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25th ANNIVERSARY

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

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VOL 23 NO. 1
January 1962

Forest Service
UNITED STATES 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.

UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962

Growth Through Agricultural Progress

Volume 23 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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Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1962

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TWENTY-FIFTH ANNIVERSARY

Fire Control Notes came into being in December 1936 because of the premise that the widely scattered, creative efforts of individuals and separate groups in fire control work could not be fully effective unless they were shared with others. The lead article in that issue, *Fire Control Offers Its Services*, is reprinted here because the purpose and aims expressed in it are as true today as they were 25 years ago.

And in this anniversary issue we have also reprinted *Fire Cooperation in Region 2—the Beginning*, which appeared in January 1937. It is of interest from many standpoints; it is also thought-provoking. After looking back to the early part of the century at the rocky but interesting road of progress in forest fire control, the author observed ". . . no doubt much was accomplished in other regions, but there was a lack of general knowledge among the field men of the various forests as to how results were obtained. . . ." Had it been possible for these pioneers in forest fire control to share their knowledge and experiences other than by infrequent personal contact, progress in the total effort would perhaps be even farther ahead today. Once again Fire Control Notes offers its services.

FIRE CONTROL NOTES OFFERS ITS SERVICES

Roy Headley
Forest Service, Washington, D. C.

The Fire Control Meeting at Spokane, Washington, in February, 1936, gave the Forest Service Division of Fire Control in Washington, D. C., a mandate to issue from time to time a publication which would serve as a medium for exchange of information and ideas between all the groups and individuals who are doing creative work in forest fire control. On the assumption that readers will respond with ideas and information to publish, the mandate is accepted.

Over a period of 30 years since the inception of organized effort to stop the fire waste of American natural resources, impressive advances have been made. Considerable body of knowledge of the arts and sciences involved has accumulated. Systems of organizing and managing human forces and mechanical aids have in some instances attained dramatic efficiency. Fire Research has won the respect of owners and managers of wild land. The advancement to date in technique entitles fire control to a place among the amazing technologies which have grown up in recent decades.

The advance of the technology of forest fire control is not, however, a completed thing. Its forward march has not even begun to slow down. On the contrary, there is good reason to anticipate a period of broader and more rapid growth. Fire control has won a large measure of public interest. Its relation to conservation of wild land resources is better understood. Financial support is increasing. A growing number of men are making technical contributions from a wider range of ability and training. More men know more about how to climb to new plateaus of efficiency in stopping this fire waste.

Future advances will come not from the work of small groups, but from the experience, thinking, and experiments of the large number of men now engaged in pushing back the frontiers of fire control. The integrated experience and study of such a body of interested men may easily yield results overshadowing all that has been gained so far.

The surprising thing is that the need for a vehicle for interchange of ideas among such men has not been recognized before. Widely scattered as they necessarily are, the creative efforts of individuals and separate groups cannot be fully effective without the aid of something which will serve as a common meeting ground, a clearing-house of developments. Fire Control Notes spires to render that service. It hopes to be a carrier of whatever men need to know to keep abreast of developments and rends in fire control.

Fire Control Notes will seek to act as a channel through which seful or suggestive information may flow to each man in this field, whether he be a fire research worker attacking some fundamental of combustion, or a fire fighter, facing the flame and smoke, who discovers some new device for organizing a crew of laborers. These pages will also hope to be used as a mouthpiece for every man, whatever his job, who discovers something which would be useful to others, or who has a criticism to make, a question to raise, or an unusual fire experience to relate.

As implied by the name, "Fire Control Notes," it matters not how long or how short a contribution may be nor what angle of fire control is presented. The man who discovers some new device which can be presented in four lines owes it to himself and others to report it. Likewise, the fire research man who needs ten pages for a worthwhile presentation of his subject should share what he has learned with others who need his help or who may be needed to supply the intelligent interest required to sustain the inquiry.

The only requirement imposed upon contributions to Fire Control Notes is that they be interesting or helpful to some group of people concerned with some phase of fire control.

FIRE COOPERATION IN REGION 2—THE BEGINNING

JOHN McLAREN
Liaison Officer, Sixth Corps Area

For many years prior to the creation of the National Forests in Colorado, I lived in Pitkin County in wooded areas which later became part of the Holy Cross National Forest. In the fall during those years one could see smoke from unattended fires at almost any point of the compass, and naturally Colorado suffered enormous timber losses, for conditions in my locality were not materially different than in other sections of the State, as I afterward learned.

The Holy Cross and other Colorado Forests were placed under administration in 1905 and 1906, and an extremely limited field force was kept busy long hours each day trying to keep up with marking and scaling timber, and fire control was about the only interruption tolerated. From the beginning, however, all forest officers were impressed with the fact that they must be on the alert to prevent fire damage, and necessarily must act promptly if fires were to be suppressed.

Foresters coming into the service today can have no conception of the situation faced in those early years, for there was an almost universal antagonism from every quarter toward forest administration, and some of it was very bitter. Timber operators and grazing men were sure their individual rights were being jeopardized, and others were "agin" it because it was something new and they were not sure it would be of benefit, so preferred to let the old order ride.

This drab outlook faced a ranger when he found it necessary to tackle a fire. Perforce he must get as many men as possible as fire fighters from any and all walks of life, and "please each man bring his own ax or shovel," for those days preceded the era of fire tool caches, telephone lines, automobiles, truck trails, and lookout systems.

Most of the old timers in field service in those days have been replaced by men with more education and nimbler typewriter fingers, but my hat is off to that advance guard that had the hardihood to stick with and worry at the job in the face of the discouraging outlook; and boys, did that bunch do an excellent public relations job, though the term did not come into usage until some years later. Strangely enough, doggedness and perseverance in fire work seemed to be the opening wedge in getting public confidence, and after a while there was a sort of grudging admission that it did really seem possible to check and whip a fire with man-power, and the efforts of the field men began to bring some praise.

Thus it became apparent that fire publicity was the best means at hand to arouse public interest in the Service and its aims and policies. Fire suppression jobs were publicized in the newspapers, and particular effort was made to give credit to civilians who took part in the work either of detection or suppression. Stress was laid on the need for eliminating fire from the ranges in the interest of stockmen; on the fact that timber must be free of fire in the interest of loggers and lumbermen, and that success in the mining industry depended a great deal upon the elimination of fire. Furthermore, if returns to the counties from the 25 per cent fund were to be worth while and maintained, the resources must be kept free of fire damage. Naturally, individual selfish interests were played upon: Farmers might be bankrupt through the loss of their improvements and the reduced fertility of the soil; a mining operation might be stopped by fire through loss of surface buildings and the necessary timber; and, too, many towns and settlements might be wiped out, with loss of life.

I have been asked how our system of fire cooperation got started. The foregoing indicates something of the way in which the start was made. As to when and where it started, I cannot say. In all probability field men were doing the same thing simultaneously on all forests. Apparently the first universal step was to interest people in detection work. "Keep a sharp lookout for fires and make prompt report to the nearest forest office." As I recall, my first personal attempt along this line was to line up teamsters hauling lumber and logs into Norrie to report railroad fires.

Logging operations were confined largely to the mountainous slopes south of the Frying Pan River, while the Colorado Midland Railroad wound a tortuous route along the mountain slopes north of the river. Only a few miles of right-of-way could be sighted from the ranger station, but the teamsters had a panoramic view of the entire railroad, so they could and did watch for fires and report them. Among those lined up to scan large areas under their immediate control were a resort owner, a mine superintendent, and a German farmer. The latter was a valuable find, for he was German born, had a very intimate knowledge of German forests and forestry practices, and was inordinately proud of having a connection, even without pay, with the U. S. Forest Service in the capacity of a fire guard. He was so enthusiastic and so willing that in a very short time fire tools were placed in his barn, and he was given authority to take direct charge of any fire in his territory and to employ fire fighters as needed.

Even after a few lookouts were manned, the public was requested to see how many times they could beat the lookout observer in reporting fires, and they gleefully responded. This voluntary service was extended year after year until there was a very large number of individuals who could be depended upon for detection and a smaller number who were entrusted to take initial action and incur expense in fire suppression. Let me repeat that this was not the only territory where progress was being made. No doubt much was accomplished in other regions, but there was a lack of general knowledge among the field men of the various forests as to how results were obtained, and such information as was obtained came largely from inspectors of the Regional Office at infrequent intervals and at rangers and supervisors' meetings.

When the Regional Office established the position of Fire Chief, a survey disclosed that while excellent progress had been made in rousing the public to be fire-minded and co-operative, it was very spotted even as to individual forests: There was a lack of standardization in fire tools both as to kind and number, and the majority of the fire plans were of the old narrative type—too voluminous and bulky to be of much value even to the men who made them. Fire tools were standardized rapidly, and Region One's Fire Organization Chart was adopted in modified form.

Effort was immediately centered on convincing each and every field man of the importance of enlisting dependable public co-operation. This, by the way, was not accomplished in a season. Eventually it did exist well toward 100 per cent as a mass consciousness from the newest member of the force, through the Supervisor's office to the Regional office, to the Regional Forester himself. There was an essential objective, for mass effort produces mass results. The chart referred to became the fire plan for each ranger district, and responsible citizens at strategic points were listed as keymen. These were men who were, and are, called on to drop their private work and devote time and energy to public interests. These plans were frequently inspected and checked in the field to insure that they were not paper plans only.

The methods employed were many and varied, and depended upon the initiative of individual forest officers and the individuals to be worked on. In general terms: "We are a skeleton force willing and anxious to do everything possible to protect the resources, but you are the owners of these forests—the stockholders in this concern—and without your whole-hearted interest and action we must fall short of the success otherwise possible."

Each forest officer must believe whole-heartedly in the worth of converting apathetic or indifferent individuals and communities to an active sense of duty in fire control—it can be done. The forest ranger has better chance for success than others, for he personally knows the people in his territory, has a knowledge of their personal interests and their idiosyncrasies, and therefore has the best approach.

TRAINING FIRE PROFESSIONALS[1]

MERLE S. LOWDEN
Director, Division of Fire Control, U.S. Forest Service

Training of professional firemen for forest fire control work has received increased attention in recent years. There is general recognition that this training is not of the quality nor in sufficient amount in most cases to do a fully satisfactory job of providing qualified personnel needed for this important job. Such training has lacked stature, financing, and the necessary interest of some administrators in the past. There are encouraging signs, however, that forest fire control training is to get increased attention and a more prominent place in the entire fire control job. My remarks on this important subject will relate most specifically to the work of the U.S. Forest Service, but the job to be done is quite similar on areas protected by the States, other Federal agencies, and private organizations.

Forest fire control involves the protection of valuable resources, is often costly, and is highly technical and important work. It requires skilled personnel who know their jobs. Decisions of supervisory personnel must be made quickly and must be right. A wrong decision may be costly in fire fighting costs, expensive in lost resources, and tragic as it concerns the lives of participants and others in the area.

All training work should start with an analysis of training needs. This in reality is the difference between total needs of capable personnel to do the needed job and those currently on hand and capable to do the work. In fire control this means determining the number of men we need for lookouts, patrolmen, smokechasers, fire bosses, plans chiefs, supply chiefs, and the many other specific positions we have to do our fire job. In the suppression organization we have specific positions. From analysis and with our qualification system, which I will describe later, we then determine the number of employees we have qualified for each position. The difference is the number to be trained. However, this is an oversimplification as some only need refresher work and others need all the fundamentals. Of course before we figure our training needs we have a plan for the desired fire control jobs which is modified to fit the money available. As you all know whether in government or in private industry, we must match the organization to the budget.

Fire control training can be divided into the three main categories of the job itself; i.e., prevention, presuppression or preparation and suppression or the actual fighting of a fire. From my experience I have noticed most attention in training is given to preparing men for fire fighting with usually decreasing attention to training for preparedness and prevention. The latter is begin-

[1]Presented to the National Academy of Sciences, National Research Council, Woods Hole, Mass., July 21, 1961.

ning to get more attention and the outlook is that prevention training will receive more deserved recognition in the future.

The Federal Forest Service requires training for four groups of personnel and their various needs must be recognized in the training program. The first group includes the full-time fire control professional who devotes all or practically all of his working time to fire activities. Next is the professional forester or other full-time employee who devotes only part of his time to fire work either regularly or as called upon in an emergency to help on a suppression job. Men with fire work as part of their normal duties may work on one or several multiple-use land management functions the balance of their time. These folks cannot be expected to know as much or be as skilled in the fire job as the full-time fireman. In addition to yearlong employees the Forest Service and most other forestry agencies employ many for seasonal work. Some seasonal employees are primarily fire employees working on such jobs as lookouts, crewmen, smoke-jumpers, dispatchers, and patrolmen. Other seasonal employees such as laborers, truck drivers, packers, and machine operators may work on construction or maintenance jobs or other work most of the time but are available for fire work when needed.

Our full-time fire employees are either foresters or professionals in related fields or employees who have come up through the ranks from seasonal fire employees. One might think that graduates from an accredited forestry school would have received fire control training as part of their undergraduate work, but usually they get very little such work in college. Most often they have had only one course in protection which may have included pest control as part of the course. One full fire course, or two fire courses at the most, is all a forester now gets in college. The work is usually more of an orientation to fire control and not of immediate application. However, often forestry graduates have worked on seasonal fire control jobs during their vacations while in college and have received much valuable training and experience in this manner. Most of our present fire leaders worked on vacation fire jobs during their college days, and in the process received many fire fundamentals.

Apprenticeship or understudying is a common method for fire control and other personnel to advance in the Forest Service. Many nonprofessional fire employees are classed as technicians and through experience and training can advance to responsible positions in fire control. At the lower grades there is less distinction between professionals and technicians in training given. In the Forest Service we are establishing training standards which, as they are refined and fully adopted, will require that men receive and pass certain specific fire control courses of increasing complexity in order to advance from one grade to another. We have a big job to get these standards fully defined and operating but I'm sure they will mean better qualified men and improve the performance in our fire work in the future.

In addition to these standards for Civil Service grades we have a qualification program that applies to men in fire suppression supervisory positions. Each of our regular men qualified for a fire overhead position has a "red" card which designates the position or positions which he can handle and those in which he needs training. A qualified sector boss may be listed as needing training as a division boss or as a camp manager. Minimum standards have been established for the top positions on a national basis and for the lower positions on a regional basis. A Class I fire boss or fire general, for example, must have passed qualified fire behavior and fire generalship courses, must be a thoroughly qualified Class I line boss, must have had current experience (within 3 years) on Class C or larger fires and experience on a total of at least 30 fires, including 10 Class E fires (over 300 acres).

Our fire training is given at national, regional, or local schools depending on the level of instruction, the number to be trained, and other considerations (fig. 1). Local fire schools on ranger districts or forests have been held for many years and many of our regions have given training in more advanced courses.

The annual fireman school is a tradition on most national forests and is a practice followed by many States. These sessions often run for 3 to 5 days and train men in such jobs as detection, smokechasing, suppressing small fires, operating machinery, fire prevention, law enforcement, and safety. Such specific skills are taught as map reading, "running" a compass, operating a fire finder, building a fireline, and similar doing jobs. These schools serve to orient many new employees and are good morale builders. Regular full-time employees mingle and work with seasonal trainees and prepare for the teamwork needed in the fire season ahead. Fireman schools haven't changed greatly through the years except more training aids are used and subjects such as air operations and fire behavior have been added. The emphasis is on real work and the men are given a chance to demonstrate what they have learned by doing the jobs in most cases. Often seasonal employees working in other activities are included to train needed replacements or to give these employees selected training in such subjects as fire fighting.

Increased attention is being given to training through special assignment; that is, training in place by working at some location other than the usual assigned station. Men are detailed to other offices or locations to do preparedness or prevention jobs or to going fires in other forests or regions. Training on fires may be as apprentice or understudy to a regular position, or part of the time may be spent in a regular organized group receiving planned training on the fire. At the national level we have been featuring interregional details for training and last year nearly 150 men received training in this manner. We have encouraged our regional officers to detail men between forests for suppression training on fires. We have trained a great many men in our Washington office by detailing them in to do specific jobs. This method has great possibilities but must be well planned, aimed at specific objectives, and carefully supervised.

FIGURE 1.—Trainees and instructors, Fire Behavior Training Meeting, Alexandria, La.

Within the past 4 years we have conducted several national courses in advanced fire work and we intend to have more. Because we had recognized an urgent need to increase knowledge in fire behavior we have had three national schools in this work of 3 or 4 weeks' duration. These schools were aimed at training men to be fire behavior officers on fires, providing training materials for additional training, and training men who could serve as trainers for others in the field. This last objective has been especially fruitful and thousands of our men as well as State and Department of the Interior employees have had fire behavior training of varied intensity and amount. We have also had courses in fire generalship and air operations in national schools. Fire personnel from State forestry organizations and the Department of the Interior have been trainees at the national courses and we plan to continue this practice.

Our regional schools are usually aimed at training for fire suppression overhead positions. Their length varies depending on number of subjects covered and experience of the men. In recent years these courses have featured tactical support in service of supply, plans, and finance subjects. Generally a more well-rounded program is emerging although we recognize deficiencies in both quality and quantity of training in various subjects and locations.

Although not in practice but on the immediate horizon is advanced university training of selected individuals for careers in fire control. We have selected several individuals this year for this training under the national training act which permits the Government to finance this training. They will be given some choice in their advanced work under general guides. We hope their specialties will vary but we want them to have general objectives. Arrangements for such advanced work have been made at Yale and the University of California.

At the national level we have underway several projects to improve our training program. Training is high priority work since it involves so many people and is so vital to success of our entire fire control efforts.

Simulation is the watchword in training these days and we have endeavored to utilize its advantages as far as we could. A special project on simulation has been underway about a year and we are near a contract with a leading development company for a completed training problem and related equipment. We have had some men attend national seminars and work conferences in simulation such as that in management conducted by the American Management Association. The principles of simulation have long been applied in our fireman schools, in national courses, and at other fire training, but we know there are many opportunities to do more of it.

Closely related to this simulation work is the use of training machines in our training. The opportunities in this field look particularly promising. Self training has always been a strong part of our program but with training machines we can apply the best techniques, teachers, and methods to individual learning.

We have leaders in this field assisting us in getting this program started and the outlook is particularly good, especially in certain fields of study.

As a strong base for training we recognize the need for basic instructional material. Our national Fire Control Handbook and specific guides such as the Fireman's Guide, Air Tanker Guide, and Air Operation Handbook are examples of fundamental material on how, when, and where to do fire jobs. We also have a national project to develop training films to aid local training efforts. Several films have been completed recently and are in widespread use. Others are in the planning or making stage. We recognize a film is merely an aid and part of a total program for any subject. Some films are aimed at general orientation and others are more specific on "how to do" jobs.

Looking ahead there are many things we plan or hope to do on training. Training machines, simulation, films, and other aids may be made better and more specifically devoted to accomplish defined objectives. We need better facilities in training centers. These are being developed now at regional and interregional locations. For many years the proposal for a national fire institute has been discussed. Finances have been one strong deterrent. The idea of a national training center for forest fire control is very intriguing and likely we'll have a facility arrangement for special advanced training for fire leaders. I'm sure, too, we'll tie more closely to universities in this work. They have facilities and discipline capabilities of many types that could not reasonably be assembled any place else. They should be able to arrange specific courses for the particular needs of fire organizations. The forthcoming staff and command school to be held by the Office of Civil and Defense Mobilization for both rural and urban firemen is a great opportunity to get underway advanced fire instructions for all fire leaders.

Not strictly training but closely allied to it is the problem of selecting the right people for fire control careers. Little has been done on this in our field and we recognize the deficiency. We are making a start in it in selecting smokejumpers, but this is not on the major problem. Those not capable of becoming good fire men or with the wrong mental attitudes must be taken out before we apply expensive training. From what my urban fire friends tell me I understand they have done much more on this than we have We also need to analyze jobs more thoroughly to know just what men in certain positions do and how well they do it. Because of the importance of the position we are making a study of our crewboss who is the key leader of men in our suppression organization. We know these men are not always as strong as they should be, but we need to know more about how they perform. what they know, how best to select and train them, and similar requisites.

The fire training outlook is encouraging. New techniques, new aids, different ideas, more funds, greater recognition of training, and the general demand for better fire control, all point to better forest fire control training in the future.

FIRE WHIRLWINDS IN THE LABORATORY

GEORGE M. BYRAM, *Physicist,* and ROBERT E. MARTIN, *Research Forester, Southeastern Forest Experiment Station*

Most experienced firefighters have encountered fire whirlwinds. These whirls, or "fire devils" as they are sometimes called, range in size from small twisters a foot or two in diameter up to violent whirls equal to small tornadoes in size and intensity. Graham[1] gives examples where tornado-like fire whirls have twisted off large trees and lifted large logs. Whirlwinds have also occurred on urban fires. In his account of the great Chicago fire of 1871, Musham[2] states that burning planks were lifted by fire whirlwinds and dropped as far as three-eighths of a mile ahead of the main fire. He attributes a large part of the destruction of the city to burning material carried by the fire whirlwinds.

Because of their importance as a hazard to firefighters and as a cause of rapid and erratic fire spread, fire whirlwinds are one of the fire hehavior phenomena being studied at the Southern Forest Fire Laboratory at Macon, Ga. These whirlwinds can be produced readily on a small scale and studied by modeling techniques.

In the past miniature whirlwinds have been produced in several different ways. In some of these there was no heat source. In others steam or heated water vapor has been used as a heat source. Usually the initial cylinder or cell of gently rotating air was produced by a blower or fan. However, a thermally driven whirlwind appears to work equally well and has the advantage of being partially self-regulating.

Chambers for producing thermally driven fire whirlwinds on a model scale are shown in figure 1. The large chamber on the right consists of a cylindrical shell 26 inches in diameter and 72 inches high over which is mounted a truncated conical shell 60 inches in height. The cone tapers from a base 26 inches in diameter to a top 13 inches in diameter. The front half of the cylinder is transparent plastic; the rear half of the cylinder and the cone are fabricated from poster board. Air enters the chamber through two ¼-inch tangential slits located on opposite sides

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[1]Graham, Howard E. A fire whirlwind of tornadic violence. Fire Control Notes 13(2) : 22-24, illus. 1952. *Also,* Fire whirlwind formation as favored by topography and upper winds. Fire Control Notes 18(1) : 20-24, illus. 1957.

[2]Musham, H. A. The great Chicago fire. Papers in Illinois State History and Transaction for the year 1940; The Illinois Historical Society, Springfield, Ill., 69-189, illus. 1941.

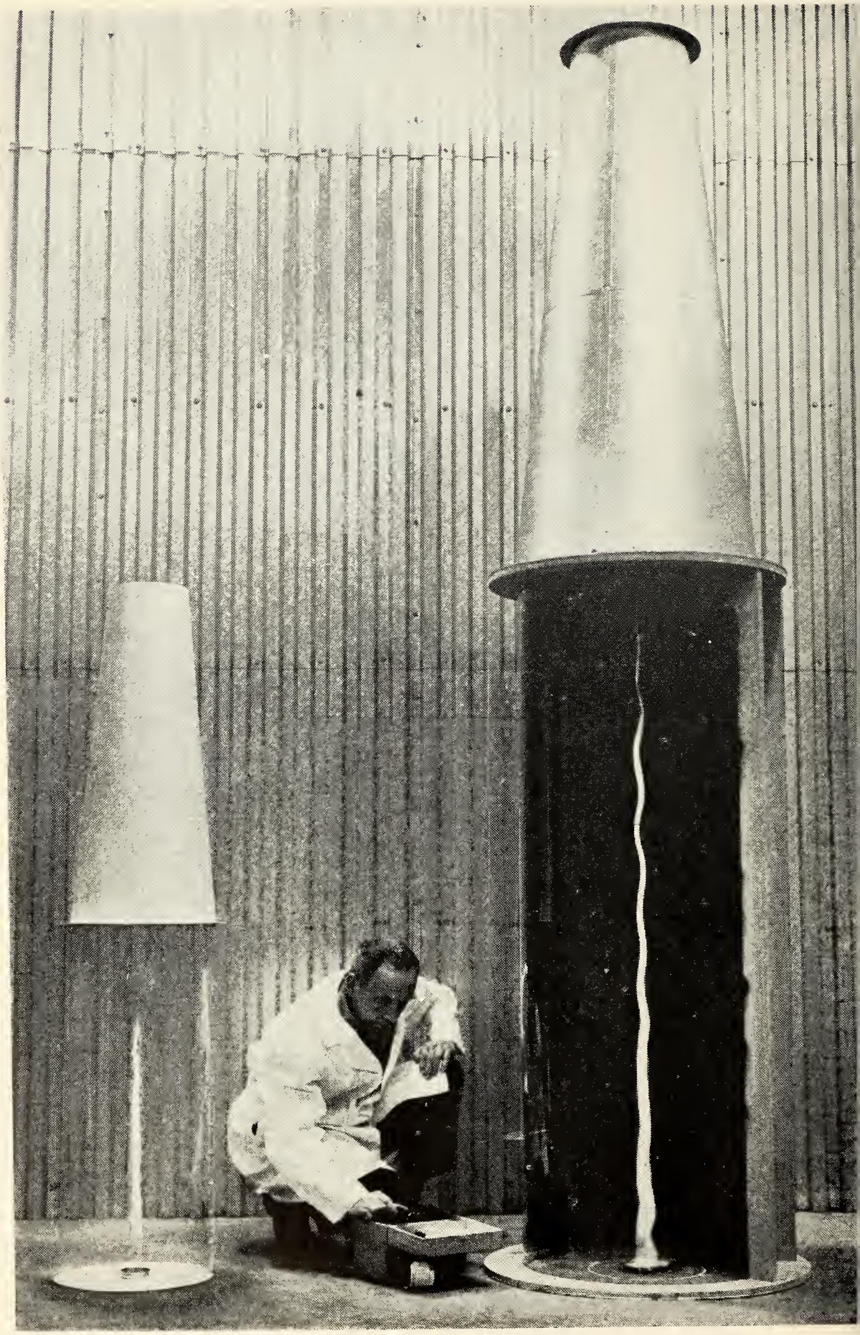

FIGURE 1.—Two sizes of fire whirlwind chambers of slightly different design. The large chamber on the right can produce whirls up to 11 feet in height. The small chamber on the left forms whirls from 15 inches to 36 inches in height.

of the cylindrical section, producing a gentle rotation of the air inside. The heat source is a pool of burning alcohol 4.8 inches in diameter and ½ inch deep located on the vertical axis of the cylinder. Its rate of heat output is about 11 B.t.u. per second, or slightly less than half the output of an average oil house furnace.

The small chamber in figure 1 was built as a portable demonstration chamber. It has an all-plastic transparent cylinder 15 inches in diameter with one tangential air entrance slit. The conical section is thin cardboard and tapers from a base 15 inches in diameter to a top 8 inches in diameter. Both the cylinder and the cone are 3 feet in length. For portability the cone can be inverted and placed inside the cylinder. Depending on the size of the burning alcohol pool, it can produce whirlwinds from about 15 to 36 inches in height. Those more than 25 inches in height show most of the features that can be seen in the whirlwinds in the larger chamber.

After the alcohol is ignited in the large chamber, the whirl forms in 20 or 30 seconds. At first the alcohol pool burns with a lazy flame. As the heated air rises and cool air flows tangentially into the chamber, the flame becomes tilted in the form of a curved arm which slowly rotates around the pan. The tip of this flame then curls back on itself and begins to spiral upward, forming the base of a crude, off-center vortex which finally stabilizes over the center of the alcohol pool. The whirl is then visible to a height of 3 or 4 feet (fig. 2), with a smooth inner column surrounded by strands of flame spiraling upward. The whirl gradually lengthens and becomes thinner. In the fully developed whirlwind, the average diameter of the inner tubelike column is about three-fourths of an inch and is visible to a height of 9 or 10 feet. At this stage the smooth inner column, which corresponds to the funnel of a tornado, constitutes most of the fire whirlwind (fig. 3). The outer spiraling flames form a column about 1.6 inches in diameter and are visible to a height of about 18 inches above the burning pool, as shown in figure 4.

For its size, the model whirlwind appears to generate a very high velocity in the hot gases spiraling upwards. This velocity has a horizontal component which creates the spin or rotation, and a vertical component, or updraft, which carries the heat from the burning fuel upwards. Although they will have to be verified by direct measurement, approximate values of these velocity components can be calculated from the energy equations using the temperature and dimensions of the whirl. The horizontal component comes out to be about 20 or 25 miles per hour at the surface of the inner column, which would give it a rotation of about 6,000 or 7,000 revolutions per minute. More surprising, and possibly more significant from the fire behavior standpoint of full-scale whirls, is the probable high updraft velocity, which has a computed value of about 40 or 50 miles per hour. If an updraft on a full-scale whirl had a velocity of five times this

FIGURE 2.—A fire whirlwind in the large chamber in its early stages of formation. A tube or tornado funnel has started to form inside the whirl near its base.

FIGURE 3.—The visible part of the fully developed whirlwind consists mostly of the smooth central column or tube, which has a very high rate of rotation.

FIGURE 4.—A closeup of the lower part of the fully developed fire whirlwind showing the strands of flame spiraling upward around the central tube.

value, it would explain the lifting capacity of the fire whirlwinds described by Graham and Musham.

Another significant feature of the model whirlwind from the fire behavior standpoint is a sudden three-fold increase in the alcoho burning rate when the whirl forms. It is possible that a marked increase in burning rate also occurs in forest fuels when whirlwinds develop.

The principal value of model whirlwinds, and other types of convection models, is in the detailed study of their physical structures and dynamic characteristics (such as vertical and horizontal velocities). Through the application of scaling laws a better understanding of the cause and behavior of the full-scale phenomenon should be possible.

TESTING AND EVALUATING CHEMICAL FIRE RETARDANTS IN THE LABORATORY[1]

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Western fire control agencies dropped 7 million gallons of fire retardant mixtures from aircraft in 1960. They are continuing aircraft drops in 1961 and are testing both retardants and suppressants in fire trucks. It is not surprising that firefighters have expressed considerable interest in learning how new materials are selected for trial on actual fires. This paper describes the first steps in the process of seeking new or improved materials and the laboratory methods used in this preliminary screening. Subsequent steps include small-scale field trials on forest and range fuels and then operational tests on wildfires.

Before any new material can be tested by field or operational trials, a great amount of factual information is required. For example, the men in charge of forest firefighting will need to know if ample supplies will be readily available; what the material will cost; whether special techniques will be needed in mixing, handling, and storage; and if the mixture could damage equipment or endanger personnel. Firefighters will also want specific answers to the following questions:

1. Are high temperatures or other chemicals required to obtain applicable mixtures?
2. How will the retardant mixture be affected by the acidity or alkalinity and hardness of the water to be used?
3. Does the material adhere well to fuels when first applied?
4. Does the coating tend to crack or crumble under extreme drying conditions?
5. Is the material sufficiently slippery to constitute a hazard to men working around fire trucks or aircraft?

Much of this information can be obtained from brochures of suppliers or through correspondence with the manufacturer. For some of the questions, however, specific answers must be obtained by laboratory evaluation.

PHYSICAL AND CHEMICAL PROPERTIES

Mixing

Simple tests will show whether the product is readily soluble in hot or cold water and whether it requires mixing by rapid agitation or by injector-type mixers. The effect of the acidity or alkalinity and the hardness of the water on the test mixture can be observed at the same time. When available, the manufac-

[1]Issued Aug. 1961 as Pacific Southwest Forest and Range Expt. Sta. Misc. Paper 59; original paper included illustrations and list of references.

turer's recommendations are very helpful in determining the best method of making a solution of the proper viscosity. A sample of the mixture is placed in a beaker and its viscosity recorded at room temperature with a Brookfield viscometer.

Stability

Fire retardants to be used by initial-attack aircraft or ground tankers often have to be mixed and stored in advance of anticipated use. To determine stability of stored mixtures, a beaker sample is placed in an oven maintained at 80°F., and viscosity is measured after 24, 48, 168, and 720 hours. The mixture is checked to see if the retardant has tended to separate or has remained in solution, if evaporation has been excessive, or if bacteria have caused spoilage. To prevent spoilage, a preservative may have to be added to the mixture.

Corrosiveness

The corrosive action of a fire retardant on metal parts of fire equipment, such as hose connections, pumps, and storage facilities, may definitely restrict its use. The increased use of air tankers makes it doubly important that corrosive effects of retardants on aircraft parts be known and eliminated, because of the danger to operating personnel and the high upkeep costs of the aircraft. Therefore, suggested retardants are subjected to two types of corrosion tests.

One type is a "static" test conducted according to the method outlined in J. H. Perry's *Chemical Engineering Handbook*. The metals used in these tests are copper, brass, bronze, mild steel, aluminum, and magnesium. Test samples 0.025 inch to 0.075 inch thick are cut into 1- by 2-inch rectangles before submersion; they are lightly polished on a buffing wheel to remove scratches and toolmarks, washed in a solvent to remove any oil film, and dried. The retardant to be tested is placed in 250 cc. beakers and allowed to stabilize for 1 hour at room temperature. A sample of each test metal is then placed in a beaker with the retardant for 5 days. Each test piece is weighed to the nearest 0.1 milligram on a precision balance before and after the test. The weight loss is calculated in milligrams per square decimeter per day.

The second type of test simulates field conditions in which the metals are not only exposed to the chemicals, but to the air as well, or they are alternately exposed to chemical and air. Materials for this "dynamic" test are prepared as for the static test, but the test pieces are suspended from a shaft rotating at 1 r.p.m. so that they are alternately submerged and then exposed to the air for about 30 seconds. This cycle is continued for 72 hours. In both the dynamic and static procedures each test is repeated from two to five times.

Fire Retardant Effectiveness

Three test procedures are used to evaluate fire retardant effectiveness. Two of these tests are relatively simple procedures used to measure resistance to ignition and reduction in combustion rate. The third, called the "steady-state fire model technique," is somewhat more time consuming, but more nearly simulates fire spread through vegetation. It is usually reserved for those materials showing the most promise in ignition and combustion tests. It should be emphasized that these tests are part of a screening process. They make it possible to determine which materials should be evaluated in the field, but they are not a substitute for field evaluation.

Ignition Test

Resistance to ignition is determined by measuring the time required for treated and untreated maple dowels to burst into flame when placed in a muffle furnace. Sixty-four maple dowels, ¼ inch in diameter by 5½ inches in length, are prepared for a single test. Eight of them are sawed into quarter-inch lengths for fuel moisture determination by the xylene distillation method. One set of six dowels is reserved as control samples. Five sets of 10 each are used for the ignition test.

All six sets are clamped upright into aluminum holders, placed in a drying oven, and held in circulating air at 115° F. for 24 hours. After drying, the control set is weighed, all sets are dipped 5 inches deep in the retardant to be tested, and the control set is again weighed. All six sets are then placed in the drying oven. The time is recorded. At the end of 1 hour, the control set is again weighed and returned to the oven, and a set of 10 dowels is removed for the ignition test. This procedure is repeated at hourly intervals through 5 hours.

For the ignition test, the dowels are placed one at a time in a holder and inserted in the muffle furnace. The time elapsing before a burst of flame is measured by a stopwatch, and this ignition time for the 10 dowels is averaged.

The control set is kept in the drying oven 24 hours and then weighed. This set provides a record of the amount of retardant and water adhering to the fuel, the water loss each hour for 5 hours, and the amount of retardant adhering to each dowel after 24 hours of drying.

This same test may be made with plain, untreated dowels and with dowels dipped in water, as a basis for future comparisons if required. The test may also be made for different furnace temperatures, usually from 1,000° to 1,700° F. at 100° intervals.

Combustion Test

The ability of a retardant to slow or inhibit combustion is determined by burning treated dowels and recording the resulting radiation intensity and weight loss.

Weight loss is measured with a 5-kilogram laboratory scale. The scale is equipped with an aluminum frame clamped to the side of its main platform. This frame supports a horizontal, slotted metal strip from which the test dowels are hung with a half-inch intervening air space between each. A pan beneath the dowels collects falling ash or charcoal. A Gier and Dunkle radiometer is placed 9 feet horizontal distance from the fire, and the radiation intensity is registered by a recording potentiometer.

Each test requires four untreated and three retardant-treated ponderosa pine dowels ½ inch in diameter and 7.5 inches long. The untreated dowels produce the heat required to burn the three treated ones with which they alternate on the slotted strip. Each dowel is hung by a small wire brad driven into one end.

Forty-one dowels are needed to test each retardant mixture. They are conditioned 24 hours in the drying oven to approach equilibrium moisture content. Six dowels in a special holder are used as a weight control. The tare weight of the holder is determined, as is the weight of the six dowels. These dowels, together with five other sets of three each, are then dipped in the retardant to be tested, and the weight of the control set is again recorded. All are then replaced in the oven for drying. At the end of each hour of drying time, the special holder of six is weighed to determine the water loss, and three treated dowels are removed from the oven and suspended from the scale in positions 2, 4, and 6 on the slotted strip of metal. Four untreated dowels are hung in the 1, 3, 5, and 7 positions.

A horizontal asbestos wick containing 6.7 cc. of ethyl alcohol directly below the dowels is ignited; at the same time the weight is recorded from the scale and a stopwatch is activated. Every 30 seconds the scale reading is recorded. These readings show the loss of fuel weight due to combustion, while the chart connected to the radiometer registers the radiant heat produced by the combustion.

These records show the comparative effectiveness of various retardants. Some retardants may slow down the combustion process in the treated dowels; others may prevent combustion. The test is repeated at hourly intervals to show the ability of a retardant to remain effective after different drying periods.

Steady-State Technique

In the steady-state test, the rate of spread, the radiant energy, and the convective heat of a fire burning in an untreated portion of a crib of ½-inch dowels are compared with measurements obtained when the fire burns into the retardant-treated part of the same crib.

The fuel for this test is a crib built of 6 tiers of 21 dowels 7.5 inches long and 6 tiers of 5 dowels 35.5 inches long. These dowels are half-inch-round ponderosa pine. They are placed in a jig, glued with small drops of resin, kept under pressure overnight, and subsequently conditioned in the drying oven for 24 hours at 115° F.

The crib is removed from the oven and weighed. One end is dipped 12 inches into the test retardant and then allowed to drain for 5 minutes. It is again weighed to determine the amount of retardant and water adhering, and replaced in the oven for a specified time (1 to 24 hours). It is then weighed again and placed on the movable center strip of the fire table.

The untreated end (in line with the eyes of the operator) is ignited with an asbestos wick containing 6.7 cc. of ethyl alcohol. As the crib is consumed, the operator cranks the fire "front" forward to keep it in a steady position before him, recording the number of revolutions he has turned the crank each minute. A Gier and Dunkle radiometer, which is aimed at the fire and mounted at a horizontal distance of 14 feet, records the radiant energy on a recording potentiometer. The 2 feet of untreated fuel bed gives the fire a chance to reach a "steady state" before reaching the retardant. After this, the drop in intensity and rate of spread, as graphically represented on the recorder charts, forms a basis for comparison between retardants.

In all tests using wood dowels or cribs, the moisture content of forest fuels is determined by xylene distillation and considered in the analysis of the results.

BOY SCOUTS USE HERBICIDES IN FOREST FIRE CONTROL PROGRAM

NORMAN H. DILL[1]
Director of Conservation, Rodney Scout Reservation, North East, Maryland

Since World War II there has been considerable use of herbicides in controlling vegetation, notably along rights-of-way and roadsides. These herbicides have also been used in controlling unpalatable and poisonous plants on the western ranges and deciduous woody vegetation in coniferous forests.

In certain forest regions, breaks of low, stable, relatively nonflammable vegetation are important in a fire control program. In times of emergency such breaks serve for access by foot or jeep and as a base from which to start backfires. Since 1957 breaks of this type have been part of a research and demonstration project in the Conservation Program at the Rodney Scout Reservation, North East, Cecil County, Maryland.

Soil erosion can become a serious problem on these breaks if all vegetation is killed. This is especially true in the southeastern Coastal Plain, and is particularly true at the Rodney Scout Reservation. On such areas a cover of low nonflammable vegetation is needed to stabilize the soil and prevent erosion.

Early Practices not Satisfactory

In recognition of the fire hazard, several firebreaks had been constructed on the 1,050-acre Scout reservation prior to the start of this program. These breaks included not only strips along roadsides and electric powerlines, but also several breaks constructed solely for fire safety purposes. The procedure had been one of cutting and felling the trees, piling branches in large brush piles at a safe distance from the fire break, and rolling the logs to the side. Vigorous resprouting of the forest trees made maintenance of these vegetation breaks a continuing and costly job. For these reasons it was decided to use herbicides to control the vegetation.

Basal Sprays Kill Unwanted Trees

The herbicides used were 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) mixed with kerosene in the ratio of one part commercial herbicide to 25-50 parts kerosene (or fuel oil). They were sprayed on the bases

[1]The program reported here was suggested by Mr. Ted S. Pettit, National Director of Conservation, Boy Scouts of America. Valuable guidance and assistance was received from Dr. Frank E. Egler, Consultant for the Vegetation Management Program at the Rodney Scout Reservation.

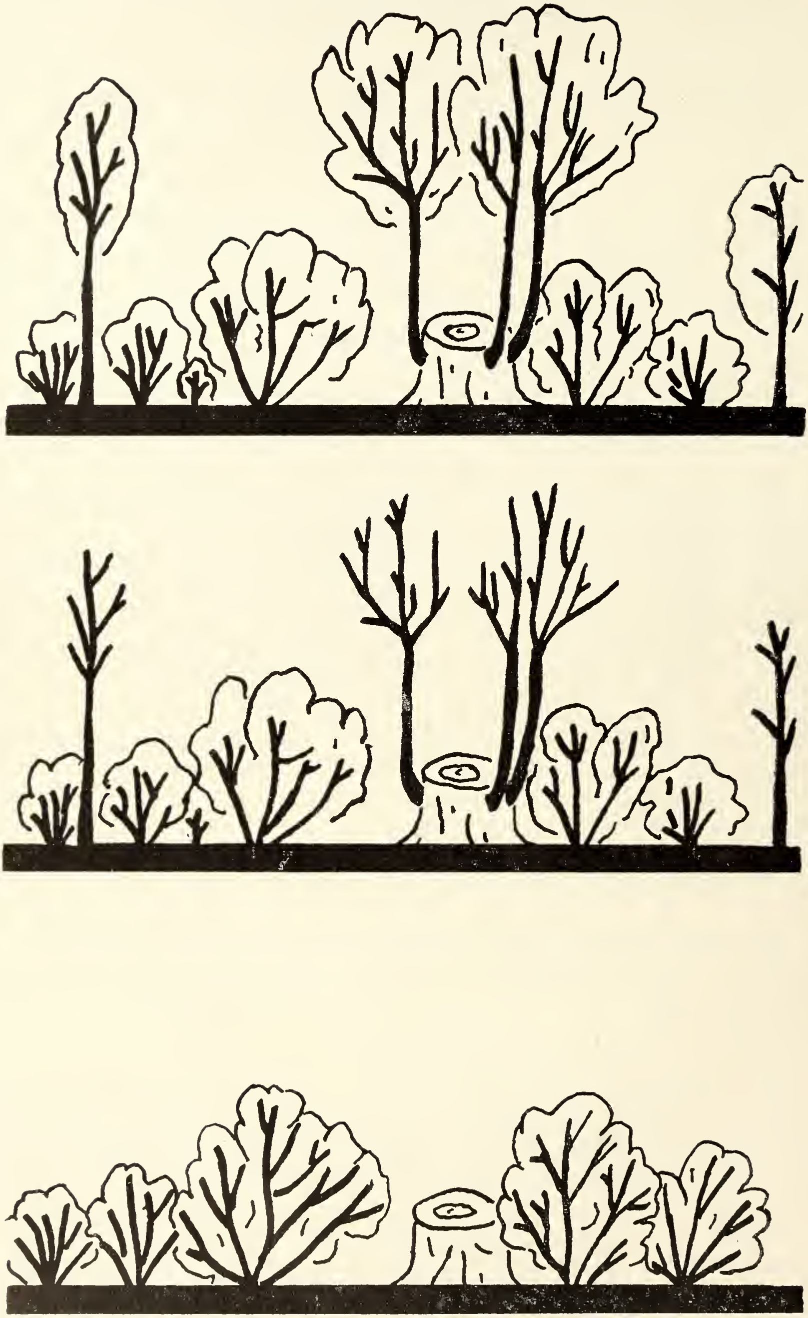

FIGURE 1.—*Top,* Diagrammatic representation of cross section of unsprayed trail showing tree saplings and stump sprouts among shrubs. *Middle,* Same cross section one year after spraying showing death of unwanted trees. *Bottom,* Three years after spraying showing closing of shrub canopy.

of the trees with specially adapted backpack sprayers. Great care was taken to spray only the unwanted tree sprouts and saplings. In new breaks, the stumps of the larger trees are being sprayed soon after cutting, thus eliminating the more costly work of spraying the sprouts a year or two later.

All desirable shrubs such as blueberry, huckleberry, azalea, and male-berry were left unsprayed so that they would grow and form a closed canopy to retard the establishment and growth of tree seedlings (fig. 1).

The powerline vegetation break at Rodney (fig. 2) was constructed in 1955. Part of its vegetation has been under yearly herbicide treatment since 1957 by Scouts working on conservation merit badges. Inadequate spraying and misses were high at the beginning because of untrained Scout assistance. Vigorous sprouting from large oak stumps and excessive rootsuckering from sassafras caused conditions which would not have occurred had adequate spraying followed the original clearing of the break in 1955. Each successive spraying, however, reduced the number of surviving unwanted woody plants and allowed the shrub canopy to close. And most important, *no reinvasion of unwanted*

FIGURE 2.—Powerline vegetation break during August 1959. Note the almost complete closing of the shrub canopy, which retards growth of tree seedlings. The shrubs in the foreground are sweet pepperbush (*Clethra alnifolia*). In the background are blueberries, huckleberries, male-berries, and azaleas. (Photo by J. Bazzoli.)

woody plants is occurring! No spraying will be required for at least 5 or 10 years.

Reinvasion of Woody Species is Low

The soundness of the selective herbicide treatment lies in the relative stability of pure shrub cover. The inability of trees to invade pure stands of shrubs is well known to foresters dealing with the hazel thickets of the Lake States and the rhododendron thickets of the southern Appalachians. The rhododendron balds in the latter areas have been surviving since Indian times.

The application of these principles for firebreaks is reported in another Scout project[2] at the Ten Mile River Scout Camps, Sullivan County, New York. In this area, a stable low vegetation was accidentally developed in one small part of a 40-mile boundary firebreak following the cessation of CCC activities in 1936. This stable vegetation, of a type that can now be purposely constructed by selective spraying, *has already lasted for 25 years* without one dollar being spent upon it, nor have any unwanted trees yet invaded it!

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[2]Pound, C. E., and Egler, F. E. Brush Control in Southeastern New York: Fifteen Years of Stable Tree-less Communities. Ecology 34: 63-73. 1953.

A DYNAMIC TRAINING EXERCISE FOR SUPPRESSION CREWS

T. L. Biddison
Assistant Fire Control Officer, Angeles National Forest

There is need for new training approaches to meet the increasingly specialized and difficult fire training job. A dynamic "battle"-type exercise for all categories of fire suppression crews offers many challenges to trainees. To be fully effective, such an exercise must fit the needs of the large-fire suppression crew and many types of initial attack crews.

A particularly perplexing training problem facing many national forests is the followup or maintenance training of initial attack crews. For example, the Angeles National Forest in southern California has a sizable training program for its 22 five-man ground tanker crews. It needed an inexpensive exercise that would require participation by all crew members, stimulate their interest and thinking, force leadership by the crew boss, and be simple and easy to operate.

A fireline game designed to meet these criteria was used by tanker crews on the Angeles during July and August 1961 (fig. 1). Without exception, crew foreman and crew members remarked that this exercise added much to their training and helped to maintain a high degree of interest. The original exercise was expanded and further refined by the foremen during the summer.

The game requires:

1. A magnetic board (about 2 by 3 feet) with a drawing of a small fire whose perimeter is marked off into 20 equal parts, or 20 chains.
2. A colored magnetic marker for each player (or team).
3. A set of practical problems of varying levels of difficulty from 1 chain (easy problem) to 4 chains (difficult problem). These problems are the key to the success of the exercise.
4. A game manager, i.e., crew foreman.
5. Individual players (or teams), i.e., crew members.

Rules for playing the game (to be explained by game manager before starting):

1. Each player (or team) is assigned a colored magnetic marker.
2. The players (or teams) draw for starting positions.
3. The game manager records the order of players.
4. All markers are placed at the initial attack position, marked X.

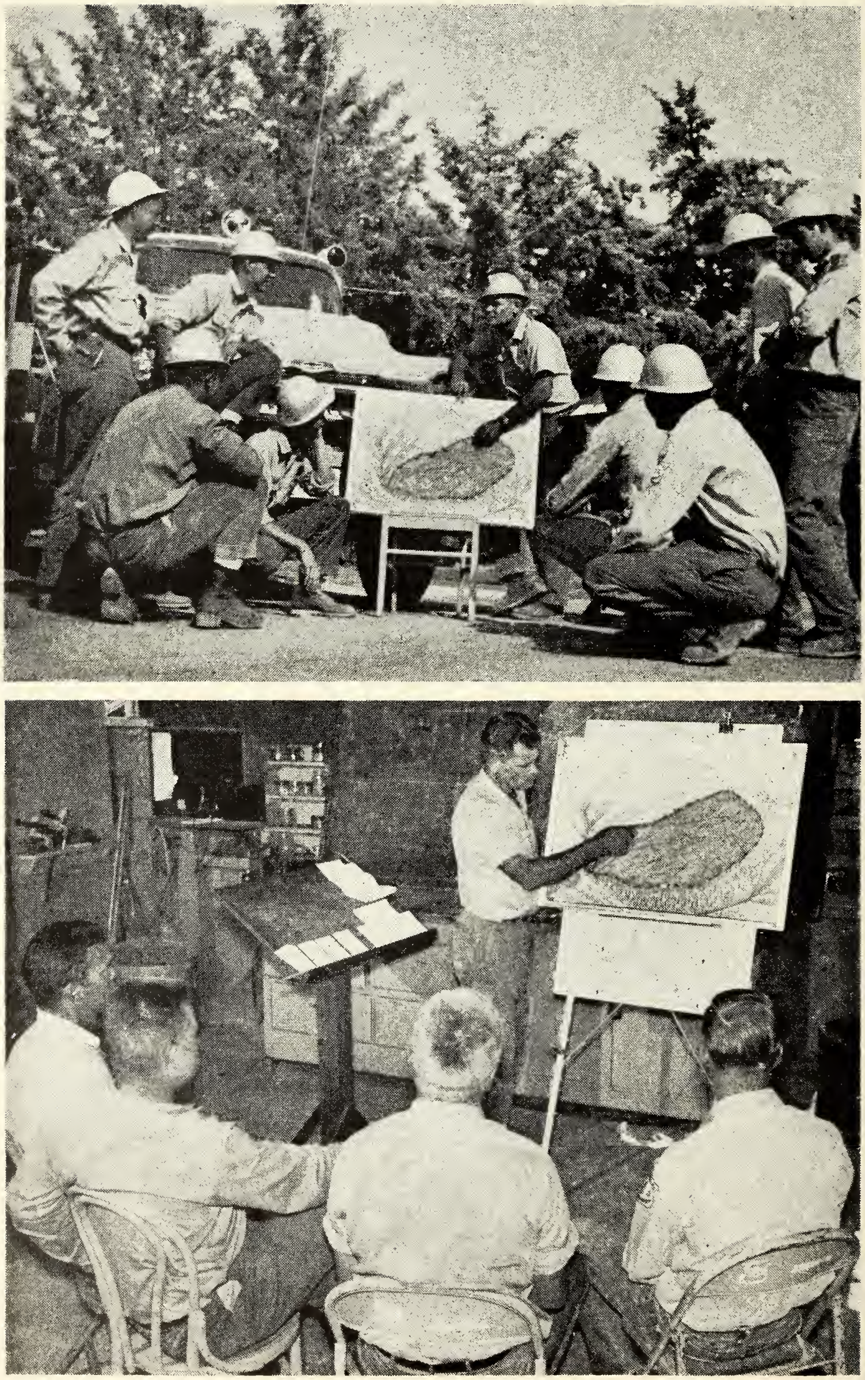

FIGURE 1.—Tanker foreman exercising two tanker crews with fireline game, and a single crew indoors.

5. The game manager asks the first player whether he wants a 1-, 2-, 3-, or 4-chain problem.

6. The first player (or team) then chooses a problem.

7. The problem is read by the game manager.

8. The player is given a specified amount of time to think of an answer; the time varies from 5 to 30 seconds, depending on difficulty of the problem.

9. The player answers the problem.

10. The game manager then asks if other players agree.
    - (a) If they do, and if the answer is correct, the game manager moves the answering player's (or team) magnetic marker ahead the number of chains assigned to the problem.
    - (b) If the other players do not agree, and if the answer is correct, the answering player must explain why it is correct before his marker is moved.
    - (c) If the other players do not agree, and if the answer or any part is wrong, the answering player loses the same number of chains of fireline assigned to the problem, and his marker is moved back.

11. The next player, and the others in turn, then proceed as above. This procedure forces participation and alertness of all players.

12. The first player (or team) to move completely around the fire wins the game.

The game manager acts as a referee and leader to bring out discussion by all players and to further specific training objectives. He also uses the game to present problems that will bring out key training points he wishes to stress.

Some examples of typical problems for the ground tanker exercise are as follows:

1-Chain problem (low level of difficulty).—Don hands you a wrench to tighten a valve on your tanker. Do you use it? If not, why not? (5 sec.)

2-Chain problem (medium level of difficulty).—Wind is a key weather factor affecting fire behavior. Name two other weather factors of concern to the firefighter. (10 sec.)

3-Chain problem (high level of difficulty).—Your fire is burning in highly flammable fuels on a steep slope. You think of standard order No. 10. What is it? (15 sec.)

4-Chain problem (very high level of difficulty).—What are four important factors in determining your point of attack? (30 sec.)

The fireline game, when properly managed, involves the whole crew, develops interest and keen competition. This game can be used for testing and evaluating trainees during fire training sessions.

TILT BED UNIT MOUNTED ON TRACTOR-PLOW TRANSPORT

Santee Ranger District, Francis Marion National Forest[1]

A tilt bed body, modified as mentioned, was used on the Santee Ranger District, Francis Marion National Forest, during the prescribed burning and fire season 1960-61 (fig. 1). The tractor-plow unit was loaded and unloaded approximately 100 times under all operating conditions during the period. No defects or difficulties in design were encountered. The only disadvantage of the tilt bed in contrast to other beds is that it costs more and requires more time for loading and unloading.

Experienced personnel formerly operating the standard droop tail bed all were enthusiastic in their preference for this new tilt bed unit.

Specifications of body:

- Schwartz hydraulic-operated ramp hoist subframe assembly complete with hydraulic-operated winches and approach plate assembly.
- Lift frame: Double 6-inch heavy (13) channel for 21-foot platform.
- Hoist cylinders: Two 5-inch cylinders with 35-inch stroke, 14-ton capacity, Model 120 T.

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[1]Taken from a report on the use of the tilt bed unit submitted by M. J. Dixon, District Ranger. The use of brand names is necessary to report factually on available data. Their use implies no approval of the products to the exclusion of others which may also be suitable.

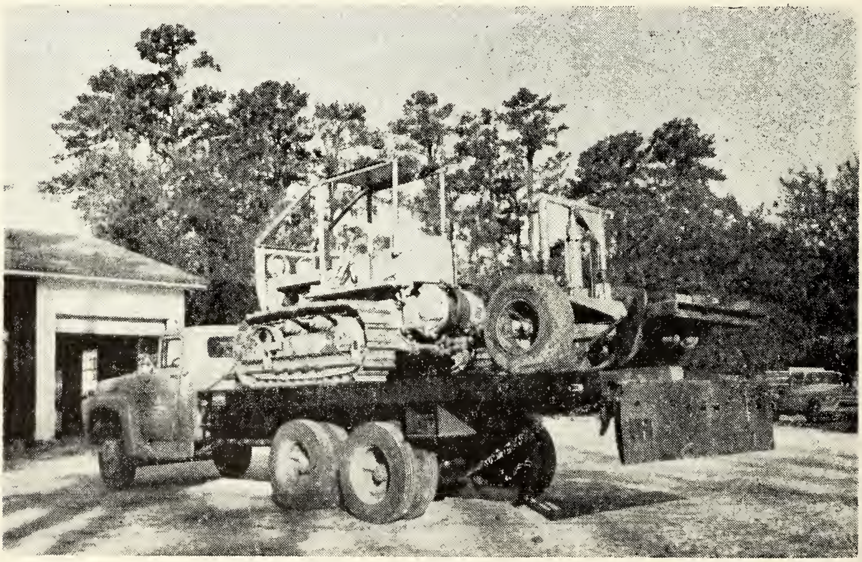


FIGURE 1.—Tilt bed with tractor and plow loaded and ready to go. Approach plate in rear of bed is down.

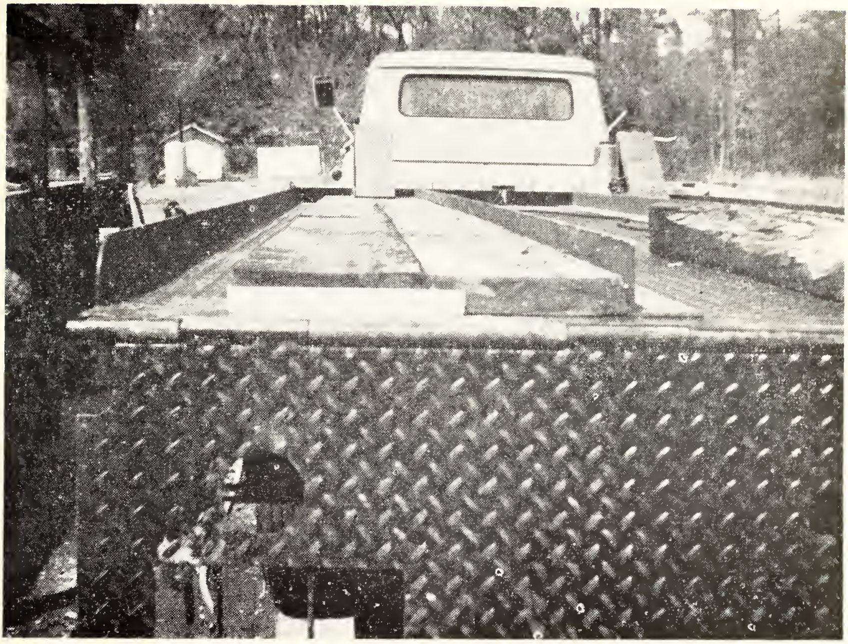


FIGURE 2.—Rear view of bed mounted on truck. Oak planks are 2 by 10 inches for tractor treads. L-irons as track guides are important to prevent side movement while TD-9 is loading.

Winch cylinder: 5-inch, 15,000-pound capacity.
Hold down clamp: Hydra-Spring unit for positive lock and automatic release when bed is raised.
Winch cable: $5/8$-inch.
Winch chain: 6-foot $3/8$-inch.

The tilt bed transport 165-024 was received on the Santee District October 17, 1960, and put into use in November. The complete unit consisted of a Ford T-700 truck, the tilt bed body, and an International TD-9 with a hydraulic Mathis plow attached.

The unit was driven 2,200 miles, for use on 30 wildfires and several prescribed burn areas. This required loading and unloading over 100 times. The unit proved to be a very satisfactory and dependable piece of equipment.

The tilt bed was used as received with the following modifications:

1. The chocks were moved to a position 2 feet back from the front of the bed to distribute the weight evenly over the rear wheels. The balanced weight made the truck easier to drive.
2. A 4-inch by 8-inch by 4-foot timber was bolted to the bed for the coulter and plow point to rest on. This prevented the plow from moving from side to side and injuring the coulter.

3. The tilt bed winch cable was shortened so that it held the TD-9 tracks tight against the chock blocks.

4. A large safety snap hook was attached to the end of the cable for ease in hooking and unhooking the TD-9, which has a steel pin with nut and safety pin.

5. L-shaped grease fittings facing down were installed under the bed of the truck so it can be greased from below. This eliminates raising the bed to get to the fittings.

6. Four oak 2 by 10's were bolted to the bed (two on each side) for the tracks of the TD-9 to run on. On the inside of these planks, two 4-inch L-irons were bolted as track guides to prevent side movement of the TD-9 while loading and in transit (fig. 2).

7. Two chains were attached to the bed with cold links for securing the front of the TD-9 and the plow. Binders were fastened to these chains with cold links to prevent their being lost.

8. A safety step was welded to the front of the bed.

Standard procedure for unloading the TD-9 (fig. 3): (1) With truck engine running, set hand brake; (2) engage bed gear; (3) set throttle to fast idle (the faster the engine runs the faster the bed operates); (4) start tractor, release brakes, and place in neutral gear; (5) raise plow to clear bed; (6) lower bed

FIGURE 3.—Tractor and plow being unloaded from tilt bed. Operator is manipulating controls. This is the maximum elevation of bed. Tractor and plow are descending slowly; held back by cable. Operator can ease the tractor unit down. Weight and momentum of tractor-plow unit permit sufficient descent until all except the last cleat of tractor is on ground. Momentum is not sufficient to have all of the treads flat on ground. Note approach plate is parallel.

to ground; (7) let winch out until tractor stops; (8) unhook winch cable; (9) drive TD-9 away; (10) turn off truck engine.

To load, the procedure is reversed.

The tilt bed body cost $2,852 complete. A droop tail body mounted on an identical transport cost $1,200. In our opinion, however, the tilt bed body is superior to the droop tail and worth the extra cost. There are no heavy runners to handle; this eliminates a danger of ruptures. Danger of tractor falling from bed and injuring driver is reduced. Loading and unloading are easier and safer; tractor is under control from ground at all times. An expert tractor operator is not needed to handle loading and unloading; personnel trained in elementary operation can handle this procedure. Truck can be used to haul other equipment and is more versatile. The entire unit is shorter than the droop tail when the approach assembly is down. The truck handles better than conventional droop tails.

FOREST DISPLAY RACK

Arcadia Equipment Development Center, U.S. Forest Service

Time and again fire protection personnel and resource officers are called upon to exhibit a wide variety of items. Foresters often display posters, photographs, timber products, collections, or new tools at ranger stations, at fairs, and in public buildings. At this Center we have found that these requests involve quite an investment, especially in man-days. It appeared that a little more care in initial layout could make such displays usable for many occasions. Much of our show material was being seriously damaged, primarily in transit and in storage.

For our use we needed a large mounting surface. Often several display boards were required and this created a transportation problem with vehicle space at a premium. Excessive "wear and tear" was another consideration. To help overcome these limitations we designed and built several racks including the features described in the following paragraphs.

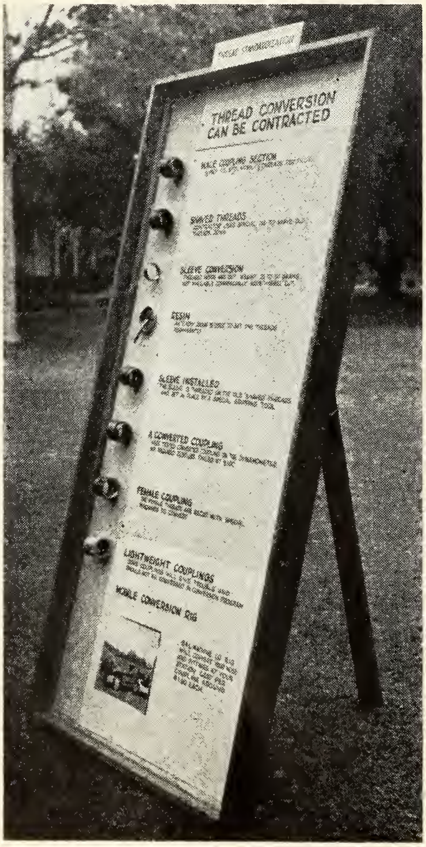


FIGURE 1.—Large display board in us at 1961 fire chief's meeting; sectio showing molding, exposed area c monk's cloth, and exhibit material and explanation.

IGURE 2.—The smaller display board demonstrating hose thread standardization.

A 36- by 68-inch section of ¼-inch pegboard was covered with ood-quality monk's cloth. A sturdy frame of 1- by 4-inch material as fitted around the board (fig. 1). The board was held in the rame by quarter-round base shoe fastened with long wood rews. Assuming that there would often be display items on the oard while in transit, the back was recessed as deeply as possible in the frame to protect them. Each display rack was carefully tailored to lie flat in the bed of a station wagon and, if ecessary, several could be stacked.

A leg of 1- by 4-inch material has been hinged to the top of the rame. A chain keeps the leg from swinging out too far. When ot in use the leg is pinned flat to the back of the rack.

We also built a smaller display rack which sits nicely on the p of a fire camp table. This 24- by 48-inch unit (fig. 2) is suported by two short legs.

The monk's cloth covers the holes in the pegboard and lends an ttractive, professional appearance. The yardage is not costly nd provides a good surface on which to mount or hang pictures nd posters. If the peg holes are used the threads of the loosely oven cloth can be easily separated without damage.

This display board offers a large mounting area on a sturdy, asy-to-handle rack. The exhibit is protected in transport and storage. After long hard miles on the road and a number of heduled showings the basic material is still neat in appearance nd ready for the next assignment. We believe the cost of the splay rack will be saved many times over.

INCREASING THE HEIGHT OF STEEL FIRE LOOKOUT TOWERS

OWEN T. JAMISON
Fire Staff, Georgia National Forests

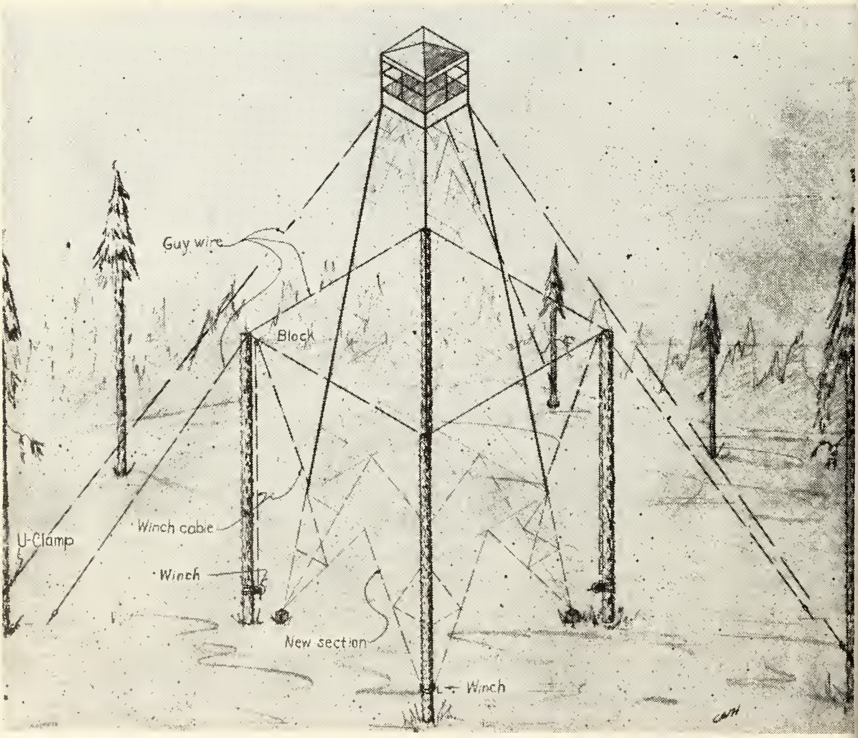
On high site index areas, especially in the South and Southeast Coastal Plains, timber growth is blocking visibility from many fire lookout towers. In such level areas, cutting trees near the tower will not restore adequate visibility.

The Croatan Tower, Croatan National Forest, New Bern, N. C., was blocked in by 60-year-old loblolly pines in 1960. The decision was made to increase the height of the tower from 100 to 120 feet.

Rather than dismantle the tower, the contractor lifted the entire tower 20 feet and bolted in the new 20-foot section.

The following steps illustrate how the job was done:

1. Larger and wider spaced foundations were constructed to the tower manufacturer's specifications.
2. Four 50-foot poles, one on the outside of each of the new foundations, were set. Cross braces were installed on



the poles at ground level to give more bearing surface in the soft soil. These poles were green, unpeeled loblolly pines.

3. The poles were guyed well to ground anchors and tied together at the top and midpoint. A powerline construction crew subcontracted this rigging job.

4. Heavy hand-cranked winches were attached to the poles.

5. One-half-inch wire rope was threaded from the winch spools, up through blocks at the top of the poles, then down and attached to the tower legs near the base.

6. Three-fourths-inch wire rope guys were attached to each top corner of the tower and to trees or other anchors 150-200 feet from the base of the tower. U-bolt clamps were used to secure these guy wires.

7. The base of the tower was unbolted from the old foundation.

8. The tower was centered between the new foundations by rolling on pipe rollers.

9. The new 20-foot section was then fabricated onto the new foundations.

10. Four men, each operating a hand winch, raised the tower evenly within the new steel base section.

11. When the top guy wires became taut, the U-bolt clamps were loosened on one guy wire at a time and the guy wire allowed to sag about 2 feet.

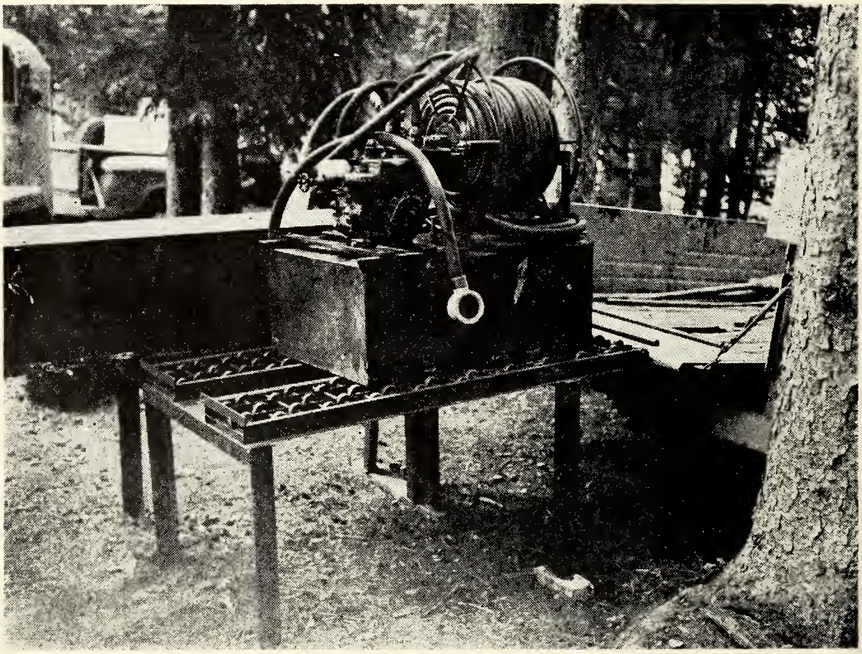
12. When the base of the tower was raised up to the top of the new section, the two parts were bolted together.

Steps #7-12 were finished in one working day to minimize the chance of an unfavorable weather change.

FIRE PUMP AND TOOL BOX LOADING PLATFORM

Lynn H. Jones, *General District Assistant,* and Edward D. Day, *Assistant Ranger, Hahns Peak District, Routt National Forest*

This loading platform makes it possible for one man to load a 50- to 100-gallon pumper full of water or a 10-man fire tool box in a pickup. It consists of track rollers welded to ¼-inch angle-iron legs, 2 by 2 inches in size, with cross braces of the same size. The rollers extend 6 inches beyond the legs on the loading side. The bottom of the rollers can be slightly higher than the pickup



bed so that the truck can back under the rollers with the end gate down.

The pumper unit or tool box can be rolled into the truck on two or three pieces of 1-inch pipe. When the pumper is loaded, it should be blocked to prevent rolling around while traveling. Cost of the platform for a pump is $20 plus cost of the track rollers, which varies depending on the quality purchased.

POSSIBILITIES FOR USE OF A TEACHING MACHINE

Bert Holtby
Forester, Division of Fire Control, U.S. Forest Service

There is no argument about the need for highly trained fire personnel; we know that after we have set objectives and policies, organized, staffed, and established controls, the successful accomplishment of the fire management job depends on the performance of the assigned firemen and fire officers. The efficient performance of these men is largely built through successful training efforts, combined with experience.

Most wildland fire control leaders have long been concerned with the challenge of how to effectively train sizable numbers of personnel to accomplish a fire management job of increasing complexity. The sharp buildup in fire personnel during the fire season, the high rate of turnover of part-time employees from year to year, the increased use of specialized fireline equipment, the development of air attack, and the need to train more individuals in more subjects, are but a few of the factors complicating our training effort.

Military and industrial organizations have faced similar problems due to the growth and complexity of "space age" technology. Since the end of World War II, there has been a concerted effort by many military and private organizations to improve training programs to meet these changing requirements.

Likewise, much effort has resulted in some improvements in fire training approaches, methods, and tools. However, in the United States the general approach has remained about the same over the past 20 years.

Now, however, we have the opportunity to use a newly developed training approach, with its special tool the teaching machine. This could provide a major improvement in our overall training efforts.

During the past year a number of newspapers and periodicals have printed articles on this training tool—the teaching machine containing programed learning or self-instructional lessons. These articles have aroused interest among many individuals and organizations, who are also looking for an efficient method to help meet their increased training requirements. Most of these articles have indicated that through the proper use of teaching machines more effective training can be done in less time.

What is a teaching machine? For our purpose we can define it simply as a "device operated by the trainee which presents a lesson in such a way that it may be understood and retained". Some of the significance of such a device may be seen in these points.

1. Instruction is provided by a written "program," which is presented by means of a machine, independent of instructor assistance.
2. Learning occurs at the individual's rate of speed.
3. Two-way communication is provided between the machine and the learner, the trainee receives immediate knowledge of his progress.
4. The lesson sequence is presented in a series of instructional items which require immediate trainee reply.

The machine is only the vehicle that presents the lesson or instructional materials. To understand the principles of the teaching machine approach, let us describe a typical operation:

1. The trainee is seated before the teaching device.
2. It presents information, illustrations, and questions or problems by means of say a 35-mm. filmstrip.
3. The trainee studies the information and answers the questions and problems by selecting from several possible answers.
4. The trainee then pushes one of several response buttons.
5. The button action uncovers the answer and indicates whether or not it is correct.
   a. If not correct, the machine so indicates and shows some additional information to allow the trainee to understand the training point or idea.
   b. If correct, the trainee turns to the next item.
6. This process continues until all the lesson has been presented and answered correctly by the trainee.

Teaching machines are not new. A very early effort in this country was made by a scientist in 1866; but the present teaching machine work was started about 1926 at Ohio State University by Dr. Sidney Pressey. It was not, however, until the early 1950's that a number of educational leaders in the United States recognized the value of a device that permitted the learner to take an active role in the learning process and to provide him with immediate knowledge of his performance. By 1959 national interest had developed to a high point as evidenced by a growing number of research and development projects carried on in many universities and in a number of military and industrial organizations.

During 1960 and 1961 interest in the teaching machine grew at an extremely fast rate. The available machines vary greatly in size, complexity, and cost.

Psychologists have performed many experiments that show a person usually learns best when—

1. He learns easily.
2. He does something as he learns, that is, "learns by doing."
3. He receives a reward for learning.

Any successful teaching program is based on these three psychological learning principles.

Psychologists also point out that a trainee becomes discouraged when he has trouble with a subject, arithmetic, for example, and makes many mistakes in each day's lesson. Often the trainee says he "hates" a subject, and may develop an unconscious block, or barrier, against learning it.

"If he can learn arithmetic without making mistakes as he goes along," the psychologists say, "he will not build up a mental block against it. And in that case he will work at it willingly and enthusiastically."

Many people are amazed when they hear that students can go through an entire teaching machine program without making, at most, more than a few mistakes. Some people think this means that the students have not really learned anything new.

Tests based on controlled experimental studies, have proved that students do learn in a carefully designed teaching machine course. For example, one class of 8th-grade students finished a whole year's work in algebra in less than one term by the use of teaching machines. They took an algebra test, together with another class of students who had spent a full year studying the same course under conventional methods. The machine-using students received higher marks than those in the other group.

A year later, on a similar test, the machine-users again received high marks. This proved that they still knew the lessons learned many months before.

The program inside the machine.—The lesson, on filmstrip, inside a teaching machine is prepared by a method called programing.

This is how an "expert" goes about programing a subject:

1. First, he breaks the subject down into dozens, or even hundreds, of small steps, or frames. Each step leads to the next, and makes that next step easy to understand.
2. Second, he adds to each frame a question, or questions, that will test the trainee's understanding of what he has just read. The trainee may be asked to work out some problem. He may be shown several possible answers (multiple choice) and asked to choose the right one. Often a question will be asked in several different ways in different frames, to make sure that the trainee really understands what he has seen and read.
3. Third, at the end of each step, the correct answer is given to each question that has been asked in that frame.
4. Fourth, the important steps are repeated in different words and at different places in the program, so that the trainee can review what he has already learned and strengthen his understanding of it.

The most successful programs have been prepared by a team consisting of subject matter specialists, training specialists (or training psychologists), and visual aid specialists.

Developing teaching machine lesson plans is no easy or simple matter. Even with good existing "human" lesson plans, it is a tedious, detailed job requiring much analysis and work to present the material point by point in a logical sequence with reinforcing information. Also, expert technical assistance is needed in preparing graphics, photographs, and visual displays to strengthen the key points in the training material.

Each word in a successful program is designed to buy something in the way of learning, and all unnecessary verbiage is cut out, "chunk by chunk," then "piece by piece," and then "sliver by sliver."

A pilot plant development was started in 1961 by the U.S. Forest Service working with a corporation primarily engaged in the design and development of large, computerized information processing systems. The machine designed for pilot plant use is known as the ikor (immediate knowledge of results). Information, visual aids, and questions are projected onto a screen at the front of the machine.

The program selected for this 'pilot plant' effort is a one hour advanced fire behavior lesson on clouds and associated fire weather.

The lesson has been developed in four parts:

Part I—What are clouds? (A quick review.)
Part II—How are they formed? (A quick review.)
Part III—What type of clouds are there? (A quick review.)
Part IV—What effect do the various types of clouds indicate in terms of associated fire weather? (Main part of lesson.)

Here is an example of *one item* from Part II of the lesson:

(Advanced Fire Behavior) Item 11

WE HAVE JUST DISCUSSED TYPES OF CLOUDS, AND HOW THEY ARE FORMED. NOW, REMEMBER WE ARE ONLY REVIEWING CLOUD *FORMATION*.
NOW, WHAT DO YOU THINK WOULD HAPPEN IF A STRONG WIND ARISES IN THE AREA WE JUST DISCUSSED?

1. Adiabatic cooling takes place and the vapor content of the air becomes uniform.
2. The air mixes and the warmer air at the ground cools as it rises.
3. The cool air high above the ground mixes with the warm air and the warm air cools down.
4. The cool air mixes with the warm air and it warms up.

Feedback to the trainee depends on which button he pushes (figs. 1 and 2):

1. Correct—Good! Go to Item 16.
2. No—but almost right. Go to Item 13.
3. Wrong—not complete. Go to Item 14.
4. Wrong—incomplete. Go to Item 15.

In developing the feedback some items are often illustrated with pictures and might be written as follows:

Item 16. Yes! That's exactly what would happen. In the top part of the layer of air the process of MIXING has

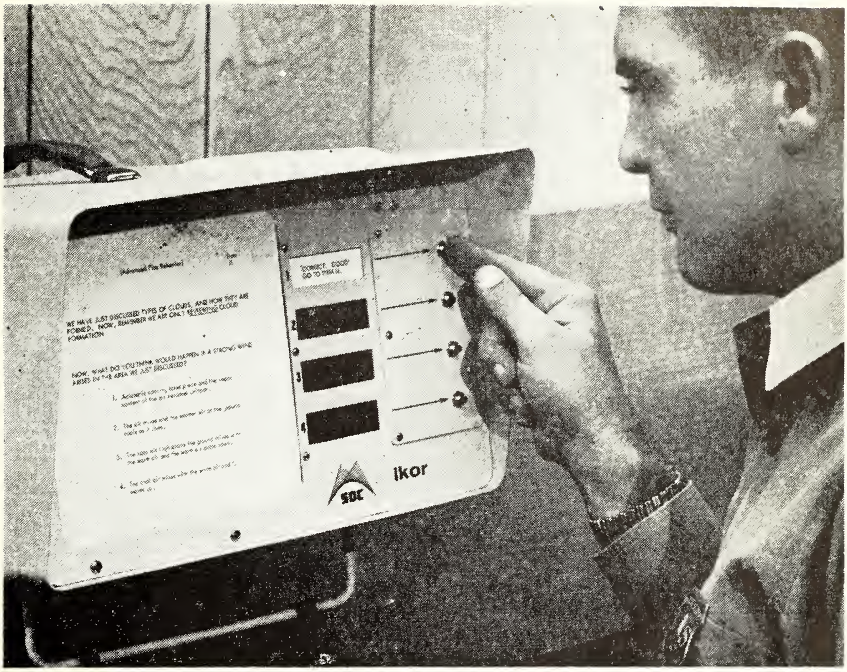


FIGURE 1.—A manually operated teaching machine designed and developed for research in programed learning techniques.

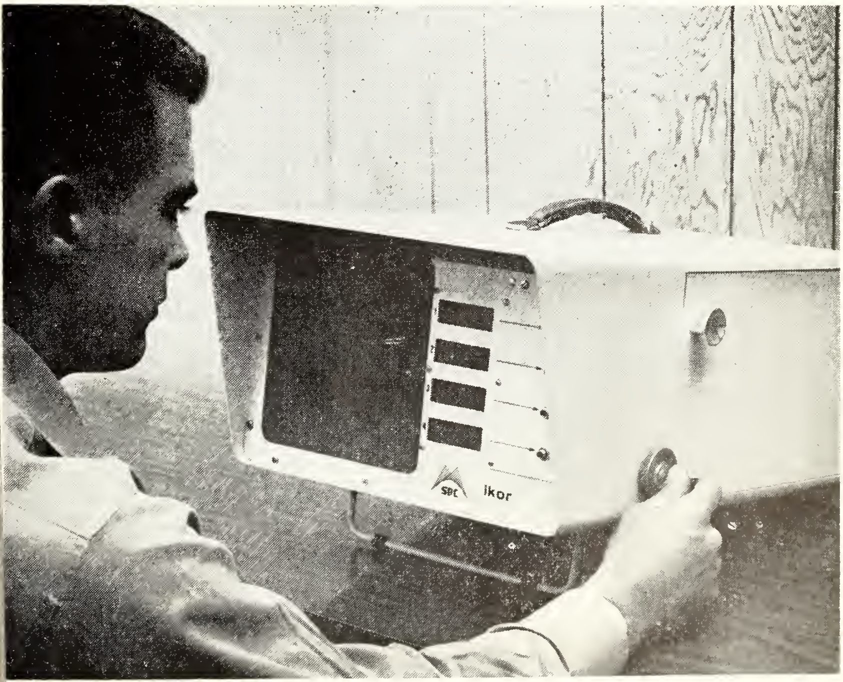


FIGURE 2.—Trainee turning handle to next training item.

created a cooling and an addition of water vapor effect. If enough MIXING takes place, a cloud will form at the top of this body of air.
Remember this though, MIXING usually occurs close to the ground.
Go to Item 17.

Item 13. That's true all right! But you forgot about the *water vapor* part of the MIXING.
Turn back to Item 11 and choose another answer.

Item 14. That's so. However, several other things happen at the same time.
Go back to Item 7 and review.

Item 15. Correct—as far as you went! Several other interesting and important phenomena occur in the process of MIXING.
Turn back to Item 7 and study it carefully. Answer all questions completely as you continue through the section on MIXING.

Part IV of the pilot plant program might begin like this:

Item 62

WE WILL NOW TALK ABOUT HOW CLOUDS ARE INDICATORS OF THE FOLLOWING *IMPORTANT* FIRE-WEATHER VARIABLES:

(a) Wind
(b) Fuel Moisture
(c) Fuel Temperature
(d) Atmospheric Stability
(e) Precipitation

BECAUSE CLOUDS ARE USUALLY ONLY THE RESULTS OF WHAT IS HAPPENING IN THE *ATMOSPHERE*, RATHER THAN THE *CAUSE* OF ATMOSPHERIC CHANGES, WE FIND THAT . . . etc.

The total pilot plant teaching machine program in advanced fire behavior will be demonstrated at the U.S. Forest Service National Training Workshop in January 1962.

A teaching machine with a carefully designed learning program is a "bridge" that permits expert instructors to reach students and to serve each as a private tutor. The idea of a private tutor is probably as old as mankind.

The teaching machine as a training tool is certainly not a magical device; without an efficient program inside it, the machine is simply an empty box. Some significant values in the use of teaching machines are—

1. They provide clear, concise, and complete training when needed, rather than when a "class" and instructor are available.
2. They present uniform information and require frequent responses by the trainee.
3. They provide immediate feedback to the trainee, in-

forming him whether his answer or analysis is correct or not.

4. They allow the trainee to work individually, and to adjust his own rate of progress to his needs and capabilities.

5. They easily provide refresher training.

This tool, if properly fitted into an overall training program, could help provide more effective training and bring about a saving in time.

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.

remember- only YOU can

PREVENT FOREST FIRES!

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IRE CONTROL NOTES

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VOL 23 NO. 2
April 1962

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TED STATES 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.

Growth Through Agricultural Progress

Volume 23 Number 2

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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Forest Service, Washington, D. C.

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CONTENTS

RESEARCH IN FIRE PREVENTION[1]

LLOYD M. LAMOIS
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We in the U.S. Forest Service have been confronted with many fundamental problems in our study of the fire prevention job on wild-land areas. We have barely scratched the surface of what is emerging as a broad and complex subject, and one in which there exists a real need for research activity on many fronts. We feel strongly that close cooperation and free exchange of information among many various fire control agencies will pay large dividends to all who are seeking more effective ways in which to prevent fire.

The number of forest fires has, after a remarkable reduction over the past few years, started to level off to an apparent "irreducible minimum." We are becoming increasingly aware that we must take a second look at this prevention problem. One hundred thousand fires a year are too many to live with in this day of increasing forest values. We are sure, now, that we can, and must, considerably improve our performance in prevention effort.

Our fire prevention research program is being conducted in cooperation with the University of Southern California and with the State of California Division of Forestry. They have accomplished what we think is a thorough overall examination of the many aspects involved in the fire prevention business.

There is much research to be done in which we "firemen" can play only a passive or indirect role. We will find ourselves dealing with aspects of human behavior of which we have barely a speaking knowledge, let alone capabilities for doing meaningful research. Turn the research job over to the "experts." If we "firemen" are imaginative enough to stimulate and guide (or finance) research effort into these avenues, or alleys, we will be doing an important part of the job—but leave the actual human behavior research to experts who know what they are doing.

The very design of test instruments with which to measure awareness, attitudes, and knowledge is a tricky business. Most of the time during the first 3 years of the California project was devoted to the design and testing of questionnaire forms that were sensitive to different levels and kinds of fire prevention knowledge existing among various groups of citizens who used our forests. Fire control men played an important part in selecting valid questions—but the "mix" and the administering of the test were the business of testing experts at the University of Southern California who know how to get *most information* at *least cost* and with the greatest degree of confidence in results.

Essentially, in preventing man-caused fires, we are dealing with problems in human behavior. We have come to break these into

[1] This is a condensed version of a presentation to an assembly of urban fire officers at the Governor's State-Wide Fire Prevention Conference at the State House, Annapolis, Maryland, November 6 and 7, 1961.

three distinct areas of investigation: Education, Law, Environment Modification.

These are the avenues open to us in improving our prevention performance and are, then, avenues we must explore intensively through research. Each has a long list of variables, some subject to manipulation, or controllable; some independent, or noncontrollable. Through manipulation of controllable education and law variables we often can directly modify or change a human behavioral pattern. Occasionally we are faced with educational or law variables we cannot manipulate—then we have the possibility of modifying (engineering) the environment in order to minimize the fire risk from a behavior pattern inaccessible through education or law action.

Education

Research into education variables is largely a study of persuasive communication. We are dealing with the passing-on of information, the giving of instruction, and the driving home of appeals.

We find that most people are very fire conscious but there are many who do not know the full story or intimate relationship between, for instance, the storage of common household chemicals and some of the fire ignition possibilities of electrical wiring, furnaces, match-carrying, and children.

One of the first problems we encounter is "What is the public image of the senders; how credible a bunch are we firemen, anyway?" How people respond to our fire prevention message depends upon the answer to that question.

Let's consider this item—our uniform. What is its impact on the public when we are informing, instructing, or appealing to? I can easily visualize fireman "x" doing his most effective "instructional" work in uniform—where it becomes a symbol of his expertness and credibility. The same fireman "x" might find his uniform a handicap in an "appeal" before a group of business men where it would symbolize self-interest or "begging" instead of objectivity or "straight talk." Almost certainly the answer would vary according to the "public" in concern—whether it is school kids, factory workers, business owners, and whether they are contacted as a group or as individuals. How about the inspection duties: Would the homeowner react more positively to suggestions from an inspector in a business suit or one in uniform? Some of the answers we get to these questions may hurt; some we can do something about; others we may have to live with. At any rate they will give us valuable clues as to the potential effectiveness of any educational campaign we may contemplate.

The message itself is another matter of concern, especially in the job of instructing. We have been very successful in conditioning attitudes, through mass media; but so-far, we have managed to contribute little in the way of how-to-do-it information. For instance, our California questionnaire revealed that the need for hazard reduction around buildings was an item that the average orest resident thought very little about. Also, there is a lack of nowledge about burning permits. Many did not know that per-nits were required to burn trash. Many others thought that ampfire permits issued by a National Forest officer were valid in ny forested area, not just on National Forest land.

In general, the first survey returns were discouraging when we onsider the public's knowledge of fire regulations. A clue, here, o prevention action on our part is the fact that nearly one-half ne people surveyed thought that law information was difficult to et. Significant also is the fact that regulations most often broken nvolved forestry or land use "jargon" which was often obscure r entirely meaningless to the forest visitor.

Another variable is the media that carries our message. Here gain is that important matter of credibility. Various media have astly different "credibility ratings" with different audiences. 'or example, certain rural audiences have strong identification vith their local radio station, but may tend to distrust "govern-nent propaganda" from large, metropolitan stations.

A most important variable in fire prevention education is the eceiver of your message. The primary problem here is to break own the "public" into "publics." We now consider two groups f forest users, the visitor and the resident. Each is identified vith a certain set of fire situations. We must learn how to break nese two groups down into more specific "publics;" i.e., summer esident, farmer-rancher, fisherman, camper, hiker, and so on. 'ach of these small "publics" must be measured and equated with pecific fire risks. They must be studied to reveal from whence ney receive their fire prevention knowledge and attitudes. All nis is aimed at the eventual pinpointing of special messages to pecific targets through highly selected media.

Law

Law and its enforcement must never be relied upon as a substi-ute for education.

The first item of research into the role of laws in fire prevention s a study of the statutes themselves. Are they adequate? Does the inguage unmistakably cover specific trouble situations, or is it mbiguous and full of loopholes? How selective is the system of egulations and ordinances? A particular prevention problem may ianifest itself only in some areas and not in others, or in one articular season of the year more than another. Where a selective rdinance can solve a particularly troublesome situation, good ecords should reveal the fact and existing regulations should be djusted to take care of it.

More important than the statutes themselves is an incisive in-ght into enforcement action of agency personnel. Foremost, ere, is the question of existing enforcement policy of the agency. it uniform from unit to unit of the agency; or is there a good eal of flexibility, leaving room for individual differences from orest to Forest or borough to borough? Are the people confused?

The need is outstanding for research in the realm of public at
tude toward law enforcement aimed at better fire prevention.
find four essentials here. If an agency is "missing the boat"
one or more of these, research should reveal the fact.

a. The public must feel that enforcement personnel a
active and alert for offenders.

b. The public must feel that the regulations are just a
reasonable; that is, with respect to enforcement action.

c.. The public must know that if a violation is observ
action will be taken. This means official action, not just
passing comment by the enforcement officer.

d. The public must feel that penalties involved are adequa
but equitable (stiff but not unduly severe).

There also is a problem of *actual* versus *implied* enforceme
Implied enforcement is almost "education" in that it aims to al
behavior prior to violation; e.g., conspicuous patrol in criti
areas. More attention to "implied" aspects of the enforceme
program may in many cases result in far less involvement
actual (often unpleasant) enforcement situations.

The law violators deserve the attention of our research effo
The key problem here is the identification of representative a
nonrepresentative behavior. Is a certain behavior pattern of
given violator typical of our average forest visitor, or hor
owner? Or can we assume that this certain behavior pattern
a good indicator of potential violation of a fire law? For instan
we discovered that fire law violators had histories of traffic ci
tions in an order of 3 to 1 over nonviolators. What is the effecti
ness of the penalty or treatment of the violator? Will his expe
ence result in his being a better or poorer risk as a fire source

Environment Modification

In some cases, modifying a fire environment may prove cheap
simpler, and more positive than either education or law in doi
a specific fire prevention job. In the Forest Service we think
terms of "use" patterns, such as the cycling of logging operatio
inasmuch as the accumulation of slash is affected. The buildi
of camping facilities with incinerators, fireplaces for cooki
and water source is also an example of this type of work on for
lands.

We also directly manipulate fuel situations through mechani
or chemical disposal or carefully controlled burning of logg
debris or by constructing firebreaks along an exposed area
hazardous fuels. The thing to remember here is that the modifi
tion of a physical situation is linked closely to a human behav
pattern. By simply moving a paper trash box in a school build
out from some dark corner, where kids are apt to sneak a smo
into a more conspicuous spot in the hallway, you may "enginee
the prevention of a school disaster.

Those factors which we cannot modify (weather, topograp
fuel types) we must learn how to measure in terms of their imp

on fire occurrence, then adjust our education effort and law enforcement in ways which minimize the importance of these non-controllable elements.

Summary

In summary then, we have explored our three main avenues which we hope will lead to some answers we do not now have; answers which should allow us to strengthen considerably our total prevention program.

1. We expect our research into education problems to sharpen our approaches to "educating the public." We must learn to identify specific "publics" and discover about each exactly what prevention problems exist, what we must say and in what manner and through the most efficient media.
2. By studying the role of laws and their enforcement in the fire prevention job, we hope to learn how to more effectively augment our education effort, especially where we have failed to "educate" away carelessness and lack of knowledge and where "malicious" and "habitual" sources are inaccessible to education.
3. Finally, research into environmental variables should teach us much as to which are controllable and which are not and what we should do about each.

☆ ☆ ☆

Ten Hours Sleep and Thirty Cigars

Along about the 20th of November the Export Timber Company sent 30 men to Lurton to cut and haul staves, as the Company was putting in a mill at Lurton.

I had got a handful of buttons at the Forest Office that read "Prevent Forest Fires." I met these 30 men at the store at Lurton, and got right in the midst of them and explained that we were trying to grow timber to keep mills like they had running and to do this we had to keep fires out of the timber. I then gave each man a button except one boy. He said, "I don't want it." I then started to work to get one on his coat. I would go to the campe at night, play pitch with them and quite often I would get this boy for a partner. I wore one of the buttons on my coat all the time. In about five nights, this boy asked for one of the buttons, and he has it on his coat today. This cost me an hour or two sleep for five or six nights and thirty or forty cigars.

BUT I CAME OUT WITH THE BUTTON WHERE I WANTED IT.—Douglas Shaddox, *Road Foreman, Ozark National Forest.* [An exact copy of an undated report in the files of the Ozark N.F. The year is believed to have been 1930. The principle illustrated is the value of appropriate and timely personal contact—a principle as valid and important today as in 1930.—Ed.]

ARE WE TAKING SMOKEY BEAR FOR GRANTED?

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As times change, our problems change, and the approach to solving these problems change, too. This truism also applies to the effective programing of the Cooperative Forest Fire Prevention Campaign, commonly referred to as the Smokey Bear Program.

Let us look back to the beginning of the campaign—back to 1942. The Wartime Forest Fire Prevention Campaign was started to minimize natural resource destruction by wildfire due to enemy shelling and bombing and to minimize the loss of firefighters to the Armed Services. Forest fire prevention became one of the first public service programs of the War Advertising Council, now The Advertising Council, Inc. The advertising agency Foote, Cone and Belding volunteered to plan the yearly campaigns; Russell Z. Eller, Advertising Manager of Sunkist Growers, Inc., became the coordinator; and the U.S. Forest Service and the Association of State Foresters were the clients. This cooperative arrangement has remained unchanged through the 20 years the program has been in effect. The first campaign kit included posters, radio scripts, newspaper ads, and bookmarks.

From the first campaign kit, we have come a long way in our mass-media approach. In 1961 the campaign produced and distributed more than 20,000,000 pieces of new material, including pamphlets, easels, bookmarks, tent cards, calendars, coloring sheets, stamps, song sheets, decals, bumper stickers, newspaper ad proof sheets, envelope stuffers, and a variety of posters. Almost 100,000 car cards of three different sizes were printed and sent to The Advertising Council for distribution to transportation companies throughout the country for display in street cars, subways, and buses. Through The Advertising Council, 6,500 of the large display posters (3-sheet) were placed in airports and railway stations, and in outside displays. A television kit, containing 6 different spots, 1 minute, 20 seconds, and 10 seconds in length, was sent to all television stations throughout the country and obtained over 2 billion home impressions. The campaign received, free of charge, public service time from radio and television broadcasters estimated to be worth $14,000,000. Equally valuable space was donated by newspapers, magazines, outdoor advertisers, and transportation companies.

More than 250,000 Junior Forest Ranger Kits were mailed to children writing in asking to become Junior Forest Rangers. As a result of a Captain Kangaroo show televised nationally, featuring Smokey Bear and the Junior Forest Ranger program, 105,541 requests were received in the month of October alone.

A teachers kit, aimed at the primary grades, was developed and is now being sent upon request to teachers throughout the country. Demand for these kits, now almost 200 a month, is increasing daily. These teachers reach a young audience of approximately 80,000 a year with a concentrated course in forest fire prevention and an introduction, through Smokey, to a future appreciation of conservation.

The commercial licensing program, now 9 years old, is an important function of this office and has earned over $220,000 in royalties in that time. These funds are used to implement the nationwide forest fire prevention program. At present, there are more than 30 commercial licenses in effect, covering production of such varied Smokey Bear items as dolls, scarves, comic books, milk mugs, belts, T-shirts, cigaret snuffers, books, games, banks, toys, cookies, ash trays, calendars, pen and pencil sets, and litter bags.

A supplemental program called the Southern CFFP was organized in 1959 to combat the specific fire problems in the 11 Southeastern States. More than half the man-caused fires of our country occur there. Operating on a budget of only $17,000, this program is aimed at an adult audience and has as its goal the reducing of incendiary and malicious woods burning. For the past 3 years television spots, newspaper ads, radio platters, posters, and envelope stuffers have been produced and distributed for this purpose.

Has the Smokey Bear Program paid off? No study has yet been made to determine why man-caused fires were held under 100,000 for each of the last 5 years as compared with 205,000 in 1942. We can only point at this record and say, "We have helped." Campaign costs have increased from $25,000 in 1942 to $270,000 in 1961. This investment has resulted in an estimated savings in resource damage of ten billion dollars over the past 20 years—or half a billion a year. This is really a small investment when the final returns are calculated. Has the campaign been so successful it may be discontinued? The answer is an emphatic "NO."

There are still too many man-caused fires. The cost of suppressing these fires runs into tens of millions of dollars each year. As our population grows and more people use the great out-of-doors, fire risks increase proportionately. We can't possibly reach every man, woman, and child personally—we must rely on the mass-media approach supplemented by local effort to make people aware of the fire danger. Because Smokey has become famous—seen on television, or a poster, or a newspaper, or any other handout item, or perhaps heard on the radio—are we taking him for granted? Have we, in the field of forest fire prevention, reached the point where we say we have exploited every possible means of communicating our message, "Remember only *YOU* can prevent forest fires"? Not by a long shot.

How can we better reach 180,000,000 actual or potential forest users today and the generations to come? There are many ways, and the future will suggest many more. Here are some of them:

1. A better understanding of how to use each and every CFFP item now being distributed; this will require intensive training.

2. Fuller use of materials now being distributed to overcome any tendency to let materials accumulate in warehouses and storerooms. Again, training, followed by inspection at all levels, is needed.

3. Better use of radio as a mass-media tool. The radio audience of today is much greater than the television audience. Our goal is to produce material annually that program directors will use, with emphasis on a greater variety of short public service announcements. Short spot announcements in script form prepared at the local level can also be effective.

4. Better coverage in magazines at national, regional, and local levels. Here again, we have just scratched the surface. More people are reading more magazines than ever before. We see many opportunities in this field.

5. In television, the use of Smokey Bear and other forest fire prevention materials in local programs by the station's own TV personality. Some of these people are doing an outstanding job of teaching prevention to local juvenile audiences. Billy Johnson, of WLW-A, Atlanta, Georgia, for example, reaches thousands of children in his daily programs. Here, too, local effort is necessary to get the programs going.

6. Working closely with the primary grade school teachers. There are approximately 5,000,000 children in the first four grades and a million more start school every year. The job of reaching these children may at first glance seem to be an impossible task, but the teachers reach them every day. Informed of our program, and aware of the materials available, these teachers can get our message to every child in America.

7. Further expansion of Smokey Bear Reading Clubs such as the one developed as a joint project by the South Carolina State Library Board and the Commission of Forestry in 1955. This idea has caught on and State Foresters have developed similar projects in other States. These are programs with a forest fire prevention and general conservation theme. It provides selected reading materials at the libraries for children, and rewards them for reading a certain number of books.

8. An earnest willingness in all of us to take these steps and find other ways also that will help the program. Let's not just rely on Smokey. He's doing a good job, but the main job in the final analysis is up to us.

ETHICS OF WOODS BURNING—A KEY TO PREVENTION

W. I. White
U.S. Forest Service, North Central Region

[This article is reprinted from the December 1936 issue of Fire Control Notes. We feel that it contains a truth as important today as it was then.—Ed.]

It seems to me that we have been pretty generally overlooking what is probably the most potent force available for real fire prevention. This force, if once aroused, will accomplish more thorough and permanent results with many people than all the arguments commonly used in preaching fire prevention. I mean the ethical sense of right and wrong.

In many parts of our forest domain, particularly in the lower Mississippi and Ohio valleys, the economic status of the rural residents within the forests is very low. It has traditionally been so, and in spite of our various plans for social uplift, the thinking and habits of a community cannot be changed over night. Discussions of economic betterment, land use planning, conservation of resources, etc., are often entirely meaningless to an Ozark mountaineer who has been taught from the cradle to believe that what was good enough for his "pappy" is good enough for him.

On the other hand it has been amply demonstrated and reported that the residents of many of these communities of low economic status have a very deep and forthright religious feeling. Even though they may not be able to discriminate between good and poor farming practice, between wasteful and conservative use of land, they do have a well-defined sense of right and wrong.

Why not, then, elevate our consideration of woods burning to an ethical plane and consider it from the standpoint of right and wrong? A man who may not be able to see any economic advantage in allowing his woods and fields to go unburned may perhaps be brought to feel a sense of stewardship for the natural resources which the Lord has placed at his disposal. Or, allowing a fire to damage his neighbor may be placed in the same category with stealing his neighbor's cow. Throwing down a burning match or cigarette by the roadside may be likened to doing the same thing in a powder magazine.

As a means toward establishing this principle in the communities where woods burning has been done deliberately for many years, I suggest that our field men make it a point to cultivate the acquaintance of the preachers who work in the forest communities, attend their religious meetings, and definitely align themselves with the apostles of right and truth. I believe that by tactful contacts the matter of malicious or uncontrolled woods burning can be brought out into the open and mentioned specifically in meetings of this kind as an unethical thing to do, the same as lying, or stealing, or beating one's wife.

There is no question about the preacher being a leader in the sort of community of which I speak, and the local Forest Officer can make no mistake by being definitely and clearly on his side.

Certainly, if the deliberate or careless setting of fires can be given a definite stamp of disapproval by the right-thinking people in any community, many other acts of trespass and evil-doing which give our law enforcement officers gray hairs will be greatly reduced also. Let's give it a trial!

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Are You Missing the Woman's Touch?

The familiar words "never underestimate the power of a woman" has, perhaps, become a tiresome and overused phrase. It is used (more often than not) in a facetious vein. But, seriously, have you thought of asking "the girls" to help prevent forest fires? If not, you are missing a bet.

Most women belong to a club of some kind, whether they are housewives, school teachers, business women, or retirees. And, most of these clubs concern themselves (or should) with conservation of natural resources. Here is a built-in organization to "spread the gospel" about forest fires and it is yours for the asking.

Women like to assist any "cause" which makes their communities a better place to bring up their children. They devote many hours as adult leaders of Girl Scouts, Camp Fire Girls, Cub Scouts, and church and other youth groups. They are, therefore, a receptive audience when reminded of the devastation of forest fires and the need for preventing them. Their clubs sponsor Smokey Bear coloring contests, essay contests, set up conservation shelves in schools and libraries, plant trees—to mention just a few activities.

Foresters are sometimes reluctant to "tackle" the President of the woman's club, garden club, P.T.A., or whatnot for fear of having to balance a cup of tea at the next club meeting. Be brave; it might not be necessary to go to the meeting. Begin at home; your wife will help you and probably have good suggestions for enlisting others. All Forest Service Regional Offices (except Alaska) now have a person in women's activities who will explain organization and objectives of various women's groups and how best to approach them. They also will suggest projects and assist in accomplishing them.

Now that your courage is up, go after distaff assistance in preventing forest fires.—Elizabeth Mason, *Division of Information and Education, U.S. Forest Service, Washington, D. C.*

ONTARIO FIRE SEASON—1961

W. T. Foster
Supervisor, Forest Protection Section,
Ontario Department of Lands and Forests

The Province of Ontario during 1961 experienced one of the most severe fire seasons in recent years. Although the number of fires, 1,305, is about the annual average, the area burned totalled 1,184,998 acres, twelve times the average annual loss during the past decade. The region of heaviest occurrence and damage was the northwestern part of the Province, west of Lake Superior to the Manitoba boundary. This area suffered from extreme drought and burning conditions while the remainder of the Province enjoyed a better than normal season.

The critical period of occurrence and spread lasted 28 days, between June 15th and July 12th. The stage for the 1961 fire season was set back in 1958, the beginning of a period of much below normal precipitation and light winter snowfalls. This period of low precipitation contributed to a fairly heavy fire load in the region during 1960—this, as it turned out, was only a "preliminary" for 1961. The build-up of unfavourable conditions was well recognized prior to the 1961 fire season. It was particularly emphasized by the water inflow data for the two major lakes and drainage areas affected. Lake of the Woods was 58 percent of normal and Lac Seul 42 percent of normal for the period October 1, 1960, to April 15, 1961.

After widely scattered thunderstorms over this region of some 100,000 square miles during the second and third week in June, the "fire build-up" produced three lightning fires on June 15th, the number increasing on June 18th to 20 new fires. By July 1st, 158 lightning fires had occurred of which 107 had been extinguished. A total of 244 fires occurred during this period; 12 of these accounted for 1,124,500 of the acres burned.

Major spreads took place on June 24th and 28th on fires in the Pickle Lake and Lac Seul areas in the Sioux Lookout district and at Boundary Lake in the Kenora district where a large fire crossed into Ontario from Manitoba on the 24th. Fires were reported spreading as much as 10 miles on the afternoon of June 28th. Lightning storms continued to plague firefighters and a storm on the evening of June 26th resulted in several new fires including two major fires that would pose a threat to the community of Red Lake. Strong shifting winds, severe burning conditions, and smoke hampered aircraft operations, fire detection, and fire servicing throughout the period.

On June 28th the Minister of Lands and Forests imposed a Forest Travel Ban in the Sioux Lookout district; Kenora district was subsequently closed to travel on July 4th. The travel closure was imposed to reduce the risk of additional fires and for the safety of people who had entered the threatened areas.

On June 30th weather reports indicated particularly severe burning conditions for July 1st—high gusting winds and low relative humidity. All headquarters and fire crews were alerted to take special precautions. By noon of July 1st, men were removed from dangerous sectors of fireline, and camps in critical positions evacuated. Approximately 60 women and children were evacuated about midday from Valora, a small community on the Canadian National Railway line about 130 miles northwest of the Lakehead cities of Port Arthur and Fort William. Valora was threatened by two major fires 6 miles to the southwest.

One hundred and fifty miles farther to the west two major fires that threatened the Red Lake area created a tense situation for this mining community of 5,000 people. Emergency plans had been put into effect with the co-operation of the town council, the Ontario Provincial Police and mine officials. The community was well organized should the fires force an evacuation. Firebreaks were constructed, emergency waterlines laid, and all available pumping equipment, bulldozers, water-dropping aircraft, helicopters, and manpower were mobilized. About 4:30 p.m. one fire about 5 miles south of the community burned across the Red Lake highway and a hydro line temporarily disrupting power, telephone service, and road traffic. This fire spread about 9 miles eastward on a narrow front to the shores of Gull Rock Lake where it destroyed a large tourist camp. The other major fire 6 miles to the east of the community spread to 30,000 acres on the afternoon of July 1st.

The strong winds which continued to blow from a westerly direction were favourable in that they kept the fires from advancing on Red Lake itself. Firefighters eventually controlled both fires without further damage, but the threat to the community was not entirely eliminated until July 18th.

To the northeast of Red Lake, 165 miles away, another mining community, Pickle Lake, was completely blacked out by smoke from fires. Dense smoke and high winds made it impossible for aircraft to operate, determine what new fires may have occurred, and ascertain how far old fires had spread. Winds during the afternoon of July 1st were westerly at 30 m.p.h. gusting to 60 m.p.h. Temperatures were in the high eighties and the low relative humidity was 22 percent.

Fortunately on July 2nd, the winds lessened and the humidity increased sufficiently to create a lull in the fire spread permittting firefighters to be regrouped and control efforts intensified. In spite of lack of rain, a continuance of severe burning conditions, and additional lightning strikes, all fires in the higher value, accessible forest areas were gradually brought under control.

Several fires which accounted for the major portion of the acreage burned over were in the most northerly inaccessible forest areas beyond present economical timber harvesting operations. These fires, because of the existing circumstances, were attacked by small, highly mobile crews using helicopters and light aircraft to strike at favourable points to gain control. Helicopters were used effectively to mop up large fires; on one fire a helicopter crew put out over 300 smudges.

To meet the fire situation Department personnel and equipment were mobilized throughout the Province and there was an orderly flow of firefighting resources, based on day-to-day requirements, into the fire area. The movement of assistance from outside the Western Region started on June 17th with the South-Central "Project Fire Team" of 17 supervisory personnel going to Sioux Lookout. Four water dropping DeHavilland Otter aircraft were flown into northwestern Ontario to assist the four Otters based in the area. Four additional Beaver aircraft from eastern Ontario and all five Department helicopters were moved into the region. In addition to the 28 department aircraft operating in the area, the Royal Canadian Air Force provided two large helicopters, Ontario Hydro Electric Power Commission two more, and the Department requisitioned the services of four additional helicopters. A large water-dropping Canso flying-boat and up to 31 commercial float-equipped machines were employed. A total of about 70 aircraft were engaged at varying periods.

Water dropping was considered a major factor in successful fire attack in several instances. During the 1961 season, 843,500 Imperial gallons (1,012,200 U.S. gallons) of water was dropped on 104 fires in Ontario.

During the emergency period, over 200 experienced Department personnel from other sections of the Province moved in to reinforce district staffs at Sioux Lookout, Kenora, and Fort Frances. Over 300 pumping units and a million feet of fire hose, handtools, and camping equipment were shipped from caches and other districts to supplement the normal complement of equipment located in the fire areas. As many as 2,600 extra firefighters were recruited at the peak of the control operations.

On July 12th light rains came bringing the first relief in a month. The Forest Travel Ban was lifted on July 13th and the summer-long job of mopup and cleanup was underway.

EFFECT OF 1956 SOUTHERN FIRE CONFERENCE DEBATABLE

JAMES E. MIXON[1]
State Forester of Louisiana

A letter survey and discussion around the Southern States indicate that indirect far-reaching results of the fire conference are evident, but the good is a matter of degree.

It is apparent that the judiciary and press became more aware of the problem of incendiarism and some were motivated to take more severe action, though these were considered in a minority.

It is probable that the increases in State appropriations generally enjoyed over most of the South since 1956 were influenced by the fire conference. Some credit is given here to the conference.

The survey does not show any relationship between State or county followup meetings and fire occurrence in incendiarism or debris burning. It would seem that the fire record would give the truest picture of conference influence.

In the Southern States the relation between total fires and incendiary and debris fires for 5 years before and 5 years after the conference is as follows:

	Total Fires	*Debris burning fires*		*Incendiary fires*	
		Number	*Percent*	*Number*	*Percent*
1951	75,559	13,469	17.8	36,259	48.0
1952	83,523	15,551	18.6	37,204	44.5
1953	60,455	12,878	21.3	25,734	42.6
1954	94,120	21,558	22.9	37,083	39.4
1955	56,784	13,234	23.3	22,739	40.0
5-year av.	74,088	15,338	20.7	31,804	42.9
1956	59,324	14,440	24.3	20,787	35.0
1957	31,156	7,958	25.5	11,668	37.5
1958	42,030	10,323	24.6	16,534	39.3
1959	47,441	14,998	31.6	17,472	36.8
1960	50,073	13,614	27.2	17,701	35.4
5-yr. av.	46,005	12,267	26.7	16,832	36.6

It is interesting to note that in relation to the total number of fires debris fires increased 6 percent after the conference while incendiary fires decreased almost the same amount or 6 3 percent. Several factors, such as the three that follow, may well be considered.

1. Several State Forestry Agencies expanded their law enforcement personnel and facilities in the period following the conference.

[1] Jim Mixon, State Forester of Louisiana, was an organizer of the Southern Forest Fire Prevention Conference at New Orleans in 1956. He has vigorously pressed a fire law enforcement program in Louisiana. Jim, early in his career as State Forester, declared war on those who deliberately set fire to woodland and so jeopardize life, property, and our economic future.—Ed.

2. During this period a reinterpretation of fire causes was disseminated to the personnel making fire reports; the new interpretation disrupted the uniformity that prevailed on causes in the period prior to the conference. This is certainly true in Louisiana.

3. Climate cannot be overlooked. Most of the South experienced a 2- or 3-year wet period in the second 5 years. This may be construed to indicate that the debris burners became careless after repeated efforts to burn debris and thereby possibly increased their percentage. On the other hand the arsonists kept waiting to "burn when the wind is high." Their chances were fewer; this could explain why their percentage dropped.

Some States feel that the fire conference had no effect in reducing incendiary or debris fires, because those who start such fires are seldom influenced by education. Yet, in spite of the marvelous preparations for the conference and the outstanding talks, some of the speakers persisted in pushing for more education.

In my opinion, education has not reached the woods burner and never will directly. The deliberate burner has not changed. Although it is six years since the conference, I still do not believe that education will reach the burner.

The Southern State Foresters generally agree that the Southern Branch of the National Cooperative Forest Fire Prevention Program was formed as a result of the conference. This is good. The program is in its third year and getting stronger. It is aimed at responsible citizens and in bold approaches makes an effort to motivate them to help stop the arsonist. I feel that this kind of education will ultimately pay off though it is indirect.

In summary, I see no direct improvement effect on the percentage of debris or incendiary fires as a result of the 1956 fire conference in New Orleans and subsequent followup State or county meetings.

Continuing programs and effort, however, have brought improvement to the South. There has been expansion in enforcement personnel in some States, better cooperation with the judiciary has been reported by some, some States have enjoyed appropriation increases at a more rapid pace, the Southern CFFP is active on the problems of arson and debris burning, and some States have brought new acreage under protection.

A SMALL AERIAL PUBLIC ADDRESS UNIT FOR FIRE CONTROL USE

RICHARD A. CHASE, *Assistant Fire Staff Officer,* and
DON E. FRANKS, *Fire Control Officer, Deschutes National Forest*

The need for a public address unit for air to ground communication often arises in fire control work. Frequently, smokechasers do not have portable radios, nor do all crews on the fireline, and instances arise when an aerial observer has information to pass on to these ground forces.

Generally, the planes used for fire patrol and reconnaissance are light craft rented from private operators. Often the same plane will not be available each time one is needed. Therefore, any loud-speaker system to be used in these planes must be light, compact, and easily mounted and demounted, so that it can be readily switched from plane to plane. At the same time, it also must have sufficient power and fidelity to carry the voice clearly a reasonable distance under the adverse operating conditions encountered.

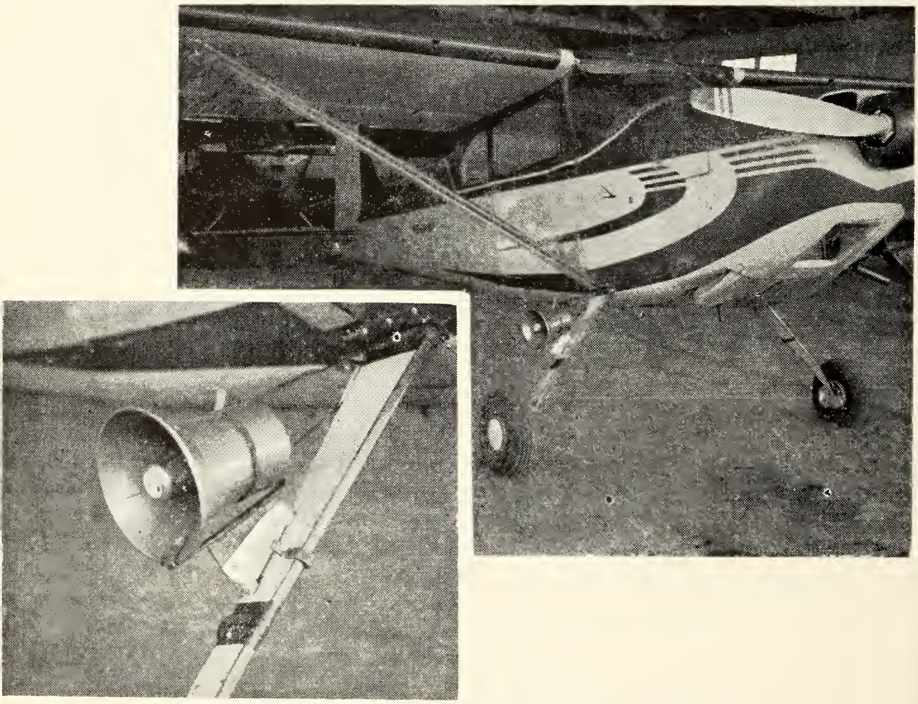

FIGURE 1.—Amplifier speaker mounted on a Cessna 180; closeup showing bracket.

One unit which meets the above requirements is rated at 50 watts; the 14-volt amplifier and speaker unit is completely transistorized, lightweight and compact. An additional feature is an electronic siren which is very effective in attracting attention before a message is started. Cost is approximately $260.

A few minor additions to the basic unit made installation simple. The amplifier is small enough to sit on the floor between the observer's feet, and an adapter on the power cord allows it to be plugged into the cigarette lighter. A bracket fitted on the speaker horn provides easy attachment to the landing gear strut (fig. 1).

Since the speaker is very directional (a factor in the unit's ability to carry the voice clearly under the operating conditions) it must remain aimed at the person being spoken to, for best results. During tests the noise of the aircraft's engine tended to drown out the message. To overcome this and satisfy the first requirement, it was found that excellent results were obtained by climbing the plane to approximately 2,000 feet above the ground, cutting power and descending in a flat spiral over the location of the message's recipient. Banking the plane as it circles keeps the speaker properly aimed, and a fairly long message can be given, or a short one repeated a number of times.

The key to successful performance is adequate practice by both the pilots and the observers who will use the unit. By trying the unit in the air and listening on the ground, the suitable aircraft flight pattern and the proper voice level, inflection, and speed are soon determined.

One unit used by forest personnel during the 1961 fire season won wide acceptance. It proved invaluable in directing smokechasers without radios to several small lightning fires in timbered areas, thereby eliminating many man-hours of search and speeding up initial attack. In one instance, it was used to call back two firemen searching for a back-country smoke that had subsequently disappeared. This was possible even though the plane could not see the men and, in fact, was not sure of their exact location.

Other uses for this aerial public address unit are warning crews of changes in fire behavior, alerting ground forces to spot fires and directing men to them, and even broadcasting short fire prevention messages to campers during critical fire weather. While the system has the limitation of not being able to blanket large areas with a message, it does adequately perform in those instances where the aerial observer has valuable information for an individual or small crew on the ground.

FLORIDA FOREST FIRE PREVENTION COMMITTEES

FLORIDA FOREST SERVICE

In any drive or movement requiring public support, the more people who can be involved, the more likely the objectives are to be reached. This is particularly true if community leaders are involved. Florida's Forest Fire Prevention Committees were organized with this fact in mind. The committees didn't "just happen." They were the outgrowth of efforts to get the forestry job done during rapid extension of fire control and other Florida Forest Service activities.

During the early 1950's, the many counties just brought under fire control presented two serious problems—fire prevention and financing. It seemed worthwhile to enlist some local help to work on both. The Florida Forestry Association agreed to appoint men selected by the Florida Forest Service to serve on county committees under the Association. It was felt that this arrangement would be beneficial to both the Florida Forest Service and the Forestry Association. Many of these committees served well. Such county groups have been used in other Southern States, although details of appointment and duties vary. Georgia has County Forestry Boards, and South Carolina has County Forestry Committees.

In 1956, at Florida meetings held as a followup of the New Orleans Fire Prevention Conference, a resolution was passed urging the legislature to provide for State and County Forest Fire Prevention Committees. Florida's lawmakers complied with this request during their 1957 session by amending the Forest Protection law to provide for these committees to be appointed by the Florida Board of Forestry.

To date, committees have been organized in 56 out of 67 counties. District Foresters, district personnel, and county personnel recommend people whom they think would make good committee members. These names are screened, and a final selection is recommended to the Florida Board of Forestry by the State Forester. Members are appointed for 2-year terms and serve without pay. Every effort is made to have each committee include a cross section of interests and activities in the county—bankers, business men, farmers, small landowners, newspaper men, civic club leaders and garden club and women's club members, although not all are included on each individual committee. Each committee must have at least five members, but most committees have six to eight. The State Committee is made up of twenty-five representatives from all parts of Florida. Most of them serve on county committees.

Committee duties are to assist the Florida Board of Forestry and the Florida Forest Service in implementing the policies and programs of the Florida Board of Forestry, to assist in forest fire prevention, law enforcement, tree planting, forest management, nd other forestry activities when called upon to do so by the 3oard.

As might be expected, some committees are more active than thers. A considerable amount of work is required to orient the ommittee members and to keep them interested, active, and helpul. In one meeting where we were trying to determine how we ould breathe life into some of the committees and how we could elp others to help us, we reached the conclusion that the prime esponsibility for successful committee action rested on the Florda Forest Service. If a committee is inactive, it is either because ve made the wrong selection of members or we failed to take he necessary steps to keep the committee interested and active.

Activities have varied greatly from one county committee to nother. This is as it should be, as no two counties have identical roblems.

One committee has set up a project for the four chapters of 'uture Farmers of America, located in four sections of the ounty, to compete in a contest to reduce careless, man-caused orest fires. Cash prizes will be awarded to the chapters with the reatest percentage reduction of fires in their areas. Another ounty has arranged with county school officials to have every ixth grade class in the county visit a Florida Forest Service Ieadquarters to learn how fires are located, how trucks are disatched, how equipment works, how fires are fought, etc. Another ommittee has worked with the Chamber of Commerce to provide show-me" trips to forest industries. One county committee purhased 10,000 litter bags with a forest fire prevention message nd distributed them through filling stations and restaurants. nother committee prevailed upon the County Commissioners to nake and erect metal roadside signs with a forest fire prevention nessage. Several committees have held essay or poster contests or school children and have furnished prizes.

Activities have not been limited to fire prevention. Several comnittees have worked with law enforcement officials and other ounty officials to provide better enforcement of the fire laws. everal counties have assisted in establishing farm forestry projcts, and in one county the committee paid half of the county's ayment for the farm forester when the county ran out of money. 'ree planting machines have been secured by at least three county ommittees for local use.

We cannot point to any particular reduction of fires and say hat the County Forest Fire Prevention Committee was reponsible for this reduction. It is difficult, and often impossible, o attribute a specific reduction of fires to a specific fire prevention ffort. We know, however, that there are some things—legislative ontacts, for example—that committees can do more effectively han the Forest Service employees. And, the more coordinated re the efforts directed toward preventing forest fires, the smaller vill be the fire damage to our forests.

We feel that the County Forest Fire Prevention Committees ave helped us in the past few years and will be of even greater elp to us in the future.

A PROFILE OF THE CALIFORNIA HUNTER

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

On June 6, 1944, the Allies opened a second front in Europ with the Normandy Invasion. The 320,000 men that went ashor that first week constituted one of the largest expeditionary force the world has ever seen. Yet every year almost twice this man armed men and women invade the forests and wildlands of Cali fornia: 560,000 licensed hunters.

The great majority of these people want and try to be carefu with fire, but their numbers alone constitute a serious fire risk. I addition, hunters are a *special* problem. Hunting (deer huntin in particular) is a solitary, back-country sport. The hunter doe not have neighboring campers available to extinguish his fire i he leaves it. He doesn't stay in improved campgrounds where th hazards have been removed for him. He may make a dry camp where water must be packed in for miles and too little is availabl to drown breakfast or warming fires. He is in the woods mostl during the dry summer and fall months when forest fuels ar most flammable.

All in all, the hunter is in an ideal position to start forest fire And he does. To avoid disaster, the hunter must be *more* carefu with fire than other forest users and the forest fire agencies mus see that every one of these men and women *is* careful with fir

To give fire control agencies the best possible tools for thei prevention job the University of Southern California, in coopera tion with the Pacific Southwest Forest and Range Experimen Station and Region 5 of the U.S. Forest Service and the Californi Division of Forestry, has undertaken a large-scale study of th fire prevention knowledge and attitudes of the State's hunters.

With the help of the California Department of Fish and Gam we polled 2 percent of the State's hunters: a random sample o 10,000 drawn from 560,000 carbon copies of hunting licenses sol in 1959-60. The carbon copies served as a source of additiona information and a check on the representativeness of replies t the University of Southern California questionnaire.

Questionnaires were mailed to the entire sample populatio Three types of information were requested: "vital statistics, answers to 16 multiple-choice questions relating to fire preven tion knowledge, and a rating of sources of fire prevention in formation. Here is what we learned about the hunters' vita statistics and a preliminary analysis of their sources of in formation.

Who is the California Hunter?—When you think of a "hunter you may get a definite mental picture. If so, discard it. Hunters i 'alifornia are an extremely diverse group. The best we can do is escribe the range of characteristics of this population and thus ut some sideboards on our mental picture of the hunter.

How old are they? Hunting, at least in California, is largely sport for men in the "junior executive" age bracket. When omparing the ages of hunters to those of all California residents 5 years old and over, we found fewer hunters than expected at ll ages from 15 to 25, more hunters than expected at all ages rom 25 to 50, and fewer at all ages over 50.

Since hunting is an active sport, it is not surprising to find articipation falling off with increasing age. But why the lack f enthusiasm for hunting by men under 25? Several possible xplanations have been advanced, ranging from a lack of financial esources to the theory that the younger generation does all its unting indoors.

Only 7 percent of the State's hunting licenses are purchased by omen, but this may be a misleading statistic in fire prevention ork. An earlier on-the-ground survey of 474 deer hunters in orthern California found 144 women and 330 men. Evidently any women enjoy the sport as a camping out experience but do ot purchase a license.

The occupations of California hunters varied so widely as to ake meaningful comparisons virtually impossible. We found oker setters, set designers, hairdressers, and seaweed inspectors. owever, more than two-thirds had "indoor" occupations where meaningful contact with fire prevention problems or practices uld be expected.

Where Do Hunters Live?—Most hunters come from smaller mmunities. Fifty-six percent of them were from towns with a pulation of under 20,000, compared to 41 percent for the general population. Only 14 percent had addresses in cities over 250,-0, compared to 28 percent of Californians as a whole. This does t mean that most hunters come from rural areas; it may be just peculiarity of California's geography. One in every two Califrnians lives in the five-county Los Angeles area in the southern d of the State, but only 25 percent of the hunters. Because of the matic pattern, almost all hunting country is in the central or rthern parts of the State. The seven-county Bay Area complex fully as industrialized as Los Angeles, but much nearer to hunt- opportunities. Here we find 20 percent of the hunters and only percent of the State's population.

Where Do Californians Go to Hunt?—We can't answer this estion directly with the data available from the survey. But we 1 get some useful clues since we know both the hunter's home dress and the place where he bought his license. We can identify nters who travel from home to a hunting area and buy their ense on arrival, but we cannot identify those who buy a license home, then travel to another area to hunt.

n the extreme northern part of California, 35 percent of the enses are sold to nonlocal residents, in southern California only ercent. This immediately points to a difference in the prevention problem between the two areas. Prevention efforts in the north must take into account a large influx of hunters from other parts of the State. In southern California the hunters are strictly local.

Where Do Hunters Learn About Fire Prevention?—Included in the questionnaire was a list of 12 possible sources of fire prevention information and a space for "other." Hunters were requested to check those sources that they felt had supplied most of their knowledge of fire prevention. Specific sources were listed in order to prevent a repetition of the response to a previous nondirected survey where nearly 70 percent of the respondents listed "common sense" or "experience" as their only source of information. Only 6 percent chose this source in the present survey.

Responses varied somewhat from one part of the State to the other, but in general:

Forest rangers, signs, and Smokey Bear took the first three places.

Television was mentioned twice as often as radio.

Newspapers consistently outrated magazines as a source of fire safety information.

Scouting received much greater mention than schools.

Since the responses represented a mixture of symbols (Smokey Bear), media (television), direct contacts (friends), and unclassifiable sources (experience), it was necessary to cross check the sources by group or cluster analysis. For example, Smokey Bear gets his message to the public through some other media. In this survey Smokey was linked primarily with signs and posters, followed in order by television, newspapers, magazines, and radio.

Comparing mass media with word-of-mouth sources of information showed that the two are nearly equally balanced. Mass media sources received 57 percent of the credit for providing an understanding of fire prevention while word-of-mouth had 43 percent of the responses.

So What?—Although the analysis is far from completed, we already know that there is no single hunter fire prevention problem in California, but a complex of many problems that vary throughout the State. In southern California the hunter is most likely a local resident from the Metropolitan area or its suburbs. A local mass media campaign would probably reach the greatest proportion of these hunters.

In the north end of the State, on the other hand, the average hunter is either a local rural resident or a nonresident from a distant metropolitan area. At the local level, a direct contact before or during the hunting season is the most feasible method of reaching most hunters.

Not only must the prevention approaches be varied to suit the area, but a successful campaign must also take into account age and educational level. As the analysis of data from California's hunter survey continues, we should know more about the kind of information needed by various groups of hunters and the most effective media to reach each group.

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.


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VOL. 23 NO. 3
JULY 1962

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IITED STATES 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.

UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962

Growth Through Agricultural Progress

Volume 23 Number 3

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.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (October 17, 1958).

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Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1962

CONTENTS

Mention of specific products in this publication is necessary to report factually on available data. Use of the names does not imply endorsement by the Department over similar products not named.

HELICOPTER FLIGHT DATA ARE EASY TO USE

HERBERT J. SHIELDS
Mechanical Engineer, Arcadia Equipment Development Center, Arcadia, California

Would you like to know the limitations of load, altitude, and takeoff distance of the next helicopter you hire? This is not as difficult as it may seem now that reliable tests have been conducted.

We have now concluded two tests under a joint program with the Army Aviation Test Office at Edwards Air Force Base and have published reports on the Bell 47G-3 and the Hiller 12E/61. Results will soon be available on the Bell 47G-3b. You can use this information in training, planning payloads, and improving safety. Pilots may use it as good basic material for operating in the mountains.

We have put much of the information into chart form. Before you let the appearance of the charts stump you, however, let's discuss a few basic concepts of how they are set up and why they work.

Hovering performance.—In most of our work in the mountains the ability to hover and lift reasonable loads while in a hover is the most useful characteristic. Since the rotor blades must move a mass of air equivalent to weight lifted, this performance is directly related to the power available from the engine.

Engine power is dependent on atmospheric pressure and temperature, which can sometimes be artificially controlled by supercharging, or "derating;" that is, only allowing use of partial power at low altitude and gradually drawing more reserve as the ship goes up until engine limits are reached.

At any power setting by the pilot, such as full power, the helicopter can lift a greater load when hovering with the skids 5 feet above the ground than it can lift with the skids at 50 feet, because of "ground effect." This effect gradually diminishes up to 20-50 feet depending upon the helicopter used.

Now, let's take a look at curve 1 (fig. 1). The top position shows a scale of temperatures, while at the left, altitudes are marked off. The lines actually indicate engine power limits for the various combinations of temperature and altitude. The warmer it gets, the less engine power is available.

Assuming an operating altitude of 9,000 feet, and a temperature of 25°C. (77°F.), we start at the 9,000-foot point on the altitude scale and go to the right until we reach the 25°C. point (1 circled), then draw a line straight down until we visually follow in between the short curves at the bottom. The helicopter can

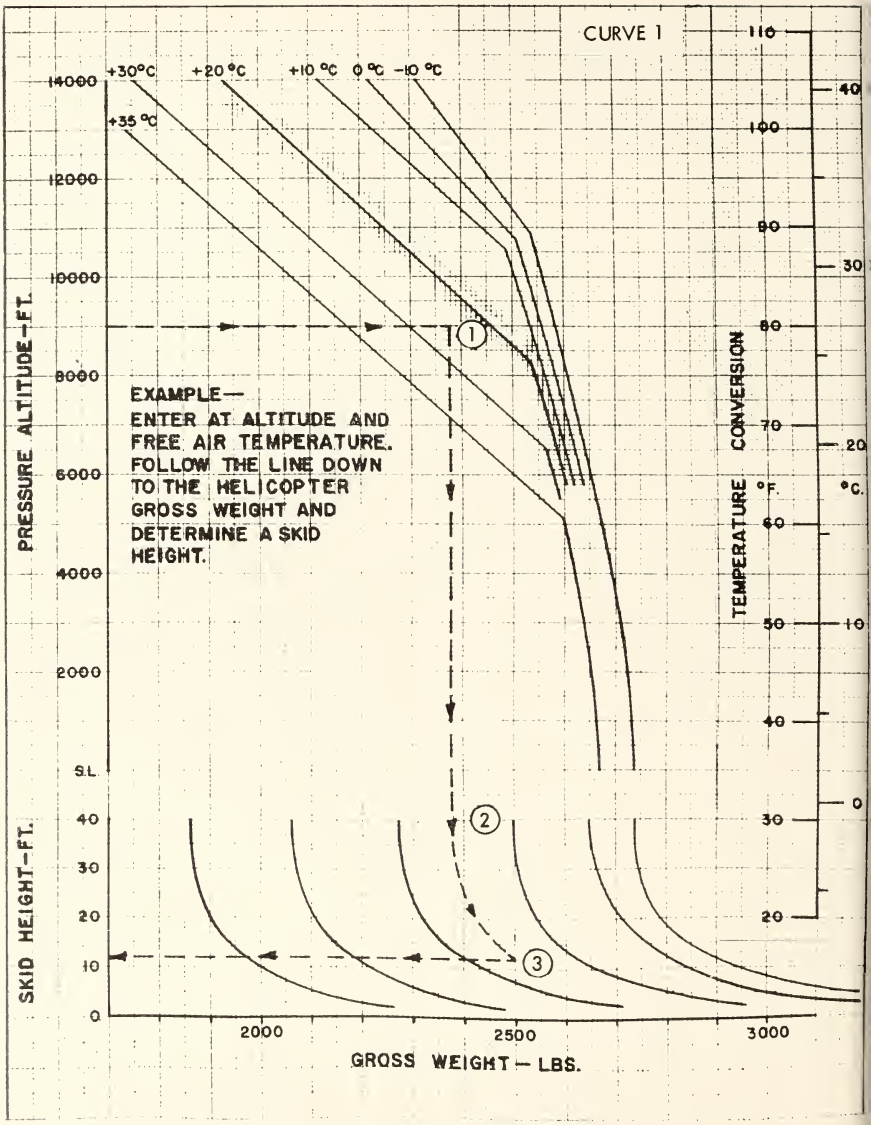

FIGURE 1.—Hovering performance, Bell Model 47G-3 (N6783D).

perform anywhere within the area to the left of this imaginary line.

If the hover condition must be 40 feet or more, *drop straight down* from point 2 (circled) to the gross weight line and read 2,380 pounds. If you only need to hover at 12 feet, follow along the curves to point 3 (circled) and then down to read 2,500 pounds. Similarly, for a 5-foot hover, read 2,650 pounds.

Now let's work backwards and see what happens. Let's say /e have to hover at 15 feet in order to hook up some cargo that /eighs 500 pounds. Assume the helicopter, fuel, pilot, etc. weigh ,900 pounds. This gives us a gross weight of 2,400 pounds. tarting at 2,400 pounds and moving straight up to the 15-foot evel, we then follow the reverse procedure until the 40-foot line s reached, then go straight up. We could hover at 15 feet at 10,000 eet at 22°C., or at 6,000 feet, out of ground effect (OGE). If we emove 100 pounds we can hover at 11,000 feet at the same emperature, or we can add 100 pounds and hover at 9,200 feet.

These values were obtained from tests conducted in *zero vind,* and therefore are conservative for most cases. Tests show hat even 4 or 5 knots of wind can improve performance data, articularly under marginal conditions.

To keep from getting lost on this curve, just remember— dding weight decreases hovering performance or altitude.

Takeoff performance.—In cases just shown where the heli- opter cannot hover more than a few feet off the ground, a akeoff can still be made. However, some distance must be covered arallel to the ground to accelerate to enough speed to climbout. This is normally the safest takeoff procedure even when a 'straight up" takeoff could be made.

Takeoff performance is commonly expressed in terms of dis- ances to clear a 50-foot obstacle. This distance includes both the cceleration and climbout runs. The length of run depends on everal variables: piloting technique, weight, temperature, alti- ude, and air speed selected for climbout.

Now, notice that weight, temperature, and altitude also directly ffect the hovering performance which we discussed. By making akeoff tests at various weights and speeds, the data can be pre- ared into various "nondimensional" factors so that the hovering nd takeoff performance can be directly plotted as shown on urve 2 (fig. 2). In other words, our engine power also directly ffects the takeoff distance.

Let's look at curve 2 more closely. On the curves at the right re noted "skid height" values. These are *hovering capability* alues regardless of all other factors. One way of finding this alue would be to bring the helicopter to a hover using *full power* nd estimate skid height to the ground. Let's say you come up vith 12 feet. If you decide to climbout at 30 knots, follow the 2-foot line from point 1 to point 2 and read across. You will eed 280 feet to clear a 50-foot obstacle. You don't have to akeoff from 12 feet, but from a normal 2 feet or so, since we vere only determining the capability for entry into the curve.

Another way of finding this value would be from the skid eight obtained from curve 1 after knowing temperature, altitude, nd gross weight. Again, you could work backwards to find your afe load if you have only a small takeoff space.

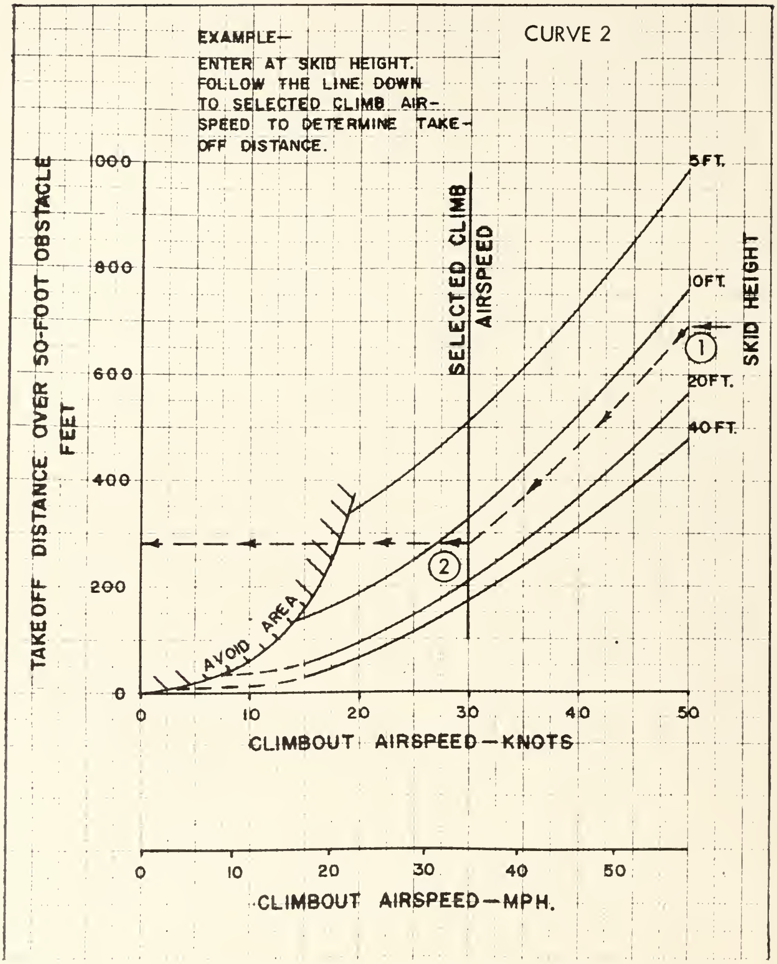

FIGURE 2.—Takeoff performance, Bell Model 47G-3 (N6783D).

Summary.—Curve 1 gives an overall picture of hovering performance by tying together altitude, temperature, and helicopter gross weight. Curve 2 shows takeoff run required at various hovering performance values for usable climbout speeds. Tables prepared from the same data used in constructing the curves are available in existing reports on the Hiller 12E/61 and Bell 47G-3. However, once you have mastered the curves you will find them giving you a more useful picture of performance.

DEHAVILAND BEAVER WATERDROPPING TESTS

J. H. Dieterich
Project Leader, Forest Fire Research,
Lake States Forest Experiment Station

Aircraft are important tools in the management and protection of the Superior National Forest in northern Minnesota. This is particularly true in fire detection and suppression activities. Float-equipped aircraft figure more prominently each year in handling these vital jobs.

In line with this increased use has been an equipment development program headquartered at Ely, Minn. Work here has been directed toward the development of equipment and techniques for increasing the effectiveness of waterdropping on going fires. Testing of this equipment has been under the general supervision of the Ely Service Center. The Lake States Forest Experiment Station has cooperated by providing assistance in design and analysis of waterdrop experiments.

Calibration tests conducted at Ely in June 1959 were summarized in *Fire Control Notes*, July 1961.[1] During each flight a DeHaviland Beaver dropped 125 gallons of water over a prescribed target area. Water concentrations and drop patterns were recorded.

On the basis of the 1959 tests, the water tank and release gates on the Beaver aircraft were modified and the tests were repeated in July 1961 (fig. 1). This report will show that the design changes produced marked improvement in waterdropping characteristics as compared to the 1959 test. It also will provide a comparison of these latest results to those obtained in a California experiment, conducted 1955-59.[2]

Test Conditions and Equipment

The 1961 tests were conducted over level, open ground at the Ely airport, using essentially the same procedures as in the 1959 tests. The airport site provided a convenient location for a network of cups in the target area to catch water for drop calibration purposes.

Only plain water was used during the 1961 tests, while both plain water and "wet" water were used in 1959.

Both morning and afternoon drops were made. The temperature averaged in the low 70's, relative humidity varied between 64

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[1]Strothmann, R. O., and McDonald, L. J. Water-bombing with the DeHaviland Beaver. U.S. Forest Serv. Fire Control Notes 22 (3): 93-95. 1961.

[2]Davis, James. Air drop tests, Willows, Santa Ana, Ramona, 1955-59. Calif. Div. Forestry.

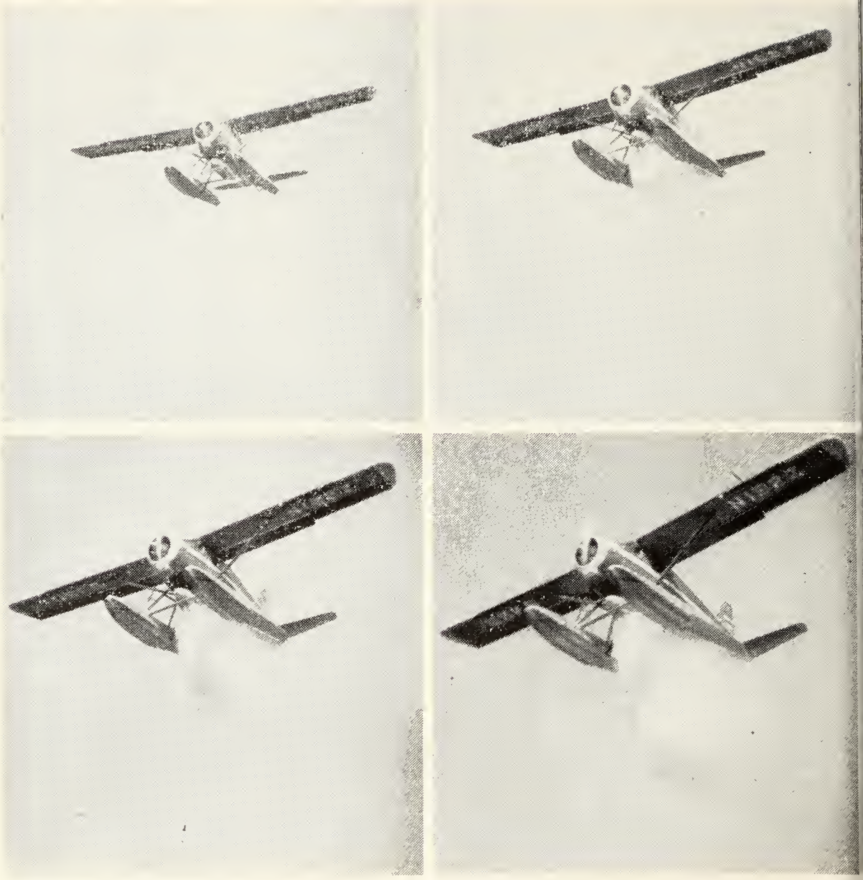

FIGURE 1.—Sequence of a test waterdrop from a DeHaviland Beaver aircraft.

and 89 percent, and the winds were generally from the southeast averaging 4 to 6 m.p.h. Three drops were made during perfectly calm wind conditions.

Airspeed averaged 80 m.p.h. Drop altitude averaged 100 feet, although one load was released at a height of 150 feet. Accuracy was excellent. Only two of the 14 drops partially missed the target area.

Ten drops were made on a grid system identical to that of the 1959 tests. Distance between cups along the 500-foot length of the grid was 50 feet. Along the 100-foot width of the grid, cups were spaced at 10 feet.

On the third day of testing, the grid length was reduced to 250 feet—one-half the original length—when it became evident that only a small portion of the 500-foot grid was being utilized. The grid width remained the same. This more compact pattern arrangement made it possible to plot the waterdrop concentration contours more accurately.

Design changes were made in the tank, pickup tube, and release opening. In 1959 a fuselage tank was used with a snorkel tube extending into the water beneath the plane. This arrangement was inconvenient, and in 1961 the fuselage tanks were replaced by streamlined exterior tanks, mounted below the fuselage and between the pontoons (fig. 2). These tanks were modified surplus wingtip fuel tanks cut down to hold 125 gallons of water. The snorkel tube was also redesigned for the 1961 tests.

The most important changes were made in the drop openings. The three openings on the 1961 model total 754 square inches, compared to only 225 square inches of opening on the tank tested in 1959. According to Arcadia Equipment Development Center standards, 500 square inches is satisfactory. The same volume of water (125 gallons) is now released through three gates that total three times as large as the drop openings in the 1959 equipment. This larger opening allows a sudden rush of water to be cascaded from the tank (fig. 3), eliminating the slow, extended release of water characterized by the smaller tank opening.

Results

Contour maps were constructed for each drop to show the water concentration and pattern. Iso-lines were drawn indicating areas having water concentrations equal to or in excess of 0.4 gallon per 100 square feet. The square-foot area within each contour was determined and averages were computed. The results are summarized in table 1.

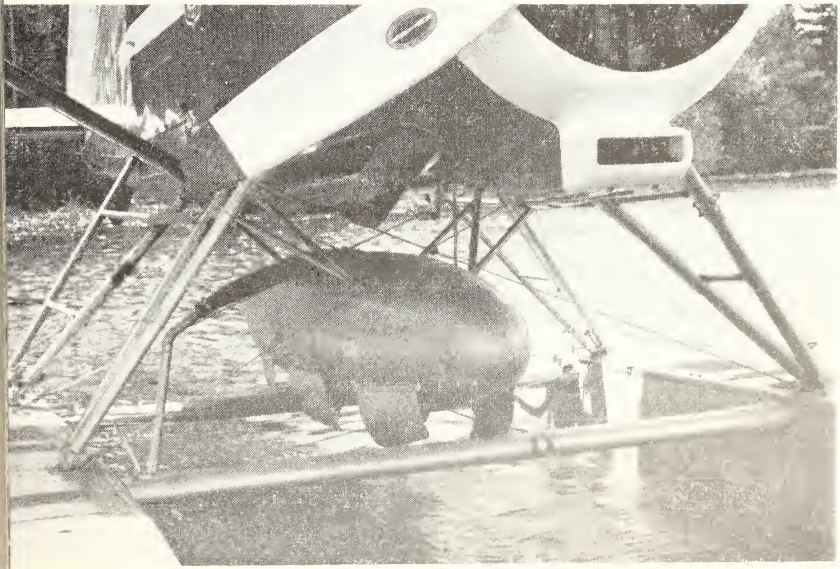

FIGURE 2.—New water tank assembly on Beaver aircraft has three release openings and modified snorkel tube for filling tank.

FIGURE 3.—Water cascades freely from enlarged gates in the redesigned 125-gallon tank.

TABLE 1.—*Area covered and concentrations in three tests*

Item	Beaver tests		California Stearman
	1959	1961	
Average *total* pattern length—feet	400	211	(1)
Average *effective* pattern (over 0.4 gal. water per 100 sq. ft.):			
Length—feet	150	157	202
Width—feet	45	61	(1)
Average total coverage for:			
0.4-0.5 gal./100 sq. ft.—square feet	4,086	5,802	6,530
1 gal./100 sq. ft.—square feet	400	2,198	3,100
2 gals./100 sq. ft.—square feet	0	507	94
Average maximum concentration per 100 sq. ft. at pattern center[2] —gallons	0.9	3.3	(1)

[1]No record.

[2]Average maximum amount of water measured in any one cup in the pattern.

1. The *average total pattern length* for the 1961 tests was about half the average length recorded in 1959. This is an improvement because now more water is concentrated into a smaller area, making each gallon more effective.

2. The *average effective pattern length* proved to be about the same for both years, while that of the California Stearman air-

raft was about 33 percent longer. The 1961 effective pattern *vidth* was about 30 percent wider than that of 1959.

3. *Surface area covered* and *average concentrations* were the most significant improvements noted. In concentrations of 0.4-0.5 allon per 100 square feet, the Beaver covered an average of 1,700 quare feet more per drop in 1961 than it did in 1959.

The biggest improvement came in the total area covered by 1 allon of water per 100 square feet. In 1961 this coverage was ve times as large as it was in the 1959 tests; it was only slightly maller (900 square feet average) than the area covered by the tearman.

4. Results of the 1961 Beaver tests were superior to both the 959 tests and the Stearman tests in area covered by a concenration of 2 gallons per 100 square feet. The Beaver tests in 1959 *ever* attained this concentration during any of the 15 drops using lain water. The Stearman tests averaged 94 square feet coverage t this concentration, compared to the Beaver's 507 square feet overage recorded in the 1961 tests.

Water-bombing with the DeHaviland Beaver in the Superior National Forest lake country has already proved successful as a upplementary fire suppression measure. The present tank and drop opening equipment allows a sufficient volume of water to each the ground to be effective in knocking down small fires or ooling hot spots on large fires. The waterdrop is now considered o be a routine fire suppression measure on the Forest. Properly quipped airplanes are available throughout the fire season—eady to take off at any time on a suppression mission.

HAZARDS TO GROUND PERSONNEL FROM AIR DROPS OF FIRE RETARDANTS

Arcadia Equipment Development Center
Arcadia, California

In June 1960, tests were conducted in an effort to obtain data that would establish hazards and defense procedures against the dangers of direct drops on personnel from air tankers. Five different air tankers were used—TBM, N3N, F7F, SNB, and Vega—to obtain differences from capacities and tank design. Direct water drops were made on an instrumented dummy. Our dummy, "Sierra Sam," equivalent in stature and build to a husky man, was equipped with accelerometers inside his chest.

The dummy was placed in a standing position for drops at decreasing increments of altitude until significant damage was evident. Drops were then made on the dummy in the prone position. This procedure was followed for each of the five air tankers (fig. 1).

FIGURE 1.—TBM dropping 600 gallons. Height 35-44 feet, speed 150 knots. Dummy lower center at moment of impact.

FIGURE 2.—Dummy after being knocked from standing position.

After the first several drops were made, it was obvious that a major portion of the hazard occurred when the dummy struck the ground after being hit with the water. When he was knocked from the standing position, high values of "g" loading were obtained in some cases just from falling down (fig. 2).

When dummy was lying down, he was carried with the liquid on very low drops and thrown to the ground. In other words, it wasn't the fall that hurt, it was the "sudden stop at the end."

The hazard is reduced when the body is in the prone position. It was difficult to obtain much body movement with a drop from above 15 feet. Below this height a veritable wall of water carries the body easily. A hardhat on the dummy, with the chin strap fastened, usually remained in place and afforded good head protection.

On some drops it was observed that a considerable amount of loose ground debris was picked up with the liquid and carried along. For this reason a prone position with the head forward and protected is recommended. If the person can grasp something firmly imbedded and hang on, any movement that can be prevented will help. Handtools, obviously, also present a hazard; therefore, they should be placed at one side.

It is difficult to evaluate injury potential to a human from acceleration figures. The nature of the obstruction against which the victim is hurled and the posture at time of contact are of greater significance. It is like comparing the injury of one who is fatally hurt after slipping on a sidewalk to that of another who survives a two-story fall from a building. Nevertheless, the results showed a deadly potential. On several drops it was noted that definite skull damage occurred, and on one drop the left arm and shoulder were torn completely free.

Conclusions

1. Drops from air tankers of any capacity are hazardous. The tankers used for test all showed that under some conditions a drop on a human can be deadly.

2. Size of load does not appear to be a major factor in initial impact forces on a human, although accuracy of a drop of large size does not need to be as exact as one of small size to obtain a hit.

3. When a human is standing, drops are dangerous at heights under 50 feet. When a human is prone the hazard is reduced and he is probably safe if drop is from a height above 20 feet. The greatest injuries appeared to be caused by the final impact with the ground after a human is carried or thrown by the liquid.

4. The dangerous target area was small, particularly lateral to the drop direction. On some drops a hazard existed from loose debris being picked up and thrown with the liquid.

5. Fatal injuries can be minimized by following these rules:
   - a. Lie down facing aircraft, with hardhat in place.
   - b. Place handtools off to side.
   - c. Grasp something firm to prevent being carried with liquid.
   - d. Do not run unless obvious escape is assured.
   - e. If in timber stay clear of dead snags, tops, and limbs in drop area. Material such as rocks, live and dead growth, and rolling material on slopes are particularly hazardous.

THE PLACE OF THE FIRE BEHAVIOR OFFICER IN THE FIRE SUPPRESSION ORGANIZATION

KEITH K. KNUTSON
Staff Officer, Division of Recreation & Lands, Rocky Mountain Region

The fire behavior officer on project fires has two primary func-)ns; first, as a forecaster of probable fire behavior for informa-)n of the fire boss in making suppression plans, and second, as ı aid in assuring safety of personnel from action of the fire. rom experience gained during the 1961 fire season, a third robable responsibility has become apparent; working in close operation with line overhead to reassure them of fire behavior nditions currently and continuously.

On a recent western project fire, it was observed that line erhead from division boss through the crew boss were some-nes reluctant to make vigorous attack. This reluctance was tributed to the potential blowup characteristics of a fire in avy fuels which were critically dry, and the inability of line erhead to properly forecast behavior of the fire. The attitude the overhead was reflected in crew effort and effectiveness of eline production at critical points and posed a major problem in e control of this fire. Some of the reasons for this reaction, iich was exhibited by personnel trained under widely varying ographical conditions, were felt to be as follows:

1. Timber types. Heavy old-growth timber at the lower eleva-ns, approximately 50,000 board feet per acre, restricted vis-lity to a very short distance.

2. Topography. Steep, rocky terrain made movement of indi-luals and crews slow and difficult.

3. Atmospheric conditions. Continued nighttime temperature versions kept immediate fire area filled with smoke well into the ive burning period, about 1100-1200 hours. This resulted in or visibility, coupled with uncertainty of behavior of the fire.

4. Morale. Because of fatigue and repeated loss of suppression e, morale of some of the crews and overhead was low. Repeated e runs of varying intensity and length caused apprehension and de the men overcautious. Alert and aggressive suppression ion became difficult to obtain.

5. Much of the fireline was built well in advance of the fire. is made burning out necessary, and when it was not done omptly, the fire moved and usually crossed the firelines.

6. Fire behavior knowledge. In discussing behavior of this fire h fire suppression personnel, it became apparent that ab-eviated types of fire behavior training tend to overstress danger

to personnel from fire action. When personnel safety is ov stressed in training of inexperienced men, they do not have nec sary background to evaluate the training, and as a result, th become timid and overcautious in face of unfamiliar fire behavi This attitude further reduces the chance of aggressive attack the fire.

Solving these problems became paramount in the control this fire. An overhead meeting was held at which top fire mana ment personnel explained the past and the expected future l havior of the fire, and its relation to personnel safety and cho of tactics needed to safely effect control. This meeting did mu to dissipate timidity and fear and to instill confidence. As followup on this meeting, hourly fire behavior forecasts we made on the fire-net radio frequency to division and sector boss With uncertainty about behavior of the fire removed, all su sequent control action was markedly more aggressive. Line ov head said the forecasts were a big morale booster and cre looked forward to the hourly broadcasts.

As a result of this and other experiences during the 1961 f season, it is felt two things are needed in order to impro effectiveness of fire suppression action.

First, the emphasis in fire behavior training must be shift from a negative attitude which induces fear of fire. The positi approach will teach fire behavior as necessary knowledge whi when properly evaluated will dictate proper tactics for fast a gressive safe control of the fire. In this way, personnel safety w appear in its true perspective.

Second, the fire behavior officer is a key man in the plans s tion. As a specialist in the factors that influence probabilities lated to how this fire will burn in intensity and spread, furnishes essential information for strategic and tactical pla ning.

It is important that the fire behavior officer be fully qualifi as a line or division boss. Ready access to the fire boss, line bo or other key line overhead on a critical portion of line will insu that important fire planning and personnel psychology aspects fire behavior will be adequately evaluated in fire suppressi strategy.

FIRE HOSE THREAD STANDARDIZATION IN THE U.S. FOREST SERVICE

Division of Fire Control, Washington, D. C.

Increasing emphasis on mutual aid in forest fire fighting be-
veen Federal, State, and other protection agencies make inter-
angeability of equipment highly desirable. Hose coupling prob-
ms have been serious on major forest fires in the United States.
ack of standard threads has resulted in fires escaping. On one
e two fatalities occurred because of interruption in water de-
very due to lack of an adapter. From a civil defense standpoint
andardization is highly important.

Fire hose adapters can provide some degree of interchange-
ility but they do not solve the basic problem. They are heavy
d comparatively expensive, and too many are needed to assure
ll interchangeability of hose and related fittings.

The U.S. Forest Service has adopted the National Fire Pro-
ction Association standard fire hose thread for 1½-inch hose
d is currently engaged in a 5-year conversion program.

Conversion work in the California Region started this year and
planned for completion by June 1963. Before starting the pro-
am they had a fairly complete inventory of thread units to be
nverted at each station. Because of the large number of units
be converted, it was decided to recut female threads and sleeve
e male threads. Most of this work is contracted. Adapters were
t used where threads could be recut or sleeves used. Adapters
e used on male threads that cannot be machined, such as those
portable pumps and hydrants.

The California Region has developed information and a few
ides which may be helpful to others planning similar programs.
ese are (1) inspect and test all hose prior to conversion, and
place obsolete hose with the new standard coupling; (2) make
omplete inventory of job to be done at each station; (3) assign
qualified man to head up the program; (4) plan and budget for
e job; (5) if the inventory of thread items is large, consider
ntracting. If the number of conversions to be made is low, it
ay be least expensive to use adapters or replace couplings. If
sirable, female thread cutting machines may be rented, and
ale adapters used; or a thread shaving die and insert tool can be
rchased to prepare male threads for sleeves. Sleeves may be
rchased from fire equipment suppliers or thread conversion
ntractors. The thread shaving die costs about $117 and the
ecial insert tool about $25.

STAINLESS STEEL HOSE PATCH

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District Forester, Geraldton District,
Ontario Department of Lands and Forests

The Department of Lands and Forests as well as the fore industries in Ontario have attempted for years to solve the pro lem of stopping leaks in fire hose during firefighting operatior To meet this need for an efficient method of stopping serio leakage from ruptured hose on the fireline, the stainless ste hose patch was engineered and perfected.

Testing commenced in 1957. A large variety of materials ai designs were tested, including linen, various types of rubbe and finally the stainless steel patch. It was found in testing stai less steel ranging from 20 to 28 gauge that 20 and 22 gauge we too stiff, while 26 and 28 gauge did not have sufficient streng and opened up under pressure. The final patch selected was man factured from 24-gauge stainless steel.

The patch is of sufficient size ($5\frac{1}{2}$ by $3\frac{1}{2}$ inches) to cover normal ruptures in $1\frac{1}{2}$-inch fire hose (fig. 1). The locking devi is very simple; the ends of the patch are folded over so that th snap together and lock securely in position when the patch wrapped around the hose (fig. 2). This makes a smooth band steel with no projections to catch while the hose is dragged acro the ground.

To use the patch: (1) *Cut pressure.* This can be done by usi a Siamese or by kinking the hose. Two men should work t gether, one cutting off the pressure and the other installing t patch. It is also possible for one man to install patches quick and easily by using a "hose strangler" to shut off the water flo (2) *Squeeze hose together* and crease lengthwise to reduce i diameter. This is not absolutely necessary but reducing the c ameter makes it easier to close the patch. (3) *Slip patch ov hose and lock in position* with the locking device on the opposi side of hose from the hole.

In 1959 the Department of Lands and Forests arranged for t manufacture of 3,000 stainless steel hose patches which we distributed throughout the twenty-two districts in the Provinc In 1960 and 1961 additional patches were manufactured and di tributed. These have been used with considerable success duri the past three fire seasons. They are now considered essenti and are carried as standard equipment in every fire pump toolbo It is recommended that at least ten patches be carried in ea toolbox to take care of all emergencies.

These patches have been used on lined and unlined linen 1½ inch hose with equal success, stopping the leak completely holes up to 2 inches in length. The original tests were carri out using a Wajax Mark I pump running at $\frac{3}{4}$ speed with tv

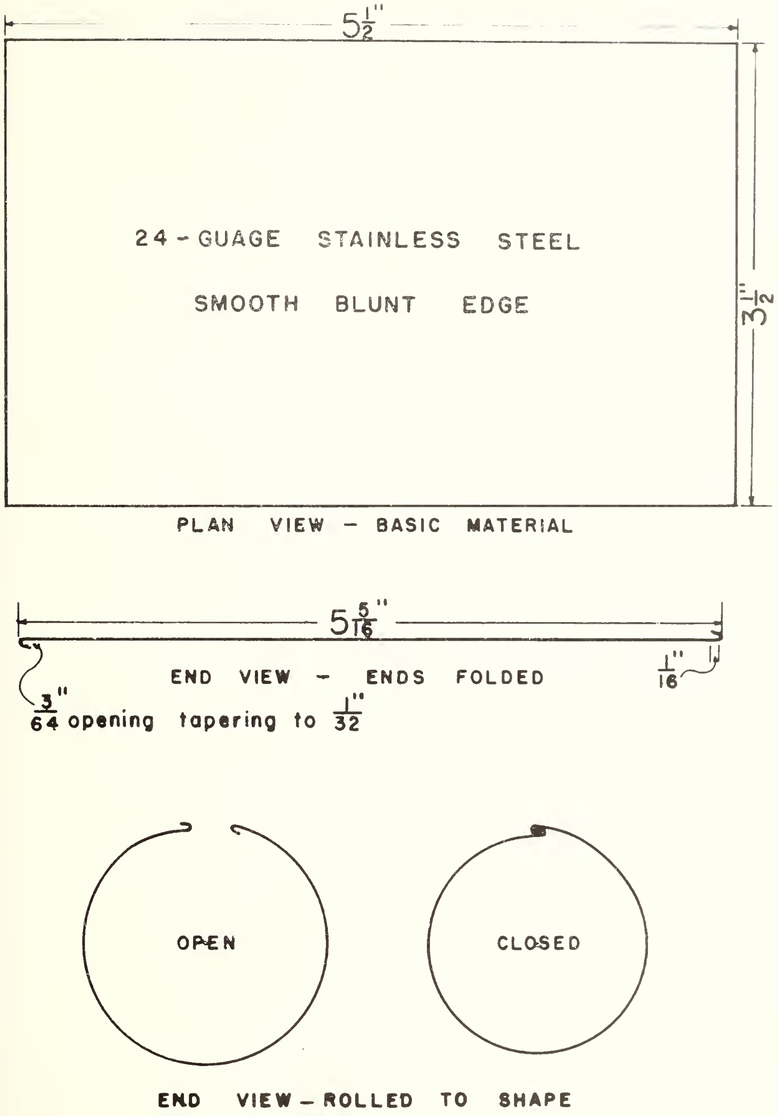


FIGURE 1.—Stainless steel hose patch.

lengths of hose to the nozzle, but in actual field conditions th patches have been used successfully with all makes of pump under all operating conditions.

Advantages of this patch are (1) simplicity of design, (2 light weight and small storage space required, (3) no speci tools needed, (4) patch remains securely on hose with the pres sure on or off and when hose is pulled over ground, (5) patche can be left on the hose to mark holes for repairing when brough in to the repair depot, (6) low cost, approximately $35 pe hundred.

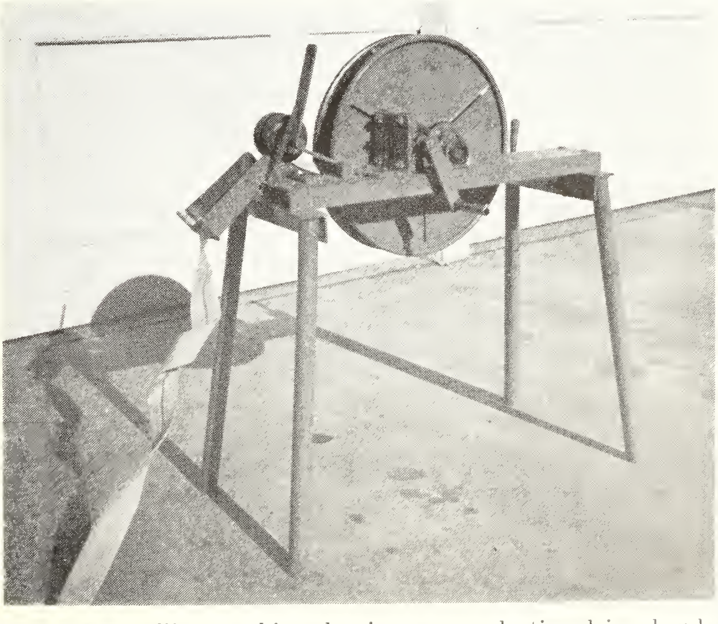
FIGURE 2.—Hose patch in open and closed position and installed on hos

FIRE HOSE ROLLING MACHINE

William C. Fischer, *Forester*, and James F. Potter,
General Supply Clerk, Boise National Forest

A machine for rolling fire hose developed by James F. Potter f the Boise National Forest is designed for 1-, 1½-, and 2½-inch re hose of 50- to 100-foot lengths. The resulting rolls are tighter, ore round, and more easily handled and cargoed than rolls proiced by hand rolling.

The machine includes a metal drum with two side disks, one of hich is removable. The drum, attached to a shaft, is turned by hand crank with a gear reduction drive of approximately a 1 ratio and is mounted on a metal stand supported by four bular metal legs. The hose feeds on the drum through a metal ough and pressure rollers mounted on the front of the machine. his feature eliminates the time-consuming task of untwisting e hose prior to rolling (fig. 1).



igure 1.—Hose rolling machine showing gear reduction drive, hand crank, trough, and pressure rollers.

The removable disk is secured by latches while machine is in peration. Slots at the end of the drum allow hose to be tied efore removal (fig. 2).

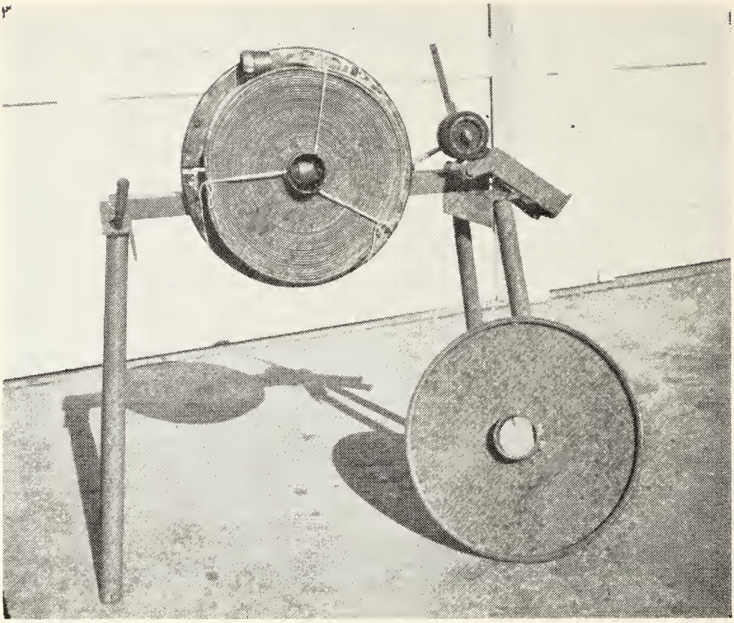


FIGURE 2.—Machine with disk removed and tied roll on drum.

The machine can be operated by one man, although it may l desirable for a second man to assist in laying out the hose. A 10 foot length of 1½-inch hose can be rolled, tied, and removed fro the drum in 2 minutes. Compared to handrolling, the machi greatly expedites rolling hose returned from the fireline an makes it more quickly available for reissue on subsequent fire

Planned modifications will make the machine more portab for shipping or cargoing purposes. Cost of the machine in i present form is approximately $160.

DEVELOPMENT OF AN ORGANIZED SUPPRESSION CREW PROGRAM

Sequoia National Forest

For many years it was possible to pick up agricultural workers ı Porterville, Calif., for fire suppression work. These men were ther citizens or legal aliens who lived permanently in Porter-lle. Since agricultural work is heaviest in the late fall and ırly spring, they were available on reasonably short notice for re suppression work during the summer months. Prior to 1958 ıe maximum number mobilized at one time was about 75 men. ı 1958 this number was increased some. The bad fire year in 959 caused us to take a more active interest in this source of anpower.

These men, until 1959, had been recruited in mass with no ıought toward a working organization, training, or crew stabili-tion. With the Southwest Indian crew organization as a guide ıd about 200 available local agricultural workers, mostly of panish-American extraction, we set out to improve the efficiency these crews.

Many of these people do not speak English, or speak it poorly. his has lead to the development of "leaders," or "contractors," in eir ranks. These leaders speak English and act as go-betweens, intermediate agents between the ranchers and the laborers. udy of these people in action led us to two natural organizers.

We sat down with these men and discussed the problem of ganization and training. We agreed to pay one man crew boss ages (the crew leader) for each 25 to 28 men, and one man uad boss wages for each 5 to 7 men. Each man in a crew was receive a complete physical examination and 8 hours of training ther on a fire or in planned training sessions. When a crew ached this status, a blue cooperator card was issued each crew ember. The so-called organizers, who are really the key to the ganization, are paid sector boss wages. They are responsible r qualifying crew leaders and squad bosses, discipline in the ews, welfare, organization, etc.

The crew leaders must all speak English. These men are not ıalified Forest Service fire crew bosses, but it is intended that ch crew leader will work with the crew boss and relay his rections to the men through the squad bosses. It is also the ader's responsibility to maintain the crew as a unit in fire camp ıd to direct its activity in the absence of the Forest Service crew ss. Many of these men could be qualified as fire crew bosses. We efer to have them called *crew leaders* to distinguish them from e crew bosses. The squad bosses are qualified Forest Service uad bosses for these crews.

Originally this program was developed as a source of followi manpower for fires on the Sequoia Forest. It was organized to t point where we could have 200 men on their way in 2 to 3 hou In 1959 word got around and crews were requested for off-fore fires. Each time this occurred, interest was created in the su rounding area and additional crews were organized. At t present time we have 22 qualified crews of 26 men each. Duri the 1961 fire season, these crews were dispatched to 8 Nation Forests and 3 other protection agencies in California. They we employed on 20 major fires and numerous smaller fires. Ma employments were 6,986 with a total of 29,000 man-days worke

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Map Azimuth Circles For Base Heliports

During periods of very high or extreme fire conditions on the Six Rive National Forest helicopters are often contracted for fire standby on t ranger districts. Two to four specially trained men are provided by t district for use as a helitack crew. The helicopter, loaded with tools a equipment and ready for dispatching, stands by at a base heliport near t district headquarters.

Quite often the helicopter pilot is unfamiliar with the terrain in whi he is to operate. If a fire call comes in, it may be necessary to brief the pi with maps and directions before he can be dispatched. Sometimes the f is located far from the base heliport in difficult, unfamiliar terrain. Valua time may be lost in searching for the fire.

On the Mad River District we have speeded up helitack dispatching using an azimuth circle placed on the dispatcher's map directly over c base heliport, exactly as is done for lookouts on the map. This azimuth cir should be offset east or west depending on the magnetic declination of t area involved. This is necessary, of course, because the helicopter is flown magnetic bearing.

A retractable string reel allows the dispatcher to reel out the string rectly over the bearing that the pilot should fly to the fire. The dispatch may then merely give the pilot a flight bearing and distance from the ba heliport to the fire or another helispot on the district. This simple use the azimuth circle can, in many areas, simplify and speed up the helita dispatching system.—JOHN D. DELL, *Fire Control Officer, Mad River Distri Six Rivers National Forest.*

"FIRE WATER" IN THE SOUTH AND A FIRE "HEAD BREAKER"

R. J. RIEBOLD
Forest Supervisor, Florida National Forests

Eighty some days of fall drought, drying swamps and bays, and ıe winter-spring fire season coming on are enough to start a ɔuthern fire control man thinking about "fire water," not fire ater in the usual colloquial sense but water that plays a part in re control.

Fires in the dry swamps are something to think about. The dry wamps are not plowable. The tractor-plows upon which all ɔuthern fire control men depend are useless once a fire gets off ıe pine land into the dry swamps. The obsolete 4-wheel-drive ınkers most fire control organizations still have are almost as seless. Sometimes they can get to the edge of a swamp and ɔmetimes their hundred feet of hose will reach the deep burning re but usually with only a hundred gallons of water. Fire crews ɔmetimes putter for days on dry swamp fires and sometimes a ry swamp fire breaks out days later and makes a new run across ıe pine land. Yet in the Coastal Plain there is an ocean of water ithin 30 feet of almost any fire. To get it, all you need is a ɔle in the ground and a pump.

When fire suppression wells were developed in Michigan in the 930's they were discussed with interest in the South but actually et with no favor. Probably fire control men then had all they ɔuld do to deal with the thousands of fires on the pine lands. The ry years in the 1950's revived interest in suppression wells. ests were made in South Carolina which were reported in Fire ontrol Notes by Devet and Fendley.[1] According to them the com-ercial well drillers are the best possible help on suppression ells. They can put down wells rapidly and cheaply. All that is eeded is a list of well drillers in the surrounding counties and greements as to availability and price.

Probably most fire control units have a few thousand feet of ever used forestry hose and one or more gear pumps. The gear ımps are not for suppression wells. Shallow well water almost ways contains so much suspended grit as to wear out a gear ımp in a short time. There are rubber blade impeller pumps that ill handle gritty water, and these can be purchased. If forestry ɔse could be concentrated in area depots, it could be airlifted to aces where it is needed in quantities sufficient to do the job. ımps could also be stocked in depots along with all accessories. ith pumps putting out 50 gallons per minute from one or more

[1]Devet, D. D., and Fendley, L. T. Underground sources of water for fire ppression. U.S. Forest Serv. Fire Control Notes 20(1):11-14, illus. 1959.

suppression wells, fires in dry swamps can simply be watered ou Nobody needs to use suppression wells on every fire; everybo could use them on dry swamp fires.

Drought can usher in severe surface fires even on pine land The usual practice of simply plowing around a fire is not qui adequate because of the frequent spotting over the plow line. Ev since World War II most fire control organizations have be without the crews of men needed to fire and hold lines in suppo of tractor-plows. Even when work crews are available they do n arrive at fires as soon as the plows do. This has led to practic designed to hold line without crews, such as double plowing, "lo plowing," and "doubling back" to catch breakovers. Even wh there are 4-wheel-drive tank trucks they cannot follow the plo in many places. Consequently, fires are not as well fought as th could be.

The means for supporting the tractor-plow without a crew men was developed about 1950 in the light tractor-tanker. Sever kinds have been described in Fire Control Notes and probably a would work well. One was briefly described by the writer in dental to a discussion of fire tactics in 1959.[2] Even though som units have been used since 1950, for some reason tractor-tanke have not been widely adopted. One man with 100 gallons of wat under 150 pounds pressure on a light tractor can give adequa line holding support to a tractor-plow wherever the plow goes.

Prolonged drought makes even ordinary surface fires burn hard and faster than usual, so much so that it is often dangerous f one or even two tractor-plow teams to cross in front of a fire. T head of a fire has a tendency to form a point which sometim becomes a column of fire. Even parallel backfiring and perpe dicular backfiring are difficult and dangerous ways of stoppi such a head. This calls for direct attack with water if it cou be done.

In the early 1930's when fire control began generally in t southern Coastal Plain, the Civilian Conservation Corps use many small tank trucks on direct attack, augmented by lar crews with handtools. The wheeled tank trucks did well unt the young pines grew too large for them to ride over. For th reason the tank trucks were practically obsolete by World W II. With the availability of 4-wheel-drive trucks after the wa many new tank trucks were obtained. Even with 4-wheel driv there are many places tank trucks cannot get to and most of the carry not more than 200 gallons of water. Obviously the tan truck is not suited for direct attack on the head of a difficult fir

It is well known that, if a break can be made in the cent of the head of a fire, the remaining two parts of the head dro in intensity and can be handled. It is also well known that th area inside a Coastal Plain fire is relatively cool and safe. At guess, the area of active burning (from ignition to completio

[2]Riebold, R. J. Tractor-plow tactics. U.S. Forest Serv. Fire Contr Notes 20 (3): 69-76. 1959.

combustion) on the head of a fire is probably not over 2 chains de. Therefore, if a tanker could approach the head of a fire m the rear, through the burned area, and extinguish a strip out 2 chains wide for a distance of about 5 chains it would bably break the head of the fire. Five chains probably allows ough for the forward spread of the fire during the few minutes the attack.

'Head breaker" is the name I would give to a proposed tracked ault tanker to be used for breaking the heads of Coastal Plain es by direct attack from the rear. The "head breaker" would sist of a 1,000-gallon tank (120 cu. ft.), 8 nozzles, a suitable mp, and an operator's seat mounted on a crawler track and me. A tracked logging sulky or the tracks and frame of a ked tractor could be used. The front, sides, and bottom would armored for protection from trees, stumps, and brush. The nt bumper should be strong enough to push down trees with same ability as a D7 or equal tractor. The rear would be pro- ed with a conventional hitch plus pushing bumpers.

To apply the water effectively, the tanker's 8 nozzles should be anged in pairs. Each pair should consist of a jet and a spray fog nozzle. One pair should aim forward; and a pair to each e at about 45 degrees. The fourth pair (both spray) should 1 downward to protect the tanker itself as it moves forward. e discharge rate would be about 6-10 gallons per minute per zle, meaning that the pump should be capable of discharging to 100 gallons per minute with pressure enough for a large ch for the jets, or fog if fog is found useful. The nozzles would elevated to obtain maximum reach. The pump can be selected obtain suitable operating pressures and power.

Any available heavy tractor would be used to pull the assault ker from the unloading point into the fire and up to the head. that point the tractor would turn itself and the tanker around l push the tanker into the head of the fire by backing up. With pump running and all 8 nozzles discharging stream and spray tanker would simply quench a hole in the head of the fire. a breakthrough is made, the "head breaker" should widen it attacking one side of the breakthrough until its water is ex- nded. An advantage of this tanker is that it does not tie up a tly large tractor. Any working tractor, your own or a con- ctor's, can pull the tanker to the head of the fire and push nto the head during the attack.

Strategically, the "head breaker" would not be considered part the initial attack force. It would be stationed as reserve at a equipment depot or work center. During the worst of the season it should be mounted on a lowboy, in readiness. When boss of the initial attack force determined that the rate of ward spread at the head of the fire was too great for successful gle attack with tractor-plows or if the fire showed signs of high ensity behavior, he should request the assault tanker as part of reinforcements and a D6 or D7 tractor to handle it. Moving assault tanker and tractor would require two lowboys and truck tractors. Additional reinforcement should put at leas plow-tanker teams on the fire.

Tactically, the first two plow-tanker teams, if they are not a to make a two-plow attack on the head, should contain and tinguish both flanks up to the anchor points and keep up w the forward movement of the head, one on each side. The n plow-tanker teams arriving as reinforcements should accompa the "head breaker" into the head of the fire from the rear. I breakthrough is achieved, the two plow teams inside the should exploit it by plowing through the break, turning right a left to form a double encirclement with the two plows at anchor points, which should attack at the same time. Exploitat of a breakthrough must be rapid because the two parts of head would burn together again in a short time.

With the wind at their backs and the head of the fire mov away from them, the men in the "head breaker" attack gro are safer than those in front of a fire on an ordinary attack. Th might be some heat but little possibility of exposure to flan Certainly they would have an adequate escape route. With t men on "head breaker," two men on tractor-plows, and two m on tractor support tankers, there would be only two men, backfire men, on the ground. They could and should travel the scene in a 4-wheel-drive vehicle with the attack group bo With the tractor and tanker equipped with brush guards, no ot special safety provisions seem necessary. The use of protect clothing has been considered, but thought unnecessary.

To summarize, here is a proposal to develop a 1000-gal tanker to break the head of a fire by direct attack from the re It is to be on tracks, to be hauled into position by any hea tractor, to be pushed into the fire behind the discharge of 50 100 gallons of water per minute in jets and spray for an atta period of 10 to 20 minutes. The breakthrough should be exploi by plow-tanker teams. With the addition of a mounted swive nozzle and the addition of a length of hose in a rack, the track tanker could be employed in many other situations for atta and mopup.

In summary, suppression wells with centralized depots pumps and hose are the tools for dry swamp fires. The lig tractor-tanker is the natural teammate for the support of t tractor-plow. The tracked assault tanker is perhaps the next strument for direct attack and for mopping up.

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.


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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF
FOREST FIRE CONTROL

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VOL. 23 NO. 4
October 1962

Forest Service
UNITED STATES 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.

UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962

Growth Through Agricultural Progress

Volume 23 Number 4

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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Forest Service, Washington, D. C.

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CONTENTS

A KEY TO BLOWUP CONDITIONS IN THE SOUTHWEST?

Robert W. Bates
District Ranger, Tonto National Forest

Can minimum nighttime temperatures be used in some areas as an indicator of one type of blowup conditions? A preliminary study of several project fires occurring on the Tonto, Sitgreaves, and Prescott National Forests in the years 1951 to 1961 showed that the night before each of these fires blew out of control was unusually warm. Of particular significance is the fact that most of them occurred following the warmest nights of the critical June fire period and often occurred at a peak after several consecutive days of rapidly rising temperatures. For some fires which occurred in July and September this also appeared to be true. Only 4 of the 13 fires in the study failed to show this, but even for those 4 the temperatures were at or above what is believed to be the critical point. Temperatures on the nights preceding the start, or blowup, of these fires varied from high of 81° in the semidesert to 52° in the pine above the Mogollon Rim. These temperatures were all unusually high for the area where the fire occurred.

Why, in June, are some fires controlled at small size while others defy control no matter what the action taken? Why can you reach some lightning fires while they are still in the tree, yet others explode into major fires? Why does a quiet or apparently controlled fire suddenly act up? A look at relative humidity showed day-to-day fluctuations and seemed not to be an adequate answer to these questions. This study seems to indicate that a deadly one-two combination of an unusually warm night followed by a warm day may be the key.

If further study should prove this to be reliable, we could determine more accurately when to increase emergency fire forces and signal the start of intensive fire prevention. Following lightning, extra efforts to ensure early detection could be undertaken. By taking 8:00 a.m. readings of the previous night's minimum temperature and plotting them on a graph, it might be possible to spot the beginning of potential blowup conditions. There is usually a very sharp rise from relatively cool nights to hot nights over a period of only 2 or 3 days (figs. 1-4). Since this leaves very little time to get ready, the use of nighttime temperatures may be a better indicator than daytime temperatures because it allows more time to prepare.

Too, the charts on the 13 fires studied actually indicate a better tie-in using minimum rather than maximum temperatures.

Fire control organizations are not fully aware of this change in conditions as it is not indicated in present fire-danger meters by any definite rise in the index. During June, the Southwest is in extreme conditions already—so it might be said that conditions have suddenly gone from critical to supercritical.

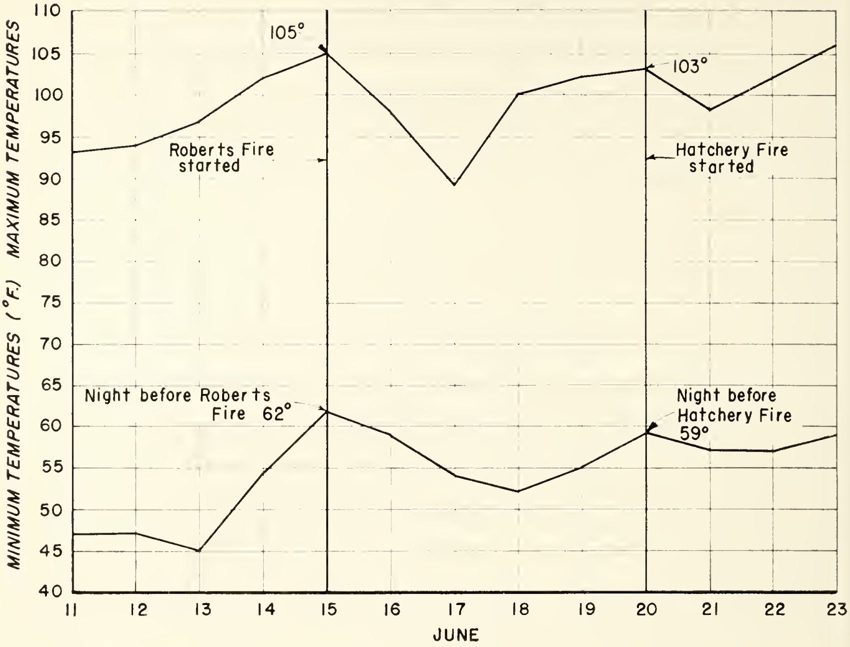

FIGURE 1.—Roberts and Hatchery Fires, June 1961.

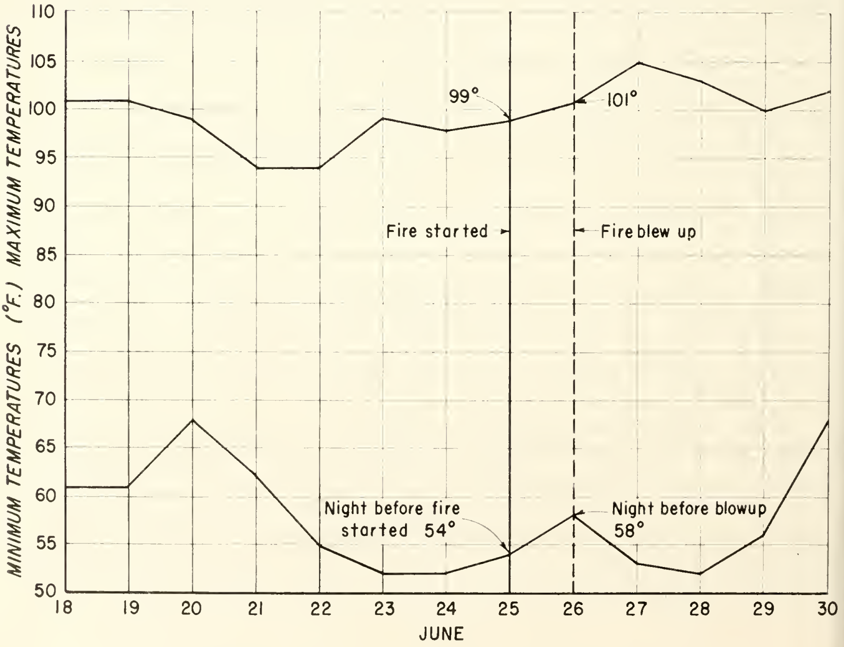

FIGURE 2.—Russell Gulch Fire, June 1951.

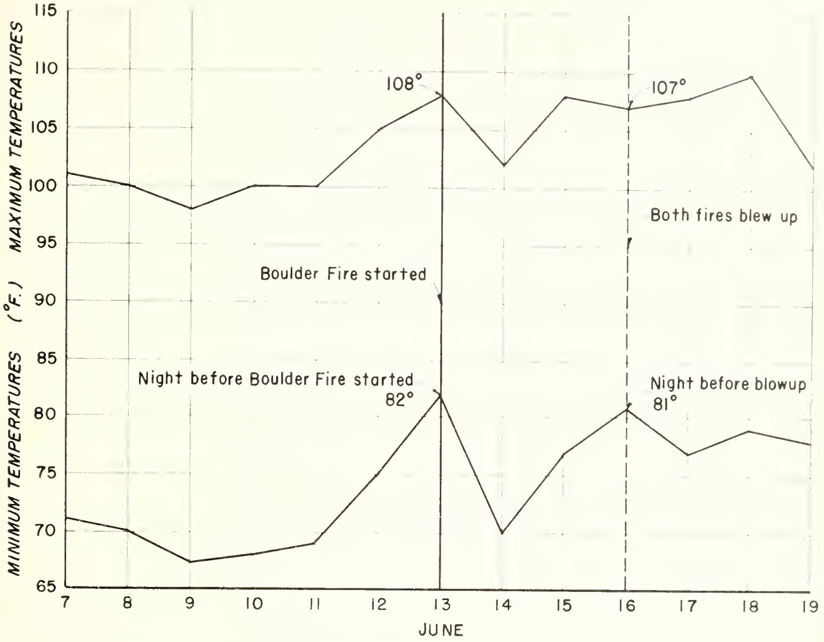

FIGURE 3.—Boulder and Pranty Fires (lightning), June 1959.

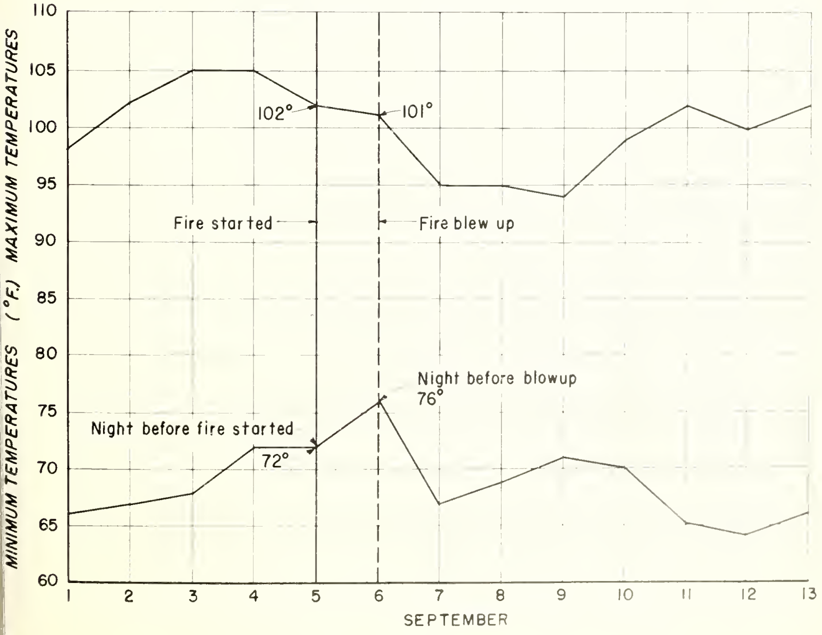

FIGURE 4.—Buckhorn Fire, September 1956.

An attempt to expand on this theory and determine an average date at which this temperature rise occurred proved futile. It can apparently happen almost any time in June in this area and may occur as early as May or as late as July in other southwestern localities. In 1956, the condition seems to have appeared in September on the Tonto National Forest on the Buckhorn Fire, coinciding with a dry fall period. However, June 10 is often mentioned as the breaking point on the Tonto. Each forest—possibly each district—would have to chart this separately and watch for the start of the temperature rise. From this temperature study, I have arbitrarily said that nighttime temperatures above 45° are critical; and with those above 55° blowup conditions exist. Cloudy nights keep nighttime temperatures high and may or may not be serious depending on whether the clouds disappear by morning. During June, there is probably only a small likelihood of nighttime clouds.

It is recognized that factors other than temperatures also contribute to fire size. Some areas have large fires during periods of high early spring winds; some fires are large because of organizational breakdowns, others because of topography; California has its Santa Ana winds; and so on. Undoubtedly, most of these fires would show temperature correlation only through coincidence. On the fires studied there was no attempt to make a complete analysis of all factors affecting the particular fire such as topography, wind, relative humidity, human error, time of day, fuels, and aspect. What was suggested by the study is that this one common denominator may provide a predictable basis for increased manning and a crash prevention effort during the critical periods.

Some assumptions and recommendations that can be made from this limited study follow.

1. High nighttime temperatures do not of themselves cause fires to blow up, but under these conditions, all other factors which tend to cause large fires are maximized.

2. If nighttime temperatures are rising, going fires must be secured before temperatures rise above the critical point. This is seen in the case of fires which blow up on the third or fourth day after start.

3. Fires occurring before and after temperature peaks are controlled at small size; some of them under much worse rate-of-spread conditions.

4. Spotting was a big factor in most of these fires although winds were not exceptionally strong. This fact was mentioned consistently in discussing these fires with people who had participated in the suppression. Some of these fires became big even though firefighters were on them at the very start when they were only a few feet across.

5. In June, before the summer lightning period, temperatures can be used as the basis for increased prevention effort at all levels.

6. When lightning occurs, detection forces could be augmented, especially in the case of long aerial patrol routes where some areas are not covered until 3 or 4 hours after daylight.

7. It might be possible to develop new rules for prescribed burning. Limit burning to times when nighttime temperatures are less than 45° and to a time when the temperature trend is down.

8. In the June dry period, rapidly rising nighttime temperatures often seem to presage the first lightning storm of the season. These high nighttime temperatures usually occur from 24 to 48 hours before the lightning storms occur. These first storms are often dry.

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Bag-In-A-Box Milk Containers for Fire Use

During the past year, milk companies have been delivering milk to restaurants, ice-cream drive-ins, and other users in a 6-gallon double plastic bag inside a cardboard box. These containers are usually thrown away after they are emptied and removed from the dispenser.

These containers can provide a useful supplementary water supply that is easily handled, transported, and stored. They can be kept filled with 5 gallons of water even during freezing weather since they cannot be damaged by ice expansion. The containers might be placed in storage sheds, attics, and other locations where the water would be available for use on small fires.

The containers can be carried in cars or trucks to provide an instant refill for backpack cans. They can be strategically dropped where a firefighter can go to refill his can.

A small folding harness was designed by Randall to enable the firefighter to carry a container for use in mopup work. The small rubber hose which protrudes from the bag can be clamped to provide a shutoff so that water can be dribbled onto burning embers or small logs in the same manner as water from a backpack can.

The best part of all is that the containers are free for the asking from most milk users, and if they wear out or are otherwise damaged, there is no replacement cost.—CLAUDE H. RANDALL, *Chief, Havana Rural Fire Department, and* GORDON O. CECH, *District Forester, Illinois Division of Forestry, Havana, Illinois.*

LET'S HANG ON TO COLOR SLIDES—THEY'RE VALUABLE

Alva G. Neuns
Information Specialist, Forest Service, USDA

Color slides have come to be recognized as very valuable assists to all types of presentation for the purpose of increasing understanding—I&E, training, in-Service staff meetings, cooperative technical sessions and extension work, to name a few.

Slides offer many advantages for these purposes. They are lightweight, occupy small space, and can be mailed ahead with written manuscripts. Projectors for them are lightweight and usually available.

But some of these advantages lead to disadvantages. Slides are expensive in spite of the fact that it is easy to photograph 20 to 36 on a camera loading. Copies are equal in cost to the original or master slide. This leads to a tendency to use the master slides for projection, as one would for home shows, and damage often results.

Unlike a B&W photographic negative, an original slide can serve for either positive projection or as the means to obtain color print enlargements. Because such enlargements are very expensive and do not serve a publishing purpose, master slides are not classed as negative material and usually no permanent, central system or file is set up for them except in small specialized units where they are kept as photographic records.

So, color slides land in desk drawers. They stack up in assorted boxes on shelves. The best, often once-in-a-lifetime chances, and most usable slides from a number of boxes are removed and combined for specific showings and these, in turn, are put in more boxes.

Soon, the ease with which slides can be utilized in infinite combinations with other slides in series becomes a disadvantage because single slides are often "lost" among dozens of others. To go through hundreds of slide combinations to find or relocate one is time consuming. And slides are often "lost" in other agency collections while on loan. They are hard to keep track of unless they are strongly identified.

To collect, edit, catagorize, put in series, title, number, label, and caption color slides for permanent use by many people is hard work. It takes selective judgment to cull slides and to keep the right ones and arrange them in usable subject-matter combinations. No matter what file or distribution system you eventually use, this job must be done. Once done then it is important to keep the slides in order.

Next it is important for people to determine quickly whether there are any slides on a subject and what they show. If slides can also be checked in and out easily and fast and a simple record maintained of when they went out on loan and to whom, one person, located nearby, can oversee the system. Or, if no one is present, sometimes the borrower should be able to review slide content and check them out or in himself.

To meet all of these specifications, a visual file and distribution rack for color slides was designed (fig. 1). It took advantage of the fact that some of the local slide processors are returning mounted slides in transparent plastic boxes. These 2- by 2- by 1¼-inch, lightweight boxes are available in most areas at wholesale prices and quantities. They have hinged snaplock covers, are excellent protection for the slides from dust and damage, and are

IGURE 1.—This slide distribution rack is being used as a review and check-out unit for a research staff.

easy to handle and store. The slides can be counted and identified without opening the box—an added damage-prevention factor.

The rack was built by the Pacific Southwest Station's Fire Research Division. It is mounted on the wall facing the secretary's desk. The Division's entire collection of color slide copies (masters are filed separately) are immediately available for review and/or use by both the research staff and their cooperators for talks, briefing sessions, project review, and other presentations. Each transparent plastic box has the Station's name and return address on the cover. A card, 2 inches square, is first filled out with the Subject or Title, Series No., Copy No., Location, Date, and Author. The card is then dropped face down into the bottom of the box and the slides placed on top of it. Another card, 2 by 3¼ inches, showing identical information as the square one is also filled out when the slides are edited and identified. This card has one column for "Loaned to" and one for the date loaned; it is placed in the rack behind the box of slides. As can be seen in figure 1, the whole collection, when installed in the rack as shown, can be readily and easily reviewed.

It takes but a few moments for the secretary to fill out the check-out card and replace it in the rack. If the borrower wishes to take only 1 or 2 slides from a category, the slide numbers are entered on the check-out card and the box is replaced with the cover side out. This way a glance at the rack will show what slides are out on loan and who has them.

Master slides should always be filed elsewhere and regarded as negative material for copying; they should not be loaned for projection. They should also, of course, be categorized and identified exactly as the distribution copies are.

The rack shown here can be any size that wall space permits. This one is mounted on one standard 4- by 6-foot sheet of mahogany plywood and matches the mahogany wall paneling on an adjacent wall.

THE PROTECTION OF VEHICLES IN BUSHFIRES

I. S. WALKER [1]

Research Officer, Bushfire Section, Division of Physical Chemistry, C.S.I.R.O. Chemical Research Laboratories, Melbourne, Australia.

Motor vehicles engaged in bushfire fighting should be protected ıgainst radiant heat, since at times they need to be used close to ntense flames, and in an emergency they may be used as refuges for firefighters.

Three major problems arise from radiation:

1. The tires may decompose somewhat, causing rapid loss of strength with the likelihood of deflation, and at times tires may ıctually ignite.
2. The body panels of the vehicle may be heated to the temperature where paint finishes decompose to give off unpleasant or toxic vapors both inside and outside the vehicle, and at times physical deformation of the metal work will cause doors and windows to jam.
3. The motor may overheat; this results in loss of power. Vapor locking in the fuel system may occur and lead to stalling of the motor and to starting difficulties.

THE HEAT REFLECTING PROPERTIES OF ALUMINUM PAINT

The only surfaces that reflect to any great extent infra-red radiation, as emitted by normal flames, are those of some polished metals. Thus aluminum which has such a power could well be used in the construction of vehicles. Even after continued use unpainted aluminum could still be expected to reflect 60 to 70 percent of the radiation falling on it.

Paints containing aluminum powder have been measured by radiometer for their reflectance of normally expected infra-red radiation. The absorbing element of the radiometer was either blackened or painted with the paint under test. The reflectance figures and general properties of three paints tested are shown n table 1. Clearly, such paints could give protection to those parts f the vehicle that are likely to be affected by heat, e.g., external teel work and the sides of the tires.

Tire sections, untreated and painted with two suitable paints, vere subjected to two different intensities of radiation (table 2). After 40 minutes exposure the untreated tire showed much reater deterioration (fig. 1). This lengthy exposure would only e experienced in unusual situations (e.g., in mopping-up proedures where vehicles may be parked adjacent to burning heaps f heavy fuel).

[1]The author is grateful to Mr. B. Oglethorpe, Technical Manager, Automotive Division, Dunlop Rubber Australia Ltd., for his technical advice, and Dr. A. R. King, Division of Physical Chemistry, C.S.I.R.O., and Mr. A. G. acArthur, Forestry and Timber Bureau, Canberra, for helpful criticism.

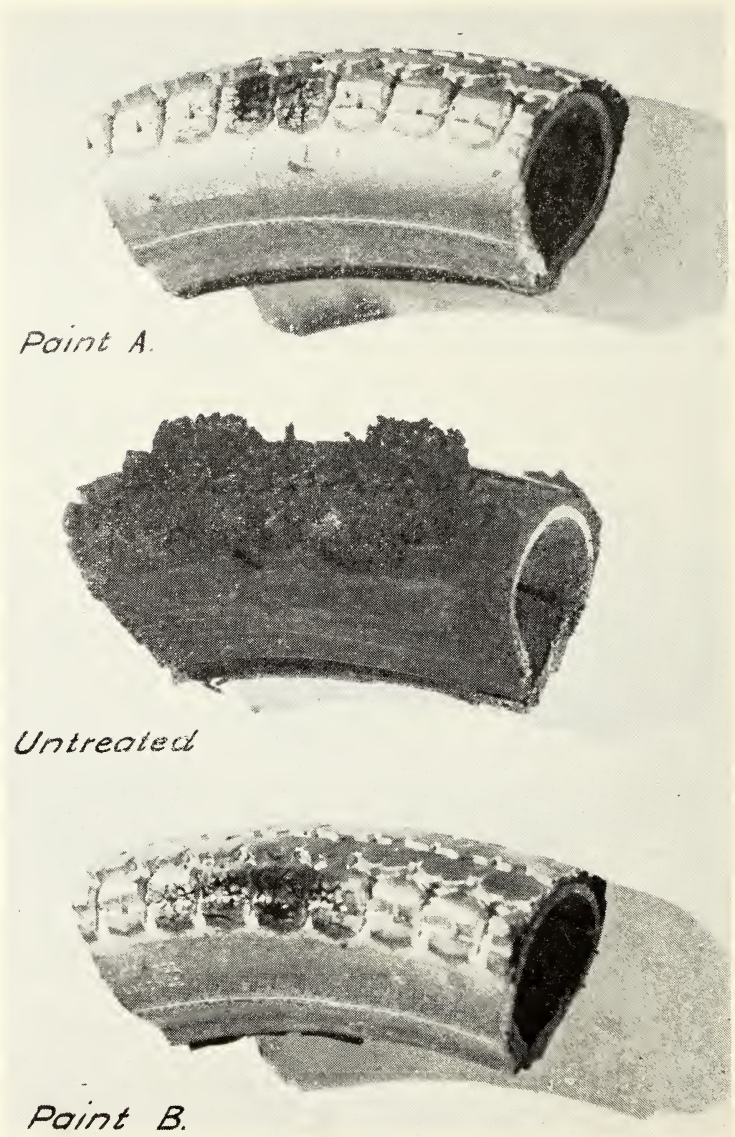


FIGURE 1.—Effect of 40 minutes irradiation on tire sections untreated and protected by aluminum paint.

In many cases it is quite possible that the inner tube would fail well before the tire had seriously decomposed since the tube will be more sensitive to heat, which is conducted to it not only through the tire wall but also by the hot wheel rim. Also over a period of time the lives of both tires and tubes are likely to be shortened greatly by frequent exposures to even comparatively low radiation intensities.

Actual experience indicates that tires, particularly if new, should be well cleaned with a solvent before they are painted, and the first coat should preferably be applied by brushing. In fact,

TABLE 1.—*Properties of aluminum heat-reflecting paints applied to tires*

Paint	Heat reflection average [1]	Heat reflection maximum [2]	Mechanical adherence to rubber	Method of application and covering power	Drying time, approximate
	Percent	*Percent*			*Minutes*
A	66	69	Excellent	Brush: use from the tin (800 sq. ft. per gal.). Spray:[3] dilute with 10-15 percent mineral turpentines (600-700 sq. ft. per gal.).	45
B	60	66	Good, but surface has a tendency to crack	Brush or spray,[3] use from the tin (covering power same as paint A).	20
C	49	52	(4)	(4)	(4)

[1] Obtained from measurements carried out at radiant heat fluxes of 0.07, 0.11, 0.17, and 0.35 cal./cm.^{2}/sec.; maesurements at each intensity.
[2] Obtained at 0.17 cal./cm.^{2}/sec. and below.
[3] Spraying however is not recommended.
[4] Surface remained tacky, even after several days, though finish appeared good. Pigment became mobile in base on heating. Rejected as unsatisfactory.

subsequent coats when brushed on give finishes that are somewhat superior (for the present purpose) to those obtained by spraying. In an emergency when the vehicle becomes a refuge, the outer surface of the windows could well be rendered reflecting by paint applied either by brush or, less desirably, by spray (paint contained in a "pressure pack"). Possibly though, a more appropriate method would be to cover windows with pieces of thin (0.005- to 0.020-inch) aluminum foil which could be pre-cut to size. In most emergency situations there would be sufficient time for the use of such protective devices on the windows. Two objections have been raised to the painting of vehicles with aluminum paint. These are that the vehicle becomes less easily seen in dense smoke and that the glare from the bonnet and body tends to dazzle the vehicle driver and other persons in the vicinity. However, actual experience with one vehicle (the Mobile Laboratory, C.S.I.R.O. Bushfire Section) has shown that these problems are not serious.

Minimum of Fuel Vapor Locking

An electrically operated gasoline pump installed adjacent to the gasoline tank (preferably below it so that the pump is gravity fed) will almost entirely eliminate the possibility of vapor locking. The gasoline will thus be pushed to the carburetor and not drawn to it by suction. Only when the gasoline in the tank is itself actually boiling will the problem become serious and this fortunately is a rare occurrence. A pump of this kind need not replace the pump already installed in a vehicle, but can be used as an auxiliary pump to be switched into use from the dash when the occasion arises.

TABLE 2.—*Heat irradiation tests on 6-inch sections 2¾- by 19-in tires*

Radiation intensity and tire treatment	Time till—		
	Smoking	Cracking	Glowing
	Minutes	*Minutes*	*Minutes*
0.35 cal./cm.^{2}/sec.:[1]			
Untreated	⅓	3	3½
Paint A	1¾	5–6	8¼
Paint B	1¾	8–9	11½
0.17 cal./cm.^{2}/sec.:[2]			
Untreated [3]	¾–1	5½	[4] 10½; 15¾
Paint A	4½	21	[4] 40
Paint B	3¼	18¼	[4] 40

[1] Radiant intensity equivalent to the average usually encountered 5 feet above ground at 5 feet from 10- to 20-foot flames.

[2] Radiant intensity equivalent to the average usually encountered at ground level 5 feet from 10- to 20-foot flames.

[3] These are the results of two tests; the time to glowing is governed in part by the specific way in which the surface cracks.

[4] Pilot ignition immediate for the untreated tire and at 40 minutes took 4 and 5 seconds respectively for paints A and B. Pilot ignition is that brought about by direct contact of the flammable material with a separate flame, as opposed to spontaneous ignition, which takes place when flaming is initiated by the interaction of the hot vapors from the decomposing tire with the oxygen in the air.

CONCLUSIONS

The measures suggested here should not be expensive to carry out. They should greatly increase the safety of a vehicle and its attendant firefighters and at the same time the vehicle's operational efficiency should also be improved.

BACKPACK MIST BLOWER FOR FIRE SUPPRESSION

Owen L. Lashley
District Ranger, Remer District, Chippewa National Forest

A backpack mist blower was used on the Remer Ranger District, Chippewa National Forest, during the spring fire season of 1962 (fig. 1). The unit was used in brush and slash areas and on running fires in hardwood leaves. Results, on the whole, were good when the machine was used alone or in conjunction with other tools. It was found that when the machine was used in dry, heavy, densely packed grass fuels, it was a great help in knocking the flames down and cooling the surface so that water from the backpack pumps could be pumped directly on the hot fuel underneath the matted surface. Use of a wetting agent increased the effectiveness of the mist a great deal.

The machine held enough water to spray continuously for a period of 8 to 10 minutes. This can be extended by running the motor at the slowest possible speed which, incidentally, is the best speed under most conditions. A man carrying a 5-gallon backpack can was assigned to carry water for replenishing the supply in the machine.

The size of the crew varied from four to six men depending on conditions. Crew organization was as follows: One man to operate the mist blower; one man to carry water for the mist blower; one man with backpack pump; two or three men with firefighting flaps, rakes, or shovels. Organization of the crew and location of the tools in the line were determined by the nature of the fire.

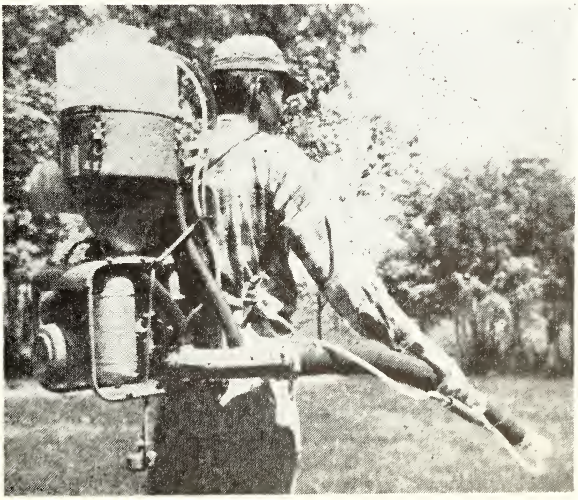


Figure 1.—A backpack mist blower being carried by a forest worker.

NEW 105-GALLON HELITANK

ROBERT C. SINGLETON
Public Information, Los Angeles County

A radically new type tank for dropping fire retardant chemicals or water from a helicopter was recently demonstrated by the Los Angeles County Fire Department at its Fire Combat Training Center. Fire officials from throughout the area who witnessed the demonstration were very enthusiastic and many stated that this new tank would drastically change helicopter air attack operations.

"The tank," Los Angeles County Fire Chief Keith E. Klinger says, "doubles and in many cases triples a helicopter's chemical carrying capacity as compared to rubber and plastic bags which were formerly used." The new all-metal tank holds 105 gallons, three times the capacity of the old 35-gallon bag (figs. 1 and 2). The new tank also is safer and more accurate, according to Chief Klinger and Roland Barton, the Department's helicopter pilot. Barton stated that the tank does not affect the helicopter's stability.

One of the 50-pound metal tanks can be installed or removed by two men in 2 minutes. The rectangular tank, which is fitted with interior baffles, is clamped to the fore and aft cross tubes of the helicopter at the four saddle points. Doors of the tank can be

FIGURE 1.—Helicopter loading 1000-gallon portable water reservoir by using 105-gallon drop tank.

perated electrically or manually. Manual control is mounted next o the pilot's left hand by the collective pitch control. Electrically, he doors are opened by the pilot pressing the cyclic stick button. 'o close the doors the cyclic stick trigger is used.

The tank was developed by the Research Section of the Los ngeles County Fire Department, under Captain Frank Hamp nd Pilot Roland Barton. "Additional information may be obained," Chief Klinger said, "by writing the Los Angeles County 'ire Department, P.O. Box 3009, Terminal Annex, Los Angeles 4, California. The cost at the present time is approximately 1,200, but this is a variable factor."

'IGURE 2.—Helicopter dropping 105 gallons of water at Los Angeles County Fire Department Training Center.

AN IMPROVED FIRE PLOTTING BOARD

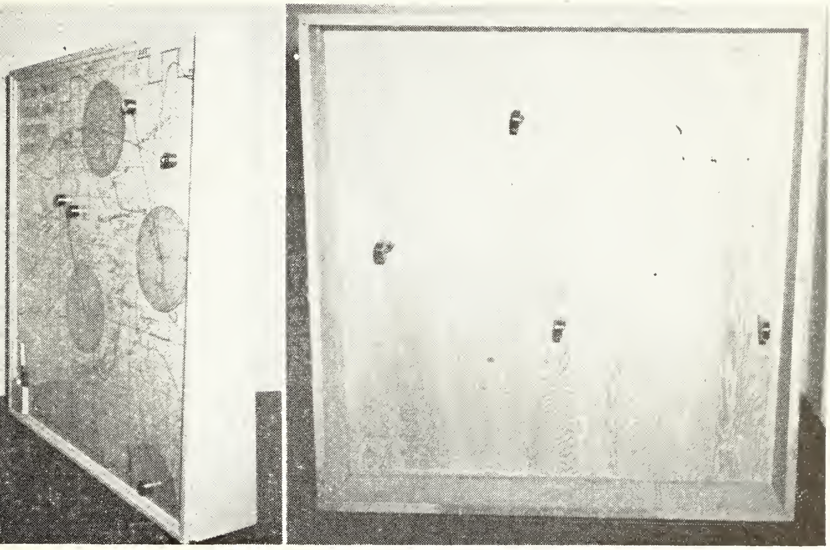
Robert L. Bjornsen
Fire Staff, Gifford Pinchot National Forest

A plotting board is an essential tool in locating fires from azimuths reported by lookouts. Over the years a number of plotting boards have been developed for use by forest fire protection agencies. On such a board the retracting string with azimuth circle makes plotting forest fire locations accurate and fast. The Gifford Pinchot National Forest uses an adaptation of the retractable string-magnet-azimuth circle board (figs. 1 and 2). In addition to plotting fires on the board, the dispatcher can write temporary notes on the plastic cover protecting the map and azimuth circles with a grease pencil. The fact that descriptive notes can be made on the map can be very useful, especially when a lightning "bust" results in a large number of fires being reported in a short period of time.

Following is the procedure for assembling the plotting and dispatching board:

1. Construct backing frame using flathead wood screws and glue all joints. Bottom of the frame should be several inches wider than the top.

Figure 1.—Retractable strings extended from lookouts, illustrating cross-shot method of locating fires. Note temporary dispatch notes in grease pencil.



'IGURE 2.—Side view showing beveled bottom of frame and back view showing retractable string steel mounting. Back should be left open for servicing.

2. Affix plywood to backing frame. Use flathead wood screws and glue all joints.

3. Attach sheet iron to plywood using contact cement. Apply adhesive to both surfaces. Note: Use temporary spacers between plywood and iron until centered, then remove spacers from center toward edges. Once two surfaces touch, further adjustment is extremely difficult.

4. Wallpaper map to sheet iron using regular wallpaper paste and brush. Small wrinkles will flatten out when dry.

5. When dry, affix azimuth circles to map. Drill holes through lookout location to receive retractable map reel.

6. Attach plastic sheet to map using wood molding or aluminum counter edge molding.

7. Attach retractable map reels. Wooden spacers will be needed on the back to take up the slack. Leave back of plotting board open for servicing map reels.

8. Attach eyebolts to top of frame for hanging on wall hooks.

'he magnets used are permanent type and guaranteed as such y the manufacturer. Orders should specify that 1/32-inch eye e slaughtered (not soldered) flush to bottom of magnet.

Materials List [1]

Item	*Cost*
Magnet, T811 with 1/32-inch dia. eye slaughtered flush to bottom; in quantities of 5 or more	$5.00
Reel, retracting string	4.15
Azimuth circle, 8-inch, red, size B	1.30
Subtotal, each lookout on board	10.45
Cement, contact, 1 pint	1.25
Plastic, clear 10 mil., $0.41/sq. ft., average size 25 sq. ft.	10.25
Sheet iron, galv. 24 ga., $0.28/sq. ft., average size 25 sq. ft.	7.00
Plywood, ⅜-inch, interior AA, 4 by 8 feet	4.75
Molding, aluminum angle, $0.20/linear ft., average size 20 linear feet	4.00
Misc., hardware and 1 pc. 1-inch select S4S pine	4.00
Map, planimetric blue line, 2 inches = 1 mile (including preparation of negative)	20.00
Subtotal	51.25
Average cost of materials per lookout = $\frac{51.25 + (10.45 \times 4)}{4}$	23.26

[1] Based on 5-ft. by 5-ft. plotting board with four lookouts. Labor costs to construct not included.

FIRE INVESTIGATION TRAINING AID

Raymond Higgins, *Fire Prevention Officer,* and
George Berdan, *Assistant Law Enforcement Coordinator,*
California Division of Forestry

This poster has been developed as a training aid as well as for posting in fire control stations where the "Fire Investigation Hints," would be a constant reminder to officers and crews. Size is 2 by 3 feet; colors, black and white with shading. Art work was done by inmates of the California Medical Facility and printed by the State Printer. Total costs are approximately 10 cents per poster. It is planned to interject new ideas into a similar design each year and possibly to produce the poster in multicolor by silk screen process at one of the State prison facilities.

THE TRACTOR-CABLE METHOD OF PREPARING AREAS FOR BURNING

Byron Baldwin and John E. Wilson
Lolo National Forest

The tractor-cable method of preparing logged-over areas for burning was adapted for use on the Lolo National Forest during 1960 and has proved to be more economical and efficient than any other method used in this Region. The condition of some stands of timber, which are diseased or stagnated or contain undesirable species, makes it necessary to harvest by clearcutting. After all the merchantable timber has been removed, tractors and cables are used to uproot the residual stand in preparation for burning and subsequent reforestation. While this method is not new, we believe the way in which it is applied is different.

The cable method was initiated on the Missoula District because of the need for clearing a residual stand on slopes that were nonoperable by mechanical methods (fig. 1). Two of these methods, tractor bunching and tractor pushover (trampling), are limited to slopes of 35 percent or less. The cable method has

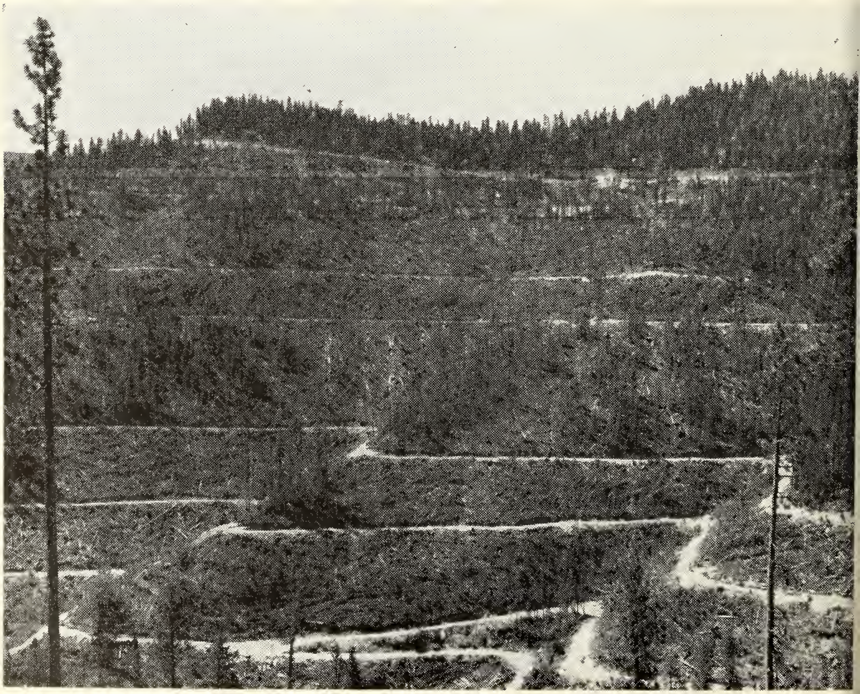


Figure 1.—Two lower terraces cleared with tractor-cable.

been used successfully on slopes ranging from level to 70 percent. Although maximum slope limitation has not been determined, it is safe to assume that this method will function on any slope where there is a usable road.

Substantial savings have resulted from the use of the cable method over a 2-year period. Costs per acre prepared should continue to decrease as the original investment is amortized and refinements are made as a result of additional experience. This type of work has been done on three ranger districts and five different areas, involving a total of 815 acres. Costs ranged from $3.84 to $25.77 per acre, and average cost on all projects was $16.96. During the same period, average costs per acre for other methods of preparation were as follows:

	Average cost per acre	
Method	*Forest*	*Region*
Tractor trampling (walkdown)	$20.82	$22.41
Tractor bunching and piling	34.00	32.51
Hand felling	32.66	—

The cost on the 815 acres done by cable was approximately $3,260 less than it would have been had the next most economical method been used. Actually, the saving was greater since an even more expensive method would have had to be applied to the nonoperable slopes.

A private owner, as a result of observing this operation, used the method on some of his lands during 1961, and the State of Montana Forestry Department has obtained equipment for use in 1962. Several industrial concerns are interested in the potential of the cable method and the possibility of large-scale manufacture of the equipment.

Application of Method

General

The cable method is best adapted for use on fairly large areas that must be cleared of all the residual stand. Two tractors are required and should be of a size comparable to the D-6 or larger. Three-quarter-inch cable is made up into 100-foot sections, and the end of each section is fitted with a pressed-on ferrule which in turn is inserted into one end of a specially made connector (fig. 2). The cable sections and connectors provide for the following:

FIGURE 2.—Tractor connector, *left*; cable connector, *right*.

1. Ease of handling by crew members.
2. Increasing or decreasing the cable length as needed.
3. Disconnection for bypassing seed trees, seed-tree groups, or obstructions such as rock outcrops and large snags.
4. Swivel action necessary to prevent kinking of the cable.

On slopes greater than 35 percent, the tractors need some form of road from which to operate. The type of road system left on an area by the jammer method of logging lends itself readily to cabling. Also the tractors can operate from firebreaks that were constructed earlier for a prescribed burn.

Soil moisture conditions are important to the success of cabling. When adequate soil moisture is present, the trees can be easily uprooted and only a few small ones will be left. Some handwork may be necessary if the fuel created through logging and cabling is insufficient to scorch out the scattered small trees that remain standing. The damage to roads and the amount of debris on them are considerably less than that created by other methods of tractor preparation.

Equipment and Personnel Required:

2 tractors of a size comparable to a D-6 or larger, in good working condition and equipped with canopies.

Approximately 600 feet of $\frac{3}{4}$-inch steel-core cable in 100-foot sections with ferrules pressed into each end.

12 straps for binding coiled sections of cable or cable reel.

2 tractor connectors and 5 cable connectors (fig. 2). (It is desirable to have one extra connector of each type for a spare.)

Signaling equipment: athletic-type whistles and signal paddles. (The signal paddles resemble large table tennis paddles and are faced with highly visible material.) Lightweight, two-way radios would supplement or take the place of the whistles and paddles.

Foreman (generally functions as a signalman).

2 to 3 crewmen (depending upon conditions).

2 experienced tractor operators.

Operating Procedure

Lay out the required number of cable sections and connectors. It is desirable to connect sufficient cable to permit a large loop to the rear of the tractors. This allows a relatively straight pull and eliminates the necessity of adding cable when the distance between tractors increases slightly.

Maneuver the tractors into starting positions. Generally the lower tractor operates slightly ahead of the upper one. This allows the cable the best chance of sliding up the side of a stump when encountered. It also reduces the hazard of rolling rocks dislodged by the upper tractor. Under some conditions, it may be necessary for the upper tractor to operate even with or ahead of the lower one.

Position the signalmen and cablemen to rear of the tractors. Signalmen must be visible to operators at all times and intervisible when possible.

The cableman's job is mainly to lift the cable over obstructions or disconnect it to bypass them. Most hangups occur on the backslope of the lower road and shoulder of upper one. Between these points the cable rides high enough on the uprooted trees and debris to clear stumps or other low obstructions. The cable should not be approached or handled until the tension on it has been relieved.

In summary, the potential of the tractor-cable method may be far reaching because of the efficiency and economy of the method. However, this method, like any other, has its limitations, and anyone contemplating its use should become familiar with them. For example, its use may influence the layout of sale areas or the retention of seed trees. The tractor-cable method will undoubtedly be improved as we gain more experience with it.

DIDYMIUM GLASSES FOR SMOKE DETECTION

D. G. Fraser
Forest Research Branch, Department of Forestry, Canada

Although there have been tales of lookout men with weak eye
sight, good vision is a prime requirement for the position. How
ever, an observer cannot report a smoke he cannot see and eve
with the best of vision it is difficult to recognize a light smok
against a light sky background, especially if atmospheric haze i
present.

Glasses with didymium lenses, the type used by glass blowers
were reported to improve the outline of smoke and clouds on
misty day. These have pale blue lenses that absorb portions o
the yellow and red sections of the spectrum. A pair of thes
glasses was tested by Department of Forestry staff at th
Petawawa Forest Experiment Station, Chalk River, Ontario, dur
ing the 1960 and 1961 fire seasons.

Individuals in any group of people may have different reaction
to the use of colored lenses; one may note an improvement whil
another will feel there is no betterment with the same type of len
under identical conditions. Thus the rating of the glasses i
necessarily based on a somewhat subjective judgment.

Throughout this test, ratings were made on a comparative basi
by observers viewing from a fixed observation point with an
without glasses. Observers tried the glasses during the 2-yea
period and observations were made during a variety of weathe
conditions. Each observer recorded on a printed form the mos
distant landmark he could distinguish without glasses, the meteor
ological conditions, and the date and time of observation. The
ratings "yes" or "no" were made for the improvement in visibilit
of light and dark smokes, cloud outlines, and distance. Fortunate
ly there were several fairly consistent sources of smoke in th
area enabling the observer to make a rating on smoke for mos
sets of observations. On some occasions additional observation
were recorded in which a pair of ordinary sunglasses with green
colored lenses were also tested.

Reports show an improvement in smoke recognition on slightl
more than half the times the glasses with didymium lenses wer
used. When atmospheric conditions were clear, or only slightl
hazy, light-colored smoke seemed easier to recognize with th
glasses. When pronounced haze or mist was present, an improve
ment in both light and dark smoke identification was noted. How
ever, on those occasions when ordinary sunglasses were tried, th
observers felt they were equally effective. Thus, though it seem
desirable for observers to have some form of light-filtering glasses
the selection of a particular type could be a matter of persona
choice.

One interesting improvement in visibility was noted during an bservation when heavy ground fog was present near the obser-ation point; when the observer looked without glasses in a irection toward the sun, no detail could be seen in the shadow reas. Using the ordinary sunglasses, he could make out the out-ine of a roadside sign about one-eighth mile away in the shadow f a hill and could distinguish a tractor working beyond the sign. Vhen the didymium glasses were used, it was possible to see and ead the road direction sign and to recognize detail on the tractor. 'his improvement in visibility, if substantiated by aerial tests, night be of interest to pilots attempting water dropping in moke-covered areas.

INDEX, 1962

[Jan., pp. 1–45; Apr., pp. 47–68; July, pp. 69–94; Oct., pp. 95–123.]

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 says:
SMOKEY
BE SURE
it's DEAD OUT

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IRE CONTROL NOTES

PERIODICAL DEVOTED TO THE TECHNIQUE OF
REST FIRE CONTROL

VOL. 24 NO. 1
January 1963

est Service
TED STATES 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.

UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962

Growth Through Agricultural Progress

olume 24 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, firefighting, 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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Forest Service, Washington, D. C.

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CONTENTS

FIVE YEAR INVESTIGATION ENDS IN CAPTURE OF "MT. BALDY FIREBUG"

Anselmo Lewis

District Ranger, Mt. Baldy District, Angeles National Forest

"Suspect's car leaving home."
"Entering Live Oak Canyon."
"Coming out of Live Oak and entering Webb Canyon."
"Back out of Webb Canyon; heading south toward Pomona."

Such were the electrifying words radioed to headquarters of the It. Baldy Ranger District, Angeles National Forest, by Fire Pre-ention Technician William J. Baden, who was on stake-out duty n a hill overlooking a suspected incendiary's home at 1:14 p.m. n August 13, 1962. The smoke rising from the head of Webb Canyon a few minutes later proved to be the final link in the solu-ion of an incendiary problem that had been plaguing the Dis-rict since 1957.

When it was definitely ascertained that the suspect's car had een the only vehicle in the area, the local police were alerted and he suspect was picked up at 4:00 p.m. in the nearby city of Claremont. By 6:00 p.m. the suspect had confessed to the set-ing of approximately 15 fires in the area since 1960. He would ot confess to any before 1960. Nevertheless, officials were con-inced that he was responsible for an additional 40 or 50 dating ack to 1957, since the same device had been found on all of them.

The Pattern of Incendiary Fires

Normally, incendiarism is not a problem on the Mt. Baldy Ranger District. In 1957, however, a device was found on the Morris Fire in San Gabriel Canyon that definitely pointed to in-endiarism, and the machinery that ultimately resulted in the pprehension of the suspect 5 years later was set in motion.

In the initial stages the usual measures to combat an incen-iary problem were activated. Patrolling was intensified, license umbers of suspect cars were "checked out," possible suspects vere screened, police authorities were checked for known "pyros," nd even employees and former employees were screened for pos-ible connection with the problem. Traps were set using employ-es in civilian clothes and private cars. They were placed with hovels in orange groves along routes of travel to the forest—imulating irrigators, sat with their wives in private cars on lovers" points, and hid in the brush along roads to check cars ntering and leaving the forest.

None of these measures were successful as there seemed to be o pattern or apparent motive as to when or where fires would e set. In 1958 two fires were set early in the season, then none. n 1959 no fires occurred on the District, but numerous others ere set in the adjacent county area. Again, in 1960, three fires ere set. No fires were set during the winter periods or during the "Santa Ana" dry, desert winds. Large fires did not seem t be the objective, since some of the sets were surrounded by nat ural barriers.

Before the start of the 1961 fire season a detailed study wa made of all available information. From this analysis the follow ing picture began to take form:

1. All of the activity was centered in two canyons, namely Sa Gabriel and San Antonio, and the adjacent county areas. No fire were being set in the central part of the District, and all wer confined to the extreme western and eastern parts.

2. There was no particular pattern as to the day or time tha the fires were set.

3. All the sets were along main traveled roads and near th mouth of the canyons.

4. Fires were set without regard to burning conditions. N attempt was made to select "bad" days or ignition points tha would result in big fires.

5. The device was the same, and the same brand of cigarett was always used.

6. The pattern of the sets indicated that the incendiary live in the local area.

Plans for Apprehension of the Incendiary

A car check system was developed to record the license num bers and entry and exit time of all cars traveling San Gabrie and San Antonio Canyons. The checkers were dressed in civil ian clothes and used personal transportation. They were in structed to move about so as not to appear conspicuous. Som were to lift the hoods of their cars to simulate travelers coolin the motor, tires were deflated to simulate a flat tire replacemen some used motorcycles, others polished their cars under trees and many hid in the brush alongside the highway.

On November 17, 1961, at 3:00 p.m. a fire was reported nea the mouth of San Gabriel Canyon in county territory. The fir was quickly extinguished and before the ashes had cooled, inves tigators were on the spot analyzing the records of the checkers This quickly pin-pointed a Volkswagen as the logical suspec from a time basis, and the owner was picked up for questioning

It was soon apparent that the checking system had nabbed "firebug," although the wrong one. He did not use a device, bu confined himself to flipping matches into the brush until on "took off." He readily admitted setting the disastrous Sierra Fire which had claimed the life of a firefighter, plus about 10 othe fires. All of these, however, had occurred on the west end of th Angeles National Forest and not on the Mt. Baldy District.

The search continued. With the advent of the winter rains operations were temporarily suspended. In June 1962 the ca check system was re-activated. Suddenly the entire pattern o the incendiary fires changed. Fires were again being set, bu only in the county portion of San Gabriel Canyon, and only afte the checkers had gone home for the night.

The Plan is Expanded

It was decided not to change the checking pattern, even though seemed to be known to the incendiary. The checkers would connue to go off duty as previously scheduled, but would be secretly eplaced by a night shift hidden on vantage points in the brush. Operation Cochise," as it was called (since it followed the patern used by the Apache Chief Cochise to trap stagecoaches in ne Arizona Territory during the 1860's), was put into effect and ne trap was set. Men were hidden at the mouth of the canyon nd tied in by radio to the lookouts on the ridges. The plan called or checking all suspicious cars and instituting a road block in ne event of fire.

Again the pattern changed. Instead of in the San Gabriel Canon area fires began to appear in the county territory around 'uddingstone Dam and in the valley below the mouth of San ntonio Canyon. During the week of August 3–10 a total of 12 ncendiary fires were set.

The first break in the case came on August 6, 1962, at approxiately 5:00 p.m. A fire was set in the county territory southwest f San Antonio Canyon. During the investigation of the fire it as learned that a farm worker had seen a white Dodge, with a ingle red stripe along the side, pulling away from the scene of ne fire. Further investigation disclosed that a county patrolman ad seen a white car parked in a nearby orange grove about 2 ours before the fire. He had taken the license number, which as XWU-926.

This license number was found a number of times in the neckers records, but could not be tied to any particular fire. fter an intensive study of the records a particular situation was oted on the traffic records in connection with the Mine Fire in an Antonio Canyon on July 19, 1962.

The records showed the following:

Time	*License No.*	*Make Mod.*	*Remarks*
1439	XMU-926	White Plymouth	Up Canyon
1521	XWX-926	Dodge	Down Canyon

The Mine Fire was reported at 3:24 p.m. (1524). At the time, ne above two license numbers had been checked, but led to cars at were of different makes and had not been in the area on at day.

It was apparent that a mistake had been made in recording the umbers. When the license number XWU-926 was compared to e above record, it was found to be identical except for one letr in each case. In one case the make of car was correct; in the her the color matched. A "make" was run on the suspected ense number, and the owner proved to be a local resident. Since e did not have sufficient evidence for a conviction, we decided t place the suspect under surveillance with the intent of catching m setting a fire, rather than to scare him off with a premature arest.

Stake-Out Pays Off

The hill overlooking the suspect's home was ideal for a stake out. On August 10, 1962, the stake-out began. It soon becam evident that no white car was on the premises. On August 12 th stake-out reported arrival of the car at 11:00 p.m. At 1:14 p.n August 13, under the eyes of Fire Prevention Technician Wi liam J. Baden on the hill above, the suspect left the house to se his last fire.

Thus, after 5 years of work and perseverence the "big one was apprehended. He freely admitted setting the fires in the Sa Gabriel and San Antonio Canyon areas and explained in deta how he had constructed the incendiary device—the same devic found on most of the "sets" since 1957. He was sentenced on Oc tober 9, 1962, on one count of setting brush and forest fires an one count of arson. The first carried a sentence of 1 to 10 year in State Prison; the second, 2 to 10 years. Sentences were ordere by the judge to run consecutively.

The operation had its lighter moments. It was necessary a times to change plans quickly, to follow up unexpected leads o evidence, and it was not always possible to immediately inforn everyone concerned. This led to some typical incidents.

There was the night when one of our men, secreted in Sa Gabriel Canyon, was routed out by a county patrolman who wa beating the brush for suspicious characters. On another occasio the stake-out was discovered and set upon by neighborhood dogs creating such a disturbance that the operation had to be aban doned. On numerous occasions checkers were challenged by high way patrolmen. A checker and his wife were on stake-out on night when suddenly a figure loomed up beside them, shoved gun through the window, and demanded to know who they wer and what they were doing there. The checker had been keeping suspect's house under surveillance for the past three or fou nights. He was unaware that his activities had aroused the sus picion of a resident reserve policeman who was keeping him unde surveillance.

THE ROADSIDE FIRE PROBLEM

RICHARD F. JOHNSON

Fire Prevention Officer, San Bernardino National Forest

It has long been suspected that the extensive system of roads ınd highways interlacing the watershed and timbered areas of he four southern California National Forests may be the spawnng place of most of the disastrous forest fires experienced in this ırea.

Mr. S. B. Show, former Regional Forester, California Region, tated in an article published in the January 1941 issue of Fire Control Notes that "On the Angeles, San Bernardino, and Clevoand National Forests, . . . 78 percent of all man-caused fires tart within 265 feet of roads, but account for . . . 69 percent of he area burned."

Mr. Show further stated that "the necessarily long-time soluion of the smoker fire problem is clear. Continuation and expanion of policing, greater attention to fireproofing so that fires canıot start, and a systematic planned and continuous campaign of ndividual education. . . ."

During the past 20 years since Mr. Show's study, good progess has been made on expansion of inspection and policing y utilizing additional, better trained fire prevention personnel ınd improved fire prevention techniques. The Smokey Bear Proram and other efforts have been successfully employed in the ampaign of individual fire prevention education. At present, ıowever, "greater attention to fireproofing," particularly along nountain roadsides, has not been fully implemented.

Analysis of the Problem

Analysis of all man-caused fires, except those from railroads, hat occurred on the San Bernardino National Forest during the 950-59 decade reveals three significant facts relating directly to he forest and watershed fire problem in the National Forests of outhern California.

1. Fifty-two percent of all the man-caused fires occurred in the critical roadside zone of 0 to 33 feet from the outer edge of a road.
2. Of the man-caused fires that burned an area of 100 acres or more, 51 percent originated in this 0- to 33-foot roadside zone. These 22 fires burned a total of 28,783 acres in and adjacent to the San Bernardino National Forest.
3. Within the critical roadside zone traffic-associated fire causes such as smoker, overheated brakes, burning vehicles, and vehicle exhausts were responsible for 189 fires or 25 percent of all the man-caused fires that occurred during the decade. Six of these fires burned more than 100 acres each and represent 14 percent of all the fires during the decade that exceeded 100 acres in size.

A secondary zone of 34 to 99 feet from the outer edge of the road accounted for an additional 98 fires or 13 percent of all the man-caused fires. Six of these fires exceeded 100 acres in size and represent 14 percent of all the large fires during the decade.

Analysis of fires caused by campfire, smoker, debris burning, lumbering, and miscellaneous causes (including such items as burning vehicle and equipment exhaust) on the Angeles, Cleveland, Los Padres, and San Bernardino National Forests for the 1950-59 decade disclosed the following facts:

1. Of the 1,556 fires classified in above causes, 670 fires or 43 percent occurred in the critical roadside zone of 0 to 33 feet from the outer edge of a road.
2. Thirty-four of these 670 fires each burned more than 100 acres and represent 26 percent of all the large fires that occurred on the four southern California forests.

The California Highway Patrol states that 679 vehicular accidents occurred in the period of May through December 1961 in the mountain areas within San Bernardino County. All occurred on a road or within the roadside zone of 0 to 33 feet and were potential fire starters.

A Sample Program

Since 1958 the San Bernardino National Forest has conducted a sample program in roadside hazard reduction along segments of two heavily used San Bernardino County roads and a main artery California State Highway.

Eight miles of Lytle Creek Canyon Road, 5 miles of Waterman Canyon Road, and 9 miles of State Highway #18, were annually treated by removing flammable materials for a distance of 10 to 20 feet from the outer edge of the road with particular emphasis placed on draws, culvert heads, and turnouts. Cost of the initial work averaged $1,100 per mile. Annual maintenance has decreased each year with an average cost of $400 per mile. The cost on State Highway #18 was lower than that on the county roads owing to a large portion of the highway being through-cuts, which did not require as much clearing.

There has been a sharp reduction in the number of fires in the test areas. The occurrence of fires along these roads for the 5 years prior to the program compared to the 5-year program is shown in the tabulation.

	Lytle Creek Canyon		*Waterman Canyon*		*State Highway No. 18*	
	Incendiary (No.)	*All others (No.)*	*Incendiary (No.)*	*All others (No.)*	*Incendiary (No.)*	*All others (No.)*
Pre-program period 1953-1957	3	3	8	7	6	7
Program period 1958-1962	0	1	4	1	5	3
Decrease	−3	−2	−4	−6	−1	−4
Percent decrease	100	67	50	86	17	57

A Suggested Solution

The following items are offered for consideration in developing a solution to the southern California roadside fire problem:

1. Every mile of public road in the mountain watershed, timber, and recreation areas should receive some type of fire hazard reduction treatment. The type and amount of hazard reduction will depend upon highway and fire prevention engineering consideration of such variables as terrain, type of soil, susceptibility to erosion, type of vegetative cover, and type and amount of use.
2. The most effective location of roadside hazard reduction, considering the frequency and severity of man-caused fire starts, is in the area of from 0 to 33 feet from the outer edge of the road. Secondary firebreaks located with an untreated strip between the break and the road edge are a poor second choice for the 0- to 33-foot zone.
3. A prime requisite for any type of roadside hazard reduction is the removal of fine fuels such as grass, leaves, pine needles, and other vegetative ground litter. Standing vegetation such as brush, shrubs, and trees should be pruned to keep foliage a minimum of 2 feet above the ground.
4. Wherever possible, the treatment should be combined with and complement existing or proposed roadside beautification and slope stabilization programs. Use of irrigated "Green Belt" zones should be incorporated into highway design when site and water availability allow such treatment.
5. Research should be accelerated to determine the best type of treatment for each zone of fuel-terrain, the best species of vegetation that can be introduced for planting in roadside strips, further study of fire causative agents to improve hazard reduction techniques.

MORE GRASS — LESS FIRE DAMAGE

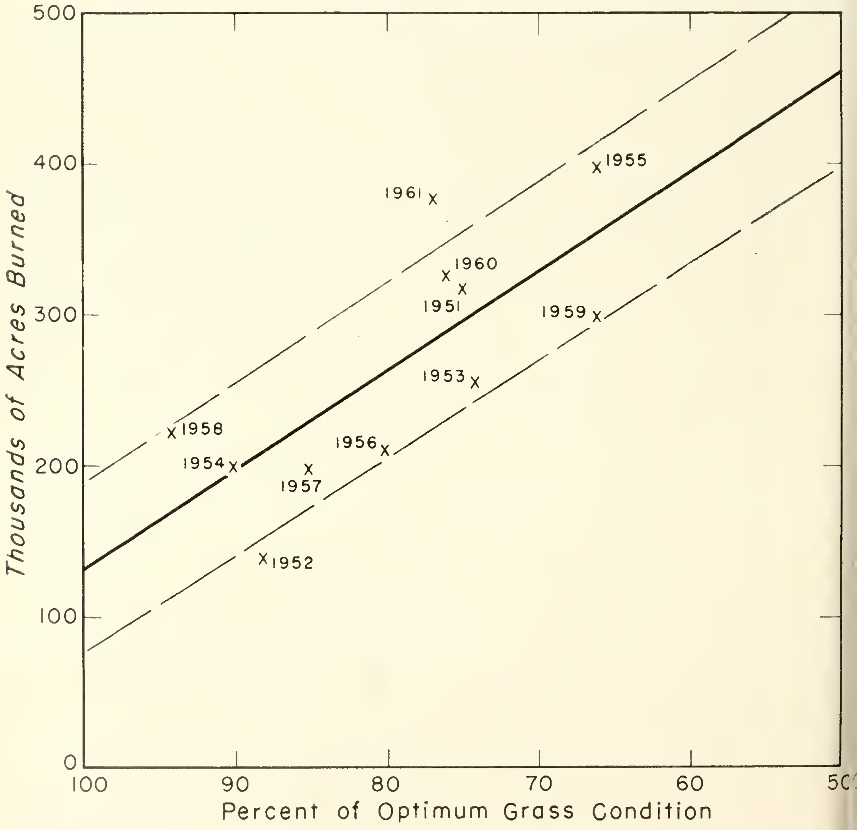
Arthur R. Pirsko

Research Forester, Pacific Southwest Forest and Range Experiment Station

"We have a good stand of grass this spring so we'll have another bad fire year."

"There's hardly any grass; everything is so dry, this year'll be a bad one for fires."

Which of these two contradictory, but seemingly logical statements is correct? According to an analysis of fires and grass conditions in California (see graph), the second is more accurate. We can infer that a better grass crop indicates average or better rainfall and a correspondingly higher moisture content in medium and heavy fuels; thus, fewer acres burned by wildfire.



Regression of acres burned related to grass condition in California, 1951-61

The annual acreage burned in California was obtained from J. S. Forest Service and California Division of Forestry reports. 'he amount of grass cover was taken from the May 1 Livestock, 'asture, and Range report of the California Crop and Livestock teporting Service.[1] Grass ratings are subjective measures; 100 epresents excellent grass condition; 90-99 very good; 80-89 ;ood; 70-79 fair; 60-69 poor; 50-59 bad; 49 and less very bad. 3oth sets of data were for the 11 years, 1951–61.

By plotting these data and computing a straight line regression, ve find that acreage burned is significantly related to grass conlition.[2] The acreage of wildlands burned decreases as the grass ıpproaches the luxuriant optimum condition.

Apparently, once a minimum grass cover is established to carry ire, the excess amount of grass is not an important factor in ire spread. At this point the controlling variables in fire spread ıre the effects of current and past weather.

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[1] The May 1 reports are used because they reflect the full effects of winter precipitation and the spring growing season.

[2] The calculated regression Y-786.47-6.57X. One standard deviation is ±50,000 acres. With 10 degrees of freedom, the "T" test was applied and found to be 3.402, or highly significant at the 1 percent level.

MOISTURE CONTENT OF GALLBERRY AND PALMETTO DURING A DRY PERIOD

ANTHONY T. ALTOBELLIS AND ROBERT W. COOPER
Southern Forest Fire Laboratory

Forest fires burn more intensely during periods of dry weather. Although the moisture condition of dead fuel has been thought largely responsible for this situation, there is considerable ambiguity concerning the role of green, vegetative fuels. If the moisture content of green fuels, such as gallberry and palmetto, is sharply reduced during periods of drought, the vegetation becomes more flammable and there will be more fire.

Moisture measurements taken for palmetto and gallberry plants in south Georgia in 1959 and 1960 indicated little relationship between the moisture content of the plants and rainfall. Both years, however, had normal or above-normal rainfall and no real moisture deficiencies were evident. In the fall of 1961 a short drought developed in the area, permitting the measurement of vegetative moisture contents during a period of apparent moisture stress, thus enabling comparisons with fuel conditions encountered in the previous fall periods.

The average moisture content of live palmetto and gallberry plants sampled twice each year between October 1 and November 15 remained fairly constant from year to year, regardless of precipitation (table 1).

TABLE 1.—*Fuel moisture conditions and rainfall during three fall seasons (September 15 to November 15) 1959-1961*

Year	Rainfall	Samples	Average moisture contents with ranges[1]			
			Gallberry		Palmetto	
			Leaves	Stems	Leaves	Stems
	Inches	*Number*	*Percent*	*Percent*	*Percent*	*Percent*
1959.........	7.65	24	116 (96-134)	83 (67-108)	117 (95-136)	141 (109-174)
1960.........	12.66	12	115 (106-119)	87 (81-92)	124 (101-137)	154 (128-180)
1961.........	0.53	24	107 (99-118)	83 (80-89)	115 (93-143)	150 (133-179)

[1] Based on ovendry weight obtained by drying fuel at 85° C. until measurable moisture loss ceases. Numbers in parentheses denote range.

If the moisture content of green fuels such as gallberry and palmetto is affected significantly by drought conditions, these measurements indicate that the conditions must be more severe or extend for a longer period of time than experienced in the fall of 1961.

FOREST FIRE RESEARCH [1]

K. W. McNasser

Southern Forest Fire Laboratory, Southeastern Forest Experiment Station

Organized forest fire control has been in operation for more :han a half century, but the unexpected behavior of some fires still perplexes fire control managers. The need to know what makes fires behave as they do resulted in the opening of the Southern Forest Fire Laboratory in November 1959. This first major forest fire research facility in the planned national network has been in operation 2 years and fills a long-existing need for concentrating specialized research personnel and equipment in an environment adequate to meet some of the basic as well as applied research demands. Since forest fire research needs are common to public and private landowners and managers, it is only natural that here in the Southeastern Forest Experiment Station territory significant cooperation has developed among the Station, the Georgia Forestry Commission, and the Georgia Forest Research Council. State-Federal cooperation in research in Georgia has gained national and international recognition.

The Georgia Forest Research Council constructed and maintains the laboratory facility and contributes funds to promote research. The Georgia Forestry Commission contributes funds. The research specialists are U.S. Forest Service employees. There are many instances of State cooperation through personnel, equipment, and facilities.

The work of the several forest fire research laboratories is coordinated to prevent both duplication of research and gaps in the forest fire research effort of the country as a whole. At the Southern Forest Fire Laboratory we are meeting our part of this total job through concentration on five major projects. Two of these—Fire Models and Fire Environment—are highly basic areas of study. The other three—Fire Potential, Fire Control, and Fire Use—are largely of the applied type.

Development and Employment of Fire Model Techniques Applicable to Wild Land Environments

Because burning fuel supplies the energy of all forest fires, studies of the energy releasing processes, ignition and combustion, are an important part of fire research. Until recently, most basic research on fire has been devoted to controlled fire for heat and power production; consequently, the work has contributed little to an understanding of a free-burning forest fire. At the Southern Forest Fire Laboratory a systematic investigation of

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[1] Presented at the annual meeting of the Western Forest Fire Research Committee, Western Forestry and Conservation Association, Portland, Oreg., December 4–8, 1961.

the many factors that influence the free combustion of solid fuel is underway. The ultimate objective of this study is to determine the physical and chemical laws that govern the combustion of solid fuel. The important variables are type of fuel, density of material, moisture content, size of fuel particle, spacing, wind, slope, and dimensions of fuel bed.

Currently, efforts are concentrated on an experimental fire model. The model consists of a crib made of wood sticks with square cross-sections. The crib is ignited at one end and moved in such a manner that the flame is kept in a fixed position in space. The rate of spread of the fire is the measured speed at which the crib is moved. After an initial period of growth the fire reaches a steady-state, permitting measurements of dependent variables such as temperature and radiant energy to be recorded over an extended period.

Fire Environment and Fire Behavior

Closely related to the basic work in ignition and combustion is fire behavior research. This work includes model and full-scale studies of convection processes, case studies of major fires and their associated atmospheric conditions, and basic work on fuels and mechanisms controlling their rate of energy release. An important part of all these studies is the accompanying mathematical and analytical work on basic concepts and the development of scaling laws which are essential to the design of experimental work both in the laboratory and in the field.

The story of blowup fires and high-intensity fires in general is largely the story of convection. Thus, an understanding of these fires may depend considerably on the progress in convection research. Convection patterns are exceedingly complex and depend on the intensity of the fire, the speed of both the surface and upper winds, stability of the atmosphere, and topographic features. One of the most complex convection patterns is the fire whirlwind, but it is one of the simplest to produce on a model scale. Measurements and observations of such models should greatly increase our understanding of the full-scale whirls on actual fires. On high-intensity fires, whirlwinds are a dreaded and destructive phenomenon. The fast spread of these fires is largely determined by violent convection both in fire whirlwinds and in other types of convection patterns, which lift burning material and drop it far ahead of the main fire to provide new ignition points.

Research on forest fuels and their burning characteristics is essential to a better understanding of fire behavior. It has been found that the burning rates and drying rates of forest fuels are closely related. This relationship has an important application in the development of fire danger measurement systems and classification of fuels. Also important in the classification of fuels is total energy, or all the energy that would be released if all fuel in the path of a fire were totally consumed. Total energy can be used to rate the fire behavior or blowup potential of different fuel types under severe drought conditions.

Fire Potential: Fire Weather and Fire Danger

Meteorological research at the Southern Forest Fire Laboratory s primarily of the applied and developmental type. The relation between certain types of low-level vertical wind profiles and extreme fire behavior has been reasonably well established through past research. Forecasting these adverse wind profiles, first recognized only a few years ago, is currently receiving research emphasis. As a first step, variations in the vertical and horizontal speed of the upper wind with time are being studied. Data obtained from double-theodolite pilot balloon soundings indicate that the most rapid short-term changes are associated with the passage of cold fronts. Attempts at correlating these changes with other weather factors are also being made.

The accuracy of the single-theodolite pilot balloon system for measuring wind speed aloft is being checked against the more accurate double-theodolite system. The largest errors using a single-theodolite system were observed when the air was unstable. Studies are being made to learn whether or not the errors are large enough to rule out using the single-theodolite system. Attempts at correlating these differences with air mass stability and the synoptic situations are being made.

Eventually we hope to be able to predict favorable or adverse wind profiles in advance of their movement into an area. Until then, however, we can obtain some degree of warning by taking soundings in high hazard areas on days when fire danger is building up. Soundings are interpreted for fire control use by means of a key. Four trial winds-aloft monitoring stations, one at Macon, have been in operation for two or more years. Favorable results have been reported in most instances. Of the fires that burned ,000 acres or more in the past 2 years in the Southeast, only one exhibited true blowup characteristics and only on this fire was an adverse wind profile observed.

A fire weather forecasting office is located in the Fire Laboratory through cooperation of the Georgia Forestry Commission, the Georgia Forest Research Council, the U.S. Forest Service, and the U.S. Weather Bureau. This office is located in a forestry environment, permitting free access and easy discussion among the forecaster and foresters. The forecaster is in a position to provide detailed, localized forecasts directed toward the forester's problems. Forecasts have also been useful in planting and spraying work. Research is continuing to improve the quality of forecasts.

A study of the persistence of surface wind direction indicates that in most areas of the Southeast westerly winds are more persistent than the north winds generally preferred in the past for prescribed burning.

One of the most effective methods for studying the behavior of large fires has been the case study method combined with analytical work. Most of the large fires in the Southeast in recent years have been documented to some extent by Laboratory personnel. Increased instrumentation in fire documentation is being stressed. Time-lapse movies, air and ground photography, winds aloft soundings, and surface weather are regularly taken. Recent observations with weather-type radar have added to our knowledge of the height and size of active smoke columns.

Developing more extensive application of fire danger measurements is another important part of the Laboratory's work. Results of a recent study indicate that danger ratings are a useful guide for aircraft patrol in Georgia. If during the spring fire season patrol is flown on days when burning index is 5 or more, about two-thirds of the fires theoretically could be detected. This would necessitate flying about 60 percent of the total days in the roughly 5-month spring fire season.

Studies are being conducted to develop a drought index for both organic and inorganic soils. One tentative system for inorganic soils uses a bookkeeping procedure for keeping track of water in the soil. Withdrawals are made according to the mean air temperature; deposits according to the amount of precipitation. It appears that a somewhat similar system can be used to estimate depth to the water table in organic soils.

Fire Control

Although fire control agencies throughout the South have been successful in reducing the acreage of forest land consumed by wildfires during the past two decades, the fact remains that the number of wildfires has not been decreasing significantly. Since most fires in Georgia and adjacent States are man caused, and since the present population growth is expected to continue, the ever present threat of wildfires is not expected to subside rapidly.

Improved suppression techniques and equipment will be welcomed by all forest firefighting organizations. Great strides have been made recently in development of chemical fire retardants and in their delivery on the fire line by aerial tankers. Monoammonium and diammonium phosphate solutions, dropped from a TBM aerial tanker for the first time in Georgia in 1959, appear to be the most effective aerially delivered fire retardants for use on Coastal Plain vegetation. Work with ammonium phosphate solutions to improve their performance is continuing at the Laboratory. Increasing the viscosity of these solutions is showing promise of a more effective extinguishing or retarding action.

Calibration test drops have been made using Georgia's TBM and Florida's C-45 tankers to measure the extent of crown penetration and distribution of retardant materials. This information is proving invaluable in providing guidelines for the most efficient and safe use of these aerial tankers. Trials are continuing in a variety of fuel types using materials with different viscosities.

Exploratory studies are being conducted to discover other possible applications for fire retardant chemicals, such as protection for naval stores faces in an area that is to be prescribed burned.

)ccasionally, the Laboratory is called on to test and evaluate new ools or procedures in fire suppression. In 1961 a sandcasting nachine developed in Michigan as a cooperative project with the J.S. Forest Service was tested in some of Georgia's more hazard-us fuels to evaluate the use of sand as an extinguishing or re-arding agent. Although the machine exhibited certain limita-ions, the principle of sandcasting was judged sound and offers romise in the control of forest fires.

Fire Use: Prescribed Burning and Fire Effects

Although fire has been recognized as one of the first great orces employed by man, it has generally been considered an nemy of the forest. We know, however, that all use of fire in the voods is not bad. Properly prescribed, fire can accomplish planned enefits in the management of forest land. If we are to realize ne maximum potential of a fire prescription, we need to know nore about this dynamic force at our disposal.

A well-rounded research program in fire use includes:

1. Measuring the characteristics of free-burning prescribed fires.
2. Studying the direct effects of fires of known intensities.
3. Studying ways and means of firing to create desired intensities.
4. Evaluating the effect of weather, topography, and fuel on the behavior and intensity of prescribed fires.

5. Measuring and evaluating the indirect side effects that may occur.

A prescribed fire has a specific task to accomplish. In order to rate the capabilities of a fire under certain weather and fuel conditions, some measurements of its thermal characteristics must be taken. Measurements of these characteristics are being made by means of thermocouples and portable pyrometers (time-temperature relationship) and water baths (B.t.u. output) in the more important fuel types in the Southeast.

The effect of fire on plants is directly or indirectly a result of high temperatures. Knowledge of the lethal temperatures and the protective adaptations of plants could increase our ability to use fire as a silvicultural tool. Since bark is one of the more important protective adaptations, studies of its insulating properties are being carried on at the Laboratory. Thermal conductivity has been found to increase with density and moisture content; specific heat increases with temperature.

Knowing the time-temperature relationships of different fires in a variety of fuel types and weather conditions as well as the bark properties and configurations of prevalent plants, realistic evaluations of direct fire effects are possible. When these determinations are complete, field tests will be made to observe the cumulative effect of entire temperature pulses associated with free-burning fires.

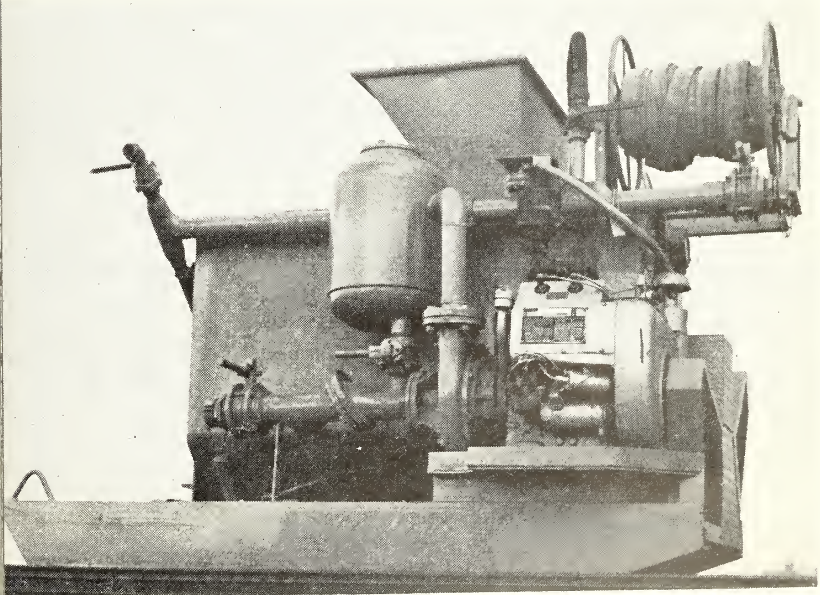
Periodic winter backfires have in the past generally been considered the best fires for rough reduction in the Coastal Plain. Preliminary investigations, however, have shown that other firing techniques and other burning periods may actually offer additional possibilities for the use of fire in forest management practices. Strip head fires, for example, have produced higher temperatures than backfires and may consequently be more effective in controlling undesirable species. Summer burns appear to do more lasting damage to this vegetation than winter burns. Fire-damaged plants have shown promise of marked reduction in rate of regrowth, as well as some mortality in heretofore difficult-to-kill understory species, after followup burns at a crucial stage in the regrowth process. Studies involving firing techniques, various burning times and intervals between repeat burns, and trials of a combination chemical-fire treatment are being continued in middle and south Georgia.

We are just beginning to understand some of the basic phenomena concerning the effect of topography, fuel conditions, and weather on fire behavior. Although hilly terrain presents some problems that are not common to the flat country, topography itself may be used to advantage in prescribed burning by minimizing the effect of some uncontrollable weather factors—wind being the most important. Variations in fuel arrangement, density, and moisture content are also important considerations in any burning effort. Through experiments in the laboratory and the field we are attempting to correlate these factors in a way that will enable us to make the fullest use of a fire prescription with maximum safety and minimum cost.

A NEW GROUND CHEMICAL TANKER-MIXER FOR FOREST FIRE FIGHTING

ARCADIA EQUIPMENT DEVELOPMENT CENTER,
U.S. Forest Service

Extensive use of fire fighting chemicals began with air tankers. Jevertheless, air tankers alone seldom extinguish forest fires. 'hey can only supplement a basic hand encounter on the fireline. 'oresters are now looking for practical means of applying chemi- als by ground tankers. Various State agencies and other fire rganizations in the western United States have pioneered in this eld by modifying existing tankers for mixing and pumping one r two firefighting chemicals, usually of the viscous water cate- ory. Very little work has been done on a basic unit capable of andling any chemical in present use. The Arcadia Equipment evelopment Center has designed and built a new tanker-mixer fig. 1) that mixes, pumps, and applies any chemical, in current se, in a few minutes without the use of any other equipment.



IGURE 1.—Tanker-mixer designed and built at the Arcadia Equipment Development Center.

Purpose and Use

The tanker-mixer is a multipurpose slip-on unit that was de- gned for use on the ground, on heavy-duty trailers, and on flat- ed trucks. In airport use it can mix up to 6,000 g.p.h. making it ideal for use as a small mixer or as a transfer unit at any airpor It can be transported by ground crews to a helispot and used e fectively as a mixer for helicopters. Basically, however, the tank er-mixer was designed for mixing and pumping firefightin chemicals on the fireline, for the pretreatment of roadside strips and to confine slash disposal fires. When mounted on a heavy-dut trailer the tanker-mixer can be tractor drawn into areas tha would be inaccessible to conventional fire trucks.

Description

The major assemblies of the tanker-mixer consist of a 300 gallon metal mixing tank, a chemical hopper, a hose reel, an en gine, a pump, and a pump priming tank. The mixing tank house a "side-entering" impeller assembly for mixing the chemical b agitation. Mounted on top of the mixing tank are the chemica hopper and the hose reel. The chemical hopper is large mouthe to facilitate pouring the chemical into the mixing tank. A knif edge is located at the mouth of the chemical hopper to cut th paper bag containing the chemical. Power is supplied to the uni by a 30-horsepower, air-cooled, 4-cylinder engine. The pump i centrifugal and is capable of producing 300 g.p.m. at 75 p.s.i for transfer or 100 g.p.m. at 100 p.s.i. for application. To insur priming, a pump priming tank has been added, which also allow drafting from points lower than the unit. This allows the unit t be supplied with water from streams or lakes as well as from fir trucks, tanks, and mother tankers.

The impeller assembly (fig. 2) consists of a 1 3/16-inch meta shaft which is supported in a 3-inch galvanized pipe. An easil replaceable impeller blade is fitted onto the shaft and is surround ed by a metal shroud which improves shearing action. The im

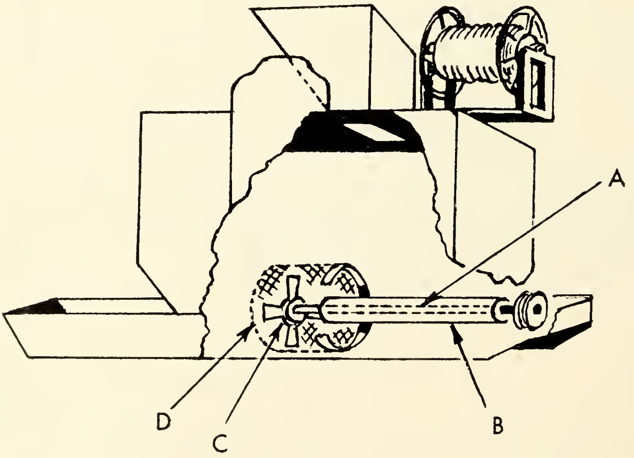


FIGURE 2.—Cutaway view of impeller assembly (*A*, 1 3/16-inch metal shaft; *B*, 3-inch galvanized pipe; *C*, impeller blade; *D*, metal shroud).

peller turns at 1,500 r.p.m. and absorbs about 10 horsepower when the engine is running at full throttle.

Overall dimensions and weight of the tanker-mixer are as follows:

Height	85 inches	Weight:	
Depth	58 inches	Empty	2,700 pounds
Width	96 inches	Full	5,200 pounds

How to Use the Tanker-Mixer

Operation of the tanker-mixer is comparatively simple. After the mixing tank has been filled with water, the engine is operated at full throttle. The chemical to be used is added while the water is being agitated. The contents of the mixing tank are recirculated to avoid overheating the pump and seals, supplement the work of the mixing impeller, and to speedup the mix.

Generally, development personnel found that they could mix algin-DAP, algin-gel, borate, CMC-DAP, and attapulgite-ammonium sulfate in 2 to 4 minutes. Bentonite took 4 to 8 minutes. Algin and CMC thickened water, DAP solutions, and pectate DAP could be mixed in less than 2 minutes.

The type of impeller blade used is dependent upon the mixing characteristics of the chemical. Where dispersion is a problem, and "dough balls" are apt to form, a screw-type impeller blade is best. In tests performed at the Arcadia Equipment Development Center, this type impeller blade has satisfactorily handled borate, bentonite, algin, MAP, and DAP. Other chemicals which disperse easily will require a very high shear action to reach full viscosity. A toothed blade, with alternate teeth bent out at right angles, will produce the necessary shear. It was found that attapulgite ammonium sulfate is best handled with this type impeller blade.

The cost of building a tanker-mixer is roughly $3,000, west coast prices. Prices may vary according to locale. Construction plans for building the unit may be obtained from:

U. S. Department of Agriculture, Forest Service
Arcadia Equipment Development Center
701 N. Santa Anita Avenue
Arcadia, Calif.

☆ ☆ ☆

Emergency Relay Tank

The modern lightweight aluminum canoe or car-top boat may also serve as a ready-made relay tank for use on fires in emergencies. Because of increasing recreation demand, lightweight canoes or boats are available almost everywhere. This is especially true on the Superior National Forest in northeastern Minnesota where a firefighting crew may load a canoe on a seaplane, fly to a lake, unload, pack a fire pump into the canoe, paddle from the lake up a stream, and hike from the stream to the fire. It is sometimes convenient or necessary to portage the canoe through the brush to the fire and use it as a relay tank. This temporary or emergency tank has one advantage over the conventional tank. It needs no set-up time and no ropes, stakes, or straps in handling.—LACY JOHNSON, *Forester, Superior National Forest.*

A FIRE-WHIRLWIND IN ALABAMA

GORDON POWELL
Management Forester, Alabama Division of Forestry

On the afternoon of February 7, 1962, Forest Ranger Georg Nunnelee and I were making routine equipment inspections i Covington County, Ala. At approximately 2:30 p.m., while o higher elevations in the north end of the county, I commente to Mr. Nunnelee that a tall smoke in the south end of the count had the appearance of a potential "blowup fire." "Blowup" seeme highly improbable because of the condition of vegetation follow ing a 1/10-inch rain two nights before. My comment was based o the appearance of the smoke which to me indicated adverse win patterns over a control fire approximately 21 miles due sout of us.

The column of white smoke (B in fig. 1) formed an angle o approximately 75 degrees from the ground, rising toward th southwest. At approximately 5,000 feet it bent to rise straigh up to approximately 9,000 feet. At that altitude the smoke colum reached a stratum of haze and scattered flattened clouds. Like th smoke columns (A and C in fig. 1) from other control fires i this vicinity, this column ascended to the stratum and flattene out in all directions. Smoke from the different columns then drift ed in the haze layer toward the southeast. Nevertheless, Colum B was different from the other visible columns in that it was th only one that bent upwards and had a "mushroom" of vapor be ginning to form immediately over the smoke column that pene trated the stratum "barrier."

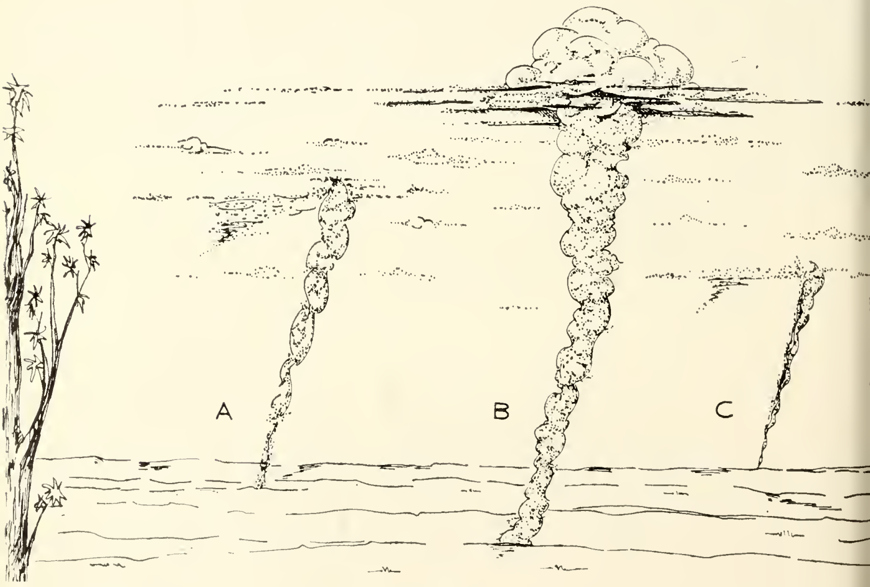


FIGURE 1.—Smoke columns over control fires as seen from a distance of 2 miles to the north. Column B is the smoke with which we came in direc contact. Columns A & C are from fires several miles from B.

As we neared the control fire the billowing smoke indicated that it was very hot. Approximately 2 hours elapsed between the time we first noticed the smoke until we arrived in the vicinity. The fire had been set along a north-south road to back eastward into the wind through some heavy logging slash and grassy vegetation. An east-west road was the boundary on the north; firelines were maintained on the east and south. The fire had burned about 500 yards from the north-south road.

At approximately 4:50 p.m. we passed by about one mile north of the fire and observed that the eastern part of the burn was the hottest. Driving southwest to approximately one-half mile west of the fire we noticed something unusual about the western part in that there was a smooth appearing ribbon of smoke, steady and lighter in color than the surrounding smoke. This "ribbon" of smoke ran from the ground to the "vapor cloud" over the smoke column. We felt that better judgment would tell us that this was a light refraction from the sun, yet it closely resembled a tornado funnel as it stood motionless amid the boiling smoke around it (fig. 2). Feeling as foolish as boys trying to find the end of the rainbow, we drove toward the ribbon of smoke.

The "hot part" of the smoke column was rising from the burning fuel with the wind to a point over the edge of the old burn and at that point rising straight up to the vapor mushroom and flattening out under the vapor in a very flat layer. Starting at the vapor mushroom there was a funnel of whirling smoke, small in diameter, reaching downward through the column of smoke, but not bending quite so abruptly as the other smoke, so that the base of the funnel was outside the fire and *in the old burn* near the east-west road on the north edge of the burn. It was there that we found it.

From any distance the funnel was whiter than the other smoke, but close observation revealed particles of burned litter whirling vigorously in the funnel. Some of these particles were released at higher elevations so that many burned particles were floating down from the smoke and settling over a wide area. The funnel was only about 6 to 10 feet in diameter and appeared to be *the same diameter at the top as at the base.* The smoke in the old burn slowly drifted counter-clockwise around the funnel which was also whirling counter-clockwise.

A close look at the funnel showed that it was not stationary as it first appeared, because the base wandered slowly around in an area about 50 feet in diameter inside the old burn. As the funnel wandered slowly around, we followed closely on foot, studying its actions.

While the base moved through the burn, it "sucked up" all the ash in the center 15–20 inches, exposing mineral soil. (However, it left no mineral soil exposed in the path because more ash was blown into it as the funnel moved off). As this center 15–20 inches passed over a smoking limb or log, it caused a sudden vigorous spewing of flame in 4 directions, with each arm of flame resembling that from a blowtorch, and the 4 arms forming a cross quartering a circle by right angles of flames.

FIGURE 2.—Appearance of funnel as seen from the west.

I stepped into the funnel and it proved to be quite intensive in
ind velocity. In fact, it filled my clothes with particles of ash
nd made my ears "pop."

At about 5:20 p.m. there was a sudden rush of cool wind from
he south, then from the northeast, and then from the west; and
he funnel was gone. Then a steady, gentle breeze caused the
moke in the old burn to drift northward at first and then to drift
ack into the column of billowing smoke still rising as before
rom the burning tops of slash.

About 30 minutes elapsed between the time we first saw the
hirlwind and the time that it disappeared. The map in figure 3
hows the general path of the funnel base and its position with
espect to fire.

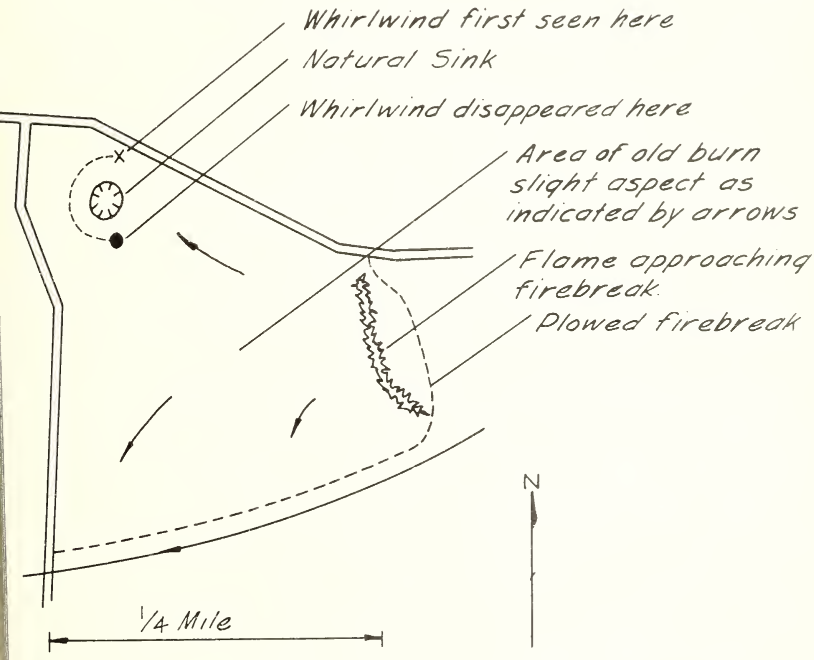


FIGURE 3.—Map of fire area.

While watching this whirlwind, I realized it was not the usual
"iredevil" or "dustdevil" type often seen in or near forest fires;
evertheless, I had no idea that others had seen and reported sim-
ilar whirlwinds. However, having read other accounts,[1] this
whirlwind seems different in that acreage of the associated fire
was small, the terrain is relatively flat, and the base of the funnel

[1] Graham, Howard E. A fire-whirlwind of tornadic violence. Fire Control
Notes 13(2) : 22-24, illus. 1952.

. . . .Fire-whirlwind formation as favored by topography and upper winds.
Fire Control Notes 18(1) : 20-24, illus. 1957.

was in a cool part of the old burn. Passage over "hot spots seemed purely accidental. It also appeared to be of a different typ from the small firewhirls produced on a model scale.[2]

Worth mentioning is that had this whirlwind wandered into th flame it probably would have drawn up flame and burning par ticles rather than burned particles. Also, it might have increase considerably in violence.

Explaining its triggering and cause would be strictly a gues with me. Perhaps the intense heat of burning logging slash, pe haps the adverse wind patterns, or perhaps the cumulus clou cap might be the key.

The weather, too, seems worthy of mention in association wit the occurrence of the fire-whirlwind. According to informatio gathered from a nearby fire danger rating station and informa tion furnished by the Southern Forest Fire Laboratory, there ar several interesting area weather features.

At ground level the relative humidity was 22 percent, and th wind was from the east and northeast at 4 m.p.h. At 5,000 fee the relative humidity was 55 percent, and the wind was variabl up to 10 m.p.h. At 10,000 feet the relative humidity was 70 per cent, and the wind was from the northwest at 28 m.p.h. For wha it may be worth, weather maps show that on the morning befor the fire, there was a 100 m.p.h. jet stream over the area at 35,00 feet.

On the 8-100 meter type fire danger rating station at nearb Lawrence Tower site, the buildup index was recorded as 3 the highest fuel moisture percent was 6.5, and the burning inde was 12 in Fire Class 3.

Fire-whirlwinds have frequently been observed in all parts c the country where fires occur, and appear to have important e fects on forest fires. It is likely that these funnels have often bee observed but not reported in Alabama; or perhaps we are to busy fighting fire to see the whirls that are present. There i hardly enough information available to fully substantiate th theories of the cause of fire whirlwinds, yet such knowledge migh answer many questions concerning unusual fire behavior that un expectedly becomes peculiarly hazardous to men and equipmen I join other observers in hoping that more detailed observatior will be reported.

---

[2] Byram, George M., and Martin, Robert E. Fire-whirlwinds in the labora tory. Fire Control Notes 23(1): 13-17, illus. 1962.

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.

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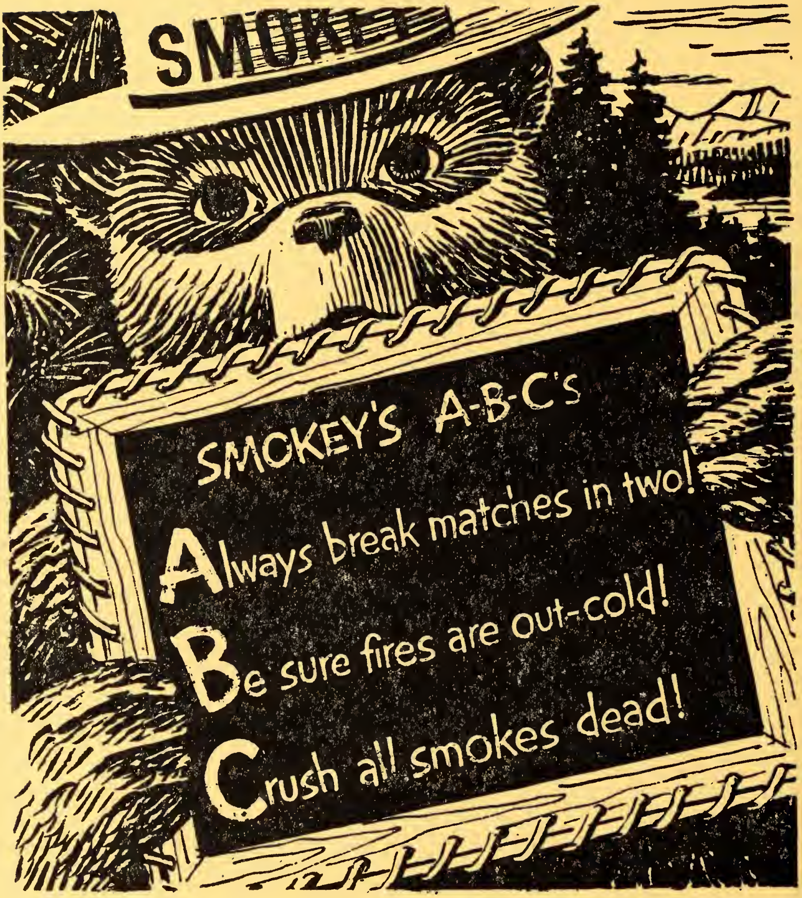

Please! Only you can prevent forest fires

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IRE CONTROL NOTES

PERIODICAL DEVOTED TO THE TECHNIQUE OF
REST FIRE CONTROL

VOL. 24 NO. 2
April 1963

rest Service
ITED STATES 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 24 Number 2

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, firefighting, 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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Forest Service, Washington, D. C.

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CONTENTS

THE FIRE CONTROL SIMULATOR

NOLAN C. O'NEAL AND BERT E. HOLTBY
Foresters, Division of Fire Control, Washington Office

Simulation is a watchword in Space Age training. A simulator attempts to represent a real situation in which operations are carried out.

The Forest Service has long been interested in a simulator program that would provide realism in command and staff decision training for campaign fire management. For many years campaign fire exercises have been run using maps, blackboards, and sometimes topographic models. These aids to the training exercise did not provide sufficient dynamics, realism, time pressure, and active trainee participation.

During 1961, the Division of Fire Control explored the possibility of development of a relatively inexpensive simulator that could be used with exercises to train fire bosses and staff, and also initial attack crews.

To be fully effective, the fire simulator needed to provide realistic simulation of:

1. A moving fire perimeter with the flames clearly visible.
2. Burned-over area showing in grey black.
3. Smoke in accordance with wind direction.
4. Movement of fire edge in accordance with wind, topography, fuel type, and effectiveness of command decisions.
5. Aerial and oblique view of fire area.
6. Tankers, tractors, manpower, and other firefighting forces shown by symbols.

Early in 1962 a contract was awarded to the International Electric Corporation, Paramus, N. J., to design a simulator and a command and staff decision-making exercise. The simulator was completed in November 1962, and the first exercise run was made in December 1962.

Simulator

TRAINING ENCLOSURE

The simulator enclosure is a portable, free-form, bell-shaped configuration, 30 feet wide and 24 feet long. There is a light-trapped entrance at the rear of each sidewall. The enclosure is constructed of rigid, lightweight, 4- by 8-foot panels, modularly designed so that assembly, disassembly, and packing may be accomplished quickly and easily. The roof is constructed of lightweight fabric.

The enclosure is divided into two sections: the Trainee Area and the Control Area (a compartment within the enclosure). The Trainee Area consists of four worktables: two side-by-side to the front and two to the rear of the enclosure. (See figure 1). The two forward tables are used for seating up to four trainees each. The two rear tables will normally seat four observers each. However,

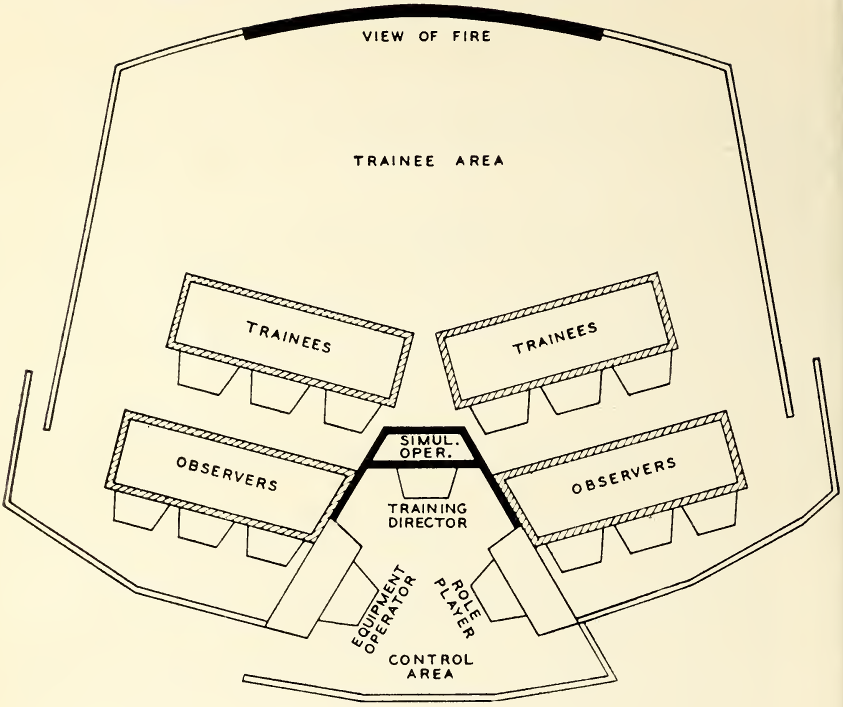

FIGURE 1.—Fire control simulator.

they may be used as trainee positions if a particular exercise requires such additional capability. This seating allows maximum flexibility to train groups of different sizes, or groups with differing operational responsibilities.

The Control Area is situated on the centerline, to the rear of the enclosure, and is wedge shaped. (See figure 1.) At the front of the control area is the Training Director's position. Above this position is the projection booth and the position for the Simulation Operator. To the rear of the Control Area is the Role-player position and the Equipment Operator position, with the audio control console and tape decks.

PROJECTION SYSTEM

The projection booth, at the front of the control area, is elevated 6 feet above floor height and houses three mirror-bounce projectors powered by standard 110-120 volts, 60-cycle. The projection screen consists of a portable snap-together frame and a curved 8- by 12-foot screen. (See figure 2.)

The capability of this equipment includes display of the wildland scene and dynamic reproduction of the flame and smoke. In addition there are two small gimbal-mounted symbol projectors for display of such symbols as air tankers, tractors, vehicles, etc. A standard 35-mm. slide projector is used for briefing (showing fuel types) and debriefing purposes.

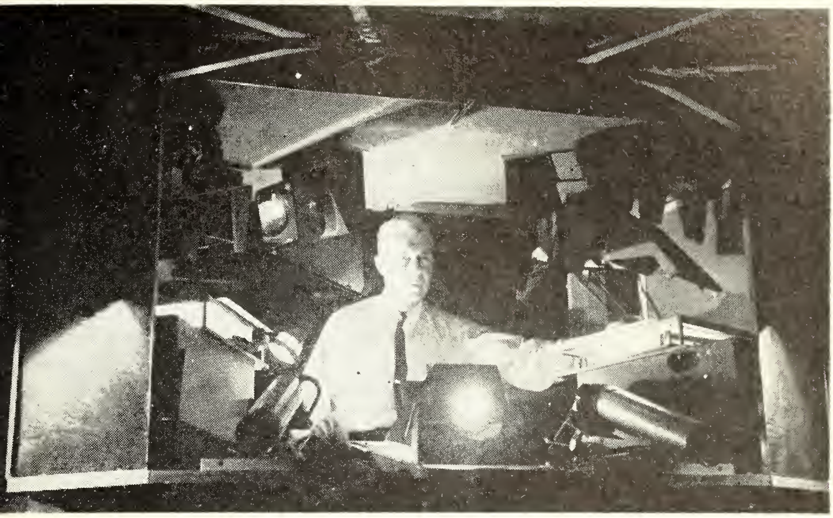

FIGURE 2.—Projection system.

COMMUNICATIONS EQUIPMENT DEVICES

The communication console, located in the Control Area, is used for control and switching of communications and tape recording. Communications methods simulated are

1. Intercom (public address—speakers)
2. Telephone
3. Ground-air radio
4. Ground-ground radio.

In addition, two audio tape recorders are available. One may be used for injecting a variety of sound effects or other desired variables into the exercise. The other tape recorder is used during the exercise as an events-recorder to ensure a complete performance record for the debriefing period.

Located on each trainee worktable and at the Role-player's position is a communication unit consisting of 8-button phone and two push-to-talk radio handsets. The base of each communication unit has four standard phone jacks, mounted on the front plate, two on each side. Each pair has jacks marked "G/A" (ground to air) and "G/G" (ground to ground). The phone is coded to permit communications with all other trainees and the Role-player. In addition, the Training Director may monitor all calls on these lines.

TRAILER

All of the equipment is designed to fit into a standard tandem wheel trailer that can be pulled by a 1½-ton truck. Dimensions of the trailer are 14 by 6 feet; weight capacity is 3,000 lbs.

Exercise

The exercise was designed to provide fire control personnel practice in:

1. Evaluating the fire
2. Ordering resources
3. Planning an attack strategy
4. Assigning resources
5. Making decisions as the fire situation changes
6. Dealing with emergency control problems
7. Monitoring and evaluating decisions.

The following is a briefing for a typical exercise:

> "The fire is located on the Brush River District of the Green Forest, Region 12. This Forest has central dispatching; all crews and equipment are dispatched through the central dispatcher. You are a Class II fire boss dispatched from an adjacent District. Your orders are to go to the fire and take charge.
>
> "A radio-equipped tanker with a 5-man crew has already been dispatched and should be at the staging area when you arrive. You reach a vantage point in about 30 minutes from the time the fire was reported, which was at 10 a.m., July 1. This vantage point is located near the fire. You have radio communication in your pickup. Telephone lines are nearby, intact and available. All firefighting resources will arrive and check with you via radio at a staging area located on the road below your vantage point."

The Simulator Operator then projects the fire on the viewing area. The fire boss appraises the fire, decides on strategy (fig. 3), and begins his control action which includes ordering resources and assigning crews. He places his calls to the dispatcher, tanker crew foreman, and others in a realistic manner using the radio communications available to him. If he fails to order sufficient men and equipment needed for suppressing the fire, it continues to burn and increase in size. If his actions would reasonably be expected to result in an effective control line, he sees this effect as the fire stops and dies out in the area being effectively controlled.

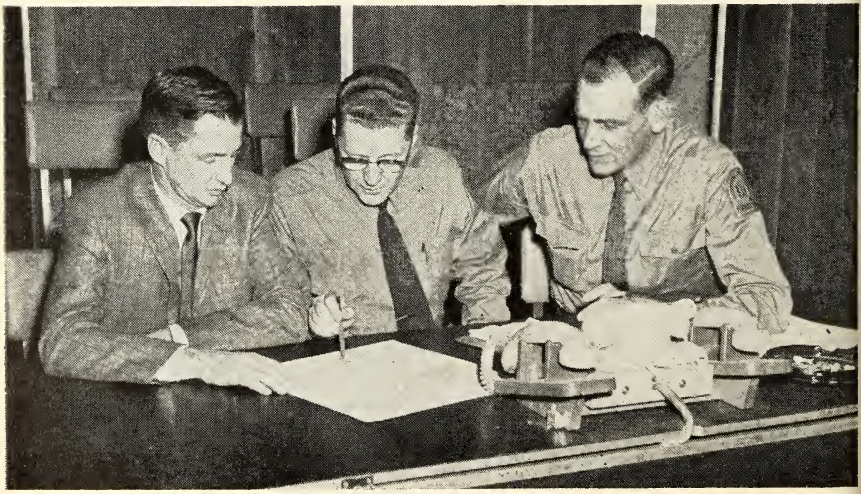

FIGURE 3.—Trainees evaluating a fire.

From time to time the Training Director ensures that realistic messages are transmitted to the fire boss through the Role-player. Some typical messages that might be sent in the early stages of the fire are as follows:

Role	*Message*
Dispatcher:	This is the Dispatcher. The Supervisor wants to know how much fire you got. Will you need a 'copter?
Dispatcher:	Just had a call from the Brushy Creek newspaper. They have sent their photographer and a reporter out to get pictures and a story. They'll arrive at the fire in about 20 minutes. How do you want to handle this?
Dispatcher:	The State Division of Forestry called and wants to know if you need any more tankers. They can have six tankers at the staging area in 1 hour. What name have you given this fire?
Dispatcher:	We've just had a weather report for the fire area. Temperature 85°, humidity 18%, and winds about 2 miles from the South. We've asked for a special forecast. Should be ready in about an hour.
Tanker Foreman:	We had a flareup here in a heavy patch of fuel. Our nozzle man was burned. He needs to be taken off the line. What should I do?

Examples of additional stress situations that might be used by the Role-player as needed are:

"Another fire has started 3 miles down the road, so we won't be able to get you any more manpower or equipment today. In addition, the Supervisor wants you to release three tankers and send them to the new fire."

"The Supervisor is on his way to see you. He thinks you should have more tankers protecting the houses at Panorama Heights."

"The sector boss wants to backfire as soon as possible from the upper road."

"The local TV station wants an interview with you and a short tape recording for showing tonight."

"A traffic jam is blocking the main access road to the fire and threatening delays in equipment delivery."

"A power company official is on the phone asking information on possible danger to powerlines that run to the homes in the fire area. He wants to know whether you feel the powerlines may have to be deenergized."

As he "fights the fire," the trainee has access to those aids he would normally have available to him in a fireline notebook. This includes fuel type descriptions, graphs and charts on rate of construction of fireline by fuel types, and charts on resistance to control. In addition the trainee is given a topographic map of the area, weather forecast, and a tabular log for cost control.

The instruction team keeps a number of forms, including the Training Director's exercise evaluation form and a resource order log. After the fire is suppressed and the fire organization demobilized, a debriefing (fire analysis) is held. Debriefing is essential. It is important psychologically that the trainees receive feedback from the results of their performance. The simulator, with its capability to display fire spread and burned area, provides the trainees with immediate feedback from some of the consequences of their decision-making. However, an approach must be followed that will allow the trainees to review all aspects of the fire management, including plans, service, and finance activities.

Debriefing is as follows:

1. This session takes place immediately after the end of the exercise. It is conducted in the training enclosure with the trainee tables rearranged. The group is seated in a manner that will encourage communication, e.g., circle, semicircle, or conference table, as opposed to a conventional classroom seating.
2. The Training Director starts the debriefing session, using his exercise evaluation form as a guide. His main objectives are to ensure adequate feedback of results and documentation of exercise events.
3. The trainees appoint a debriefing leader and recorder from among the trainees. The debriefing leader guides the discussion to
   - (a) Ensure total group participation
   - (b) Identify problem areas
   - (c) Give constructive direction to the discussion
   - (d) Seek resolution of problems
   - (e) Make recommendations for use in future training exercises and, more significantly, actual firefighting operations.
4. Each trainee has maintained a decision log of the exercise during the time that he was not serving as the active fire boss. During the debriefing period these logs should be used as a means of reviewing dissenting opinions of actions taken by the active fire boss and also in examining alternative courses of action.
5. Team members and the debriefing leader may evaluate any new procedures tried during the training session and decide whether to continue, discontinue, or modify these procedures.
6. Team members and leader may elect to relate a problem being discussed to other problems and discuss similarities and applications of techniques and methods.

The agenda of a proposed 3-day training exercise calls for a morning session of orientation of the trainees in the simulator operation. The afternoon session is devoted to a series of warmup problems for the trainees. The second and third day is devoted to the actual simulator exercise, preceded by a short pre-exercise briefing of ground rules. The third day's activity ends with a debriefing session.

Summary

The main advantages of the fire control simulator and exercise for command and staff decision-making training for campaign fire management are

1. Maximum individual participation
2. Stress and time pressure on decision-making
3. Easy transfer from exercise experience to job experience
4. Emphasis on teamwork
5. Rapid feedback of results of decisions.

The "heart" of the simulator is a projection system which displays an oblique aerial view of a typical wildland area and a fire starting and spreading across this area. The spread and intensity can be controlled to closely approximate the combined effects of topography, forest fuels, and weather.

The Simulation Operator starts the "fire" and simulates fire perimeter, burned-over area, and smoke.

Through projected symbols such as aircraft, tractors, and fire crews, the sequence of firefighting actions can be simulated.

Information on weather conditions, availability of men and equipment, and other key facts are fed to trainees over intercommunications and public address systems which closely simulate the environment of a fire headquarters. The trainee's commands and requests for information are responded to by fellow trainees, who are members of his firefighting team, or by a role-player instructor.

Two dual-track tape recorders provide sound effects and also permit recording of important aspects of the exercise and the responses of the trainees.

The Training Director gives pre-exercise briefings, directs the start of the exercise, modifies inputs to trainees, and determines success or failure of control action taken by the fire boss.

The Simulation Operator provides the fire, smoke, burnout, and symbols. The Equipment Operator handles the audio and recording equipment to simulate ground-to-ground, ground-to-air, and telephone channels. The fourth member of the instruction team, the Role-player, takes the part of dispatcher, cooperative agency head, Forest Supervisor, and other personnel.

We have found that an adequately simulated fire with provision for immediate feedback of information on the results of performance has significant impact on the trainees. It's a rare person who can shrug off failure when he's practicing his own skill. Although it causes him some pain, he becomes increasingly aware of the need for information about the consequences of his decisions and actions, and he begins to evaluate these consequences critically. Each member of the team rediscovers his ability to think and solve problems.

LIGHT AIR TANKER USE IN NORTH CAROLINA

ARTHUR A. BELT
Chief Pilot, North Carolina Division of Forestry

With the start of the 1963 fire season the North Carolina Division of Forestry began its sixth year of using air tankers in fire control. Early in 1958 following TBM demonstrations by the U.S. Forest Service and the able assistance of Georgia and U.S. Forest Service TBM's on several going fires, the Division leased a biplane to conduct a series of fire and chemical tests. Results of the tests indicated that 200 gallons could be an effective drop on average coastal fuels. It was recognized from the beginning that both large and small tankers have a place in the complete aerial delivery operation. But primarily because of strip availability and cost consideration, both of which will be explained below, a decision was made to begin with small tankers using mobile base facilities. Subsequently, two surplus N3N's with this capacity were acquired and fitted for training and operational use.

The first year of N3N activity was largely one of training personnel and refining equipment. Lightplane patrol pilots were checked out in the tankers and in lead plane flying. A number of air knowledgeable fire control officers qualified as air attack bosses. All ground personnel received training in loading and servicing the light tankers. On the premise that the tankers were to be working for and directly with them, the ground woods crews were taught how to control and to fully utilize close air support. Seven aerial delivery training sessions were held over the coastal region. Since the inception of aerial delivery, this subject has been stressed at all annual training sessions and will be a continuous training requirement.

Among operational procedures tried and adopted was a standard drop description for radio communication of drop requests. The drop request, as originated by the crew, sector, line, or air attack boss, consists of four basic elements, each stated in one word or phrase of standard terminology:

1. *The type of drop.*—This is covered by the word DIRECT (on the fire) or INDIRECT (ahead of the fire).
2. *The tactical purpose of the drop.*—The terms HEAD, FLANK, SUPPORT, REINFORCEMENT, BREAKOVER, SPOT, SNAG, GROUND FIRE, LINE CONSTRUCTION AND SAFETY (ground crew protection) Drops have each been given a definition. This tells the pilot what the drop is expected to do; and because of the way certain tactical purposes are defined, this phrase also helps to convey the desired target location.
3. *The content of the drop.*—RETARDANT, WATER, WET WATER, DYE, or combinations of these are specified according to the needs of the particular attack.
4. *The target designation.*—This element of the drop re-

quest describes the location of the drop as briefly as possible. Head or Flank locations are localized by using compass point description, i.e., SOUTHEAST FLANK, NORTH HEAD. If the target requires repeated attacks, it may be "designated" by assigning it a code name based on the phonetic alphabet. Advance designating of targets on fire status maps is a timesaver when future targets are known during planning or briefing sessions.

When multiple tank aircraft or several tankers are being used, a fifth element is used. This specifies the number of drops requested on the designated target and, in the case of multiple tank aircraft, the method of dumping, i.e., Single, Trail, Salvo, etc.

A sample call would go out as: "Air Attack to Tanker 5; Drop Call; DIRECT, SUPPORT DROP, RETARDANT, SOUTH FLANK, DESIGNATE TARGET ECHO, THREE DROPS." In practice, several advantages of the drop request sequence are apparent. It serves as a checklist to preclude important elements of the request from being left out of the call. It helps all involved in the drop—on the ground and in the air—to "picture" the type of drop that is to be made. It reduces radio traffic by use of concise language and by providing a "thinking guide" for personnel taking an active part in the drop operation. It is extremely helpful in defining target areas.

A wallet-size card describing the call system was printed and distributed to all fire control personnel for ready reference. The reverse side of the card lists safety precautions for ground crews endangered by low drops.

A Condition-of-Readiness standby plan was also devised to allow tanker crews to adjust their working schedules to current fire danger. Four states of alertness were recognized, varying from a normal "one day's notice" condition to the "5-minute—on standby" situation. Each district uses daily burning index and buildup index information plus local factors as guidelines in computing their fire danger in terms of air delivery needs. Central dispatching is kept informed of any change in district Condition-of-Readiness status.

In order to utilize the flexibility of the small tanker fleet, a concept of remote area landing strips, mobile mixing and support equipment, and universal training in the ground support function is required.

This also calls for a close tie-in with the changing fire danger picture. The air tanker ground service units consist of tractor-trailer tankers and mixing tank and aviation gasoline trailers. One of the tractor-trailer tankers has a capacity of 4,000 gallons; the other three carry 2,000 gallons each. One of the open type 1,000-gallon mixing tank trailers is fitted with an engine-driven agitator in addition to the standard recirculating and loading pump.

An inventory of retardant chemical is packed on pallets with forklift trucks available for easy handling and distributed about the region. Monammonium phosphate, with a corrosion inhibitor added, is being used currently, but recent tests indicate probable

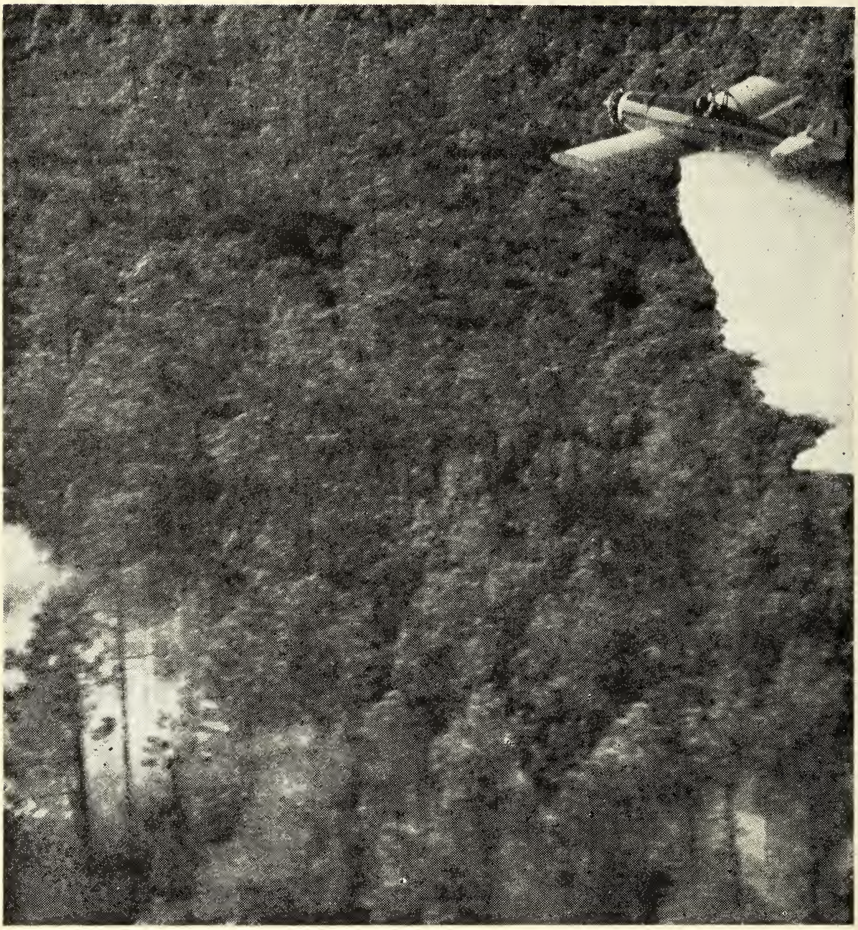

FIGURE 1

change in the near future to one of the higher viscosity mixtures now under development.

The original airstrip check of the region revealed that, of 52 landing areas with runways 2,000 feet or more in length, only 12 were hard surfaced and suitable for air tankers of medium and above-medium capacities. An airstrip development program was begun to encourage construction and proper maintenance of strategic landing strips in the area.

In the past 4 years five additional small tanker strips have been constructed by cooperators with technical assistance from the Division. Facilities such as ponds, permanent pumping equipment, and storage buildings were added as required.

Every year pre-fire season surveys are made of usable strips, and information obtained is used in updating charts in dispatching headquarters.

As operational experience was acquired, many refinements were made in aircraft and ground support equipment. Tanks were modified on the N3N for better visibility and lower drag. Drop gates were changed for cleaner, more positive drops. Wing area was increased for greater lift, and tailwheel locking devices installed for better control on rollout. Mixing tank bottoms were vee'd for improved agitation. One stationary mixing tank was elevated for gravity-feed loading in the event of personnel shortage at the central base. Pumping equipment underwent constant development and alteration as improvements for faster loading and increased dependability were suggested.

Early in 1962, after a survey of current production aircraft, one of the N3N's was replaced with a 450-hp. low-wing tanker of 300-gallon capacity (fig. 1). This late-model air tanker has proved well suited to Division coastal suppression requirements. Initial cost is in line with the cost of a new tractor-plow unit. In its retardant capacity, short field capabilities, simplicity of operation, and maintenance demands it is a practical air tanker for day-to-day grassroots fire suppression work. Its slow drop speed (75 to 90 m.p.h.), excellent visibility, control simplicity, and cockpit structural design are important safety features.

Present Division plans call for two more of this type aircraft in tanker operations in 1963. Through cooperation between Division and manufacturer, these aircraft will have many improvements beneficial to aerial tanker service, including additional load capacity and a larger engine. Specialized aircraft design is recognized as the prime need in development of the forest fire air tanker program.

FIRE CONTROL HELIPORT

Melvin B. Henle
Assistant Fire Control Officer, Yakima Indian Reservation, Bureau of Indian Affairs

On the Yakima Indian Reservation helicopters were used for the first time as a suppression tool during the 1961 fire season. The reservation is located in south-central Washington where the average yearly rainfall varies from 8 inches in the grass-brush areas to 40 inches in the higher fir forests. With the forested areas containing some 8½ billion board feet of ponderosa pine and Douglas-fir, and subjected to severe lightning storms, a method of quick initial attack and followup was needed.

The nature of the 1961 season afforded excellent opportunity to test the helicopters in all phases of fire control work, such as reconnaissance, shuttling, rescue, and supply. The favorable results of these initial trials indicated that helicopter use was practical, and a heliport was planned and constructed on Signal Peak. "The Peak," which has an elevation of 5,111 feet, is located in the approximate center of the reservation's timbered area, is served by a good road, and overlooks the area where 75 percent of the timber fires occur.

The heliport was constructed according to F.A.A. specifications, with work having been started in late summer of 1961 and completed in midsummer of 1962. All work was done by summer fire control aids stationed at the Signal Peak Ranger Station.

The heliport is located on the south edge of the summit of Signal Peak and offers a 220° takeoff and approach pattern. Winds are generally from the west, with occasional winds from the east; both of these approaches are unobstructed. The Signal Peak

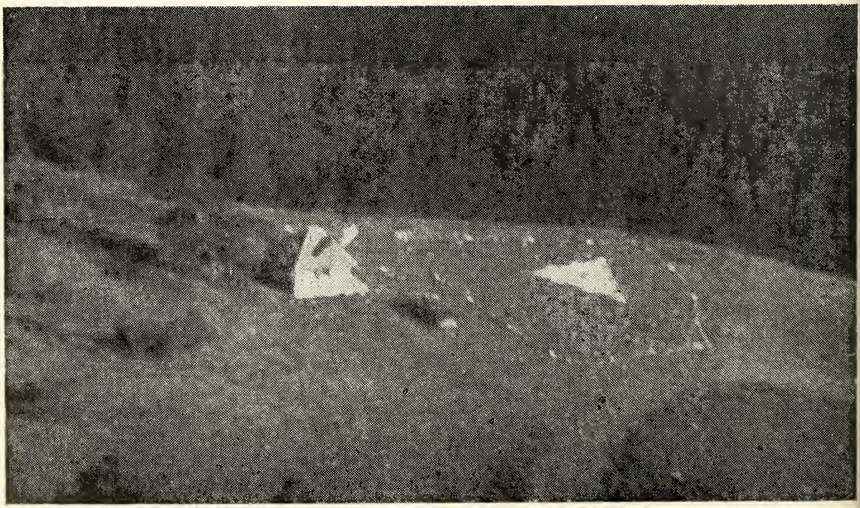

Figure 1.—Heliport (from northwest), showing approach patterns.

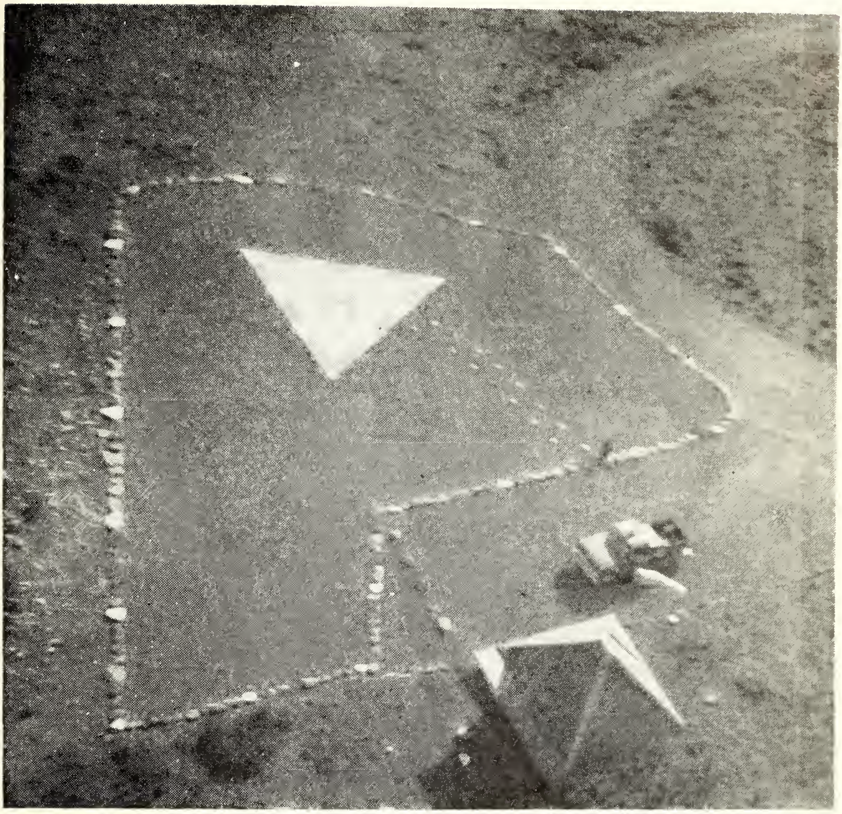

FIGURE 2.—Heliport (from overhead looking south), showing storage shed, parking area, and layout detail.

lookout, lookout cabin, and heliport storage shed, as well as a few trees, block the north approach.

The concrete pad is surrounded by a border of large flat rocks with every 10th rock being painted white, and the area between the pad and border filled with 5/8-inch minus washed gravel to eliminate dust. A graveled parking area large enough to accomodate six or seven pickups or cars, a large storage shed, and a standard wind sock are adjacent to the outside border.

The storage shed, which contains tools packaged for helicopter transport, extra gasoline and oil, and other miscellaneous supplies necessary for helicopter operation, is painted a light gray with the roof international orange. Fire protection is provided with two 25-lb. CO_2 extinguishers.

CABINET FOR LOOKOUT TOWER CAB

GEORGE F. ALVERSON, *Fire Control Technician; and*
A. H. BROADHEAD, *Forester, South Carolina National Forests*

The 79- by 79-inch cab on the Whitmire Lookout Tower imposes a limitation on the size of any cabinet to be used within. Yet, such a cabinet has been designed as a stand for the firefinder, for radio and telephone installation, and for storage of miscellaneous supplies. Because the peak of the fire season is during the colder months, an electric heater was included and housed in the lower compartment of the cabinet.

The cabinet is 23 inches square, 3¾ feet high, and constructed of ¾-inch birch veneer plywood. The writing shelf is 21½ inches square and made of ¾-inch plywood. The drawer below the shelf may be used for a dispatching map or other purposes. The radio compartment has hinged doors on opposite sides to provide ventilation during operation of the radio.

The cabinet is placed slightly off center in the direction of the tower orientation stake with 22 inches between wall and cabinet on that corner. The remaining space on the opposite side is enough for easy operation and use of the writing shelf, firefinder, map, and radio, and for clearance of the trapdoor. The telephone is mounted on the side of the cabinet nearest the trapdoor. Also mounted on this side of the cabinet is the anemometer buzzer and switch controlling it, so that windspeed can be measured direct from the cab (fig. 1). The Osborne firefinder ordinarily has overall dimensions of 24 by 27 inches. To conserve space the tracks were cut down in a metal lathe from 27 to 24 inches. This reduction in size did not hinder the lateral displacement needed for clear observation around the cab corners.

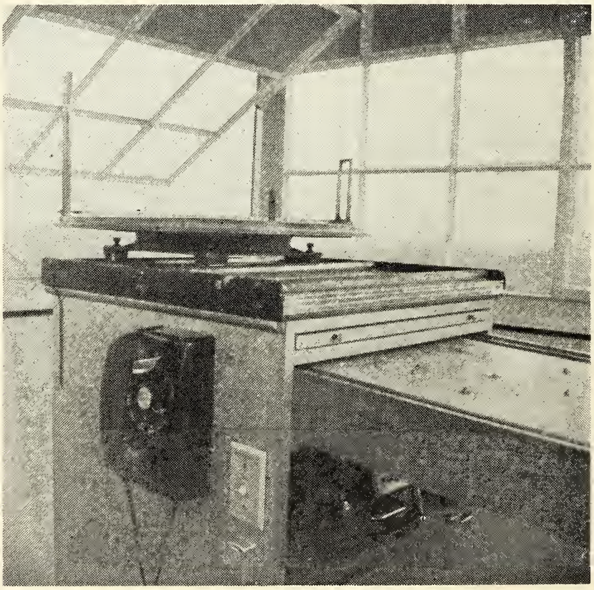

FIGURE 1.—Cabinet, with dispatcher's map drawer extended above radio compartment.

SKID-PAN CARGO CARRIER FOR CRAWLER TRACTORS

MISSOULA EQUIPMENT DEVELOPMENT CENTER
U.S. Forest Service

For several years various makeshift skid-pan cargo carriers have been used with tractors on large fires. Before skid pans came into use supplies and firefighting equipment were often lashed to the tractors for transport to and around the fire.

Missoula Equipment Development Center engineers have designed, constructed, and tested an improved skid pan for use with tractors. Construction drawings (Drawing No. ED-208A-R1) and materials list are available from the Missoula Equipment Development Center.

Field tests of the designed skid pan during the 1961 fire season proved its value wherever used. Comments from field personnel were very favorable. Major improvements over other types are

1. A telescoping pushpole facilitates maneuvering by allowing the tractor to push the skid pan backwards—an important feature in rough terrain. When descending steep slopes the towing cables are slack, and the telescoping pushpole prevents the skid pan from sliding into the tractor. The towing cables absorb all the strain when traveling on level ground, sidehill, or uphill. The pushpole lengthens and takes no strain unless it is telescoped to the stoprings when making turns, backing up, or descending slopes.
2. Wide-channel iron runners control slippage on steep side slopes.
3. The improved skid pan is designed so that the pushpole and towing cables may be attached at either end. Conveniently arranged tiedown loops are provided for lashing down cargo quickly and easily.

Skid-pan cargo carrier. Note arrangement of pushpole and towing cables assembly.

HOSE-FOLDING MACHINE

Venoel J. Henderson
Maintenanceman, Bureau of Land Management

The washing, drying, and repacking of firehose used in the control and mopup of forest fires is a time-consuming task. To reduce the man-hours it requires has led to the design of various types of equipment by fire control personnel.

In Alaska portable pumpers are extensively used to control wildfire. Thousands of feet of dirty hose have to be reconditioned almost every day during the peak of the season. Because of the size of the area requiring fire protection (225 million acres) and the lack of roads, our fire control operations are largely aerial. Hose is usually packed so that it can be dropped by parachute. For best handling, hose is folded and placed in packs containing 300 feet each.

By former methods, which involved manual techniques and a jig designed for the purpose, 20 minutes were required to pack 300 feet of hose. We could not afford this much time during peak fire periods. The new hose-folding machine (fig. 1) was designed to cut time. It neatly and firmly folds hose at the rate of 100 feet per minute. It now requires 5 minutes to complete a task that formerly took 20. The saving in time is indeed significant, and the resulting product is better.

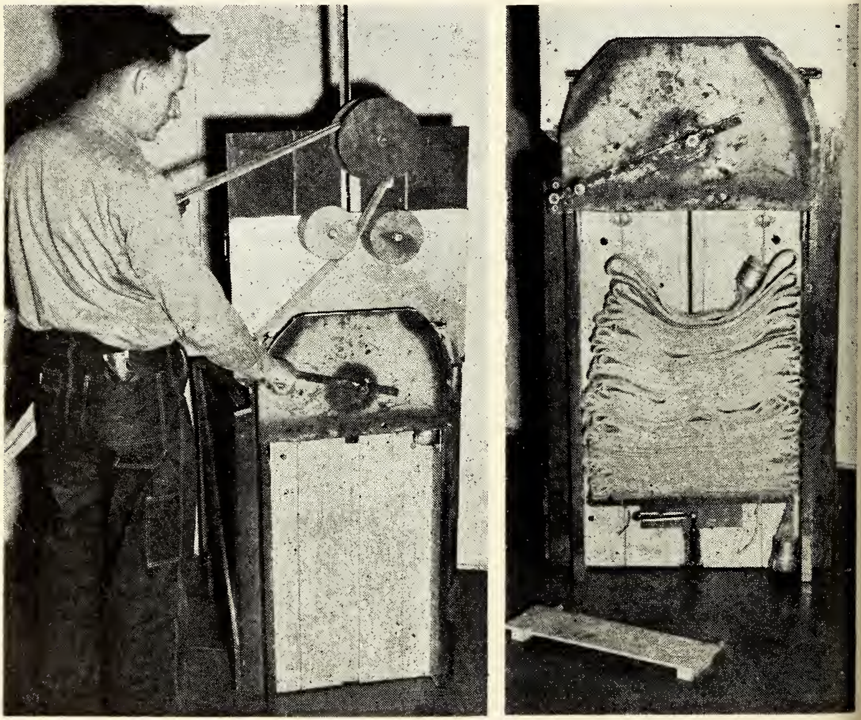

Figure 1.—Hose-folding machine in operation.

One- or 1½-inch unlined linen hose is fed into the machine by a simple up-down stroke on the handle of the folding arm. Hose is folded in any desired width of pack. When the last fold of the section is made, an automatic device compresses the section. The folded section is then tied and placed on a hose sacking table. When three sections are stacked on the table, the lengths are then coupled.

The tie cords are then cut, and a pack sack is slid over the hose pile. The hose pack is then pushed off the tabletop into a backpack, and the hose is ready for use.

The material cost of the units is approximately $60 including the sacking table. It can be constructed in approximately 30 man-hours.

Detailed plans and a list of materials needed are available from the State Director, Bureau of Land Management, 6th and Cordova Streets, Anchorage, Alaska.

RECORDING DEW GAGE

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Intermountain Forest and Range Experiment Station

Instrument

The instrument developed by Intermountain Forest and Range Experiment Station to record duration and amount of dew (fig. 1) consists of an expanded polystyrene block mounted on a balance, a clock-driven drum, and a pen geared from the balance to the drum. Changes in weight of the expanded polystyrene block as dew or rain is deposited are recorded on a chart mounted on the drum. This record shows the amount and time of dew formation and dissipation. The instrument also records time and amount of rainfall.

Balance

The balance was developed during the 1930's by personnel of the old Northern Rocky Mountain Forest and Range Experiment Station (now part of the Intermountain Station) to record wind velocity, duff moisture, and wood moisture. Mr. H. T. Gisborne sketched a possible instrument layout in 1932. In 1933 Mr. Dunlap, senior engineer, Forest Products Laboratory, Madison, Wis., completed plans for such an instrument and constructed and delivered one model to the Priest River Experimental Forest. Seven more instruments were ordered and delivered in 1934 at a cost of $331 each. The eight instruments, called anemohygrographs, were used

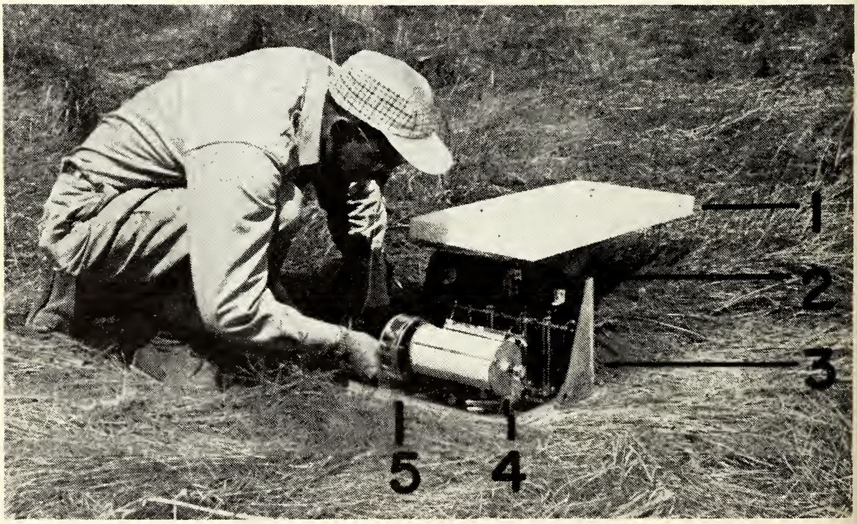

FIGURE 1.—Dew gage with block of expanded polystyrene in place, and the cover removed for adjustment of the balance: *1*, Expanded polystyrene dew block; *2*, support; *3*, base; *4*, drum and chart; *5*, 7-day-clock drive.

with modifications in forest fire research through 1940. Wartime restrictions prevented their production and none have been produced since. The original eight units are now at the Northern Forest Fire Laboratory, Missoula, Mont.

Dew Block

To measure dew, the fuel moisture sticks originally used on the anemohygrographs were replaced by blocks of expanded polystyrene. The duff moisture indicator and wind recorder, with their pens, were removed. Expanded polystyrene is nonhygroscopic and relatively stable when exposed to weather. This inexpensive material, used commercially as insulation, is readily available in sheets 1½ by 12 by 108 inches at $2.50 each. One sheet contains enough material to make three dew blocks. Hirst[1] in England used expanded polystyrene to measure duration of leaf wetness. He found that a block of polystyrene became wet and dry at almost the same time as the leaves of the crop he was studying.

The dew blocks for this instrument are each 1½ by 12 by 24 inches. They are suspended at three points on the balance. Two points are pivoted at the ends of a T-shaped support that acts as a fulcrum. The remaining suspension point at the other end of the block is connected through pivots and counterweights to a pen. The pen records changes in weight of the dew block on a chart mounted on the 7-day clock-driven drum. The blocks weigh approximately 225 grams, and the frames for their support weigh 75 grams. Dew deposit ranged to as high as 68 grams during a summer night in 1958. Tables were constructed to convert grams of moisture deposited to equivalent fractions of an inch of precipitation. For dew blocks of the surface area used on this instrument, 5 grams of dew would equal approximately 0.001 inch of precipitation.

Calibration

The gages are calibrated by placing successive 5-gram weights at the center of the dew block and marking the deflection of the pen arm on the chart. The variable weights of the counterbalance make it possible to adjust the gage to a zero mark.

Operation

Since the gages are light in weight and the drum is clock driven, the instruments are portable and excellent for field use. The dew block is 12 inches above the base of the instrument. Therefore, when the instrument is on the ground, observations are obtained at 1 foot above ground. For observations at other heights, the instrument can be set on stands mounted on poles. Dew could be recorded at ground elevation by placing the instrument in a 1-foot pit with the dew block at ground level. Apparently, polystyrene has radiational characteristics similar to those of leaf surfaces. A brief test with two gages, one dew block exposed normally and the other covered with green leaves, yielded similar deposits of

[1] Hirst, J. M. A simplified surface-wetness recorder. Plant Pathology 6: 57–61. 1957.

dew. The 7-day clock and chart permit recording of dew deposition for extended periods. However, gusty afternoon winds can blow the dew block from its mounting. Best results are obtained in sheltered locations, or when the instruments can be checked daily after the afternoon wind has died down and prior to dew formation.

The most dew recorded at the Priest River Experimental Forest during a summer night in 1958 was almost 0.015 inch. Although the instrument also records time and amount of rainfall, amounts greater than 0.020 inch extend the pen arm to its limit. Recorded deposits of rain and dew are easily distinguished; dew is deposited slowly and regularly, but rain causes sudden changes in the trace. Figure 2 shows a typical pen trace during two nights when dew was deposited.

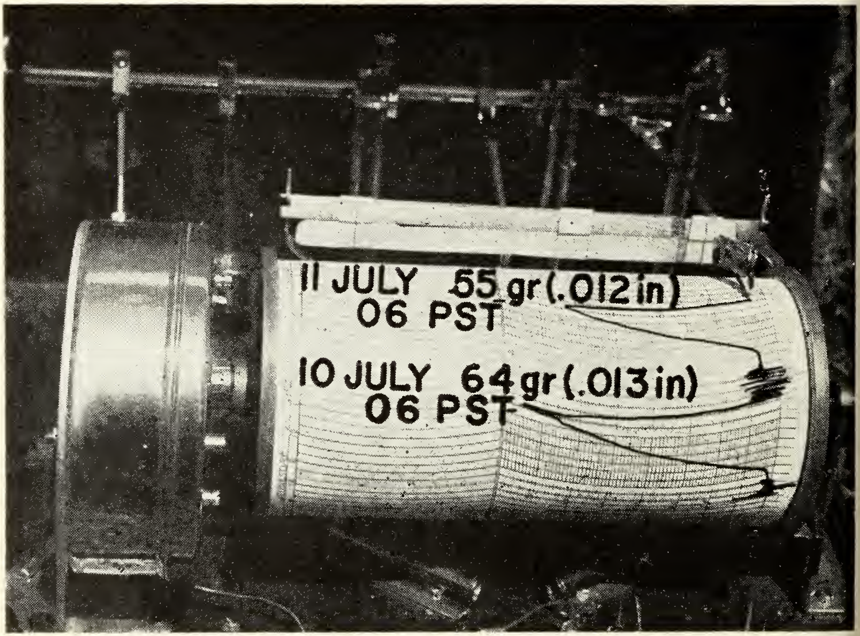

FIGURE 2.—Dew gage at 1030 P.s.t., July 11, 1958. The weight of moisture deposited on the dew block and the equivalent inches of precipitation on the mornings of July 10 and 11 are shown on the chart.

HOW MANY FIRES?

DAVID BRUCE
Chief, Division of Forest Fire Research
Pacific Northwest Forest and Range Experiment Station

As forest fuels dry out, the number of fires per day increases. Since most fire-danger meters sort days into classes with different general levels of fuel moisture, there have been reports from all parts of the world on the relation between fire-danger classes and daily numbers of man-caused fires. Sometimes a linear relation has been shown between average fire frequency and danger rating or burning index. But these average numbers include many days with no fires as well as some with more than the average. Accurate description of how often each number of fires per day occurred in the past should help fire control planning by giving a clue to the probability of heavy fire loads as well as to the average level of fire business. A method of preparing such a description will be outlined here.

Examination of fire records from Louisiana and Missouri suggested that the actual frequencies could be closely approximated by negative binomial distributions. These distributions have been found useful to describe many things that are counted in equal units of space or time, such as insects per plant (*1*), seedlings per quadrat (*5*), or accidents per week (*2*). The properties of these distributions have been discussed, and methods of fitting them to observed data have been described (*1, 3, 5*). The purpose of this note is to show how they can be used to describe past fire occurrence in a given area. To do this some of the properties of the distributions will be discussed briefly.[1]

An imaginary model can be described that would give rise to a random frequency distribution of fires in space and time. The space is an area with a nonuniform fuel bed. The time is divided into 1-day periods. The fuel moisture is changed by daily weather conditions which can be classified by a fire-danger rating system. The danger ratings indicate the proportion of the fuel susceptible to ignition by a standard firebrand. A fixed number of these firebrands contact fuel at random locations each day.

The average number of ignitions in large groups of days with a given danger rating will be proportional to the susceptible fuel. On some of these days, none of the random contacts will be in fuels susceptible to ignition; on other days, one or more of the firebrands will start fires. The frequency distribution of number of fires per day in this danger class will be described by a Poisson distribution. For example, if there is an average of two fires per day, there will be no fires on 14 percent of the days, one fire on 27 percent, two fires on 27 percent, and three or more fires on 32

[1] There are two kinds of numbers involved in this. The first is the number of things counted in each unit of time or space—the count. The second is how often each of these counts is made—the frequency.

TABLE 1.—*Partial fire records from Clark National Forest 1946-52*[1]

Danger rating class	Average danger rating	Total number of days	Number of days with no fires	Percent of days with no fires	Total number of fires	Average number of fires per day (m)	Estimated k
0-1	0.80	2,163	2,146	99.21	17	0.0079	∞
2-6	4.28	1,012	925	91.40	107	0.1057	0.285
7-12	9.57	1,528	1,241	81.22	398	0.2605	0.480
13-24	18.10	1,772	1,176	66.37	904	0.5102	0.970
25-49	32.53	817	413	50.55	797	0.9755	1.007
50+	58.47	72	20	27.78	143	1.9861	1.560
All	11.35	7,364	5,921	80.41	2,366	0.3213	0.298

[1] Based on data furnished by John S. Crosby. See also (*4*).

percent. This distribution has the useful property of being completely specified by the mean. The distribution can be found in tables or computed readily. Since increases in danger rating are accompanied by increases in mean number of ignitions, a family of Poisson distributions will completely describe the fire occurrence for the area.

However, actual fire records aren't described this easily. Days having the same danger rating do not all have the same proportion of the fuel susceptible to ignition. Actual fire-danger ratings are based on windspeed as well as fuel moisture. There are seasonal changes in fuels that are not completely described by danger rating. Firebrands are not uniform in heat output and do not contact fuel at fixed rates in random locations. As a result, there are more days with no ignitions and more days with many ignitions than indicated by a Poisson distribution for any given danger class. There are many "contagious" or "overdispersed" distributions which can describe such frequencies. Of these, the negative binomial is one of the easiest to fit. It is completely specified by two parameters: the average count (m) and the exponent (k). The larger the exponent, the nearer the distribution approaches the Poisson distribution; the smaller the exponent, the greater the excess of zero and high counts.

Fire-occurrence records from the former Clark National Forest in Missouri for the period 1946-52 (table 1) will be used to show how the frequency distribution of fires can be estimated by computation. These records are for seven Ranger Districts including nearly a million acres of National Forest and another million acres of private land within the protection boundaries. They include the fall and spring fire seasons in the months of October, November, February, March, and April. This gives 1,052 days of record for each Ranger District. Combining the figures for 7 years and seven Districts reduces variability of the frequencies.

Table 2 shows the comparison of actual to estimated fire frequencies in terms of number of days having various numbers of fires in each danger rating class and suggests that the differences are no greater than could be attributed to chance in all classes but danger rating 25-49. Similar tables for 3 years of data from four individual parishes in Louisiana having 352,000 to 430,000 acres of forest land show no more significant differences between actual records and estimates than those in table 2.

TABLE 2.—*Actual vs. estimated days having the indicated fire frequencies*[1]

Danger rating class[2]	Number of fires per day: 0	1	2	3	4	5	6	7	8	9	10+
	Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
0-1	2,146	17	0	0	0	0	0	0	0	0	0
	2,146.0	16.9	0.1	0	0	0	0	0	0	0	0
2-6	925	72	10	5	0	0	0	0	0	0	0
	925.0	71.3	12.4	2.6	0.6	0.1	0	0	0	0	0
7-12	1,241	212	53	12	8	1	0	1	0	0	0
	1,241.0	209.4	54.6	15.9	4.9	1.5	0.5	0.2	0	0	0
13-24	1,176	394	135	43	18	1	3	0	2	0	0
	1,176.0	393.2	133.5	45.6	15.6	5.4	1.8	0.6	0.2	0.1	0
25-49	413	198	126	32	19	13	8	3	4	1	0
	413.0	204.6	101.1	49.8	24.6	12.1	6.0	2.9	1.5	0.7	0.7
50+	20	18	9	12	5	2	2	3	1	0	0
	20.0	17.5	12.6	8.3	5.3	3.3	2.0	1.2	0.7	0.5	0.6
All	5,921	911	333	104	50	17	13	7	7	1	0
	5,921.0	917.0	308.5	122.5	52.3	23.3	10.7	5.0	2.4	1.1	1.0

[1] Based on data furnished by John S. Crosby. See also (*4*).

[2] In each class the upper row shows the actual number of days; the lower row shows the estimated.

To make it possible to estimate probable frequencies for a com-
plete range of danger ratings rather than broad danger classes
graphs can be prepared (fig. 1). The expected numbers of days
having each number of fires are converted to percent of the tota
days in each danger class and plotted as cumulative percent over
the average danger rating (from table 1) for the class. Reading
from the curves at a danger rating of 25, 59 percent of the days
will have no fires and 82 percent of the days will have either one
or no fires. Thus, the estimate is that 23 percent of the days wil
have one fire, 10 percent will have two fires, and 8 percent wil

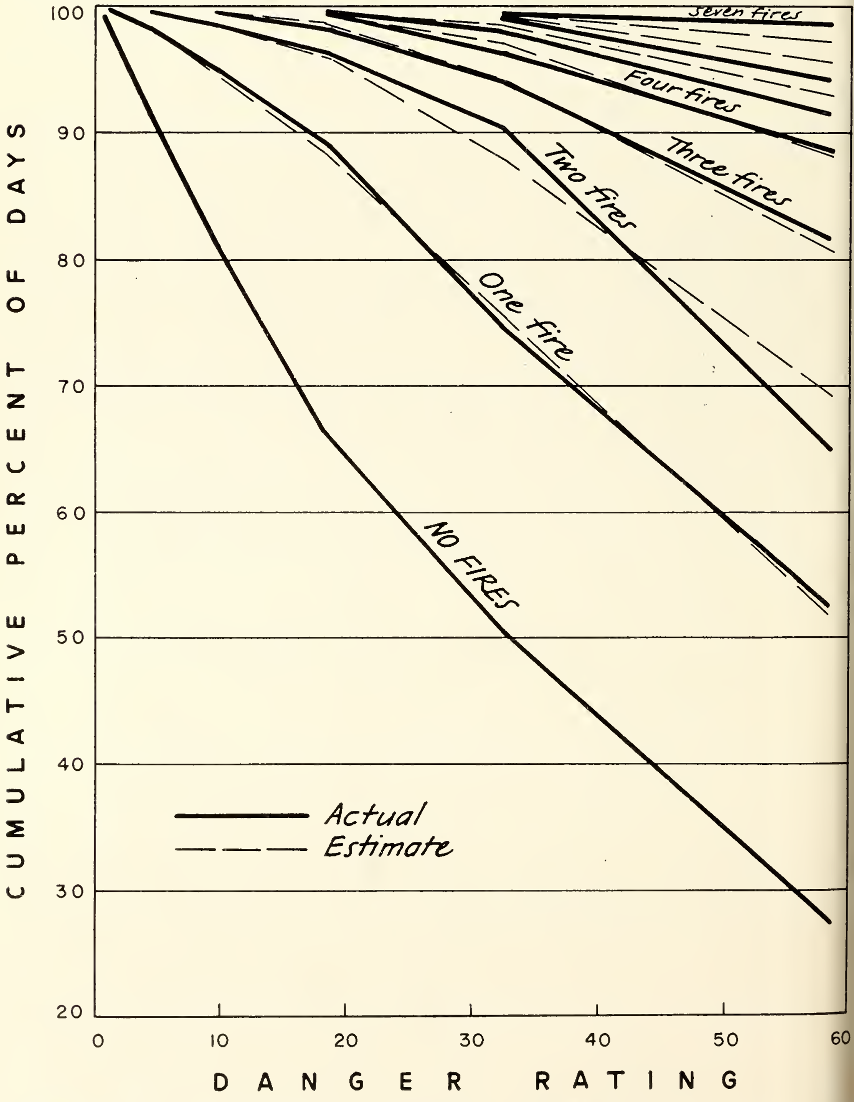

FIGURE 1.—Cumulative percent of days with indicated number or fewer fires per day.

ıave three or more fires. Graphs like this can be prepared from the actual frequencies, but use of the estimates appears to smooth some of the irregularities in the data.

Use of these estimated frequencies depends on the area and period for which the records are analyzed. The estimates do not tell the whole story because they do not include information about size of fire and fire control expenditures. Although it is tempting to consider combining these estimates with the relation of average area burned per fire in each danger class, this is not likely to be meaningful, because average fire size may be related to number of fires per day within each danger class. Therefore, it seems wise to limit the use of these estimates to suggesting how often the various numbers of fires per day can be expected. Local experience in fighting fire will suggest what disposition of forces can most effectively deal with this many fires on days with these danger ratings.

How to Compute the Expected Frequency

Take danger rating class 7-12 as an example. The necessary values are in table 1. The following method begins by estimating the exponent k from the frequency of days with zero fires.[2] If four significant figures are carried, the total estimated frequency and total number of fires should be accurate to three significant figures. This procedure is followed for each class.

The value of the exponent k is computed from the relation

$$\frac{f_o}{N} = \left(1 + \frac{m}{k}\right)^{-k}$$

where: f_o = frequency of days with no fires (1,241)
N = total number of days (1,528)
m = mean number of fires per day (0.2605)
k = exponent of negative binomial (unknown)

Using logarithms, the equation is solved by successive approximations:

$$\log N - \log f_o = k \log \left(1 + \frac{m}{k}\right)$$

$\log 1{,}528 - \log 1{,}241 = 0.090351$

try $k = 0.5$, $0.5 \log 1.5210 = 0.091064 > 0.090351$

try $k = 0.4$, $0.4 \log 1.65125 = 0.0871232 < 0.090351$

try $k = 0.48$, $0.48 \log 1.54271 = 0.090376 > 0.090351$

try $k = 0.479$, $0.479 \log 1.54384 = 0.090337 < 0.090351$

---

[2] This method of estimating k will not work where there are no days with zero fire count. In this event, estimates of k and f_o based on the mean, the variance, and the total number can be used (*3*, *5*).

The next step is based on the relation:

$$f_x = \left(\frac{m}{m + k}\right)\left(\frac{k + x - 1}{x}\right) f_{x-1}$$

where f_x is the frequency of days having x fires

$$\frac{m}{m + k} = \frac{0.2605}{0.7395} = 0.35227$$

The second term has to be tabulated for successive values of x. Next, these values are multiplied by 0.35227. Finally, the actual number of days with no fires is substituted for f_{x-1} to obtain the frequency of days with one fire, and other values of f_x are successively computed. For example (from the tabulation below) $f_1 = 0.1687x1,241 = 209.4$.

Fires per day (x)	$\left(\frac{k + x - 1}{x}\right)$	$\left(\frac{m}{m + k}\right)\left(\frac{k + x - 1}{x}\right)$	f_x	$p_x = \frac{f_x}{N}$
0	—	—	1,241	0.812
1	0.4790	0.1687	209.4	0.137
2	0.7395	0.2605	54.5	0.036
3	0.8263	0.2911	15.9	0.010
4	0.8698	0.3064	4.9	0.003
5	0.8958	0.3156	1.5	0.001
etc.				

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VOL. 24 NO. 3
July 1963

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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 24 Number 3

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, firefighting, 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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CONTENTS

MANAGEMENT DESIGNS FOR CONFLAGRATION CONTROL, DUCKWALL TEST UNIT[1]

R. W. Bower

Forester, Division of Fire Control, Region 5

The Problem

Many wild land management areas in California contain extensive continuous stands of highly flammable vegetation. These areas have a high frequency of very high to extreme fire danger days each season. Use is high, with peaks of intensive use during the fire season. The combination of fuel, use, and fire danger results in conflagration type fires that quickly overwhelm the normal initial attack organization, cause extensive loss of resources, and require high suppression expenditures—as illustrated in California by the extensive timber losses of 1955, 1959, and 1960.

The cost of maintaining a fire control organization to meet these conditions would be prohibitive; therefore, the problem must be attacked by doing something about the fuels on the ground.

Fuel Treatment

The size, complexity, and cost of a direct fuel treatment program are also prohibitive. Slash disposal on timber sales, firebreaks, prescribed burning, and brush clearing for forage production are some of the programs being effected piecemeal. To secure the desired results, the concept to integrate fuel treatment with all of the multiple use management programs on these high hazard areas on a *complete area management plan basis* was developed.

This concept was entitled "Management Designs for Conflagration Control." It could also be called Integrating Fuel Management with Multiple Use Management.

The Duckwall Test Unit

To determine how this concept could best be carried out, a test area was selected. The Duckwall Unit on the Stanislaus National Forest met the criteria for an active multiple use program, high hazard fuels, and a history of severe conflagrations. Extensive high-value timber stands and recreation areas lie within and contiguous to the area. The Duckwall Unit consists of about 40,000 acres clearly defined by the middle fork of the Tuolumne River on the south, Clavey River on the east, Duckwall Ridge on the north, and the north fork of the Tuolumne on the west. Elevations vary from 900 feet in the canyons to 5,800 feet on Duckwall Ridge.

Cover types consist of annual grass on the lower river slopes, woodland-grass on the upper canyon slopes and lower spur ridges, with dense brush fields taking over nearer the timber belt. Timber

[1] The concept and program for the test unit was worked out by a management team from the California Region, Pacific Southwest Forest and Range Experiment Station, and the Stanislaus National Forest.

types range from young pure ponderosa pine stands to mixed conifer in the intermediate elevations and to some sugar pine-fir areas at higher elevations. Some small patches of oak are interspersed with the conifers.

Soils range from Bandarita, which has a low vegetative capability (annual grass and light brush) ; Mariposa, with a capability for hardwoods, heavy brush, and some pockets of conifers in the deeper soil areas; and Josephine soil, with a high capability for coniferous timber.

Precipitation amounts to 20-25 inches of rain annually, normally occurring from November to April. There is some snowpack on the upper elevations. Summer climate is hot and dry. Temperature often exceeds 100°, and humidities fall to 5 percent. Daytime winds are normally strong enough to result in many days of high to extreme fire danger.

About 20 percent of the unit is in private ownership. Most is commercial timberland, some tracts are patented mines, and some are small homesteads.

Management history shows two grazing allotments with some range revegetation done on both Government and private land, three public campgrounds, and some wildlife habitat improvement on the winter deer range. Most of the private timber has been cut over. There have been some small sales of National Forest timber. Fire history indicates that since 1910 about 83 percent of the Duckwall Unit has burned at least once, 25 percent has burned twice, and 10 percent has burned three times.

Conflagration Control Program Procedure

The first step in the program was to have a complete pre-attack survey and plan made for the area. The completed pre-attack plan shows the firelines, fuelbreaks, and other facilities needed by suppression forces for an adequate, safe place to make a stand on any fire that escapes the initial attack on a high fire danger day. The general guide for the layout was to break the area into about 2,500 acre blocks with continuous firelines and fuelbreaks or natural barriers. All available resource inventory and multiple use maps were used as references.

The next step was to overlay the area pre-attack plan with maps of current management operations and operations planned for the immediate future, such as the 5-year timber operating plan. Highest priority went to a major continuous fuelbreak and fireline at the general line of demarcation between the heavy brush on the steep river slopes and the high-value timber on the gentler topography of the ridges and basins above the river. A soil survey was made of this area.

Every multiple use operation that could contribute to this priority program was examined and, if feasible, was scheduled for early start. Areas where the multiple use program could not contribute were identified, and the work scheduled as direct construction out of fuel treatment funds.

The following programs were used in first unit development:

1. *Range revegetation.*—Conversion of brush areas to perennial grasses. One unit on National Forest land and one on private land were already done. These were tied into the plan, and the new work on both private and National Forest land was designed to extend the fuelbreak as far as possible.

2. *Wildlife habitat.*—Some work had been done on deer browseways in the winter feed areas on the river slope and spur ridge brush fields. This work was tied in and new work programmed to contribute to the high priority fuelbreak.

3. *Recreation.*—Rehabilitation of one campground adjacent to the general fuelbreak location included a fuel reduction plan for fire prevention.

4. *Timber sales.*—A 3,000,000 board feet timber sale included about 1 mile of the primary fuelbreak location. The portion of the sale area included in the fuelbreak was designated as a "fuelbreak cut unit." Marking was modified to remove a large portion of the mature overstory and thin out the intermediate-size class in order to get proper spacing of the trees on the fuelbreak and still maintain shade on the low ground cover. All slash is disposed of on the fuelbreak cut unit.

5. *Stand improvement.*—Stand improvement funds are used to thin the material under merchantable size up to point justified for silvicultural practice. Additional work needed for fuelbreak purposes is paid out of fuel treatment funds. All trees on the fuelbreak are pruned so as to completely eliminate the continuous vertical distribution of fuels. All stand improvement slash is eliminated by chipping or piling and burning.

6. *Timber plantations.*—On good timber soils, there is a regular program of stripping brush for planting of commercial trees. One such unit is contributing to the primary fuelbreak. Current work is underway on the proper plantation design to get nearly full production on the timber soil and yet maintain the efficiency of the fuelbreak.

7. *Fire control-fuel treatment.*—Handlines on the steep canyon slopes have been put in by fuel treatment funds in order to effectively tie the fuelbreak into unit boundary natural barriers. Helispots and water source improvements are being carried out concurrently with the fuel work.

8. *Watershed management.*—All work is checked for erosion control, such as water-breaks on firelines and surface ground cover to be maintained on fuelbreaks.

9. *Other activities.*—There will not be any major engineering projects in this test unit. Management designs for conflagration control are needed in connection with major highway construction, powerline locations, reservoir clearing, and similar projects.

Private Land

The Duckwall area land ownership pattern requires work to be done on the private lands to make the program totally effective. The area plan and purpose of the program were explained to the land owners, county officials, and adjacent communities. Complete endorsement of the program resulted. In one case the private landowner was interested enough to do all the work at his own expense with the advice of the project leader. This included ½ mile of main fuelbreak, one helispot, and ½ mile of secondary fuelbreak on a spur ridge.

Other landowners doing work for range conservation were able to qualify for financial aid under the Agricultural Conservation Practice Program for brush conversion and firebreak practices authorized by the State and county conservation committees. One mineral land patent owner having no interest in the surface values, which were low, gave the Forest Service an easement to do the work across his property.

A problem yet to be explored is how far commercial timber landowners whose lands are now cut over can go in participation in the plans.

Cooperation with Research

Research personnel from the Pacific Southwest Forest and Range Experiment Station have been on the management team and have been delegated the major responsibility for physical and economic evaluation of the work. They are working on such aspects of the program as determination of the volume of fuels before and after treatment, effect of the treatment on the microclimate on the fuelbreak, effect of the fuelbreaks on fire behavior under various weather conditions, best types of low ground cover

FIGURE 1.—Some 450 acres of fuelbreak were cleared along the Paper Cabin Ridge. The brush from the cleared break was burned. The brush-cleared areas were planted to perennial grass. Groups of oak and pine were thinned and pruned.

to maintain on the fuelbreaks, and best methods of disposal of fuels to be removed.

The findings from these investigations will make it possible to prepare more complete specific management guidelines for the application of the conflagration control concept to the multiple use management programs throughout the Region.

Progress to Date (fig. 1)

Work was started on the pre-attack plan in January 1962. By January 1963, the following have been accomplished:

1. Pre-attack plan for 40,000-acre Duckwall Unit completed.
2. Fourteen miles and 1,056 acres of major fuelbreak completed by the following:
   a. Two miles by timber sale and plantation preparation.
   b. Two miles on private land by owners.
   c. Two miles on private land by Forest Service under easement.
   d. Six miles accomplished by range revegetation and wildlife browseway work supplemented by fire funds.
   e. Two miles of handline out of fuel treatment funds.
3. About 3,000 snags felled in and adjacent to the fuelbreaks.

First Fire Test

On July 3, 1962, a fire on a very high-danger day built up too fast for initial attack to handle, crowned upslope, and hit the Paper Cabin Ridge fuelbreak. The fuelbreak stopped the head of the fire and made the suppression job much easier. Conservative estimate places the suppression cost savings at $25,000, which is about double what has been spent on the Paper Cabin Ridge fuelbreak.

Summary

Progress to date indicates that it is feasible to integrate fire fuels management into the multiple use management program on an area plan basis.

Some modification of treatment may be necessary on specific fuelbreak areas. This can be done with a small increase in costs and without reducing the productive capacity of the land.

Multiple use management measures must be supplemented by fuel treatment funds to make the program fully effective.

THE FIRE BEHAVIOR TEAM APPROACH IN FIRE CONTROL

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Pacific Southwest Forest and Range Experiment Station

[*Editor's note.*—The authors of this article have been leaders in the development and application of the fire behavior officer job in the fire suppression organization. They present a very strong case for a team approach to the fire behavior officer's work on major fires. Although the organization proposed here has not as yet been adopted as standard for the Forest Service, it points a way to the possible organization of the future. It is important to integrate the fire behavior work with cooperation by the Weather Bureau under the National Plan for Fire Weather Service.]

"The weathermen just don't understand our problems." Perhaps many of you have heard this or similar complaints by the fire boss faced with a new fire problem when some unexpected and seemingly unusual wind pattern carried a nearly controlled fire completely out of control again. Nearly as common is the answering complaint of the fire weather forecaster: "We could give the fire control people more information, but they don't know how to use what we give them now."

Perhaps both complaints are greatly exaggerated, but they also contain much truth. The growing value of wildland resources and the encroachment of manmade improvements into wildland areas have greatly complicated the fire control problem. No longer is it possible to wait for the fire to "come out" to a position where control can readily be attained. Instead, even hot-burning, aggressive fires must be attacked and controlled where they are. His margin of safety greatly narrowed, the fire control man now needs much more precise and detailed fire weather information. He must have an accurate evaluation of the integrated effect of weather and fuels on fire behavior, often sector by sector.

To provide this information, we need people with training in both fire behavior and meteorology. Only thus can we make full and efficient use of the data provided by the weather forecaster. It is the primary responsibility of the fire control agency to furnish its organization with personnel of such skills. This is the purpose of the fire behavior officer in the Forest Service fire control organization.

Development of the Fire Behavior Officer's Job

Although the fire behavior officer or fire behavior specialist has been used occasionally on fires for a long time, it was not until 1957 that the job received formal recognition by the Forest Service. The position was adopted on the recommendations of a task force set up by the Chief of the Forest Service to study major fire disasters in wildland areas. Looked upon at first by field men as a sort of "super" safety officer position, the job has gradually evolved toward its proper purpose—that of predicting fire behavior resulting from changes in the environment surrounding the fire.

The evolution of the fire behavior officer's job has probably been more rapid in California than in any other part of the country. The long and critical fire season and frequent large fires focus the need for the specialized services of the fire behavior expert. Since 1959, three successive drought years in California accelerated development of the fire behavior officer position.

Organization of the Fire Behavior Team

The growth of the fire behavior officer's job has been largely a trial-and-error process. Each fire presented some new problems and new situations that the current procedures, equipment, and organization of the job did not fit well. As a result the operational base of the job has been constantly revised and broadened to take care of as many different situations as possible. The magnitude and complexity of the fire behavior officer job has also grown as fire bosses became aware of the kinds of service the fire behavior officer can provide.[1] Thus, he is not only used on many more fires but also to a much greater extent on each fire. To meet the obli-

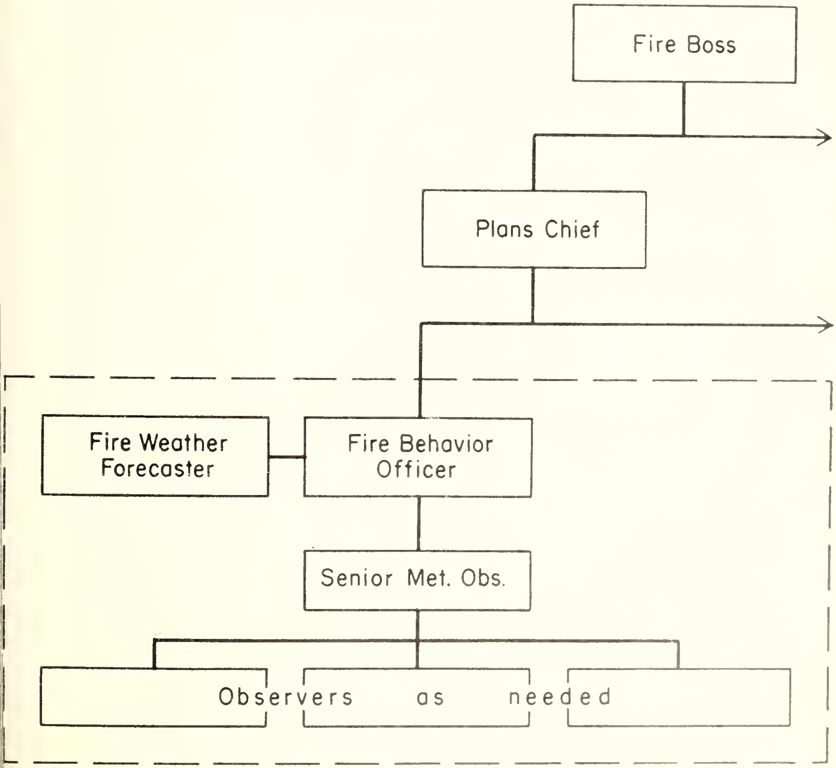

FIGURE 1.—Section of fire fighting organization showing fire behavior team.

[1] Chandler, Craig C., and Countryman, Clive M. Use of fire behavior specialists can pay off. Fire Control Notes 20(4): 130-132. 1959.

gations of the job, we now believe that the position cannot be adequately filled by one man, but requires a team approach. A fire behavior team was tried operationally during the 1961 fire season and proved to be highly successful. Organization of the team, as we see it now, should be as shown in figure 1.

Duties of the Fire Behavior Team

Fire Behavior Officer

The fire behavior officer is an adviser to the plans chief and the fire boss. He has final responsibility for localizing the general fire weather forecast for specific sectors of the fire. He must integrate information on weather, fuels, topography, and anticipated fire control action into a forecast of probable fire behavior. This forecast should be as specific as possible, while fully recognizing any forecast uncertainties. It must be written and provided in time for each shift, special forecasts being made whenever needed for unexpected changes. The fire behavior officer is specifically responsible for apprising the plans chief and the fire boss of any planned line location or fire control operation that he regards as unsafe because of probable fire behavior.

Although the fire behavior officer may provide assistance for specific line jobs on request, he must weigh the probable value of such assistance against the probable loss of contact with the fire situation as a whole. There is always a strong temptation to dash off to "where things are doing" with a resulting neglect of situations developing on other sections of the fire.

The fire behavior officer is responsible for securing local weather measurements and observations of fire behavior. He arranges for the necessary help and special equipment to make the measurements and observations. He is responsible for communications between himself, the various members of his team, and the plans chief and fire boss.

Senior Meteorological Observer

The senior meteorological observer is responsible to the fire behavior officer for obtaining and compiling accurate and complete meteorological observations in and around the fire area. To do this he needs to be thoroughly familiar with all types of meteorological equipment and with procedures for computing and compiling pertinent weather variables. He should make sure that the meteorological observers under his supervision are competent in the use of the necessary instruments and forms. Experience in collecting and compiling data is essential—often research men can fill this position very well. It is also a good position for a fire behavior officer trainee.

The senior meteorological observer prepares such summary graphs and tables of meteorological elements as may be requested by the fire behavior officer, or as experience dictates. He prepares and delivers current summaries of all observations to both the fire behavior officer and the meteorologist in ample time for their study before the preparation of fire weather and fire behavior forecasts.

He maintains fire weather equipment, including both manual and recording types of instruments, in good operating condition. He may also supervise special observations, such as pilot balloon runs and helicopter soundings.

Clearance for balloon runs and arrangements for helicopters or fixed wing flights are obtained *only* by the fire behavior officer. Senior meteorological observers should not deal directly with line or air operations overhead.

Meteorological Observer

Meteorological observers are under the direction of the senior meteorological observer. They should be familiar with common weather instruments and their use to measure temperature, humidity, and wind at times and locations specified by the senior meteorological observer. They should be capable of obtaining accurate and neatly recorded information with a minimum of supervision. They may also assist in special measurements such as pilot balloon observations or helicopter soundings. Usually these men can be drawn from the fire control force, often using men with minor injuries, such as blisters, to advantage.

Gains from Team Effort

In a fire behavior team organized as described, the meteorologist or fire weather forecaster is relieved of the responsibility for making observations in the fire area and thus has more time for weather analysis and preparation of detailed forecasts. When a fire behavior team is at a fire, the weather forecaster does not necessarily have to be there, but can set up shop wherever he can best obtain information needed for his forecast. This freedom of movement is particularly advantageous when there is more than one fire in the forecaster's area of responsibility. Adequate communication with the fire behavior officer is absolutely essential, and two or more conferences per day are necessary.

The Future

The organization of the fire behavior team does not mean that the fire behavior job has reached its ultimate goal and peak of performance. As more experience is gained, the operating procedures (see Checklist) and duties for the various members of the team will doubtless be revised for better performance of the entire team. New positions may need to be added. During difficult fires, for example, the fire behavior officer is more and more frequently called on for "on the line" help and advice. As this type of service increases, a fire behavior specialist may need to be added to the team so that the behavior officer can fulfill his duties to the fire as a whole.

Perhaps the most important implication of the increased use of the fire behavior officer is recognition by the fire control agencies of their responsibility in bridging the gap between the fire boss and the fire weather forecaster, thus enabling the fire boss to make full use of the service the forecaster can provide.

A Checklist of Operating Procedures

Fire Behavior Officer

Dispatch:
- Leaves immediately with fire weather trailer.

Arrival at fire:
- Leaves itinerary with plans chief.
- Arranges operating procedures with fire weather forecaster.
- Establishes observation routes and schedules.
- Sets up recording stations.
- Arranges for specialists and equipment as needed.

As soon as possible:
- Briefs senior meteorological observer on personnel, observation routes, schedules, safety plans, and any special observations needed.

Daily:
- Maintains contact with fire weather officer.
- Prepares fire weather (when no Weather Bureau forecaster is at the fire) and fire behavior forecasts.
- Holds briefing session with senior meteorological observer.
- Attends planning sessions.

Senior Meteorological Observer

Dispatch:
- Sets up transportation arrangements with meteorological observer.
- Inventories equipment.
- Leaves for fire.
- Arrival at fire.
- Checks with plans chief.
- Meets with fire behavior officer.
- Goes over ground with meteorological observer.
- Trains extra observers.

Daily:
- Collects observations.
- Prepares summary graphs and compilations.
- Conducts or supervises special observations.
- Inspects stations.

Meteorological Observer

Dispatch:
- Contacts senior meteorological observer for travel arrangements.
- Leaves for fire.

Arrival at fire:
- Checks equipment.
- Receives route and safety instructions and goes over ground with senior meteorological observer.

Daily:
- Makes and records observations.

CONNECTICUT FIRE WEATHER SEMINAR

CHARLES F. SNYDER
Acting Fire Control Officer,
Connecticut State Park and Forest Commission

The Connecticut State Park and Forest Commission, in cooperation with the Hartford Weather Bureau, arranged and held a fire weather seminar at Bradley Field, Windsor Locks, Conn., on March 9, 1963. As far as we could determine, this was the first of its kind ever held, if not in the nation at least here in the East.

The primary purpose was to indoctrinate the forest fire personnel in basic weather, in the relationship between weather and fire danger prediction, and in the use of specialized fire weather forecasts in forest firefighting and control.

Jack Rimkunas, a meteorologist, described the various pressure systems with their associated weather and wind circulations. He stressed the various weather types that affect Connecticut during the spring, summer, and fall. In addition he explained the causes of local wind conditions and reviewed the concept of humidity.

Warren Silverzahn, Fire Weather Meteorological Specialist, related the basic weather concepts to the prediction of fire danger.

He explained how long- and short-range planning could be formulated by use of the Weather Bureau's 30-day and 5-day forecasts. He pointed out that the Hartford Weather Bureau is now forecasting rainfall in terms of probability or number of chances in 10 for rain in any area. The information will be used this fire danger season as an additional guide for the fire danger prediction. Fog, wind, adverse wind profiles, inversion, and fronts were explained and related to forest firefighting and control.

Larry Mahar, meteorologist in charge, summarized the preceding papers and explained the excellent communications set up for dissemination of the fire danger predictions.

After the showing of a fire weather film and a tour of the Hartford Weather Bureau facilities, the group was taken to an outdoor demonstration held with the cooperation of the airport management and the Bradley Field Fire Department. A mockup aircraft was set on fire in the woods; fire department personnel then quickly rescued the "pilot" and extinguished the blaze with foam.

Over 100 persons attended this seminar, including Harry Swift, chief fire weather forecaster from Weather Bureau headquarters in Washington, D. C., and D. C. Mathews, Director, State Park and Forest Commission of Connecticut. The rangers and patrolmen indicated by general comment that they now had a clearer understanding of the weather and could now better appreciate its effects in forest firefighting.

In a meeting of this type a closer relationship is established between the weather specialists and the forest firefighting organization. This can only result in better cooperation, better understanding, and better control of our larger forest fires. Such a fire weather seminar would be of advantage to any fire control operation.

HELITACK STUDY PROJECT ON CUMBERLAND NATIONAL FOREST

Carl E. Burgtorf
Staff Assistant, Cumberland National Forest

Due to forest improvements and the increased value of forest land on the Cumberland National Forest, it has been necessary to step up forest protection proportionately. During forestwide planning in 1959, it became apparent that the cost of ensuring adequate protection by increasing the number of standby crews would be prohibitive. As an alternative, use of new equipment was considered. The helicopter, which provides quick access to remote areas, seemed to be the answer.

The situation.—Topographic conditions are unique on the Forest, since Cumberland County is on an eroded plateau. Erosion has resulted in vertical sandstone and limestone cliffs 50 to more than 200 feet high. In places there are three levels of cliff lines between a river channel and the upper plateau. The topography has long restricted use and development of the natural resources of the Cumberland, and similarly has posed many problems in protecting the Forest from fire. Some of the problems are:

1. Limitation by the terrain of vehicular and foot travel.
2. Frequent restriction of communication between the various land levels.
3. Usual limitation of visibility from fire towers to upper plateau or exposed upper slopes. Most lower slopes, coves, and shores of lakes and rivers receive only indirect detection coverage from fire towers. Actually less than one-third of the forested area within the protection zone may be seen.
4. Frequent movement of smoke, by wind, down into canyons and out of sight of the towermen.

Forest fuels are flashy—both coniferous and Appalachian hardwoods. Timber harvesting, mining, recreation, and land clearing is continuous on the numerous private holdings intermingled with National Forest land. Two-thirds of the land area within the proclaimed boundary is privately owned.

Area of the study.—Four southern Ranger Districts, containing the most consolidated public ownership on the Forest, were selected for the study. Within these Districts there are 424,065 acres of protection area, composed of 254,334 acres of National Forest and 169,731 acres of private holdings. During the past 5 years fire occurrence on the southern unit has averaged 45 fires per year. Recreation is expanding, and risks are increasing with more intensive use.

The helitack study plan.—The study plan was developed after an analysis of the situation and fire control problems on the area being considered. In brief, the objective of the study was to investigate the operational and economic feasibility of using a helicopter to transport men, equipment, and supplies in the initial attack phase of fire suppression and support of conventional ground forces. Initially, a crew leader and five firefighters were trained to serve with the helicopter at the headquarters heliport; later, several men were trained on each of the Districts.

The operating plan.—An operating plan was prepared to guide the project officer and to acquaint Forest Service personnel with the pertinent details of the helicopter operation. In brief, the operating plan included the following details:

1. Concept of operations with outline of the study area.
2. Arrangement for maps at the central heliport headquarters, at the dispatching offices, and for use by the helitack crew.
3. Dispatching procedures for single and multiple fires and crew travel.
4. Safety precautions and responsibility.
5. Organization and individual responsibilities.
6. Equipment.
7. Training.
8. Fire records.

Study equipment.—Study equipment included a three-place helicopter (fig. 1), conventional handtools, and, at the start, miscellaneous radio equipment from various sources. In the fall of 1962, the Cumberland acquired its own air-net system of radio communication. During the first two fire seasons of operation, lack of adequate communication was one of the most serious handicaps to satisfactory helitack operations. The helicopter was

FIGURE 1.—Type of helicopter used in helitack study.

equipped with a wire litter basket which held handtools and supplies for the crew. Cargo-carrying equipment included a bomb shackle and cargo rack with a sling—electric release—for cargo handling. Standard 10-foot cargo chutes were included and have been used in several training exercises. No provision for training or use of jumpers has been provided in our helitack plan.

Summary of Operations

1. Helicopter transport of men and equipment has proved quite satisfactory during the 2-year study. Many thousands of acres in half-hour-control zones were reached within the time limitation by the helicopter crew, whereas 1 hour or more is required by ground crews going to the same fires.
2. Small crews of two to six men have achieved control of more than 85 percent of our fires with the aid of the helicopter.
3. Initial attack by helitack crews costs less than 5 cents per acre of protected land, and it is believed they could have been effective on a larger percentage of fires if more helispots had been available.
4. Only two to four men are needed at the base heliport during medium fire danger, provided extra crew members are available near helispots, where the helicopter may pick them up. These extra men in work status need ready communications with the dispatcher.

The dispatcher at headquarters must have sufficient information to provide the helicopter pilot with compass headings, or azimuth bearings, and distance to landing spots and fires. Helispots may be located by similar bearing and distance information.

5. During planning stages and early operation of the helitack unit, we considered the desirability of securing a four-place helicopter; however, because of higher operating costs, we were unable to finance a larger unit. Actually, experience shows that the smaller unit is adequate during average fire weather. Other helicopters could be hired during critical fire periods. Perhaps increased efficiency in operating procedures will enable one helitack unit to protect one-half million acres with minimum ground support.

PRESCRIBED BURNING FOR HAZARD REDUCTION ON THE CHIPPEWA NATIONAL FOREST

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An unusual combination of fuel types on the Chippewa National Forest, northern Minnesota, has resulted in annual prescribed burning in marsh meadows as a fire prevention technique. Vast areas of marsh meadows constitute a high-hazard fuel when in the cured stage. These meadows contain primarily grasses, rushes, and sedges. Woody shrubs are not uncommon, particularly along meadow perimeters and on natural levees adjacent to water-courses. During the spring months meadows are frequently flooded during years of normal or above-normal precipitation. This frequent flooding is a factor that contributes to the continuance of the meadow cover type.

Because of the elongated patterns formed by this vegetative type, a wildfire can quickly increase in perimeter and enter adjoining timber at several widespread locations. Figure 1 shows a meadow which is recognized as having an exceptionally high fire hazard. A fire on this meadow could quickly expand to 25 miles of perimeter. A rate of spread of 400 chains of perimeter per hour can occasionally be expected on meadow fires. Thus, in the case

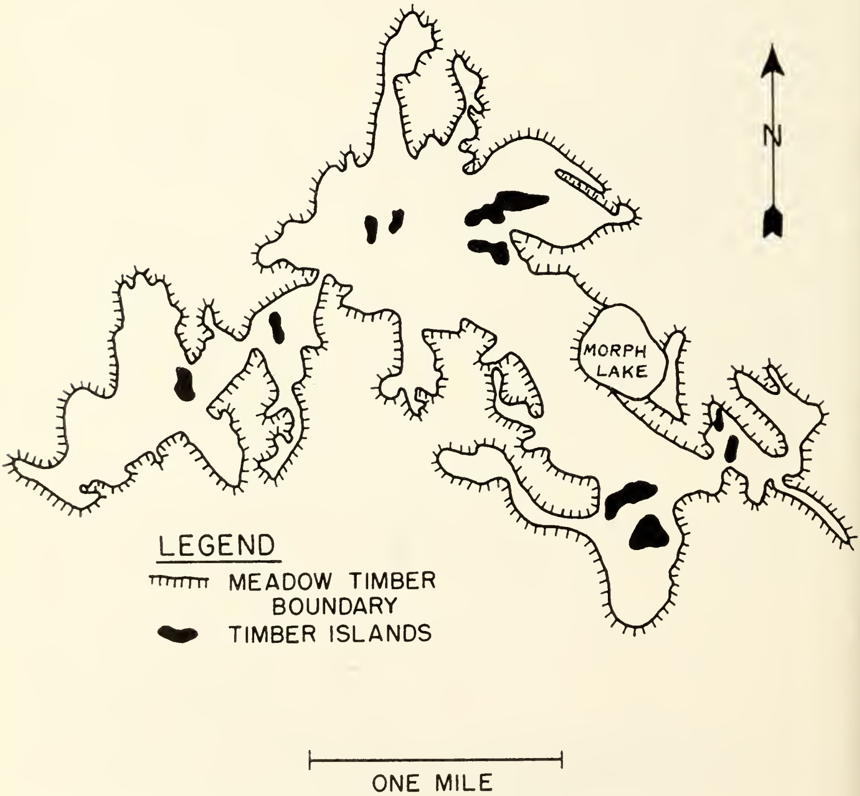

FIGURE 1.—Morph Meadow, Blackduck District.

illustrated, a fire could reach 25 miles of perimeter in 5 hours. Inaccessibility and difficulty of rapid travel are also part of the fire control problem. Incendiary fires are common and during the past 5 years (1958-62) accounted for 23 percent of all wildfires on the Chippewa National Forest.

In addition to the physical features of the land, the sociological aspects are also significant in fire prevention. Public education in fire prevention is an important part of fire control activity. The problem of public education in fire prevention is similar to that in the Southern States.

In northern Minnesota a long tradition of meadow burning exists, perhaps beginning in the early use of meadows for hay production because annual burning was thought to produce better hay. Meadow hay is known to have commonly been cut as late as 1950. Prescribed burning of meadows has been a management tool for approximately 35 years on the Chippewa National Forest. The objective has been to reduce the hazard by burning under safe conditions. Safe conditions for prescribed meadow burning exist throughout an approximate 3- to 4-day period in the spring. At this time snowmelt exposes marsh vegetation and dries rapidly in the open. Under the cover of adjoining timber snowmelt lags, and residual snow provides an efficient firebreak. The date of burning may vary by several days from meadow to meadow, depending upon latitude, orientation, and snow catch.

Meadow burning is frequently done individually or by two-man teams. During the 3- or 4-day period when conditions are optimum, several thousand acres must be burned by the four- or five-man staff of each ranger district. Table 1 shows the area burned by each ranger district and total acres of meadow available by district. A meadow burning team will commonly burn a river meadow 5 to 10 miles long in a day. Burning is usually done in the same manner as backfiring; wooden matches or drip torches are most commonly used for ignition. The fire is usually set so that the wind will carry flame across the meadow to be burned. No attempt is made to control the fire, since residual snow under adjoining timber provides an adequate control line. Because of river oxbows and snowdrifts, burning is never uniform; neverthe-

TABLE 1.—*Meadow type available and acreage prescribed burned by ranger districts*

Ranger district	Available*	Prescribed burned annually*
	Acres	*Acres*
Bena	20,000	12,500
Blackduck	5,500	3,545
Cass Lake	3,300	1,600
Cut-Foot Sioux	11,285	3,050
Dora Lake	5,540	1,650
Marcell	313	45
Remer	10,240	5,760
Walker	22,000	4.837
Totals	78,178	32,987

* Varies with annual water level.

less, breaking the continuity of fuel conditions suffices to prevent wildfire from spreading unchecked.

The need for prescribed meadow burning has often been evaluated and discussed by forest personnel. Generally the conclusion has been that burning is necessary for effective fire prevention, particularly in light of the incendiary fire problem. It is better to burn when conditions in the woods are safe than to take a chance on the area burning during periods of high fire danger.

WIND MEASUREMENT WITH HYDROGEN-FILLED BALLOONS

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Wind velocity is an important variable to be measured during test fires and many other investigations in forest fire research. This report describes trials of hydrogen-filled balloons, tethered to the ground, and used to measure the speed and direction of light air currents (0-5 miles per hour) near or around experimental fires. The hypothesis was that when a tethered balloon is displaced by a certain wind speed, the angle between the tether and the vertical ("angle of lean" of the balloon) can be correlated with the speed of the wind. This hypothesis was investigated at the Petawawa Forest Experiment Station at Chalk River, Ontario, in the summer of 1962.

Balloons for studying air movements are common in meteorology and have been employed to a lesser extent in climatology. MacHattie[1] used captive balloons for studying low-level winds, including their variation from point to point. Use of tethered balloons for measuring wind velocity was suggested for prescribed burning experiments, where a relationship between indrafts and ambient winds was sought. It was later thought that tethered balloons might also be used to determine air movements on other occasions, such as the observation of 2-minute test fires. In view of the importance of wind measurement in fire research, anything that may permit the measurement of speed and direction of light winds in a simple and direct manner should be investigated.

Various balloons were tested; these included toy balloons of different shapes and standard 3-inch meteorological balloons. The latter were more satisfactory as they retained their shape and stayed inflated longer than the toy balloons. Balloons were tethered to the ground by a No. 8 linen thread fastened to short blocks of two-by-four. Angles of lean were measured with protractors of 2-foot radius and graduated in 5-degree intervals, and made from quarter-inch plywood.

Preliminary observations revealed that the displacement, and consequently the angle of lean, induced by a certain wind speed was dependent on the size (degree of inflation) of the balloon and the amount of lift caused by the hydrogen (fig. 1). Displacement also varied with the length of the tether. The larger the balloon, the stronger the wind needed to produce a given displacement; also, the longer the tether, the stronger the wind required to give a comparable angle of lean. These determinations meant that each combination of balloon size and length of tether would require a separate conversion table to relate angle of lean to wind speed.

Conversion tables were constructed, and a hot-wire anemometer was used to measure wind speed. Fifty to 60 measurements of angle of lean and corresponding wind speed were taken for sev-

[1] MacHattie, L. B. Study of meteorological drying effects on forests. Unpublished report. Department of Northern Affairs and National Resources, Forestry Branch, 34 pp. 1954.

FIGURE 1.—Same wind speed induces a different angle of lean when balloons of different sizes are used. From left to right the diameters of the round balloons are 6, 7, 8, 9, and 10 inches.

eral combinations of balloon size and tether length. When angle of lean was plotted over wind speed for each combination, a linear relationship was indicated. Straight lines were fitted to the data using the method of least squares, but the correlation was not good; there was considerable scatter about the line. Wind speeds in feet per minute corresponding to angles of lean (0° to 80°) were then read from the line and tabulated. Observations of several sizes of balloons, 7 to 14 inches in diameter, tethered 2 to 10 feet above ground were "calibrated" in this way. No balloons smaller than 7 inches in diameter were tested owing to insufficient lift to pull the tether reasonably straight. Balloons larger than 14 inches showed little, if any, relation between wind speed and their angle of lean.

Balloons were tested during fire observations three times: twice at small bonfires of piled slash and once at a small-scale prescribed burn in a plantation. The bonfire tests were conducted to determine whether the balloons would be useful for detecting and measuring indrafts, caused by the fire, in relation to ambient winds. At the first bonfire test, pairs of balloons, 7 inches in diameter and on 4-foot tethers, were placed on each of the four cardinal directions; one balloon of each pair 10 feet from the fire, and the other 20 feet from the fire. An attempt was made to measure simultaneously the angles of lean of the balloons in each pair. It was hoped that comparison between the angles in each pair would permit the detection of any effect of indrafts on the balloon nearest the fire. Also, wind direction was concurrently estimated. At the second bonfire the same procedure was followed, with 10-inch-diameter balloons on 6-foot tethers. During the plantation fire the angle of lean of a single balloon, 10 inches in diameter and on a 4-foot tether, was measured every half-minute. This record was compared graphically to measurements taken with a cup anemometer (fig. 2).

The following facts became evident during the development of the conversion tables and the field tests of the balloons at fires:

1. The angle of lean of the balloons was very difficult and often impossible to measure with any precision because they were rarely sufficiently steady; they "bobbed" and "weaved" in all directions, even when the wind was relatively steady. This constant motion was probably caused, in part, by turbulence and by eddies and swirls in the air flowing around the balloon. It was once thought that a small vane, attached to the thread below the balloon, might have a steadying effect, but this was disproved.

2. When angle measurement was possible, it was found that for a specific wind speed, size of balloon, and length of tether, the angle of lean was not consistent. Thus, the angle of lean is not a reliable indication of wind velocity. The range of angles for a given wind velocity increased as the size of balloon increased.

3. Estimation of wind direction as indicated by the balloons was no more accurate than the age-old method of holding a dampened finger in the air and feeling which side is coolest. The constant swinging in a horizontal plane made the determination of wind direction at any instant practically guesswork. Also, as wind speed decreased and the tether thread assumed a more nearly vertical position, estimation of wind direction became even less positive.

4. There was no discernible correlation between indrafts and ambient winds. Also, sparks and the heat of the fire exploded several balloons, and tether threads often became entangled in low vegetation.

5. The record from the plantation test fire, when compared graphically to measurements taken with a cup anemometer, showed roughly the same trend of wind velocities throughout the fire (fig. 2). The balloon record, with measurement every half-minute, showed the distribution of the gusts of the wind, whereas the anemometer readings gave average velocities over 1-minute intervals. Although measurements of gustiness may be important when evaluating factors of fire behavior such as rate of spread, in light of (1) and (2) above, the record of balloon observations has to be interpreted with some reservations as to the absolute reliability of the wind speeds recorded.

These tests indicate that the use of tethered, hydrogen-filled balloons cannot be expected to provide reliable and accurate measurement of wind speed or direction near the ground. However, for qualitative assessment of general air movements around test fires, and where more precise or elaborate instrumentation is not possible, the balloons are useful when tethered at various positions and heights around areas to be burned and then observed or photographed at desired time intervals.

FIGURE 2.—Ccmparison of wind measurement by balloon and cup anemometer at plantation test fire.

PROTECTING THE TRACTOR-FIREPLOW OPERATOR FROM RADIANT HEAT

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Tractor-fireplow operators working close to wildfires are often exposed to high-intensity radiant heat. Although it generally causes only discomfort, painful burns may be inflicted. For efficiency as wll as safety, some form of protection seems desirable.

Enclosed cabs would be expensive and would probably require air conditioning in hot weather. Visibility and maintenance might be troublesome. Proper wire screens, on the other hand, may provide inexpensive protection from heat without the problems of complete enclosure. Wire screens[1] were found to be effective heat shields capable of reducing the amount of transmitted heat in proportion to their metal area. Thus, if 25 percent of a screen consists of openings (75 percent metal area), transmitted radiant heat would be reduced to approximately 25 percent of that without protection.

The screens could be mounted directly on the tractor. The screen behind the operator might be installed permanently, while those on the sides and front could be rigged to be raised overhead when not needed. On most fires, only the screen on the side toward the flames would be lowered, thereby permitting free air circulation from the other sides. Mounted in this manner, the screen shields should provide protection against branches and snags, in addition to being versatile and easily maintained radiant heat reducers. Screen of varying metals, wire size, and mesh is available from several manufacturers.

The author solicits comments from tractor operators or others interested in this idea or who may have had occasion to use shields.

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[1] Downs, L. E. and Bruce, H. D. Attenuation by window screen of thermal radiation from nuclear weapons. Tech. Rpt. AFSWP-341, Forest Products Laboratory, 1957.

HANDY RIVET PUNCHER

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Chief, Forestry Relations, Virginia Division of Forestry

Cutting rivets can be time consuming and dangerous. The Virginia Division of Forestry used the cold chisel and hammer system to cut rivets in repairing fire rakes until an enterprising Division employee developed a better method. Armed with a cutting torch, electric welder, drill press, scrap metal, a few bolts, and odds and ends, Porter Caldwell, Chief Forest Warden of Botetourt County, assembled a little hand-operated machine (fig. 1) that punches out old rivets and "brads" new ones. The punch is only a common high-quality steel punch, and the "brader" is a 3/8-inch studbolt. These items, when mounted as shown in figure 2, will permit an efficient and safe operation.

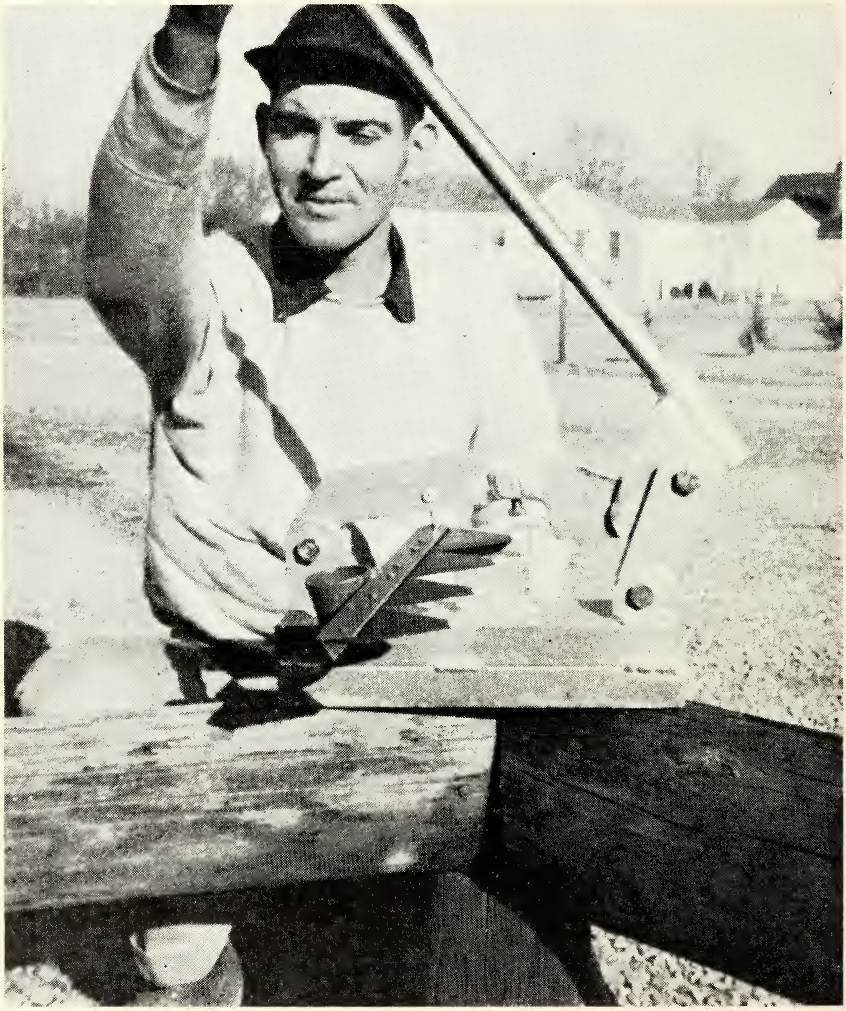

Figure 1.

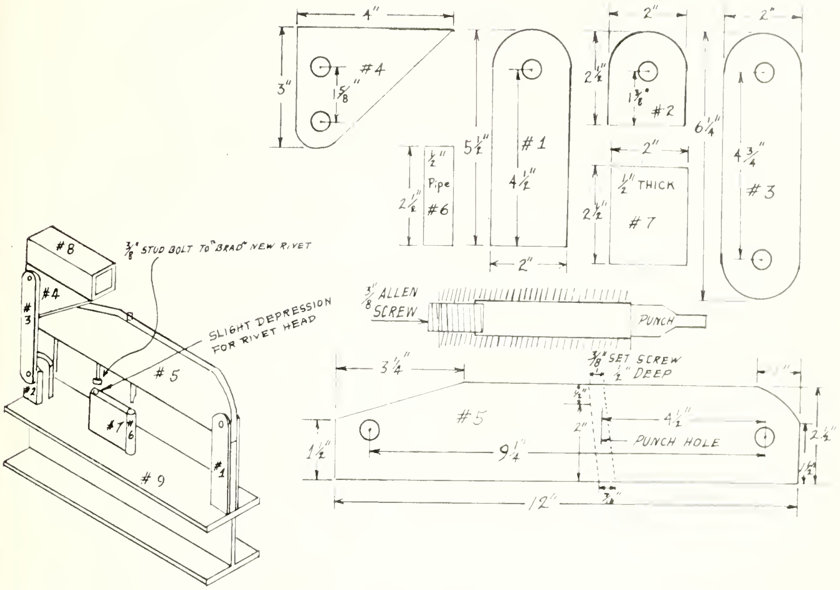

FIGURE 2.

Referring to figure 2:

1. All boltholes are five-eighths inch.
2. Two of each of parts #1 through #4 must be made.
3. Lower hole in #4 and left hole in #5 must be riveted to permit clearance with part #3.
4. Hole under #6 is cut to permit rivets to drop out.
5. Part #8 is constructed from two 4-inch-long pieces of angle iron ($1\frac{1}{4}$ by $1\frac{1}{4}$ by $\frac{1}{4}$ inches).
6. Removable handle, made of pipe, axle, or drill bit, inserts into #8.
7. Part #9 is an I-beam 12 inches long.

A TABLE FOR CHECKING THE REASONABLENESS OF ENTRIES ON FIRE REPORT FORMS

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Northeastern Forest Experiment Station

When fire reports (form 929, later revised as form 5100.29) were analyzed in a rate-of-spread study in 1959, a number of discrepancies or impossible combinations of entries were noted. For example, one fire report showed elapsed time from origin to attack as 1.5 hours, rate of spread or perimeter increase as 3 chains per hour, and the area attacked as 4 acres. If the time and acreage figures were correct, the reported rate of spread was less than one-sixth what it should have been.

Since this type of error or discrepancy seemed fairly common, table 1 was developed to aid in checking the reasonableness of certain entries on fire report forms. It is solely a means of checking and is not for use in computing acreages or perimeters. It shows the probable acreage of a fire spreading at various rates for varying periods of time. It can be used for any period in the fire's history for which data are available between any two of the following times: origin, discovery, attack, and control.

The probable acreages were computed from what was believed to be a normal-shaped fire and, although subject to adjustments, seem quite representative—at least for fires in the East. Of course fire shapes do vary, and figures computed for perimeters will frequently differ from those derived from this table.

These differences are limited when the perimeter computed from data on the fire report is less than that derived from table 1. A difference of 25 percent less would indicate a circular or near-circular fire, and this is the maximum possible difference. In general an error should be suspected when this difference reaches 20 percent, unless the fire is very small (1 acre or less).

On the other hand, there is no specific limit to the extent to which a fire perimeter may exceed that derived from the table. A fire may be extremely long and narrow or may have a very irregular margin, resulting in a very high perimeter-area relationship. However, when a computed perimeter exceeds that derived from the table by more than 30 percent, an explanation should be required. Such a difference indicates a fire of unusual shape or an error in the report.

How to Use the Table

First, this table can be used to check the reasonableness of the final perimeter and area-when-controlled entries. For example, suppose a report shows the area when controlled as 10 acres and the final perimeter as 24 chains. Are these figures reasonable and compatible?

A glance at the table shows that they are not. In the table both

TABLE 1.—*Probable acreage burned, in relation to rate of fire-perimeter increase and elapsed time*

Elapsed time	Area burned when perimeter increase in chains per hour is—														
	2	3	5	10	20	30	40	50	60	70	80	90	100	120	140
Hours	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
0.1	....	....	....	....	....	....	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.7	1.0
.2	....	....	....	....	0.1	0.2	.4	.5	.7	1.0	1.3	1.6	1.9	2.6	3.5
.3	....	....	....	....	.2	.4	.7	1.1	1.6	2.1	2.6	3.3	4.0	5.7	7.7
.4	....	....	....	0.1	.4	.7	1.3	1.9	2.6	3.5	4.5	5.7	7.0	10.1	13.4
.5	....	....	....	.1	.5	1.1	1.9	2.8	4.0	5.4	7.0	9.0	11.0	15.0	21.0
.6	....	....	....	.2	.7	1.6	2.6	4.0	5.9	7.7	10.0	12.6	16.0	23.0	30.0
.7	....	....	0.1	.3	1.0	2.1	3.5	5.4	8.0	10.2	13.4	16.6	21.0	30.0	41.0
.8	....	....	.1	.4	1.3	2.6	4.5	7.0	10.0	13.5	17.5	21.5	27.0	38.0	53.0
.9	....	....	.1	.4	1.6	3.3	5.7	9.0	12.3	17.0	22.0	27.5	34.0	48.0	66.0
1.0	....	....	.1	.5	1.9	4.0	7.0	11.0	15.0	21.0	27.0	34.0	41.0	59.0	80.0
1.1	....	0.1	.2	.6	2.2	4.8	8.5	13.0	18.5	25.0	32.5	40.5	49.0	72.0	98.0
1.2	....	.1	.2	.7	2.6	5.7	10.1	15.0	22.0	29.5	38.0	47.5	59.0	86.0	117.0
1.3	....	.1	.2	.9	3.0	6.7	11.8	17.5	26.0	34.5	44.5	55.5	69.0	100.0	136.0
1.4	....	.1	.3	1.0	3.5	7.8	13.4	20.5	30.0	40.0	51.5	65.0	80.0	115.0	157.0
1.5	....	.1	.3	1.1	4.0	9.0	15.0	23.5	34.0	46.0	59.0	75.0	92.0	132.0	179.0
1.6	0.1	.1	.4	1.3	4.5	10.1	17.2	27.0	38.5	52.0	67.0	85.0	104.0	151.0	204.0
1.7	.1	.1	.4	1.4	5.1	11.2	19.7	30.0	43.5	58.0	75.0	96.0	117.0	170.0	230.0
1.8	.1	.2	.4	1.6	5.7	12.5	22.0	33.5	48.5	65.0	84.5	107.0	130.0	191.0	258.0
1.9	.1	.2	.5	1.7	6.4	13.7	24.5	37.0	53.5	72.0	94.5	119.0	146.0	212.0	287.0
2.0	.1	.2	.5	1.9	7.0	15.0	27.0	41.0	59.0	80.0	105.0	132.0	163.0	234.0	318.0
2.1	.1	.2	.6	2.1	7.7	16.8	29.5	45.0	65.5	88.0	115.0	145.0	179.0	260.0	350.0
2.2	.1	.2	.6	2.2	8.5	18.5	32.0	49.5	72.0	96.5	126.0	158.0	196.0	285.0	385.0
2.3	.1	.3	.7	2.4	9.3	20.0	35.0	54.0	78.5	105.0	137.0	172.0	213.0	310.0	420.0
2.4	.1	.3	.7	2.6	10.1	22.0	38.0	59.0	85.0	115.0	150.0	189.0	233.0	337.0	457.0
2.5	.1	.3	.8	2.8	11.0	24.0	41.5	64.0	92.0	125.0	163.0	206.0	254.0	364.0	495.0
2.6	.1	.3	.9	3.0	11.8	25.5	44.5	69.0	99.0	135.0	176.0	222.0	273.0	395.0	535.0
2.7	.2	.4	.9	3.3	12.6	27.5	48.0	75.0	107.0	145.0	189.0	239.0	294.0	425.0	577.0
2.8	.2	.4	1.0	3.5	13.4	29.0	51.5	80.5	115.0	155.0	203.0	256.0	316.0	457.0	621.0
2.9	.2	.4	1.1	3.8	14.2	31.5	55.0	86.0	123.0	167.0	218.0	276.0	340.0	490.0	666.0

TABLE 1.—*Probable acreage burned, in relation to rate of fire-perimeter increase and elapsed time* (Continued)

Elapsed time	Area burned when perimeter increase in chains per hour is—														
	2	3	5	10	20	30	40	50	60	70	80	90	100	120	140
Hours	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
3.0	0.2	0.4	1.1	4.0	15.0	34.0	59.0	92.0	132.0	179.0	234.0	296.0	364.0	524.0	712.0
3.1	.2	.5	1.2	4.3	16.0	35.5	62.5	98.0	140.0	190.0	249.0	315.0	387.0	560.0	760.0
3.2	.2	.5	1.3	4.5	17.2	37.5	66.5	104.0	150.0	202.0	265.0	335.0	413.0	597.0	811.0
3.3	.2	.5	1.4	4.8	18.5	40.0	70.5	110.0	160.0	215.0	282.0	357.0	438.0	635.0	862.0
3.4	.3	.5	1.4	5.1	19.7	43.0	75.0	117.0	169.0	229.0	300.0	379.0	466.0	673.0	914.0
3.5	.3	.6	1.5	5.4	21.0	46.0	80.0	125.0	179.0	244.0	318.0	402.0	495.0	712.0	968.0
3.6	.3	.6	1.6	5.7	22.0	48.5	84.5	132.0	189.0	257.0	335.0	424.0	522.0	755.0	1,025.0
3.7	.3	.6	1.7	6.0	23.5	50.5	89.0	139.0	200.0	271.0	353.0	447.0	551.0	798.0	1,083.0
3.8	.3	.7	1.7	6.4	24.5	53.0	94.0	147.0	211.0	285.0	372.0	472.0	580.0	841.0	1,142.0
3.9	.3	.7	1.8	6.7	25.5	56.0	100.0	155.0	222.0	300.0	393.0	497.0	613.0	885.0	1,201.0
4.0	.4	.7	1.9	7.0	27.0	59.0	105.0	163.0	234.0	318.0	414.0	524.0	646.0	929.0	1,263.0
4.25	.4	.8	2.1	8.0	30.5	66.5	118.0	184.0	264.0	359.0	468.0	591.0	732.0	1,050.0	1,425.0
4.50	.4	.9	2.3	9.0	34.0	75.0	132.0	206.0	296.0	402.0	524.0	662.0	817.0	1,174.0	1,597.0
4.75	.5	1.0	2.6	10.0	38.0	83.0	147.0	229.0	329.0	448.0	583.0	737.0	910.0	1,310.0	1,780.0
5.00	.5	1.1	2.8	11.0	42.0	92.0	163.0	254.0	364.0	495.0	646.0	817.0	1,007.0	1,450.0	1,970.0
5.25	.6	1.2	3.1	12.0	45.5	101.5	179.0	279.0	401.0	545.0	712.0	892.0	1,110.0	1,597.0	2,167.0
5.50	.6	1.3	3.4	13.0	50.0	111.0	197.0	307.0	440.0	599.0	783.0	987.0	1,215.0	1,750.0	2,378.0
5.75	.7	1.5	3.7	14.0	54.5	121.0	215.0	334.0	480.0	654.0	853.0	1,080.0	1,330.0	1,910.0	2,599.0
6.00	.7	1.6	4.0	15.0	59.0	132.0	234.0	364.0	524.0	712.0	930.0	1,174.0	1,450.0	2,070.0	2,831.0
6.50	.8	1.8	4.7	17.8	68.5	155.0	273.0	424.0	613.0	835.0	1,090.0	1,375.0	1,695.0	2,440.0	3,322.0
7.00	1.0	2.1	5.4	21.0	80.0	179.0	316.0	495.0	712.0	967.0	1,260.0	1,597.0	1,970.0	2,831.0	3,853.0
7.50	1.1	2.3	6.2	24.0	92.0	205.0	364.0	565.0	817.0	1,110.0	1,450.0	1,830.0	2,256.0	3,249.0	4,422.0
8.00	1.3	2.6	7.0	27.0	105.0	234.0	414.0	646.0	929.0	1,260.0	1,695.0	2,070.0	2,567.0	3,697.0	5,032.0
8.50	1.4	2.9	8.0	30.5	118.0	258.4	466.0	730.0	1,050.0	1,425.0	1,850.0	2,347.0	2,898.0	4,174.0	5,681.0
9.00	1.6	3.3	9.0	34.0	132.0	294.0	522.0	817.0	1,174.0	1,597.0	2,070.0	2,632.0	3,249.0	4,679.0	6,369.0
9.50	1.7	3.6	10.0	37.5	147.0	329.0	583.0	910.0	1,310.0	1,780.0	2,317.0	2,932.0	3,620.0	5,213.0	7,096.0
10.00	1.9	4.0	11.0	41.5	163.0	364.0	646.0	1,007.0	1,450.0	1,970.0	2,567.0	3,249.0	4,012.0	5,776.0	7,862.0

10 and 10.1 acres are found in several places. By multiplying the rate of perimeter increase for the column in which these entries appear by the elapsed time in hours for the row, we get an expected approximate perimeter of 47.5 or 48 chains. The 24 chains shown on the report is approximately 50 percent less than that obtained from the table, indicating an error in the report. A little computing shows that a 24-chain perimeter, even in the form of a circle, would enclose an area of only 4.6 acres. A circle would require a perimeter of approximately 36 chains to encompass an area of 10 acres. Of course the chances of a fire burning in a perfect circle are rather slim, so the perimeter of a normal 10-acre fire would have to be somewhat greater than 36 chains, probably 45 to 50 chains as indicated by the table.

Now assume a 61-acre fire. No 61 is found in the table, but 59 appears in several places. Multiplying the chains per hour by the elapsed time in hours for any of these entries gives 120 chains as the expected perimeter of a 59-acre fire. By interpolating we would get approximately 122 chains for a 61-acre fire. In this way the expected perimeter of any fire can be computed, up to the maximum acreage shown in the table.

A second and probably more important use of the table is in checking the rate of spread from discovery to attack. This is the one item that seems most subject to unreasonable entries. The elapsed time from discovery to attack is definite. In general, the estimate of area-when-attacked is fairly good, but in many cases there is some doubt concerning the figure shown for perimeter increase per hour.

The use of the table for computing rate of spread differs slightly, depending on whether the origin and discovery times are approximately the same, or whether the fire had already attained a reportable size when discovered.

Consider a simple case in which origin and discovery times are the same, time from discovery to attack is 2 hours, and size at attack is 20 acres. First, we locate the elapsed time of 2 hours in the column at the left; then reading across to the right, we find 15 acres in the 30-chains perimeter-increase column and 27 acres in the 40-chain column. By interpolation we see that 20 acres would fall approximately at 34-chains-per-hour perimeter increase.

In a fire report actually checked, the following data were given: Elapsed time from discovery to first attack, 1.2 hours; area when discovered, 0 acres; perimeter increase in chains per hour, 15; final perimeter, 90 chains; area when attacked, 18 acres; and area when controlled, 26 acres. The table indicates a perimeter of approximately 78 chains for a 26-acre fire, but the 90-chain entry is well within acceptable limits and would not be questioned. However, the perimeter increase of 15 chains per hour is obviously low if the size at time of attack and elapsed time from origin to attack are correct. Reading to the right from 1.2 hours in the elapsed-time column of the table, we find 15 acres in the 50-chains-per-hour column and 22 acres in the 60-

chains-per-hour column. Interpolating for 18 acres, we would get 54 or 55 chains per hour as the rate of spread, rather than 15 as indicated. Thus, in 1.2 hours elapsed time the perimeter would be 65 or 66 chains, which is reasonable for an 18-acre fire. Where such large discrepancies are found, it is probable that the report would be returned to its source for correction.

A slightly modified procedure is required where a fire has attained a reportable size at time of discovery. The first step is the same as above—locate the elapsed time from discovery to attack in the column at the left. Then read to the right to obtain the rate of perimeter increase that gives the area when discovered, and subtract this figure from the rate of perimeter increase that gives the area at first attack. The difference is the rate of spread from discovery to attack.

This table will be useful to anyone responsible for reviewing fire report forms.

MEASURING HUMAN EFFORT AND FATIGUE

MISSOULA EQUIPMENT DEVELOPMENT CENTER
Missoula, Mont.

An important criterion of the worth of a machine, handtool, or work technique is the amount of human effort required to use it. Frequently the adoption or rejection of a machine or work technique, or the acceptance of one of several similar machines or work techniques, is contingent upon the answer to this question: which one is less tiring to use?

Heretofore, Missoula Equipment Development Center engineers have determined human fatigue or stress in an informal manner. Men testing new tools or work techniques would be asked how tiring it was to perform a task in a prescribed manner or to operate a particular machine, or which of several machines was less tiring to operate. The opinions of men actually doing a job will always be important in the evaluation process. For comparative purposes, however, results obtained subjectively are of little use. Such data cannot be plotted on a graph or a chart. A project has been started to develop objective methods for measuring fatigue or stress produced when performing physical tasks common to forestry activities.

A method of measuring energy cost, fatigue, or stress must meet these requirements:

1. The apparatus must not hamper the test subject's normal movements while performing tasks such as hiking, running, digging, chopping, or sawing.
2. The apparatus must be rugged enough for field use.
3. The measuring technique must not require extensive training or special knowledge on the part of the operator.
4. Equipment must be inexpensive.
5. The method should follow accepted practices and be a valid index of human stress.

Methods of Measuring Human Energy Costs, Fatigue, or Stress

A search of pertinent literature disclosed two accepted methods of measuring energy expenditure:

Analysis of waste respiratory gases.—Test subjects wear a closed-circuit breathing apparatus; gases expired during a prescribed exercise period are collected and analyzed. A person's oxygen consumption per minute is calculated from the volume of oxygen remaining. Oxygen consumption is then converted to energy expended, expressed as calories per square meter of body surface per hour (calories/m.^{2}/hr.). One liter of oxygen consumed is equivalent to 5 calories of energy or 3,086 foot-pounds of work. This method is best suited to laboratory experiments.

Monitoring Heartbeat.—Human fatigue and stress can also be evaluated by monitoring the test subject's heartbeat prior to, during, and after exercise. The degree of fatigue is indicated by the time it takes the test subject's heart rate to return to the pre-exercise level. Instruments for monitoring heartbeat include the common stethescope, heartbeat totalizers, and audio and photo-electric counting devices. Heart rate analysis seems most promising. Some monitoring devices of this type are small, do not hamper the test subject's movements, and are rugged enough for field use. A photocardiotachometer, which measures the rate of heartbeat by recording blood pulsations in the test subject's ear lobe, is now being assembled by our electronic technician. Data obtained by monitoring heart rates shows excellent correlation with those obtained through gas analysis.

Our engineers have completed a mechanical treadmill (fig. 1), a device widely used as an exerciser by physiologists wherein temperature, humidity, workload, and type of exercise must be closely controlled. It is expected that this exerciser, the photocardiotachometer, and gas analysis equipment will enable us to obtain objective data on fatigue, stress, and energy costs incurred while performing various types of Forest Service work both in laboratory tests and in the field.

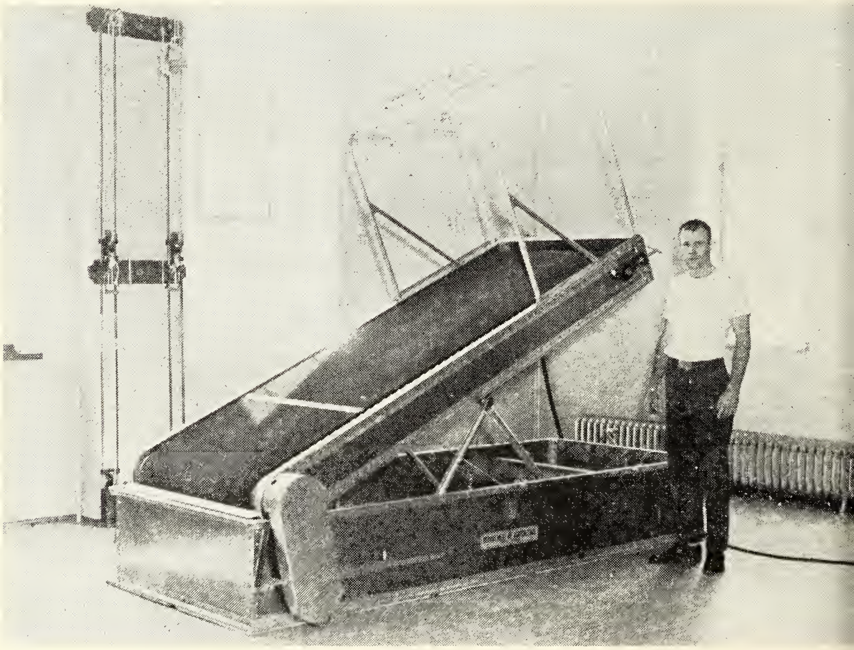

FIGURE 1.—The treadmill is a standard exerciser for calculating human fatigue.

Experiments to Determine Fatigue

Tests were conducted to determine the practicality of using heart rate and monitoring devices to validly indicate fatigue and stress.

Test Procedure

The time interval required for the rate of heartbeat to return to normal following exercise is an indication of physical fatigue. The primary factors affecting the subject's rate of heartbeat are environment and workload. Environment includes temperature, humidity, and clothing. Heavy workloads increase the rate of heartbeat and lengthen recovery time. Lighter workloads result in lower heart rates with faster recovery time.

Four tests were run with two independent variables—environment and workload. A bicycle ergometer (fig. 2) was used as an exerciser. Varied workloads were established. Ten 5-minute work periods were established for each of the four tests, for a total of 50 minutes per test.

FIGURE 2.—Bicycle ergometer used in experiments to determine human fatigue.

Heart rates were measured with standard stethescope and stopwatch at controlled room temperature. Blood pressure readings were taken to reinforce and supplement the measurement of normality.

Fatigue and stress indicators were curve plotted and evaluated by finding the sum of the ten 5-minute exercise period *partial* recoveries and the time elapsed from the moment exercise ceased (end of the 50-minute work period) until recovery was restored.

Heart rate tests in the laboratory have substantiated this method as being practical for measuring fatigue in the field. In future tests a motor-driven treadmill will be used as an exerciser, and a phototachometer will be the monitoring instrument. Further experiments will measure the energy cost and fatigue incurred by firefighters operating two types of motor-driven fireline trenchers. Also, the energy cost and fatigue of backpacking a load will be compared with wheeling it.

CHILDREN-CAUSED FIRES ARE INCREASING

E. S. Bliss
Forester, Southwestern Region, Forest Service

[*Editor's note.*—This article presents a new and somewhat revolutionary proposal to help prevent fire caused by children. Some may argue over the practicality of this suggestion, but it points to a problem that is not being adequately handled. Other ideas and suggestions are invited for publication in Fire Control Notes.]

Analyses of wildfires started by children in the Southwestern Region, U. S. Forest Service, indicate that they are increasing. Such fires occur most frequently where cities or towns encroach upon the forests. Also, children-caused fires have often occurred near campgrounds and not so often at picnic grounds. There is no record in this Region of fires started by girls, but some were started by boys only 4 and 5 years of age. Considerable thought has gone into preventing children-caused fires. Close cooperation with city fire and police departments has helped. Intense patrolling of critical areas has also prevented many fires. Public appeals to parents have not been fruitful. One based on personal danger to the children yielded no apparent result. Parents seemed fatalistic, at best, about the welfare of their children.

In legal jargon any attractive nuisance that will burn, such as brushpiles, stacks of papers, etc., seems an open invitation to children to set it afire. Unburned brushpiles in the near vicinity of a camping area were the indirect cause of eight wildfires in 1962, all started by small boys. Piles of fuelwood at campgrounds are also an attraction to children, but usually are too difficult for them to light. Preventive measures should include disposal of all needless hazards before the fire season starts. "Fireproofing" critical areas has also been found reasonably effective if most dead flammable material is removed from the ground, dense growth thinned, and lower branches of larger trees pruned. Young trees growing where they could carry fire into the tops of mature trees should also be removed.

Most States have parental responsibility laws similar to those of Arizona and New Mexico—that parents are liable to some degree for the wrongs of their children if the children's acts are motivated in malice. Making these laws ineffective are the criminal laws of most English-speaking jurisdictions that children under 14 years old are not responsible for their criminal acts unless it can be clearly shown that the child knew the wrongfulness of the act at the time it was committed. (On this basis children under 14 committing such acts are not usually considered malicious.) As children seldom have estates in their own right to satisfy court judgments, and under 14 are almost immune to criminal law, legal measures to prevent children-caused fires are largely precluded.

Where laws do not prohibit publishing the names of youthful offenders and their parents, publicity has been found effective in curtailing youthful depredations. Encouraged by lawmen, several States are considering repeal of existing juvenile probation laws that prevent publicly naming young offenders and their parents. Most of these laws were passed about 50 years ago, sparked by Judge Ben Lindsay and his followers who openly declared that there were no bad children, only bad parents and bad environments. Children must be protected against public censure for bad acts for which they should not be blamed. The fallacy of this argument is now evident to any thoughtful person, and it has resulted in great increases in juvenile delinquency.

This article submits for consideration a measure to curb children-caused fires in very critical fire areas. Where authority exists or can be obtained, these areas should be closed to children under 14 years of age unless accompanied by their parents or other responsible adults during critical fire conditions. Patrolmen would be needed to enforce this measure, but their efforts would then be more effective. Probably less patrol time would be needed than at present, when a patrolman must frequently follow a gang of boys for hours to make sure their activities do not include fire starting. The gang would be put out of the closed area, and—after making sure they were not returning—the patrolman could go about other business. Curfew laws have been effective in some States and England in preventing this and other juvenile offenses. The cost of preventing and controlling fires has mounted to the point where new and possibly restrictive measures seem justified.

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.

THE FUTURE OF OUR FORESTS

IS IN YOUR HANDS!

Follow Smokey's A-B-C's

***A**lways hold matches till cold —then break in two!*

***B**e sure you drown all fires out—cold!*

***C**rush all smokes dead—in an ash tray!*

FIRE CONTROL NOTES

PERIODICAL DEVOTED TO THE TECHNIQUE OF OREST FIRE CONTROL

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VOL. 24 NO. 4

October 1963

orest Service
NITED STATES 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 24 Number 4

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, firefighting, 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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Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1963

CONTENTS

FIRE BEHAVIOUR STUDIES IN AUSTRALIA

A. G. McARTHUR AND R. H. LUKE[1]

[*Editor's note.*—At this time, when we in the United States are about to embark on a national system of fire danger rating, a report of accomplishments to that end in Australia is gratifying. Admittedly, the problem there is different because the range in climate, topography, and vegetation is not great and because comparatively few organizations are involved. Thus, uniform guidelines for application have developed to a degree far greater than would be possible among the diverse geographic regions in the United States.]

Hazard-wise, Australia can be classified into three main types of area:

Insufficient fuel	60	percent
Subject to grass fires	36	"
Subject to forest and scrub fires	4	"

Broadly speaking, the protection of grasslands and some scrub areas is the responsibility of farmers and graziers organised as unpaid volunteers into legally recognised bush fire brigades. The forest services of the States and Territories are responsible for the protection of about 50 million acres of commercial forest.

The acceptance of national fire danger tables does not present great difficulties in Australia. Because of the small number of States there are only a dozen or so organisations to be consulted, and the range in climate, topography, and vegetation is not great. The work of preparing national tables has been entrusted to the Commonwealth Forestry and Timber Bureau, Canberra, in consultation with State and other authorities.

Since 1953 some 5,000 individual fire reports have been analysed, and 500 large-scale experimental fires studied, under a wide range of fuel and weather conditions. The detailed analysis of major "blow-up" fires has also contributed to our knowledge of fire behaviour.

As a result of this work national fire behaviour tables have now been produced for both grassland and forest conditions. The majority of fire protection agencies are now using them, but it is too soon to say that they have been universally adopted. The Commonwealth Bureau of Meteorology is using the tables in providing fire danger forecasts to the general public through press and radio.

The tables adequately represent the present state of our fire behaviour knowledge. For convenience only 6 variables out of a possible 12 or 14 have been used. As our knowledge increases through a careful programme of experimental burning in a wide range of fuel types, the tables will be improved. A reappraisal would be desirable at least every 5 years.

In preparing the tables the use of hazard sticks for the assess-

[1] Respectively, Senior Forestry Officer, Forestry and Timber Bureau, Canberra, and Fire Protection Officer, New South Wales Forestry Commission.

ment of fuel moisture has been dropped in favor of "straight out" meteorological elements.

In the forest fire danger tables a basic fire danger index is first derived. This assumes that (1) the lesser vegetation is 100 percent cured and (2) no residual wetting from recent rain is present in the heavier fuel components. Shade temperature, relative humidity, and wind velocity are the variables used to derive a range of basic fire danger from 0 to 100. The index of 100 represents "worst possible" conditions in a surface fuel concentration of 5 tons per acre. This is a representative figure applicable to eucalypt forests which have been unburnt for 10–15 years. A 5-point classification of low, moderate, high, very high, and extreme is used and is directly related to rate of spread and difficulty of suppression in the 5-ton-per-acre fuel type.

The effect of recent rainfall is taken into consideration in arriving at a drought factor based on the amount of rain, elapsed time, and the degree of curing of the grass component of the surface fuel. At a drought factor of 1 the full basic index is effective. At values less than 1 the basic index is reduced proportionally.

Tables tend to be somewhat inflexible due to the necessary grouping of classes. To overcome this, the national system has been converted to slide rule form. Mark I of this system was in a square form with three slides. This has been recently converted into a circular slide rule similar in format to the U.S. Forest Service Type 8-100-0 meter. Additional variables can be built in as their relative influence on burning conditions is defined.

Rate of spread for a given fuel quantity is related directly to the fire danger index (table 1).

TABLE 1.—*Rate of headfire progress over an extended period in high forest*[1]

Fire danger classification index		Quantity of surface fuel		
		10 tons/acre	5 tons/acre	2 tons/acre
		Chains per hour	*Chains per hour*	*Chains per hour*
Low	1–5	1–8	½–4	0–2
Moderate ...	6–12	9–18	5–9	2–4
High	13–24	19–37	10–18	4–9
Very High ..	25–50	38–75	19–37	9–12
Extreme	51–100	76–150	38–75	12–30+

[1] Tables for grasslands are organised on similar lines. See McArthur, A. G. Fire danger rating tables for annual grasslands. Forestry and Timber Bureau, Canberra. 1960.

The fire intensity in a specific fuel type is related directly to the fire danger index and is thus proportional to the rate of forward progress. Similarly fire damage per acre is directly proportional to the fire danger index in a constant fuel type. The potential size of a fire is the product of the rate of spread and suppression difficulty as represented by control time. It is a power function of the danger index.

In Australian forests, because of the oil content of eucalypt leaves and of the flash fuels common on the forest floor, fire behaviour, during periods of very high to extreme danger, often

FIGURE 1.—Experimental fire No. 556 south of Dwellingup, Western Australia, 21.3.62. This fire is burning in a 20-year-old fuel type averaging 7 tons per acre and represents behaviour 1 hour from origin. Flame height is around 20 feet, and the headfire is throwing spotfires 15–20 chains in advance. This is a three-dimensional, high intensity fire and provides much necessary information on erratic fire behaviour.

involves crowning, long distance spotting, and high rates of spread. In some forest zones containing scattered grassland areas, long distance spotting and virtual mass ignition have produced forward rates of spread of 6–8 miles per hour for several hours. Effective suppression under conditions of very high to extreme fire danger is therefore difficult and sometimes impossible while a fire is making its run.

FIGURE 2.—Experimental fire No. 563 near Dwellingup, Western Australia, 23.3.62. The fire is burning in 2-year-old leaf litter averaging 1.5 tons per acre and represents behaviour at 120 minutes from the time of origin. Flame height on the headfire is 2 feet down to 1 foot on the sides. This is a two-dimensional, low intensity fire and represents ideal control burning conditions in this fuel.

A glance at table 1 will emphasise why there is widespread interest in hazard reduction as a means of restricting fire spread under severe conditions. Naturally the studies made first for the preparation of fire danger tables soon led to the examination of means to carry out control burning safely and economically (see Forestry and Timber Bureau Leaflet No. 80, "Control Burning in Eucalypt Forests" by A. G. McArthur). The factors to be considered are total quantity of surface fuel; quantity of surface fuel available for burning, determined by the pattern of recent rainfall; ambient temperature and relative humidity relationship which affects surface fuel moisture content; time of day in relation to safety and fuel sorption; and the effect of wind, slope, and these other factors on rate of spread and flame height. Flame height is related to scorch level. The height to the base of the crowns of the eucalypts determines permissible scorch level and therefore the permissible flame height. The control burner must then study weather and fuel conditions to enable him to restrict flame height.

The burner must also study the spacing of the spotfires and the pattern of burning in order to avoid undue increases in fire intensity when adjoining fires draw together.

When reading an account of any research programme, there is a tendency to ponder the extent of its application in the field. In this case the relationship is a very close one. Western Australia has recently felt the need to overhaul its hazard reduction programme, and a large proportion of the control burning studies

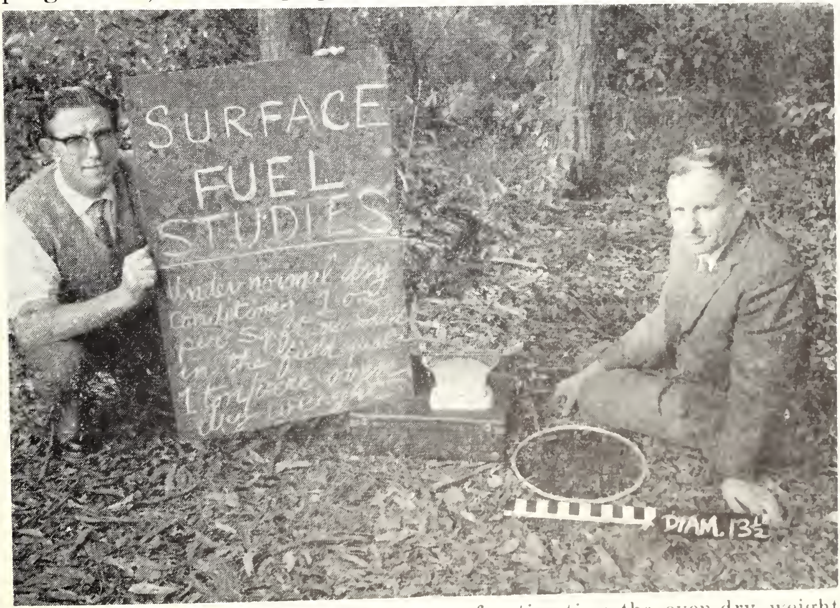

FIGURE 3.—Illustrating a simple means of estimating the oven-dry weight per acre of cured surface fuels within the range of 10–25 percent fuel moisture content.

were done with early application in view. The desire for a satisfactory system of fire danger rating has been universal in all States. In this article, however, we will confine ourselves to the position in New South Wales.

The first step in that State has been the production by the New South Wales Forestry Commission of fire behaviour tables in an abbreviated form for quick reference in office or field. On a card measuring 12 by 10 inches, folding to 4 by 10 inches, the tables relating to forest fire danger rating and to control burning in eucalypt forests appear in summarised form. There are also some additional graphs and tables which suggest to the forester the means for making local forecasts of temperature, humidity, and wind in relation to the movement of air masses and the location and spacing of isobars.

One thing always leads to another, and in New South Wales two further steps were taken. The first has been the provision of field weather kits, similar to those on issue within the U.S. Forest Service, so that foresters may measure the suitability of local conditions for control burning or prepare local forecasts in the field. The second has been the issue of photographs to illustrate various fuel types and to suggest simple means of making fuel studies in the field.

FIGURE 4.—This site, which has not been burnt for 16 years, is in an outer suburb of Sydney. The tree in the foreground is *Eucalyptus saligna*. Bladey grass (*Imperata* sp.) is a dangerous flash fuel when cured.

There are few specialists in the Australian forest services. Most field officers are accustomed to carrying out a wide variety of marketing, budget accounting, silvicultural, construction, and protection tasks. One of the jobs of the specialist is to digest his specialty into a few simple suggestions so that the field practitioner is not inundated with paper. Part of our purpose in preparing this article was to indicate our own attempts to get down to earth.

THE INTERREGIONAL SUPPRESSION CREW

DIVISION OF FIRE CONTROL, U.S. FOREST SERVICE

The recruitment, training, development, and organization of men into well-conditioned, highly skilled, versatile firefighting crews has always been an objective of the Forest Service. The "40-man," "Hotshot," and similar crews have been examples. A crew with high mobility along with the other criteria mentioned that can reach a large fire and do effective work during the first burning period has long been a dream of Fire Control people. The ability to move a crack firefighting crew to a critical fire situation on short notice adds a new dimension to a local unit's plan for control of a wildfire. The Forest Service had five commando-type interregional fire crews for the 1961 fire season and increased these to nine for the 1963 season.

Men for these crews have been recruited and trained in the western United States and are used primarily as reinforcement to initial attack forces. Crew headquarters have been carefully selected. Ideally, they are located near large airports and available to high priority fire work. This enables rapid transport by large aircraft to critical situations. When not actively engaged in training or suppression, they perform hazard reduction, maintenance, or construction duties.

Movement and use of interregional fire crews among the Regions has been coordinated by the National Fire Control Coordination Center in Washington, D.C. This permits a central office, which has the national fire control picture, to analyze and estimate potential situations and assign priorities when the demand for crews is greater than the supply.

A crew is normally composed of a foreman and 1 alternate, 3 squad bosses with 1 alternate, and 24 crew members. Men must be from age 18 to 45 and pass a yearly physical examination. They must be willing to fly and be away from home base for extended periods. Some crew members are required to have had previous firefighting experience. A few are trained in special skills such as operating power saws, trenchers, pumpers, and radios. Emphasis is placed on handline construction, mopup technique, use and care of hand tools and specialized equipment, organization, fire behavior, and safety. Each crew member is equipped with a fireman's pack and can be self-sufficient for 48 hours. Crews can be broken into several smaller units if conditions warrant, or can be combined with another crew if the going is slow and a larger crew is needed.

Experience has already shown that assignments to the interregional crews are highly prized. In some cases, the experience is used as a steppingstone to selection for smokejumping. It is customary for these "high-production" crews to be assigned control of the most difficult sectors of project fires. Outstanding performance under difficult conditions is expected and obtained. High morale and a certain esprit de corps are present in these groups, which consider themselves "the best." Performance to date indicates that they are meeting their objectives and giving the Forest Service a crack reinforcement force not previously available. Experience and training on these crews should also encourage students and other young men entering the Forest Service to consider careers as fire control professionals.

FIREFIGHTERS' WORK SHIRT

MISSOULA EQUIPMENT DEVELOPMENT CENTER
U.S. Forest Service

Several firefighters have died in the past few years from burns resulting from the ignition of clothing by flames and sparks. Evaluation of fire-resistant, orange workshirts during the 1961 fire season by smokejumpers and other special crews was extremely favorable. These personnel, in completing questionnaires, indicated the following assets of these shirts:

Color.—The bright orange color permits the quick location of men on fires by personnel in aircraft. Fireline overhead can maintain better contact with personnel when smoke and dust cause poor visibility.

Durability.—The shirts were equal to or better than ordinary work shirts.

Protection.—The shirt material is treated with a permanent, fire-retardent chemical. The shirts can be laundered or drycleaned many times without losing this protection. The material will char when in direct contact with flames or burning embers but does not support flame.

Use of these shirts averted a disaster on one large fire. During a blowup, a 20-man smokejumper crew was cut off from the escape route and took refuge in a helicopter spot. Intense heat and dense falling embers ignited several crew members' trousers and canteen covers. Later examination of their shirts showed only minute spark holes. The helicopter pilot who evacuated the crew stated that the orange shirts enabled him to locate them.

Because of the successful use of this shirt,[1] the Forest Service has adopted a Service-wide policy regarding issuance and use of flame-resistant clothing. Distribution of this clothing depends on the employee's estimated probable exposure to hazardous fireline conditions.

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[1] An interim specification has been prepared for the orange fire-resistant shirts. The specification includes small, medium, and large sizes. The neck sizes and sleeve lengths of the shirts are 14½–15 and 32 (small), 15½–16 and 33 (medium), and 16½–17 and 34 (large). The cost of each shirt is approximately $5.

MICHIGAN SAND CASTER—MODEL III

STEVEN SUCH
Supervisor, Forest Fire Experiment Station, Roscommon, Mich.

The Model III Michigan Sand Caster is a machine created to retard and suppress forest fires. It was designed and manufactured by the staff of the Forest Fire Experiment Station, Michigan Department of Conservation, Roscommon, under a project which began in 1957 in cooperation with the Forest Service, U.S. Department of Agriculture.

This machine is the third in a series of sandcasters, all of which were developed to test the effectiveness of sand in large volumes on forest fires. This model is intended to come as close as possible to a final design. The Model III is a self-contained unit having two engines—one to propel the crawler-tractorlike machine, and the other to provide power to the caster head. The caster, or rotor, is mounted in front and is hydraulically controlled to provide swiveling action through a 90-degree arc. It also has a hydraulically actuated deflector, permitting control of the trajectory of the discharge. Operation of the sandcaster is a two-man job; one man being in charge of the tractor movements, and the other controlling the sandcasting.

The physical dimensions of the sandcaster are:

Height	8 feet
Width	6 feet
Length	14 feet
Weight	15,000 pounds

Performance characteristics indicate a consistent discharge of 4 cubic yards of sand at velocities of about 6,000 feet per minute (70 m.p.h.), reaching elevations of 25–30 feet and distances of 50–75 feet. Fire conditions determine the pattern of sand discharge.

In practical use the sandcaster may have several functions. It is capable of building line similar to that produced by a fireline plow; it can extinguish flame by the direct application of the sand; it can pretreat areas ahead of the fire by placing sand on the ground or in aerial fuels—the sand acting as a retardant. The capability of pretreating makes this machine unique among other methods of forest firefighting. Sand is an excellent retarding agent, besides being a fine suppressor.

The Model III Sandcaster moves at 1 to 3 m.p.h., depending on the terrain and the density of growth. It operates in various cover and soil types, but discharges smaller volumes in the heavy sods and clays because such soils are more demanding of power. Buried obstacles such as rocks, roots, and stumps either stall the machine

or are discharged by the rotor or pushed aside. If the machine is stalled, a shear pin device protects the power train; also, the spring-mounted rotor head allows for some vertical movement to compensate for such occurrences.

Transportation to and from fires is accomplished by the use of a lowboy type semi-truck, such as those used for hauling tractors. Therefore, the speed of delivery to a fire is governed by road conditions and the speed of the truck itself.

The potential of forest fire sandcasters has not yet been established because of the lack of machines and experience. Because of their impressive performances, however, there is a growing conviction that they will eventually find their way into regular usage.

IMPROVED FIELD DESK

MISSOULA EQUIPMENT DEVELOPMENT CENTER
U.S. Forest Service

Fire bosses, timekeepers, blister rust control camp bosses, and others who must keep many records in the field will find their work greatly simplified by a portable desk designed by the Missoula Equipment Development Center (figs. 1 and 2). Constructed of light sturdy plywood, the desk folds into a compact unit which may be airdropped or trucked to remote areas. The cost of constructing the desk is approximately $160. Plans and materials lists are available from the Regional Forester, Missoula, Mont.

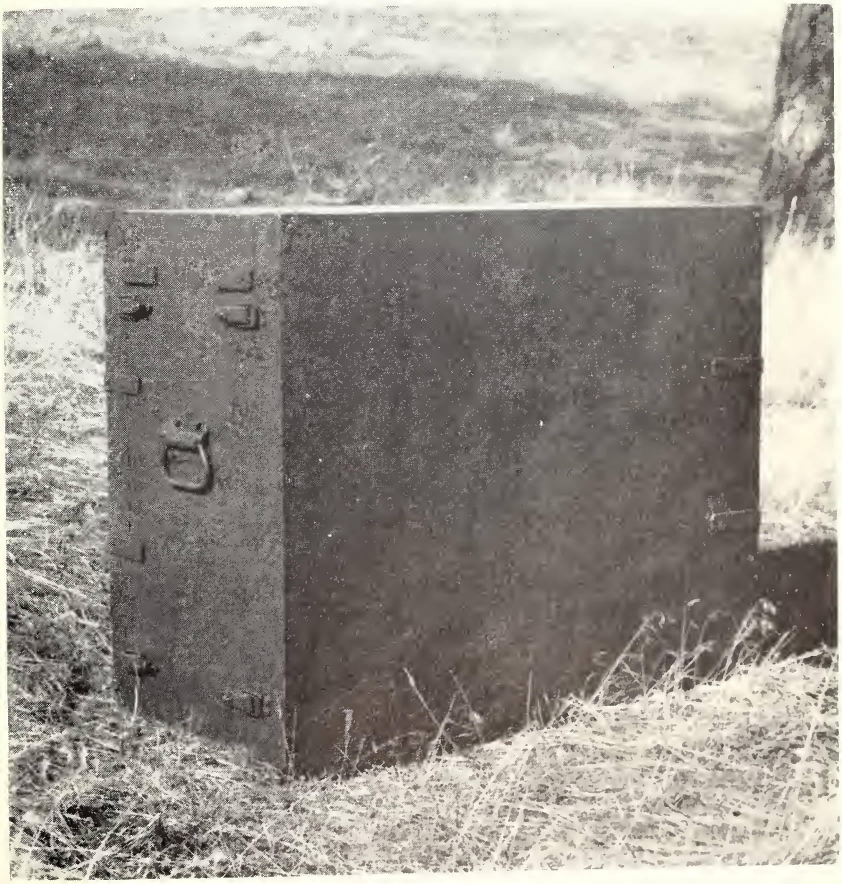


FIGURE 1.—When folded, the desk contains chairs, records, forms, writing supplies, and a gasoline lantern. The desk is 33½ by 28 inches. When empty, it weighs 106 pounds.

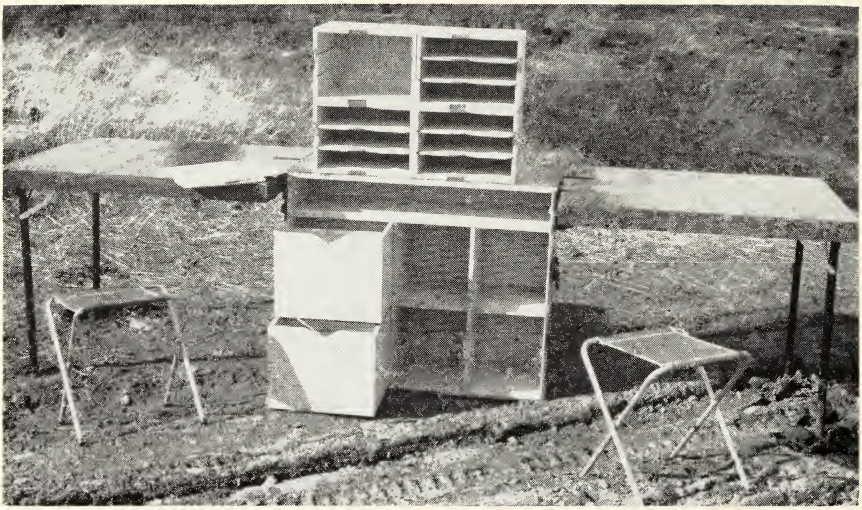
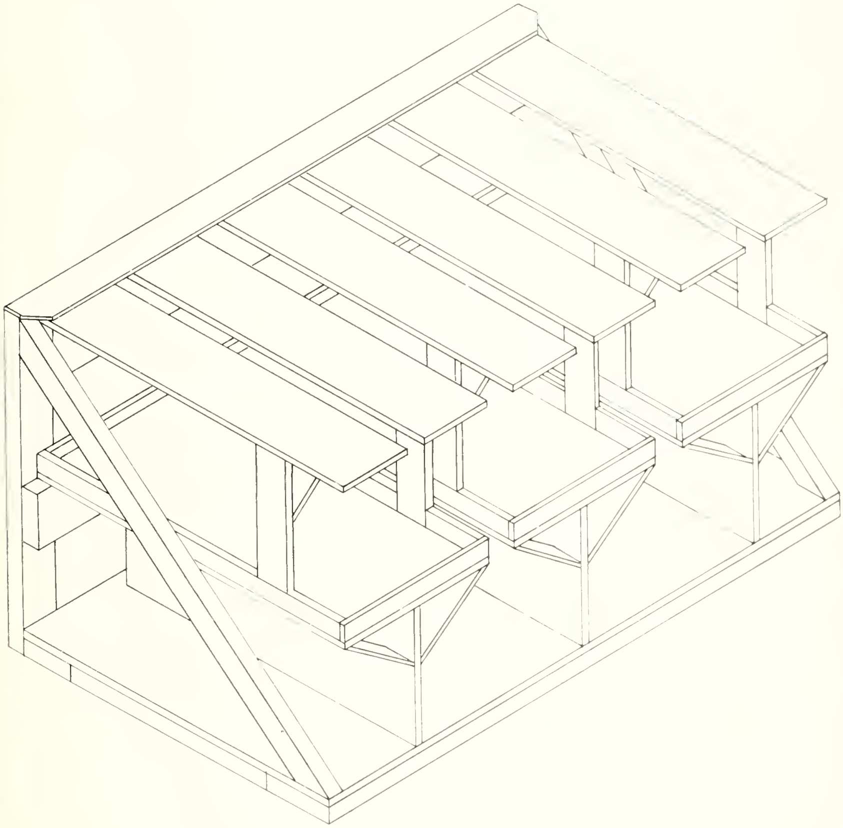


FIGURE 2.—When unfolded, the desk's covers convert to tables. Drawer partitions are adjustable.

CARE AND STORAGE OF HANDTOOLS

INTERMOUNTAIN REGION
U.S. Forest Service

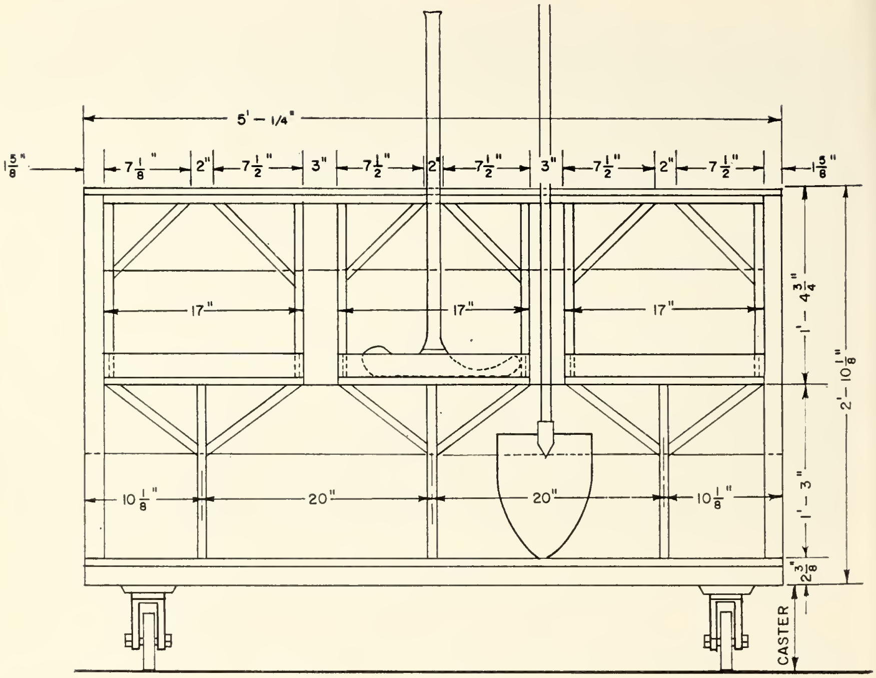
One method of storing fire control handtools such as shovels, pulaskis, and axes is by use of the rack shown in figure 1. The rack can be constructed easily from the specifications (fig. 2), using the material listed. Attaching castors to the rack facilitates loading, since it can be easily rolled to a doorway or ramp close to the truck. In some National Forests similar portable racks have been constructed for use in fire camps. Such racks help reduce damage to fire tools which often results when the tools are piled.



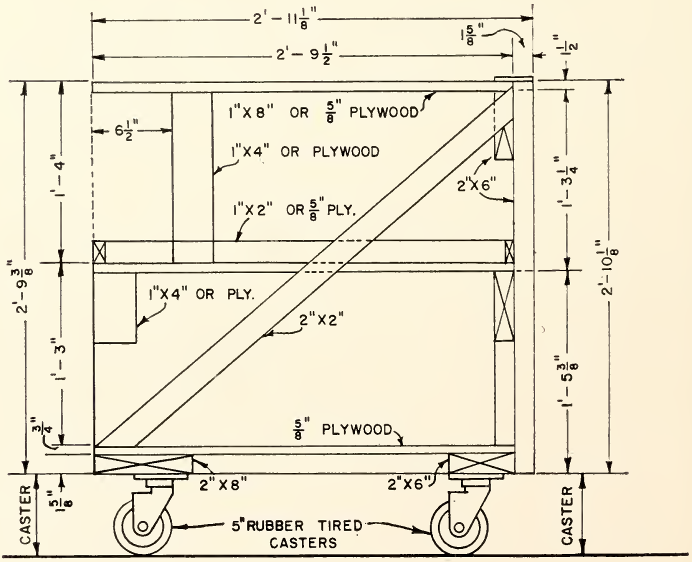
MATERIAL LIST	
QUANTITY	ITEM
2 Sheets	5/8" X 4' X 8' PLYWOOD
1	2" X 8" X 6'
2	2" X 6" X [illegible]
1	2" X 4" X 6'
1	2" X 2" X 6'
3	1" X 2" X 10
4	DARNELL NO. 1-75K CASTERS

NOTE: NAILS NOT INCLUDED IN MATERIAL LIST

FIGURE 1.



FRONT ELEVATION



SIDE ELEVATION

FIGURE 2.

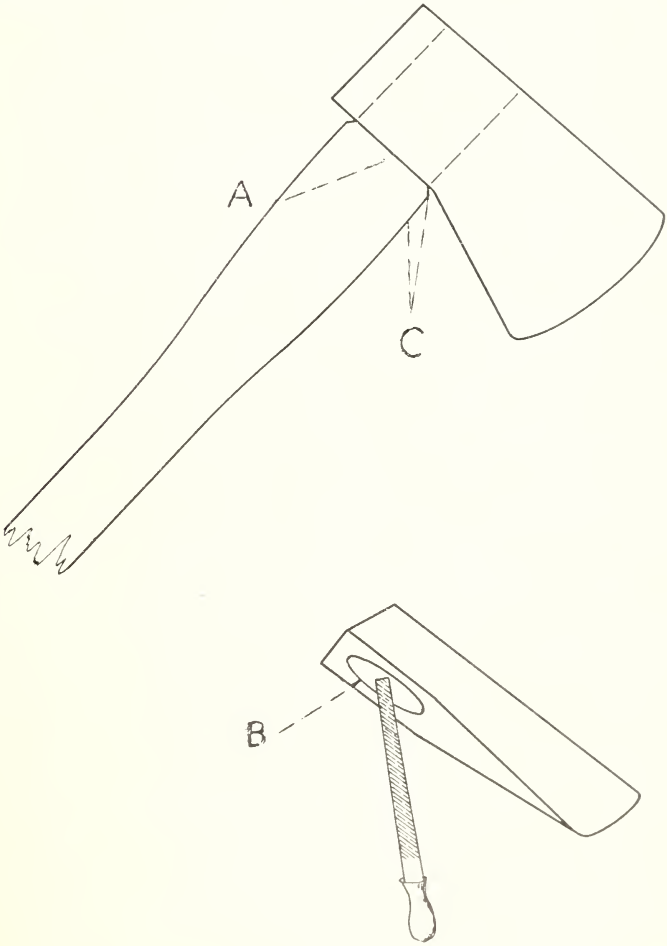
HANDLE BREAKAGE PREVENTION

LACY JOHNSON
Forester, Superior National Forest

Ax, pulaski, and hammer handles break most frequently just below the head (*A* in the figure). Much of this breakage can be prevented. Two factors, singly or combined, cause most handle breakage.

The first factor is the sharp metal corner at the inside edge of the handle hole (*B*). This corner forms a sharp apex from which handle breaks may start when a glancing blow is struck. This damage can easily be eliminated. When fitting a handle, file the inside of the hole to a rounded or beveled edge. This type of edge permits compression of wood fibers at the critical point.

The second factor is the presence of a heavy handle cross section close to the sharp corners of the haft hole (*C*). The heavy handle allows little spring or bending during the shock of a blow and in twisting of the blade. The heavy handle should be trimmed with a rasp, drawshave, or power sander before installation.



PLASTIC TENT FLY

MISSOULA EQUIPMENT DEVELOPMENT CENTER
U.S. Forest Service

Laboratory and outdoor tests of a 16- by 20-foot, reinforced plastic tent fly have been completed. This model has the following advantages over the standard cotton duck fly:

1. Unit cost is about $15, compared with $46 for the cotton duck fly.
2. It weighs 8.5 pounds, versus 46 pounds.
3. The plastic fly will not mildew and is a better reflector of heat and light.

Nylon reinforcing scrim, 22 threads each way, is sandwiched between two layers of plastic film. The material is cut and fabricated on the bias. Seams and grommet reinforcing patches are heat sealed. Tiedown grommets are at 3-foot intervals along the edges.

The plastic fly was exposed to outdoor weathering conditions for a 30-day period. Weather conditions during this testing period varied from mild temperatures with light rain to subzero temperatures, heavy snow, and wind velocities up to 30 m.p.h. Inspection of the fly after testing revealed no appreciable damage. All grommets held, and there was no seam separation.

LITTER FUELS IN RED PINE PLANTATIONS

J. H. DIETERICH
Research Forester, Lake States Forest Experiment Station

The weight and composition of forest fuels in red pine plantations are being studied over a large area in central Lower Michigan. These studies are designed to obtain basic information on total volume, moisture content, composition, and distribution of combustible material available in specific forested areas. To date, only red pine plantations have been studied. Fuel weight—especially available fuel weight—is an important factor in predicting fire behavior and intensity. Other factors that may be equally important are fuel moisture content, fuel size and arrangement, and chemical composition.

As a part of the Lake States Station's fuels study, some detailed measurements have been made on ground fuels under plantation stands (fig. 1). This work is a continuation and expansion of the red pine plantation fuel work done by LaMois[1] in 1958. In 1961, 16 separate stand conditions were sampled. Two 1/10-acre plots were randomly located in each stand. Age, site, and stand density were determined, and 10 subsamples of forest floor material were collected from each plot. The subsamples consisted of all dead organic material on the forest floor that could be readily separated from the mineral soil. In young red pine plantations, a sharp line apparently separates combustible material from the layer that is predominantly mineral soil.

As each subsample was collected, it was divided into two parts: The L layer (litter) and the F layer (all material below the L layer to mineral soil). The layers were relatively easy to separate by carefully removing the surface needles down to where the darkened needles were matted and lightly bound together by fungus mycelium. These two layers of material make up that portion of the forest floor that would be consumed by fire if the fuel moisture content was sufficiently low. The L layer is the surface fuel component that changes rapidly in moisture content and affects rate of fire spread.

Individual samples were analyzed in the laboratory by determining the oven-dry weight of the needles in the L layer, branchwood in the L layer, all material in the F layer, and miscellaneous material such as bark and cones. After these results were obtained, a total dry-weight value was determined and applied on a per-acre basis.

Depth measurements were also made of both L and F layers. Four depth measurements were averaged for each subsample. Knowing the depth and weight per acre of both layers, a total weight per acre of forest floor material was determined.

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[1] LaMois, Loyd. Fire fuels in red pine plantations. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 68, 19 pp., illus. 1958.

FIGURE 1.—A typical plantation of good site, 33-year-old red pine showing surface fuel conditions. This stand contains approximately 150 square feet of basal area and nearly 10 tons of combustible surface fuels per acre.

By separating the two layers and obtaining both depth and weight for each layer, density values were computed that indicate rather clearly why the less dense litter layer changes moisture content rapidly and may burn more readily. They also show why the F layer, with higher density, may retain more moisture and burn as a smoldering fire. These density values are:

L layer	7,000 pounds per acre-inch
F layer	11,600 pounds per acre-inch
Average forest floor	9,300 pounds per acre-inch

The *total weight* of forest floor fuels correlates well with basal area in the stands that were sampled. Figure 2 shows a weight prediction curve based on stand density or basal area per acre. Stand age may also be used to strengthen the prediction equation

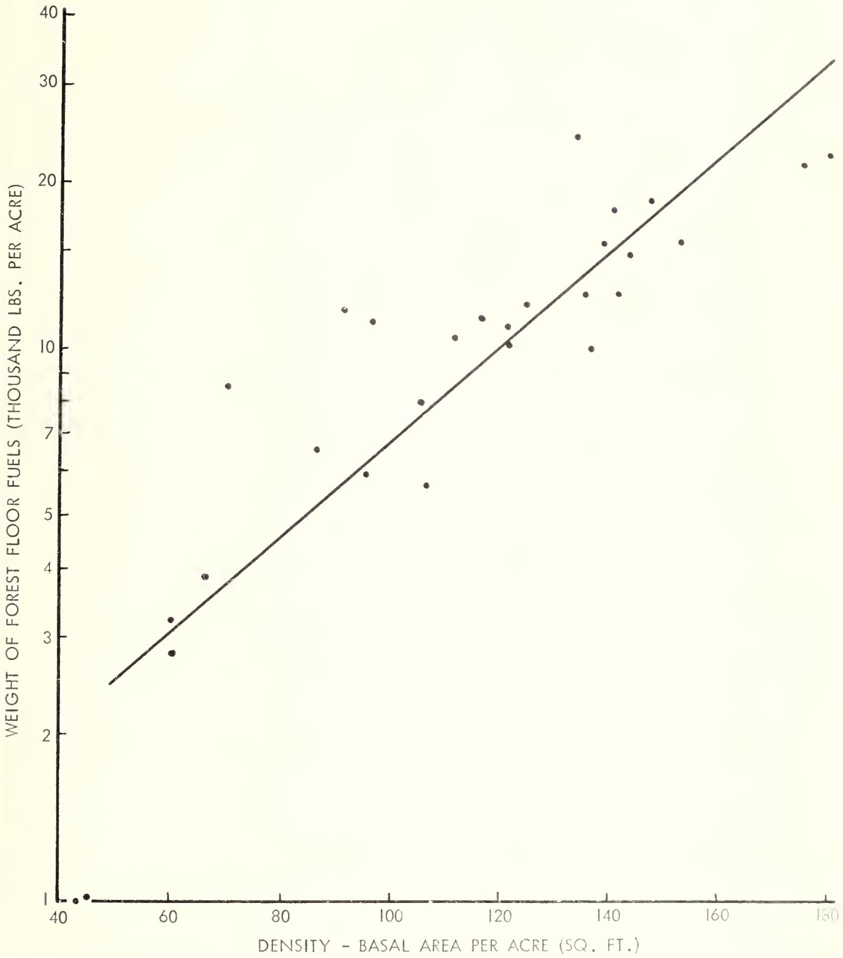

FIGURE 2.—Weight of forest floor fuels, according to stand density in red pine plantations on good sites in Lower Michigan. The prediction equation is: Log (forest floor fuel weight) = 2.9640 + 0.00877 × (basal area per acre).

for determining total weight per acre, but it was not included in plotting the data for figure 2.

Litter weight (L layer) also correlates well with stand density in stands 15 to 20 years old (fig. 3). Not enough stands older than 25 years were available for a representative sample in that category. The stands younger than about 10 years still had a mixture of grass and weeds on the grounds that precluded meaningful fuel estimates.

This study has established a procedure for systematically sampling surface fuel conditions in pure plantations of red pine. The work should now be extended to cover other conifer types and stands of mixed conifers, as well. It is generally recognized that surface fuel weights increase with both stand age and stand density. The amount of these increases has not been established for Lake States forest types. Surface materials are an important fuel component in established pine stands or plantations. Fuel volume determinations for these stands may eventually create a better understanding of fuel-fire relationships.

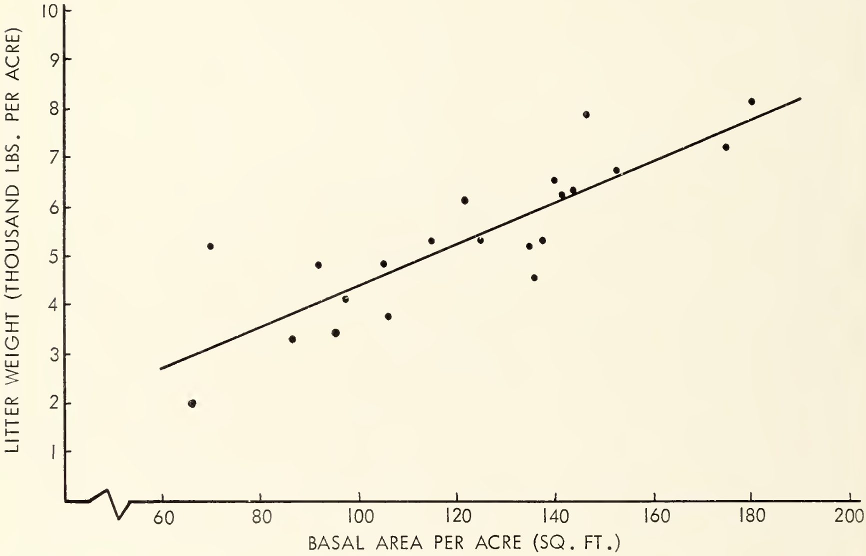

FIGURE 3.—Weight of upper layer needles or litter on good site red pine plantation, 15–25 years old, Lower Michigan. The prediction equation is: Litter weight in thousand lbs. per acre = 355 + 41.18 × (basal area per acre).

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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.*

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