades that helps to perpetuate the pine forest and maintain the grasses and sedges in the glades (a grassland with scattered islands of trees). Prior to the arrival of European man, lightning fires reduced hardwood competition with the pine, thereby assuring the perpetuation of the pine type. These fires also interacted with water during the wet season from June to October to inhibit hardwood invasion into the glades.

Since 1900, the role of fire in the Everglades has changed drastically. Because of man's activities, drainage for flood control and land development has lowered the water level as much as 5 to 6 feet below historical levels. This has resulted in the loss of much of the organic soil which acts as a sponge to hold water. As drainage continued, the incidence of man-caused fires increased, particularly during the dry season from November to May. Many saw grass glades and tree islands were destroyed by deep-burning fires. Exotic plants invaded thousands of acres of disturbed glades and pineland and displaced native vegetation. By the 1940's much of the Everglades was changed by the drainage and increased fire stress.

In a climate in which there is a wet and a dry season, soil moisture is a critical factor influencing the effects of fire on vegetation and animal populations. Fires that occur during the wet season have little serious effect on the plant and animals, because the glades are usually flooded. However, during the dry season, the surface water disappears and the organic matter becomes combustible. During severe droughts, when the humus layer moisture content drops below about 40 percent (oven dry weight), tree islands (hammocks, bayheads, and cypress heads), and the saw grass peat soils will burn.

## Fire History

Fires in Everglades National Park are large because of the wide expanses of flash fuels. Between the time the Park was established in 1947, and the present, 335 recorded fires have burned an estimated 315,000 acres (128,000 hectares). Man-caused fires, occurring mainly during the dry season, accounted for 191 of these fires (239,000 acres or

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97,000 hectares), while lightning, occurring mostly during the wet season, accounted for the remaining fires.

Early fire suppression efforts were generally successful during wet years and before drainage lowered the water levels. However, during severe drought years, control of peat fires and fast-spreading glades fires was impossible. The tracked vehicles used in fire suppression efforts left scars that are still visible today.

It was imperative that a fire management program be developed. Before the program could be implemented, the exact role of fire—as related to other environmental factors such as water, soil, man, and exotic plants—had to be determined.

Fire ecology studies were initiated in 1953 and have become an important part of the Park's fire management program. In fact, Everglades was the first National Park to institute a prescribed burning research program, doing so in 1958. The results of these fire ecology studies are the basis of the fire management program. The program initially was in accordance with the National Park Service Natural Fire Policy implemented in 1968, and was revised in 1975 to meet the new National Park Service Fire Management Policy.

## The Everglades Fire Management Program

It was recognized that the natural ecosystems in Everglades had been so altered by man that allowing only natural fire to burn and suppressing all man-caused fires would not perpetuate the fire maintained cover types—the pine forest and glades.

The main objective of the program is to integrate fire management and water management in the Park in order to perpetuate a dynamic ecosystem characterized by the vegetative mosaics of pine forest, interior glades, and coastal prairie. The program is updated as necessary to reflect new knowledge and to accommodate changes in both National Park Service fire policy and the management of lands adjacent to the Park.

Fires are classified as either management fires or wildfires. *Management fires*—including lightning-caused, man-caused, and prescribed burns—contribute to the attainment of the resource management objectives of the Park. All fires not classed as management fires are *wildfires*. The basic plan includes provisions for all fires as outlined below:

- Lightning-caused and man-caused fires, occurring under a favorable prescription and when they meet approved resource management objectives, are allowed to burn in certain zones at certain times.
- Prescribed burning is conducted when other management fires do not occur with enough regularity to maintain the pine forest and glades.
- Smoke is a major consideration in the classification of fires. Fires which produce smoke that will affect metropolitan areas, are classed as wildfires and suppressed.
- All management fires are contained in predetermined fire management units.
- All fires that threaten cultural resources, physical facilities, threatened or endangered species, or human life; threaten to escape from the park; or otherwise do not meet the prescription are classified as wildfires and suppression or contained.

**Everglades National Park was the first park to use prescribed burning to perpetuate a natural community (NPS photo).**

## Fire Management Units and Prescriptions

Three fire management units of some 705,000 acres (285,000 hectares) comprising the mainland portion of the Park are described in the Fire Management Plan.

Unit 1 — Mangrove/Coastal Glades (328,000 acres or 133,000 hectares)

Unit 2 — Glades (357,000 acres or 145,000 hectares)

Unit 3 — Pineland (20,000 acres or 8,100 hectares)

Fire management prescriptions had to be developed for each of these units to insure all management fires occur and remain within acceptable fuel, soil, and weather conditions. The two most important parameters are drought index (Keetch and Byram 1968) and soil moisture; other parameters include wind direction and fire location in respect to high value areas.

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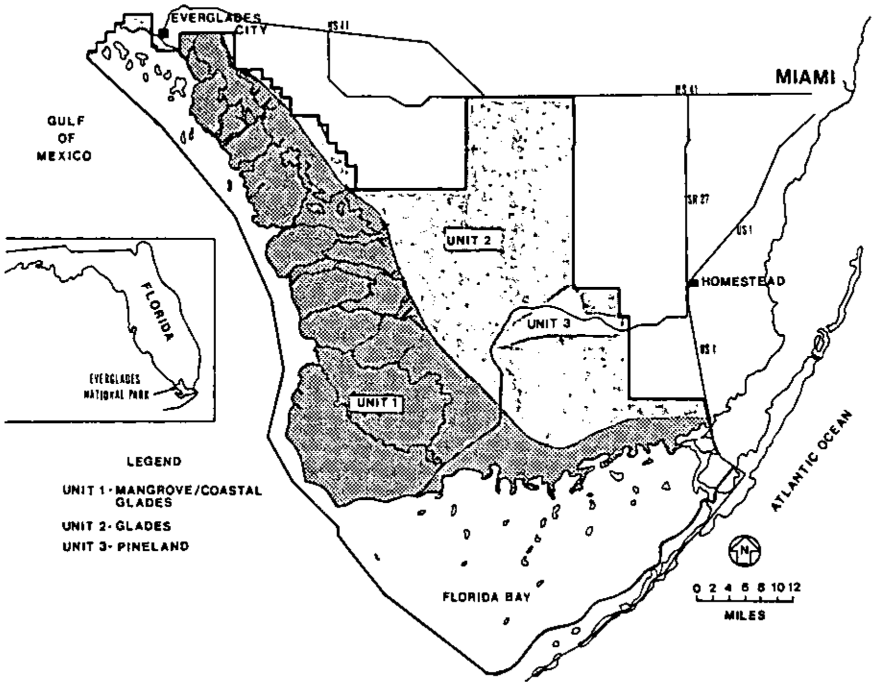


**Everglades fire management units.**

## Wildfires

Depending on the fire prescription, wildfires are either contained or suppressed. The techniques chosen are the ones that will do the least amount of damage to the resources while still controlling the wildfire.

When the organic soil moisture is 40 to 45 percent (oven dry weight) and the drought index is 550 to 600+, all fires are declared wildfires and are either suppressed or contained. Fires occurring when organic soil moisture is greater than 45 percent and drought index is less than 550—and when the remaining prescription requirements are met—are in the observation prescription and declared management fires.

Since 1972, a total of 126 fires, 44 man-caused (86,000 acres or 35,000 hectares) and 82 lightning-caused (15,000 acres or 6,000 hectares), have occurred. All of the lightning fires and 22 of the man-caused fires (7,000 acres or 2,800 hectares) were declared management fires. The remaining 22 man-caused fires were declared wildfires and were contained or suppressed.

Total cost was $9,300 for all management fires and $70,600 for all wildfires.

Six major wildfires (one suppressed and five contained) burned 61,500 acres (25,000 hectares) during the severe drought of 1974. Due to the severe burning conditions, direct attack was impossible. Damage to hammocks and saw grass communities, although extreme, was much less than would otherwise have occurred because prior prescribed-burning operations had reduced fuels prior to the fires.

## Prescribed Burns

Because of the unnaturally low water table during much of the year, many wildfires must be suppressed or contained. Fires that are designated as management fires often stop at roads or airboat trails. Therefore, prescribed burning has become necessary to achieve the resource management objectives. Currently, about 10,000 acres (4,000 hectares) are prescribed burned annually at an average cost of about $1.36 per acre ($3.36 per hectare). Some 177 prescribed burns (40,000 acres or 16,000 hectares) have been conducted since 1972. These costs are expected to decrease as prescribed burning techniques and prescriptions are improved. Prescribed burns are initiated in highly sensitive areas, such as along the Park boundaries and near administrative sites, where the ignition point must be preplanned.

They are also started in areas that do not get enough lightning- or man-caused fire starts to meet the objectives of the management plan.

**Prescribed burning is used to perpetuate sawgrass, a fire-dependent species (NPS photo).**

## The Future

The fire management program in Everglades National Park will expand in the years ahead. Research regarding the effects of the fire management program on plant communities and animal populations will be expanded, because it is *vital* that we know the short- and long-term impacts of our program on the ecosystem. The program will change as the ecosystem changes and as we acquire more knowledge about fire. If water levels continue to drop, fewer fires will occur in an acceptable prescription. Because of these conditions, more prescribed burning may be needed to reduce fuels and fire damage during the more frequently occurring droughts. By intelligently managing fire and water levels that generated this unique environment the vegetation mosaic of Everglades National Park will be perpetuated for future generations to enjoy.

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## PAF
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currence factors. Colorado land-use legislation likewise charged the CSFS with mapping wildfire hazard areas in areas receiving much subdevelopment pressure. The PAF has proven to be an effective tool in this work.

The PAF is made of clear plexiglass and is 3 by 4 inches (7.62 by 10.16 cm) in size. An azimuth circle and a north-orientation arrow are etched in the rectangular base. Two transparent wheels, that rotate independently on a common axis, are mounted on the base. An arrow is etched on each wheel. When the PAF is placed on a map and oriented to the map north, the wheel arrows can be positioned on a contour line and the wheels rotated slightly to determine the aspect. The device identifies one of four 90° aspects (N, E, S, W) or two of eight adjacent 45° aspects (N, NE, E, SE, etc.).

Patent application has been made through the Colorado State University Patent Office. Manufacture of the tool is dependent on sufficient demand. For more information contact Lorraine Seger or Clara Frobig, Colorado State Forest Service, Building 360, Foothills Campus, Colorado State University, Fort Collins, Colo. 80523, phone (303) 482-9512.

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## SUBJECT INDEX–con't.

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