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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 22 Number 1

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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NOTE: The April 1961 Fire Control Notes will emphasize Fire Suppression. Special assignments of certain articles have been made but the editor would welcome additional items on this general subject. These should reach the Washington Office by February 1.

ALINEMENT CHART FOR PERIMETER INCREASE OF FIRES

ARTHUR R. PIRSKO
Forester, Pacific Southwest Forest and Range Experiment Station, U. S. Forest Service

An important statistic in fire control planning is the perimeter increase of a free-burning fire. Because this statistic describes what happens in the time period up to attack, or before any control action is taken, it provides a measure of the fire control job as influenced by weather, fuel, and topography. Therefore field data and computation of perimeter increase must be accurate.

One critical entry used in the California Region up to 1959 was the size of fire at discovery. The discovery size was used as the base size in computing net fire area before attack. Fire report analyses show the estimated discovery size to be so questionable that it is an invalid statistic. How accurate was a lookout's estimate of fire size when he was 15 or 20 miles from the fire? How could a lookout estimate fire size when the fire producing the smoke was on the back side of a ridge or hill? How dependable was a tourist's estimate of fire size when he stopped at a ranger station to report a fire?

In view of questions like these, the California Region is now bypassing the discovery size estimate in computing acres burned before attack. Perimeters of fires will only be calculated when the time of origin is known. Initial fire size will be assumed to be a spot or slightly larger. Rate of perimeter increase will be based on elapsed time between origin and attack.

The perimeter of a fire is a function of its shape. To find the rate at which a fire perimeter increases, we need information on shape, size, and time. Estimations by the initial attack crew as to fire shape and size must be reasonably accurate. The perimeter increase is usually expressed in chains per hour. Elapsed time can be determined rather precisely now that radio communication gives the dispatcher more exact times of attack than he had in the past.

The need for careful observation and computation was shown in a recent study correlating perimeter increase with fire-weather variables. Thousands of individual fire reports were scrutinized to see if the perimeter increase agreed with the source data of net acres and elapsed time. A high percentage of the reports failed this simple cross check. One fire, for example, was reported as having burned 2 acres in the 43 minutes before attack. The rate of perimeter increase was given as 10 chains per hour. This is impossible. The smallest perimeter for any given area is the circumference of a circle, which is 16 chains for 2 acres. To get a perimeter increase of 10 chains per hour, a typically elliptical-shaped 2-acre fire could not have been attacked in less than 2 hours and 23 minutes. If the 43 minutes is a correct entry, then the fire could only have burned 2/10 of an acre. Which entry is

incorrect? The fire planner is not in a position to judge so he is forced to discard this fire report as invalid data.

The greatest source of error, assuming size estimates to be reasonably accurate, probably is in arithmetic—in converting minutes to multiples of an hour, or in converting acres burned to chains per hour.

Hornby[1] provided some help in reducing error when he presented tables correlating fire area and perimeter by 3 shape classifications, but these tables did not help with time computations.

A simple straight line alinement chart presented here (fig. 1) takes care of the entire job. When the time from origin to attack and the acres burned in that time are known, the perimeter increase in chains per hour can be read directly from the chart.

Use the alinement chart this way:

1. Locate on the lefthand vertical column the elapsed time (in minutes) from origin to attack.
2. Locate on righthand vertical column net acres burned.
3. Lay a straightedge on the chart so it intersects the time and acres found above in steps 1 and 2. Where the straightedge crosses the middle vertical column, you will find the perimeter increase in chains per hour.

For example, given:

Origin to attack time—30 minutes. Area at attack—0.75 acre.

Then:

1. 30 minutes is located near the middle of the lefthand column.
2. Locate the 0.75 acre on the righthand column.
3. Use a straightedge to intersect the 30 minutes on the left and 0.75 acre on the right column. Where the straightedge crosses the middle column, the perimeter increase of 29 chains per hour is found.

The perimeter increase in the alinement chart is based on a fire perimeter being 1½ times the circumference of a circle. Such a perimeter relationship describes a fire shape where the length is twice the width. Hornby found that nearly all fires had a perimeter 1½ times the circumference of a circle. Experimental rate of spread tests conducted in California showed the same relationship. Exceptions occur in steep topography or when winds exceed 20 miles per hour.

These exceptions are taken care of in the Fire Shape Correction chart (fig. 2). The perimeter increase found in the alinement chart is multiplied by factors ranging from 0.67 for a circular fire to 1.33 for a flattened elliptical fire. Such correction calculations are simpler than other methods as the basic data is already converted to a length per unit time number. Correction examples are shown in figure 2.

Fire control planners will continue to need accurate base data to properly evaluate the size of the fire control job. Guides such

[1]Hornby, L. G. *Fire Control Planning in the Northern Rocky Mountain Region.* Northern Rocky Mountain Forest and Range Expt. Sta. Progress Rpt. 1, 179 pp., illus. 1936.

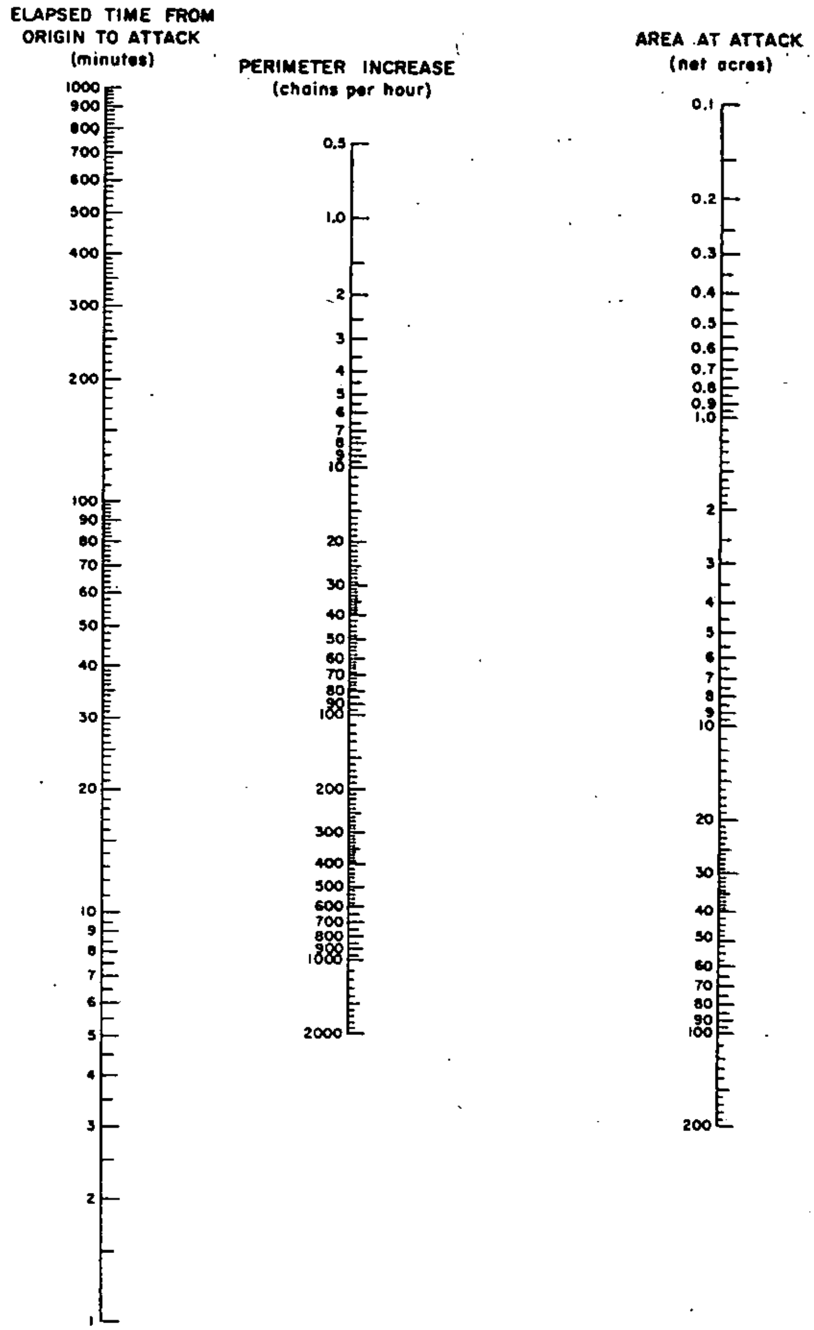
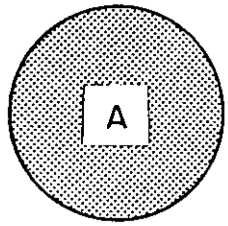
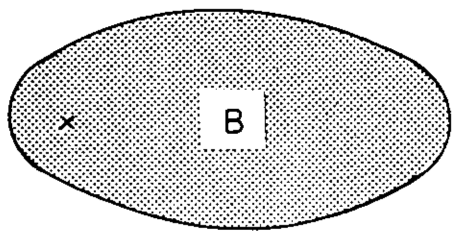


FIGURE 1.—Straight line alinement chart, perimeter increase of fire when time and acres are known.



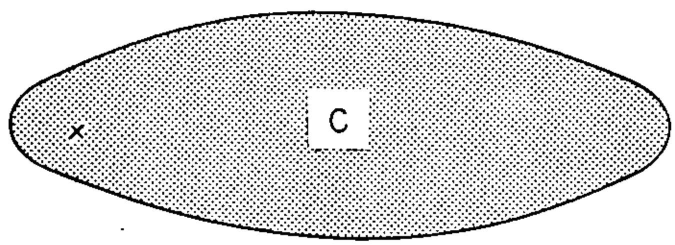
FIRE SHAPE: EQUAL LENGTH AND WIDTH. MULTIPLYING FACTOR: 0.67

If the fire shape is a circle (fire shape A), multiply the normal perimeter increase by 0.67. In our example the 29 is multiplied by 0.67 and becomes 19 (rounded off from 19.43). Fire shapes between A and B would require other multiplying factors between 0.67 and 1.0. Use your estimate of the factor for correction.



FIRE SHAPE: LENGTH IS TWICE THE WIDTH. MULTIPLYING FACTOR: 1.0

If the fire is as fire shape C, then multiply the normal perimeter increase by 1.33. In our example, 29 x 1.33 becomes 39 (rounded off from 38.57). Fire shapes in between B and C require other multiplying factors between 1.0 and 1.33. Use your estimate of the factor for correction.



FIRE SHAPE: LENGTH IS THREE TIMES THE WIDTH. MULTIPLYING FACTOR: 1.33

Figure 2.—Fire-shape correction for perimeter increase. NOTE: Multiplying factors below 0.67 are erroneous as the circumference of a circle represents the smallest perimeter for any given area.

as this alinement chart for computing perimeters will help them eliminate mechanical errors that may invalidate basic planning data. The alinement chart can also be used to speed up the checking of many fire reports at the end of a fire season.

SURVIVAL CLOTHING FOR FOREST-FIRE FIGHTERS

[From An Interim Progress Report by the Missoula Equipment Development Center, U. S. Forest Service.]

In cooperation with the Quartermaster Research and Engineering Command, the Forest Service has developed and tested several types of forest-fire fighter survival garments of heat-reflecting and fire-resistant materials. The Missoula Equipment Development Center, where development work has been in progress since 1959, recently tested various pilot models of fire protective clothing under burning conditions at temperatures and duration of fire believed to exceed those that would be encountered in most brush and forest fires (fig. 1).

Twelve items were placed on dummy frames at two locations within a mass fire test area of about 4 acres. Approximately 500 tons of assorted dry scrap lumber was placed in 75 piles 20 by 15 by 7 feet spaced 12 feet apart in three concentric rectangles. The corridors between rows were about 40 feet wide. The fire burned with intense heat for 2 hours (fig. 2).

Motion photographic coverage was made periodically during the fire. Films showed that the garments were subjected to intense flailing and buffeting from the fluctuating thermal air currents. They show in some cases that the garments were engulfed in flames for split-second periods. Completely adequate and reliable temperatures were not obtained because of lack of suitable

FIGURE 1.—Survival clothing located in mass fire area.

FIGURE 2.—Mass fire 20 minutes after ignition.

FIGURE 3.—Paper-foil cone before fire. Material is scrim-reinforced crepe paper laminated to 0.00035 aluminum foil. Weight, 2 pounds 10 ounces.

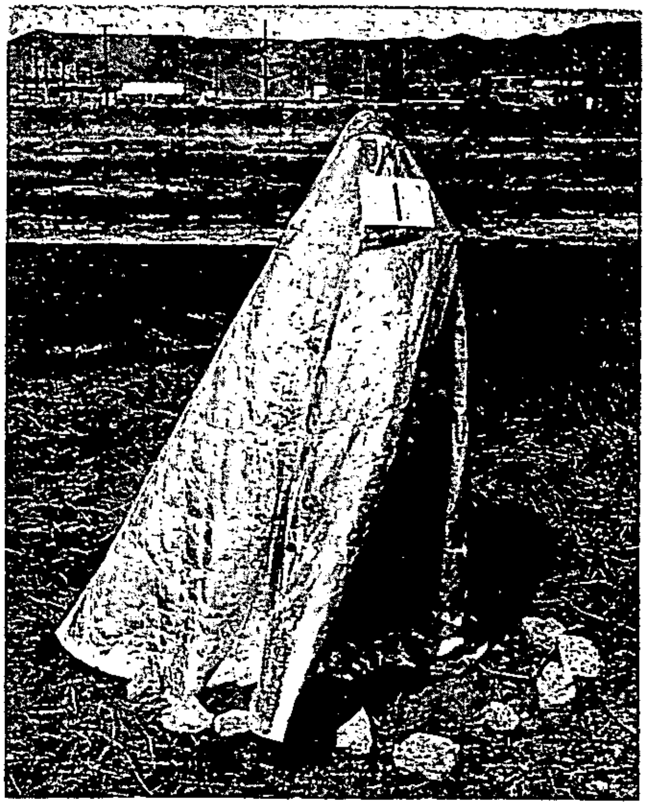


FIGURE 4.—Paper-foil cone after fire. Outside sustained temperature, 750 degrees. Air temperature inside garment, 300 degrees.

thermocouple equipment that would give a time-temperature history. While the temperature measurements were of a rudimentary type they nevertheless furnished relatively good information as to the durability and reflective efficiency of the garments. Maximum sustained temperatures were 188 degrees Fahrenheit 40 feet from piles, 750 degrees 12 feet away and 1800 degrees at the edge of piles.

It was found that the simplest designs, the aluminized paper cones, gowns, and bags offered more protection than the complete suits (figs. 3, 4, and 5). This might be due to the greater inside air volume since the paper-foil rigidity and more spacious design prevented them from deflecting and collapsing under erratic thermal air currents. In most instances heat energy absorption and temperature rise was less in the roomier garments. From the standpoint of reflectivity, the paper-foil laminates are equal if not better than the expensive aluminized fabrics. The aluminum surface of two fiberglass garments deteriorated under temperatures that had no damaging effect on paper-foil garments. Aluminized fabrics are more durable and will withstand flex and

FIGURE 5.—Quartermaster Research and Engineering Command proximity suit. Material is scrim-reinforced flameproof kraft paper laminated to 0.00035 aluminum foil. Weight, 3 pounds.

tear damage better. However, it is believed that the paper-foil garments are sufficiently durable as an expendable protective garment for forest-fire fighters.

Prone or sitting positions seem to offer the best chance for survival in fire entrapment, but further tests with better instrumentation are needed to establish the best positions and procedures to be followed in emergency situations. The survival clothing development project is scheduled for completion early in 1961 at which time a project report will be published.

WHAT DO PEOPLE KNOW ABOUT FIRE PREVENTION[1]

CRAIG C. CHANDLER, *Pacific Southwest Forest and Range Experiment Station*, and JAMES B. DAVIS, *California Division of Forestry*

You have to be carefully taught. Although this is the title to a song from a recent stage play and motion picture, it could well be the basis of our forest fire prevention effort. More and more we are finding that education is the key to success in forest fire prevention. But it must be a careful education, and we are finding that half an education may be no better than none. This is because a successful fire prevention campaign is one that does two things—

It teaches *why* we must be careful with fire.
It teaches *how* to be careful with fire.

Simple, isn't it? But the prevention man faces several problems in trying to apply these two easy maxims. The first problem in organizing a prevention campaign is how to divide the total effort between the "why" and the "how."

After this question has been answered, the prevention man faces the problem of what to teach. To catch and hold attention, information must be important, clear, and fresh. If the presentation is too technical, people are confused. Too simple or trivial information, on the other hand, can be boring or downright insulting.

These problems can be solved only if we know what the forest-using public already knows and believes about fire prevention. It becomes obvious that if we are to be good teachers we need to know a great many more facts about the people we are trying to teach.

To supply these facts is the object of research being conducted by the University of Southern California School of Public Administration under a contract with the Pacific Southwest Forest and Range Experiment Station. A recent progress report prepared by the University of Southern California staff offers some interesting reading for those concerned with forest fire prevention.[2]

This report discussed primarily the part of the research which sought to devise various kinds of questions that could be used in future surveys of the fire prevention knowledge and attitudes of various forest-using groups. Secondary aims of the study were to try various methods of administering questionnaires in the field

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[1]Issued August 1960 by Pacific Southwest Forest and Range Experiment Station as Miscellaneous Paper 50.

[2]Herrmann, W. W. *Progress Report on Research Activities Relevant to Human Behavioral Aspects of Forest Fire Prevention.* Univ. South. Calif. School Public Admin., 188 pp. 1959. [Processed.]

and to develop a program for rapid processing of questionnaire results by electronic computers.

Eight questionnaire forms were tested. Five of these were designed for forest recreationists and three for summer home owners. Some of the forms were used by a trained interview team from the University of Southern California, some by forest fire prevention personnel with the assistance of a trained University interviewer. Still others were used by prevention personnel aided only with written instructions. The next step was the establishment of an analysis program for the computing equipment at the University.

The University of Southern California researchers now have the tools they need, including interview techniques, computing procedures, and a stockpile of questions for the next phase of the test—a large-scale survey of California hunters that should provide a definite answer to the question "What do people know about fire prevention?"[3]

In addition, an important bonus benefit was obtained from the preliminary tests. The progress report goes to some length to point out that the results of the eight test questionnaires should be accepted with caution. Each of the questionnaires was designed and administered differently. Consequently, the data could not be pooled, and no rigorous statistical treatment was possible. Nevertheless the answers are quite informative. Certain patterns of response run consistently through the whole series. A subjective appraisal of the 2,645 questionnaires that were completed shows some leads that may be of direct benefit to fire prevention program directors.

Men scored consistently better than women in fire prevention knowledge. This is hardly surprising in view of the subject matter.

People in the age bracket from 25 to 50 had the most correct information on fire prevention. Under age 25 the problem seemed to be one of lack of information, and over 50 one of misinformation.

Except among workers in lumbering and forestry, who scored consistently high, knowledge of fire prevention paralleled quite closely general educational and intellectual level as indicated by occupation. One rather disturbing fact is that agricultural occupations, which should be exposed to more fire prevention information than many other classes, scored lower than people in professional, sales, clerical, and service categories. In view of the exceptionally high level of knowledge in the lumber industry, it appears that we have failed to reach the rancher-farmer with our present fire prevention program.

Length of residence in California did not affect the scores, but length of residence in the local area had a very marked effect.

[3]A 2 percent survey of California hunters will be conducted by the University of Southern California School of Public Administration during 1960, using a systematic sample of hunting license records provided by the California Department of Fish and Game. This study is being financed jointly by the U. S. Forest Service and the California State Division of Forestry.

This seems to shoot holes in the often expressed idea that it is the newcomers to California who are our biggest fire problem.

Local residents had more fire prevention knowledge than visitors. Local residents who neither hunt nor fish did better on the recreationist questionnaires than did hunters from outside the area. Yet statistics on fire causes show that 60 percent of California's man-caused fires are started by local residents. It would appear that we have a situation where the local resident knows all about fire prevention but doesn't much care, while the city visitors have a very good attitude towards prevention but just don't know what to do to prevent fires.

Perhaps some of the problems implicit in the above paragraph can be explained by an analysis of the sources of information. It was immediately apparent from such an analysis that people get little "how to do it" information from the organized, mass media fire prevention campaigns. This should be accepted as a statement of fact and not an implied criticism of the mass media programs. The primary intent of any large-scale advertising program is to condition attitudes and make people aware of a product or situation, not to impart specific knowledge. In arousing a desire to "prevent forest fires," the mass media campaigns have been outstandingly successful with the audience for which they were designed.

In any event, if we exclude "common sense," an often listed source of both information and misinformation, the analysis shows that more correct and less incorrect information was obtained from talking with other people than from any other source. This seemed to be true regardless of whether the people were our own employees, parents, friends, or the gas station attendant.

Looking at the content of individual questions, one fact stood out like a sore thumb. We have apparently failed to get acceptance of the necessity for hazard reduction around buildings. This was in the top five most commonly missed questions in every questionnaire where it appeared. All the alternative answers were for clearance requirements *less* than adequate, and of the residents who answered correctly, half of them merely guessed that the largest clearance listed was the one they ought to put down.

There are two other general areas of misinformation that may be of practical importance. The California burning permit regulations were not well known by local residents. It may be argued that because nearly everyone who missed these questions thought that the requirements were more strict than they actually are, the level of knowledge in this area is no cause for concern. However, it is unlikely that anyone who believes that a burning permit is required for all fires for all 12 months of the year has ever applied for a permit. Therefore, the misinformation about permits probably means that the individuals concerned have either never needed a permit or never bothered to obtain one.

The campfire permit of the Forest Service also appears to be a subject of misinformation. About one-third of the people sampled thought the permit was valid on private as well as public land

within a national forest, and 10 percent thought it was a blanket permit, good on any land in the State.

There are other areas that may pose particular prevention problems as indicated by these preliminary surveys, but in most cases the questions need to be revised to give significant guides for action.

The six words, "You have to be carefully taught," were extremely successful for their writers. There is good reason to believe their application, guided by the facts about what people know (or don't know) about fire prevention, will be equally successful for us.

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Diesel-Powered Tractor Starts Fires

Quite a few people hold the belief that diesel-powered equipment will not start fires. Unfortunately this belief has been strengthened by some unsuccessful attempts to prove that exhaust sparks from diesel engines will ignite forest fuels. We now have eyewitnesses to an actual case which will be of interest to fire control people.

On July 12, 1960, at 11:00 a.m., 4 fires were started by a diesel-powered tractor at the Missoula, Mont., airport. The tractor was equipped with a 4-yard end loader. The exhaust pipe was extended over the hood of the engine as a part of standard equipment, but there was no spark arrestor. The owner of the tractor stated that it was a 1954 model and had approximately 200 hours running time since it had been overhauled.

The machine had been idling for a short time before the operator put it in high gear and gunned the motor. He traveled a distance of 395 feet from the spot where it was idling and in this distance started four fires at intervals of 140, 90, and 130 feet. Each fire burned approximately one-tenth of an acre before it was brought under control.

The fires were observed by the writer and one other person who were on the fires immediately and started an investigation while the tractor was still near the scene of the last fire. The tracks of the tractor were plainly visible through the burned areas; the fires started within and adjacent to these tracks.

The investigation disclosed conclusively that the fires were started from hot carbon particles blown out of the exhaust and landing in flash fuels under weather conditions favorable for ignition.—E. R. DE SILVIA, *Chief, Division of Fire Control, Northern Region, U. S. Forest Service.*

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Safety Signaling Device For Crew Trucks

A small red light mounted in the cab, about 20 feet of wire, and a push button mounted in the rear of the truck may prevent a serious accident. Its purpose is to provide a fast and positive means for the crew in the back of the truck to signal the driver in case of any emergency that might arise. With the push button mounted at a handy location it eliminates the need for a crew member to leave his seat to yell or pound on the cab to get the driver's attention. [Ed.—See also "Rear-Step Push Button for Enclosed Cab Fire Trucks" by Anne C. Holst, Fire Control Notes 17(2): 21. April 1956.]—ROBERT K. HAZARD, *Suppression Crew Foreman, Eldorado National Forest.*

WHAT PEOPLE THINK ABOUT FIRE LAW ENFORCEMENT[1]

JAMES B. DAVIS, *California Division of Forestry*, and CRAIG C. CHANDLER, *Pacific Southwest Forest and Range Experiment Station*

There is an old story about a farmer that had a very intelligent, hardworking mule. However, always before giving it a command he hit the mule between the eyes with a baseball bat. Not because the mule needed discipline, but because this was the only way the farmer knew to get the mule's attention.

In a sense this may be the problem that we face when we try to get compliance with forest fire laws in California. Are people paying attention to fire safety rules, and, if not, should we make more use of our legal baseball bats to insure their attention? A recent study may give us some clues.[2]

The study was conducted by the University of Southern California under contract to the Pacific Southwest Forest and Range Experiment Station. Its objective was to develop the framework for a larger scale research study to determine the attitude of the public toward law enforcement. Though primarily a search for satisfactory experimental design, this pilot test points out some important differences between violators and nonviolators as a group. The results show that the average fire law violator is an honest, intelligent citizen, well aware of the importance of fire prevention, but that we have just failed to get his attention on specific fire regulations.

Since the study sought to find differences in attitude and knowledge between fire law violators and nonviolators, Dr. Herrmann prepared two lists of persons. Names and addresses were obtained from lists of property owners on file at the Big Bear sheriff's substation, from Arrowhead District Ranger Station, and from license numbers of cars driven by forest motorists.

The names of fire law violators were taken from the law enforcement records of the San Bernardino National Forest. The violators came from 66 towns and cities throughout southern and central California. Their distribution was about what could be expected, taking into consideration population and distance, with two possible exceptions. No violators were "out-of-State" residents, and only 11 percent of the violators were forest residents despite

[1]Issued August 1960 by the Pacific Southwest Forest and Range Experiment Station as Miscellaneous Paper 51.

[2]Herrmann, W. W. *A Research Design for the Evaluation of Attitudinal Aspects of Fire Law Enforcement.* Univ. South. Calif. School Public Admin., 48 pp. 1960. [Processed.]

the fact that nearly half of the use and slightly more than half of the man-caused fires on the San Bernardino Forest come from local residents. Of 675 people in the combined lists, 256 nonviolators and 42 violators agreed to cooperate in the study.

Admittedly the 298 persons sampled is a very small percentage of the San Bernardino Forest's visitors, let alone California forest visitors. Yet the study can give us some pretty good ideas on how people feel about fire law enforcement in southern California. In addition it gives us some information on the makeup of the fire law violator group.

WHAT KIND OF LAWS ARE VIOLATED?

For the most part the laws were *not* broken because of a lack of what could be called "common sense." They were rather specific regulations that needed to be learned and some of them actually involved forestry jargon or shop talk. For example, the most persistent violation concerned fire closure areas. The USC researchers found "closed area" means many things to many people.

The 138 violations were broken down in the following way:

Closed area	62
Improper use of fire	44
Smoking illegally	9
Trespass	3
Miscellaneous	20

The miscellaneous group includes such items as dumping hot ashes, blasting without a permit, and inadequate spark arrestors.

DO FOREST USERS KNOW THE LAW?

Most people think that it is difficult to keep from violating fire laws. Thirty-one percent of the nonviolators and 53 percent of the violators said that they did not have enough information about laws or rules to avoid breaking them.

When asked "Do you think it is easy or difficult to get information concerning forest fire prevention rules?" both groups agreed that it was pretty difficult. Forty-two percent of the nonviolators and 48 percent of the violators thought that it was either difficult to get information or had never tried to get it.

Even more striking, 53 percent of the nonviolators and 71 percent of the violators believed that fire prevention laws are *not* known to most other people.

WHAT DO PEOPLE THINK ABOUT FIRE LAWS?

Even though they don't know what the laws are and can't seem to find out, most people questioned think that fire laws are as important as traffic laws. This applies for both violators and nonviolators. People were definite about this point; only about 5 percent said they didn't know about the relative importance, and some of the nonviolators tended to consider fire laws even more important than traffic laws. When asked "Which would you observe more carefully?" most people said they would observe fire laws "about the same" as they would traffic laws.

HOW DO PEOPLE FEEL ABOUT FIRE LAW ENFORCEMENT?

Reaction to enforcement depends to a degree on whether one is a violator or a nonviolator. The great majority—87 percent—of the nonviolators thought that there should be more law enforcement. The violators were not quite so positive about this; many had no opinion, but less than half thought that there should be less enforcement.

Almost all the nonviolators believed that people contacted by a forest ranger regarding a violation are treated fairly. Only 3 percent thought the treatment might be severe. Of the violators, however, 30 percent said they had not been treated fairly. Although most thought their treatment had been fair, some believed that it had been severe.

WHO VIOLATES FOREST FIRE LAWS?

The survey indicates that most fire law violators were well-meaning persons who did not realize that they were making a mistake. However, some made "well-intentioned mistakes" outside the forest, too. When asked "Have you received any traffic citations in the past 2 years?" fire law violators answering yes outnumbered nonviolators three to one. Again, this seems to be a matter of lack of awareness, rather than disregard for law. For example, when asked to name some of the California National Forests they had visited, over half the violators named Yosemite, Joshua Tree, or other National or State parks. Only 5 percent of the nonviolators group make this mistake. Similarly, more than half of the violators said they had never seen a burned-over area even though such a sight is difficult to miss in southern California mountains.

TO SUM IT ALL UP

We find that San Bernardino National Forest visitors and residents think that fire laws are important. However, they think that it is difficult to get enough information to keep from breaking the law.

Despite an active fire prevention program which has had a notable effect in increasing public consciousness of the fire problem, we have not been very successful in calling people's attention to the fire laws. This is particularly true with the violator group.

In forest fire prevention there appears to be a real need to improve our educational methods. The baseball bat method was the only technique the farmer knew. We hope that continued research can find a more satisfactory method for foresters.

WHY TIE FIRE CONTROL PLANNING TO BURNING INDEX?

ARTHUR R. PIRSKO
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How many men? How much equipment? These questions are always asked when planning a fire control organization. Such questions are generally answered by a counterquery: "What values are you protecting and what burning conditions do you expect to encounter?" Experienced fire control men know that the key answer lies in an adequate description of burning conditions or expected fire behavior.

No two forest fires burn at exactly the same speed or intensity. One fire may creep through an area and burn only a part of the ground cover. On another day a fast spreading fire will burn the adjacent area clean of vegetation. If fuels and topography are almost the same in both areas, then the differences in fire behavior can be readily explained by changes in weather.

For all fire control agencies in California, the effect of changes in weather on the spread and intensity of fires is expressed in a burning index. The index is rated on a 0 to 100 scale with 0 meaning no appreciable fire spread and 100 meaning explosive spread and high intensity fires. The index tells the planner how fast the fire spreads, or in terms of job load how much fireline the initial attack crew must build to halt the forward spread of the fire. Consequently the burning index is a basic tool of fire control planning.

Given a picture of expected fire behavior, the planner designs the fire organization around initial attack crews. He also considers the resource values and the goals set up for protecting the resource unit. To protect resources for continued use, the present goal is to keep fires under 10 acres in size. Success in meeting this goal depends upon detection efficiency, plus adequate initial attack plans covering strength and speed of attack. California Region elapsed time standards for initial attack forces after discovery, which should be as soon as possible, are as follows:

Item	*Elapsed Time* — *Day (minutes)*	*Elapsed Time* — *Night (minutes)*
Report to dispatcher:		
Forest Service phone or radio	2	2
Other phone line	5	5
Fireman get-away:		
Foot or car	2	5
Saddle horse	5	10
Pack horse	10	20

Because initial attack is directed at small fires, all planning tools aim at the small size fire. Every tool, no matter how it is

designed, has one primary purpose, and also limitations of use. The burning index is no exception. It is specifically designed to measure the influence of weather alone on the spread and intensity of fires. The burning index, as an administrative tool, cannot be used as a direct measure of large fire behavior when weather is no longer the prime controller. Some high intensity fires need be only a few acres in size before they exceed the design limits of the burning index.

A key question the planner asks is "How much time does the initial attack crew have to do the job?" Time is the firefighters' biggest asset and should not be wasted. Every minute saved in attacking a fire means a reduction in the amount of fireline needed. The less fireline there is to build, the fewer number of men are needed to do the job.

The interrelationship between men, time, and burning index is illustrated in figure 1. Charts like this are used as fire planning guides in the California Region of the Forest Service to determine needed goals for strength and speed of initial attack. The charts are based on a correlation of rate of spread with the burning index as found through fire reports and weather records. In figure 1, the fuel type is second-growth pole-sized timber. For this fuel type, the fireline construction rate found by field tests is 0.5 chain (33 feet) per man-hour. The job load related to fire size at discovery can be found if the burning index is known.

How the chart is used can be shown if we assume a 0.2-acre fire is discovered on a day when the burning index is 10: Read up from burning index 10 until you intersect the 0.2-acre curve. Then read left to the vertical time axis. At this point we see that 270 minutes from now the fire will reach 10 acres in size. If a crew was at the spot, it would take 5 or 6 men to control the head of the fire and stop forward spread. Or, it would take 23 men to build a complete fireline around the fire before this 0.2-acre fire exceeded 10 acres.

But this estimate does not allow for report, get away, and travel time. If it takes 2 minutes to report the fire; 3 minutes to gather and load the crew in a truck; and 55 minutes to drive and walk to the fire, we have lost 60 minutes. The crew actually has only 210 minutes to build a fireline before the fire is over 10 acres. Eight men are needed to control the head of the fire, or 30 men to encircle the fire.

Suppose the burning index is higher, say 50. Then the 0.2-acre fire will reach 10 acres in 55 minutes. Even if the crew were on the fire at discovery time, 30 men would be needed to control the head of the fire, or 120 men to encircle it. If they were 60 minutes away, the protection goal would be lost before they arrived. To compensate for the changed burning conditions, the fire planner has two possibilities: cut travel time and add equipment to speed fireline construction.

Prompt attack buys time to do the job and is more economical than sending additional men. When burning indexes are high, the planner scatters additional crews throughout the area so that any location may be reached in less time. He avoids the pitfall of

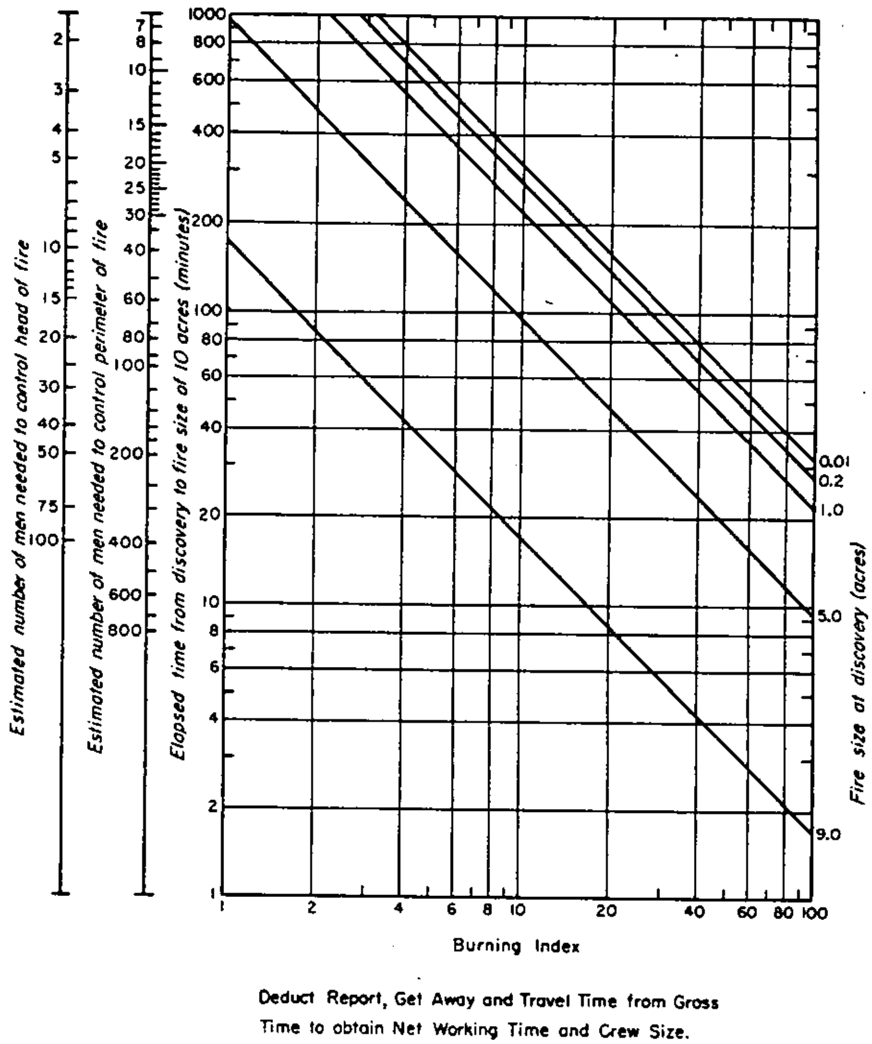

FIGURE 1.—The interrelationship between men, time, and burning index.

enlarging a 4-man crew to 10 so they would need a slow moving truck instead of a faster pickup. The planner aims at buying time rather than boosting the size of an individual crew.

When the burning index is 50, the planner need not give up because a 30-man crew is not available. He knows that the usual 60 minute discovery-to-attack time is inadequate and might plan for a 10-minute attack time. This means hiring additional crews and scattering their operating headquarters to buy time. With 10 minutes attack time, the fire will be 10 acres in size 45 minutes after the crew's arrival. It would still require 35 men to control the head of the fire. But extra men are not easy to hire, especially

for short-term jobs. The alternative is to add equipment such as pumpers, tractors, plows, or aircraft to compensate for the lack of manpower. Each piece of equipment can be evaluated as being worth so many men. The job load of the fire is then divided between men and equipment. Although such fire planning is complicated, it is unavoidable if we are to come near our resource protection goals.

To sum up, in designing the manpower and equipment requirements of a fire control organization, the planner needs information on how the fires will burn so that he can describe the potential job load. The tool he uses to evaluate fire behavior is the burning index. By considering the burning index and fire size at discovery, he can then plan for number of men plus amount and type of equipment needed to do the job.

☆ ☆ ☆

Date Stamp Converted To Fire Prevention Use

A secretary in the office of the Montana State Forester gets credit for this idea. She proposed for all our mailing a rubber stamp that kept a running count of the fires in the State. On investigation we found that a prevention message could be included as well.

An ordinary dater was made into the fire prevention stamp. Now, all outgoing mail from the office of the Montana State Forester carries a reminder of the fire situation and a fire prevention slogan.—E. THOMAS COLLINS, *Fire Prevention Forester, Office of Montana State Forester.*

MONTANA FOREST FIRES
TO DATE
Man Caused Lightning

218 782

Remember, only you can prevent Forest Fires

☆ ☆ ☆

Marking The Way To A Fire

"Use your pressurized marking paint to mark the way in to a fire", advises Dale Thompson, Management Forester of the Sedro Wooley District, Washington State Department of Natural Resources.

"Spray yellow paint on the road, either hard surfaced or dirt. On dirt roads, the paint will last for the first 24-48 hours. That's when people are most confused and there aren't any signs. Squirts on the leaves and duff will work as well as blazes."

"Dust will cover the yellow arrow in the road or other mark in a short time, but the various men going and coming from the fire scene can remark the spot in a few seconds. And by then there'll probably be a trail to the fire."

"The nice thing about paint is that it shows up well at night—and is located in a spot where the driver is supposed to be looking—in the road!"—From "Timber Tips," *U. S. Forest Service.*

TIME-TEMPERATURE RELATIONSHIPS OF TEST HEAD FIRES AND BACKFIRES[1]

LAWRENCE S. DAVIS and ROBERT E. MARTIN
Southern Forest Fire Laboratory, Southeastern Forest Experiment Station

Time-temperature relations were measured during the course of a preliminary investigation of the thermal characteristics of forest fires. Observations on 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs on the Alapaha Experimental Range near Tifton, Ga., are the basis for this report.

All burning was done on July 22, 1959, between 10 a.m. and 2 p.m., with air temperatures about 90° F. The moisture content of the upper layer of fuels, as measured by fuel-moisture sticks, decreased from 12 to 8 percent during the burning period. Winds varied from 1 to 4 miles per hour and the burning index was 1. Fuels, including litter and lower vegetation, averaged 5 to 10 tons per acre. Backfires advanced at the rate of about 1 chain per hour and head fires at the rate of 10 to 20 chains per hour. Temperature measurements were made at 3-second intervals as the fires (with about a 20-foot run) passed thermocouples located at 1- and 4-foot heights above ground.

Chromel-alumel thermocouples, when used with leads insulated with fiberglass and stainless steel mesh, were very satisfactory in these tests. Milliameters were used as measuring devices because they are relatively cheap and are readily wired and transported. Recording potentiometers would serve the purpose better but are expensive and more cumbersome to use in the field.

Composite time-temperature lines for these head and backfires are plotted on the accompanying chart (fig. 1). At the 1-foot level, the head fire temperatures rose abruptly to a maximum of about 1600° F. They then fell off, at first sharply, and then at a decreasing rate. The slower moving backfires produced temperatures from 250° to 600° F. at the 1-foot level and maintained this temperature range for several minutes. The second temperature peak associated with backfires occurred when the line of fire had passed the thermocouple, but the flames were still directed at it as a result of wind movement.

At the 4-foot level, head fire temperature peaks barely exceeded 500° F., backfire temperature peaks at the same level barely exceeded 125° F.

Lindenmuth and Byram[2] made a comparison of heat factors associated with backfires and head fires in the longleaf pine type.

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[1]This article was presented as Southeastern Forest Experiment Station Research Notes 148 in June 1960.

[2]Lindenmuth, A. W., Jr., and Byram, G. M. Head fires are cooler near the ground than backfires. U. S. Forest Serv. Fire Control Notes 9(4): 8-9. 1948.

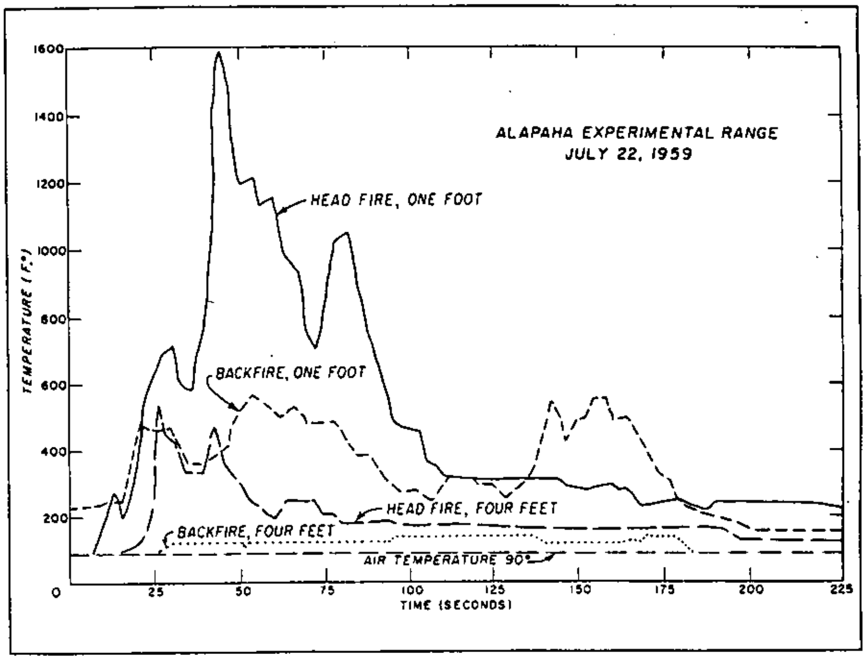

FIGURE 1.—Temperatures developed by 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs.

In this type, which was primarily grass mixed and overlain with longleaf needles, their measurements indicated that head fires are cooler near the ground—up to 18 inches—than backfires. Our measurements do not indicate such a relationship for the gallberry-palmetto roughs, at least at the 1- and 4-foot levels. If there is a zone in this type where head fires are cooler than backfires, it is probably within a few inches of the ground.

A plot of temperature against time represents one of a fire's most significant thermal characteristics. By measuring these relationships at different heights above ground, a three-dimensional, quantitative analysis of a fire can be made which in turn can be used to rate fuels according to heat yields. Vegetation damage should be closely related to a fire's time-temperature behavior if initial vegetation temperature is taken into account.

Many more fires in different fuels under different weather conditions must be measured before the energy release that takes place in wildfires can be estimated. Detailed and carefully documented studies are now in progress at the Southern Forest Fire Laboratory.

WEATHER AND FOREST FIRES

L. M. LaMois
Research Forester, Division of Forest Fire Research, U. S. Forest Service

SAN FRANCISCO, CALIF. 8-4-60
U. S. FOREST SERVICE
WASHINGTON, D. C.

FIRE SAN BERNARDINO SAYLES. CAUSE UNDETERMINED. ACRES 5564 INSIDE 1055 OUTSIDE. MEN 534 F.S. 159 STATE. CATS 3 F.S. 2 STATE. TANKERS 15 F.S. 11 STATE. 15 AIR TANKERS, 2 COPTERS. ESTIMATED TOTAL COST $225,000.

FIRE DANGER INCREASING THROUGHOUT REGION AGAIN. MOST AREAS IN HIGH AND VERY HIGH.

LOS PADRES WHITE MT. ACRES 11,900 MEN 750 10 CATS, 3 REGULAR FIXED WING PLANES 9 COPTERS 16 AIR TANKERS. ESTIMATED TOTAL FF $750,000.

TAHOE STATELINE MEN 305 TIMBER LOSS 1125 M VALUE $15,000 ESTIMATED TOTAL FF $65,000.

NORTH ZONE LIGHTNING STORM 20 FIRES YESTERDAY. STORM CONTINUED ALL NIGHT WITH SOME SCATTERED RAIN.

CENTRAL ZONE LIGHTNING STORM IN PROGRESS SEQUOIA AND SIERRA FORESTS TODAY.

ANGELES SAN DIMAS. LIGHTNING 7000 ACRES INSIDE 500 OUTSIDE, MANPOWER 260 FS 450 OTHER AGENCIES, 6 CATS, 51 TANKERS FF. TOTAL $63,750 MOST OF SAN DIMAS EXPERIMENTAL FOREST BURNED OR WILL BURN, GAS HOUSE AT HEADQUARTERS EXPLODED, MAY LOSE OTHER BUILDINGS. WINDS TURBULENT FIRE DANGER VERY HIGH.

POLECAT FIRE, 4550 ACRES, SAN GABRIEL RIVER, 1500 FIREFIGHTERS, 15 TRAILBUILDERS, 50 TANKERS, 13 AIR TANKERS, 4 HELICOPTERS. THREATENS WATERSHED. DAMAGE $4,500,000 COST $300,000. CAUSE SMOKER-FISHERMAN. ESTIMATED COST $500,000. CONTROL 50 PERCENT. WEATHER VERY HIGH FIRE DANGER.

FIRE STATE OUTSIDE LOS PADRES, 9000 ACRES, POSSIBLE THREAT. WEATHER VERY HIGH TO EXTREME.

SOUTH SIERRAS EXTREME WEATHER.

NORTH AND CENTRAL PREDICTED LIGHTNING.

Telegrams such as the above, arriving daily at the Washington Office of the Forest Service from forest regions throughout the West, reveal two unmistakable facts. The first is that the Western States suffered their worst fire experience since the early 1930's. The second is that *weather* plays the dominant role in forest fire occurrence and behavior.

The early 1960 fire experience was crucial. A prolonged period of high temperatures, low humidities, and practically no precipitation brought extremely critical burning conditions throughout the Western States during July. More than 4,000 fires occurred; most of these started from heavy concentrations of lightning storms which struck California, Oregon, Washington, Montana, and Idaho.

The far western portion of the Weather Bureau's Bulletin Highlights Map for June 1960 revealed many clues to the background for the July forest fire crises.

Sacramento	One hundred percent sunshine for second consecutive June, for only 2 times since 1905.
Oakland	107.1° second hottest recorded in any month.
Las Vegas	87.3° average June temperature. Hottest June.
Pocatello	13.7 m.p.h. average June wind speed. New June record.
Boise	0.01 inch June precipitation. Driest June since 1919.
Lander	61 m.p.h. wind on June 20. New June record.
Helena	0.25 inch precipitation. Driest June.
Sheridan	January-June precipitation least since 1908.
Cheyenne	January-June precipitation least since 1916.
Winslow	76.4° average June temperature. Hottest June.
Phoenix	Only trace of rain since March 2.

How does weather affect the ways in which forest fires start and burn? All of the answers are not known yet—but what we do know is surprisingly many sided. Weather factors play a dynamic part in every stage of the forest fire problem from ignition to final control. Weather's influence can be subtle and indirect, or it can be brutal and immediate. Weather can help or hinder the firefighters. It can be an angel of mercy or a devil in disguise. Only one thing is certain—the story of a forest fire is the story of weather from the beginning to the end.

Climate usually determines the general kind and character of the vegetation that is the fire's fuel. Precipitation, relative humidity, and temperature determine how dry the fuels are and how intensely they will burn. Wind is a driving force that makes fire spread. Condition of the upper air often determines whether or not a fire will virtually make its own weather and become a heat engine which can "write its own ticket" in a blowup situation. And finally, it often is weather itself that strikes the match, in the form of lightning.

Lightning accounts for nearly 70 percent of all forest fires in the Western United States. Several factors are linked to the seriousness of lightning-started fires. First and foremost is the fact that most lightning strikes occur in the high country which is most inaccessible to firefighters. Also more often than not lightning fires occur in bunches—from 10 to 50 during a single day on a forest being not uncommon in some parts of the West. To complicate matters, the resulting fire is oftentimes at the top of a tall snag or moss-laden dead tree. Burning material from these sources are scattered by wind and slopes to the fuels below resulting in an "area ignition" pattern of considerable size. Turbulent winds accompanying thunderstorms may fan these fires to immediate problem dimensions.

Sometimes, however, lightning strikes give rise to an even more threatening situation. Here the fire is first confined to the inside of a dead snag, where it smoulders, undetected, for considerable length of time to burst forth in full bloom days later when burning conditions may be more critical than during the storm.

The flammability of the fuels in which fire starts is the key to any fire situation. Weather plays a dual role in conditioning forest

fuels. The moisture content of larger fuels such as heavy limb wood and logging slash is determined largely by amounts of precipitation over relatively long periods of time. Marked shortage of spring rain, coupled with less than normal reserves from winter snows, can set the stage for forest conflagrations during the early summer fire season. Short-term weather, however, largely controls fire occurrence through the moisture content of the lighter fuels which account for rapid spread of flame. The flammability of these flash fuels can change drastically in a matter of hours. Air temperature, relative humidity, solar radiation, and air movement combine to regulate the moisture content of dead grass, dried foliage, and small limbs or twigs on the forest floor. When severe drying conditions prevail at the end of an extended period of low precipitation the curtain is ready to be raised on the drama of major fire disaster.

On the fireline, wind plays the dominant role. Wind acts on the flame front in a double-edged manner. In addition to increasing the rate of combustion through supplying oxygen, wind action tilts the flame into unburned fuels in front of the advancing fire. With wind speeds in excess of 10–12 m.p.h., spotting from burning embers often becomes a factor in the advance of the fire front.

The air mass under which fire burns governs to a large extent the many and varied ways in which wind may influence a fire. Unstable air or the passage of a squall line may result in gustiness which will whip a fire into a fury that defies control action. The passage of a front often is accompanied by a 90° switch in wind direction; and an extended, relatively passive fire flank suddenly becomes a broad fire head, sweeping relentlessly across narrowly constructed holding lines into fresh fuels beyond.

Negative wind shear through the lower air profile can lead to the dreaded phenomenon, a "blowup." The "blowup" occurs when a lower wind speeds aloft, over the fire, and builds a strong, well-developed, convection column. In this situation a forest fire actually becomes a closed system, much like an airtight stove, in which heat energy is converted to mechanical energy in the column. This energy in turn draws in its own oxygen supply from all directions to feed the burning fuels in a "chain" reaction phenomenon, leading to the fire growing from its own power. Almost always "blowup" fires are complicated by long distance spotting. The strong convection column supports and carries aloft to great heights pieces of burning limbs and bark, often large enough to carry fire more than a mile. Because wind aloft is often different in direction from that near the ground, resulting spot fires frequently appear in deceiving locations.

As an agricultural crop, then, our Nation's timber stands deserve the full attention of our weather service. Forecasting of fire weather becomes of utmost importance to those charged with protecting our timber crop from fire. Weather reporting, also, must take into account the factors which bear so heavily upon the seasonal threats to our wood supply. The story of this July's fire tragedy in the West is written in the record of weather—weather that set the stage, drew the curtain, and provided the action on the fireline.

GEAR CASE OILER FOR PORTABLE FIRE PUMPS

Louis F. Deyak
Fire Control Aide, Superior National Forest

Manufacturer's instructions for certain portable fire pumps are to fill the pilot gear case to oil level of the upper plug with a good grade of SAE 30 oil and to change oil after 10 hours of operation. After use on a fire the gear case should be refilled before storage. In storage there is usually oil seepage through the seals making for untidy conditions and necessitates checking for oil level before use on a fire. With time the essence, checking and filling to level consumes precious minutes. It is necessary to tip the pump up and pour the oil into the small plug opening. This might have to be done several times to ensure proper oil level.

To overcome these disadvantages a glass body wick-feed oiler of one ounce capacity, with the wick and center tube removed, is mounted in the upper hole of the gear case (fig. 1).

No oil is kept in the gear case or oiler during storage. At the fire and before the pump is started, the oiler is quickly filled which brings the oil to the required level. The oil can be changed while the pump is shut down or operating by the simple method of removing the lower gear case plug until the oil is drained and immediately refilled through the oiler. The oiler is protected by drilling and tapping two holes in the gear case and attaching a light metal guard with #8 x 32 screws (fig. 2).

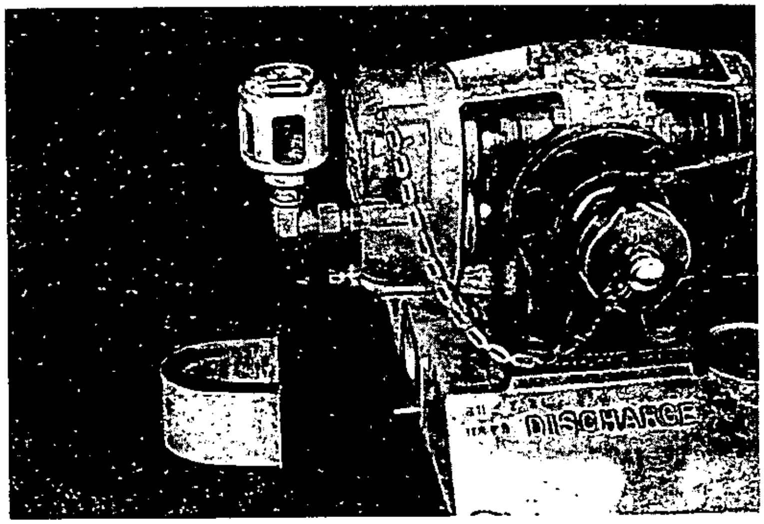

FIGURE 1.—Oiler mounted in upper hole of gear case.

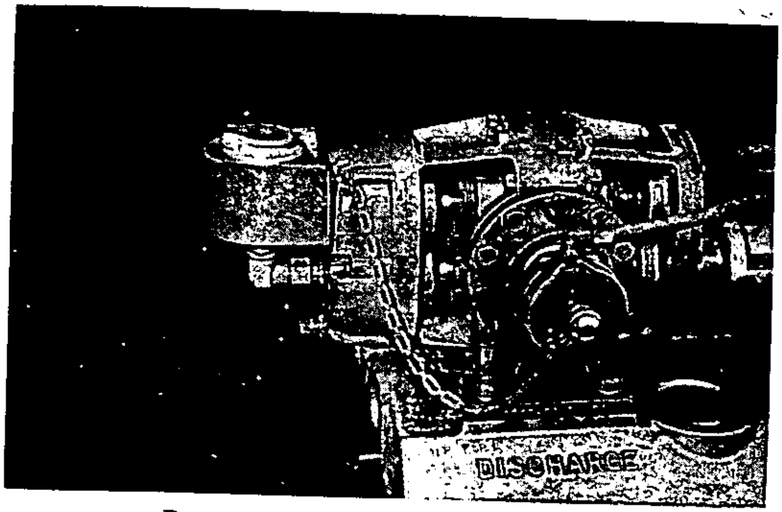

FIGURE 2.—Guard attached to gear case.

The oiler was not installed in the lower gear case, which would give a visual reading at all times, because of (a) slowness in filling gear case, (b) erroneous reading due to surging when pump is operating, and (c) complicating the draining of the gear case.

Installation cost of oil feed, guard, fittings, and labor was $6. This method can be used on Pacific Marine Type Y, 5A7, and 5A8 pumps or any pump with the same type of gear case. Size of the oiler depends on capacity of the gear case.

☆ ☆ ☆

Safeguarding Tanker Equipment From Freezing

A recent employee's suggestion indicated the feasibility of wrapping engines and pumpers, and vulnerable accessories, with electrical heating tape to eliminate the need of nightly drainage during freezing temperatures while tankers are still in use. An installation was made and used successfully under such conditions on the Mt. Pinos District of the Los Padres National Forest.

The installation would require approximately 20 feet of tape for a small slip-on pumper to 60 feet of tape for a large demountable tanker. Tape would have to be plugged into a 110 volt AC or DC outlet. Cost of the tape is about 25 cents per foot.

Benefits resulting from an installation when plugged in would include—

1. Removal of possibility of freezing and pumper damage if temperatures should fall below freezing during the night. Pumper damage if severe enough could put the pumper out of operation.

2. Elimination of time required to drain pumper at night and refill when needed.

3. Making starting easier and quicker.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.


SMOKEY
never leave a trash or
debris fire unattended
remember:
ONLY YOU CAN PREVENT FOREST FIRES!