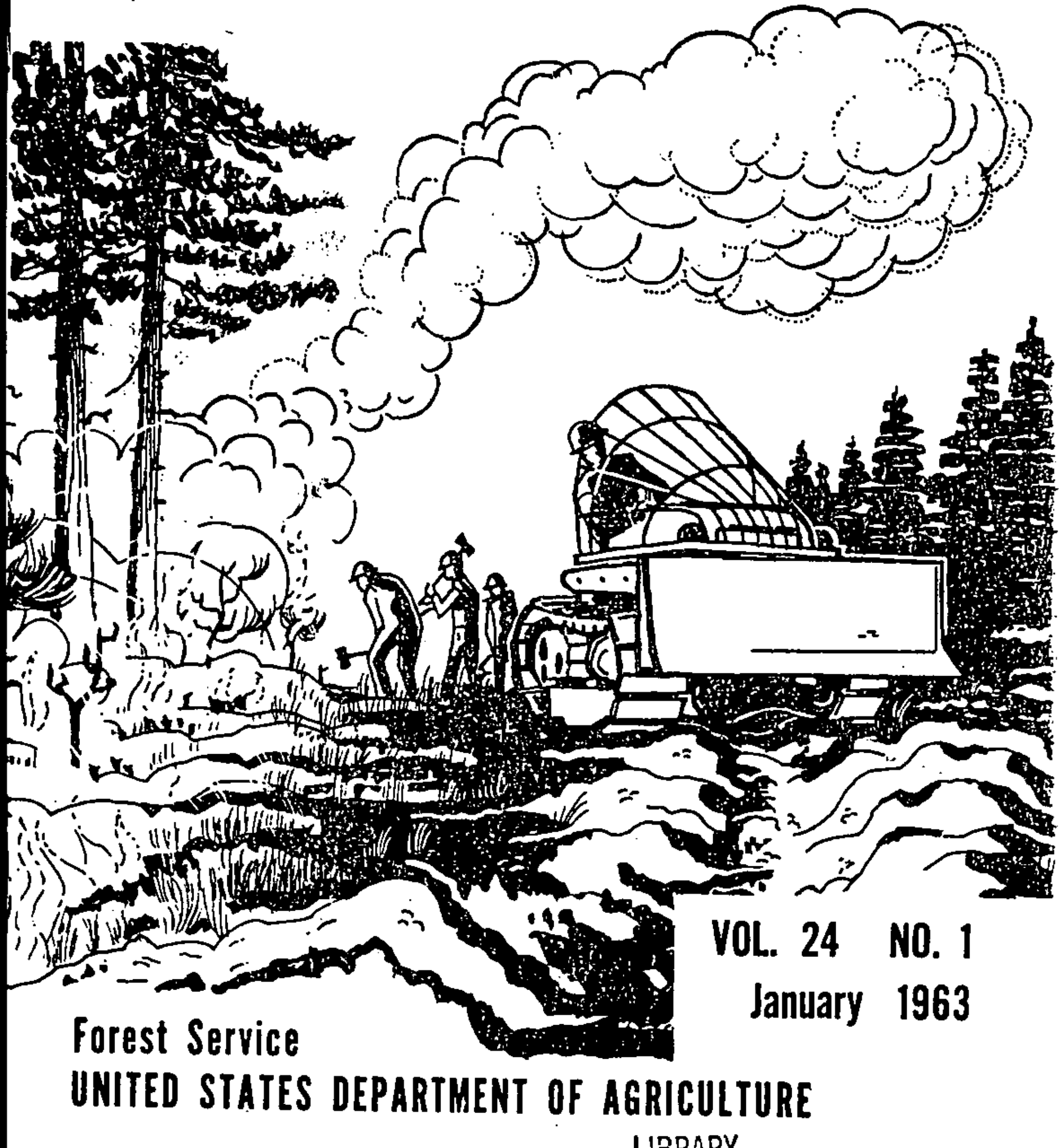
FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL



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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.

Growth Through Agricultural Progress

Volume 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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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 Mt. Baldy Ranger District, Angeles National Forest, by Fire Prevention Technician William J. Baden, who was on stake-out duty on a hill overlooking a suspected incendiary's home at 1:14 p.m. on August 13, 1962. The smoke rising from the head of Webb Canyon a few minutes later proved to be the final link in the solution of an incendiary problem that had been plaguing the District since 1957.

When it was definitely ascertained that the suspect's car had been the only vehicle in the area, the local police were alerted and the 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 setting of approximately 15 fires in the area since 1960. He would not confess to any before 1960. Nevertheless, officials were convinced that he was responsible for an additional 40 or 50 dating back 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 incendiarism, and the machinery that ultimately resulted in the apprehension of the suspect 5 years later was set in motion.

In the initial stages the usual measures to combat an incendiary problem were activated. Patrolling was intensified, license numbers of suspect cars were "checked out," possible suspects were screened, police authorities were checked for known "pyros," and even employees and former employees were screened for possible connection with the problem. Traps were set using employees in civilian clothes and private cars. They were placed with shovels in orange groves along routes of travel to the forest—simulating irrigators, sat with their wives in private cars on "lovers" points, and hid in the brush along roads to check cars entering and leaving the forest.

None of these measures were successful as there seemed to be no pattern or apparent motive as to when or where fires would be set. In 1958 two fires were set early in the season, then none. In 1959 no fires occurred on the District, but numerous others were set in the adjacent county area. Again, in 1960, three fires were set. No fires were set during the winter periods or during

the "Santa Ana" dry, desert winds. Large fires did not seem to be the objective, since some of the sets were surrounded by natural barriers.

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

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

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

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

4. Fires were set without regard to burning conditions. No attempt was made to select "bad" days or ignition points that would result in big fires.

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

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

Plans for Apprehension of the Incendiary

A car check system was developed to record the license numbers and entry and exit time of all cars traveling San Gabriel and San Antonio Canyons. The checkers were dressed in civilian clothes and used personal transportation. They were instructed to move about so as not to appear conspicuous. Some were to lift the hoods of their cars to simulate travelers cooling the motor, tires were deflated to simulate a flat tire replacement, 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 near the mouth of San Gabriel Canyon in county territory. The fire was quickly extinguished and before the ashes had cooled, investigators were on the spot analyzing the records of the checkers. This quickly pin-pointed a Volkswagen as the logical suspect from a time basis, and the owner was picked up for questioning.

It was soon apparent that the checking system had nabbed a "firebug," although the wrong one. He did not use a device, but confined himself to flipping matches into the brush until one "took off." He readily admitted setting the disastrous Sierra Fire, which had claimed the life of a firefighter, plus about 10 other fires. All of these, however, had occurred on the west end of the 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 car check system was re-activated. Suddenly the entire pattern of the incendiary fires changed. Fires were again being set, but only in the county portion of San Gabriel Canyon, and only after the checkers had gone home for the night.

The Plan is Expanded

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

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

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

This license number was found a number of times in the checkers records, but could not be tied to any particular fire. After an intensive study of the records a particular situation was noted on the traffic records in connection with the Mine Fire in San 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, the above two license numbers had been checked, but led to cars that were of different makes and had not been in the area on that day.

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

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 became evident that no white car was on the premises. On August 12 the stake-out reported arrival of the car at 11:00 p.m. At 1:14 p.m. August 13, under the eyes of Fire Prevention Technician William J. Baden on the hill above, the suspect left the house to set his last fire.

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

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

There was the night when one of our men, secreted in San Gabriel Canyon, was routed out by a county patrolman who was beating the brush for suspicious characters. On another occasion the stake-out was discovered and set upon by neighborhood dogs, creating such a disturbance that the operation had to be abandoned. On numerous occasions checkers were challenged by highway patrolmen. A checker and his wife were on stake-out one night when suddenly a figure loomed up beside them, shoved a gun through the window, and demanded to know who they were and what they were doing there. The checker had been keeping a suspect's house under surveillance for the past three or four nights. He was unaware that his activities had aroused the suspicion of a resident reserve policeman who was keeping him under 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 and highways interlacing the watershed and timbered areas of the four southern California National Forests may be the spawning place of most of the disastrous forest fires experienced in this area.

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

Mr. Show further stated that "the necessarily long-time solution of the smoker fire problem is clear. Continuation and expansion of policing, greater attention to fireproofing so that fires cannot start, and a systematic planned and continuous campaign of individual education. . . ."

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

Analysis of the Problem

Analysis of all man-caused fires, except those from railroads, that occurred on the San Bernardino National Forest during the 1950-59 decade reveals three significant facts relating directly to the forest and watershed fire problem in the National Forests of southern 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

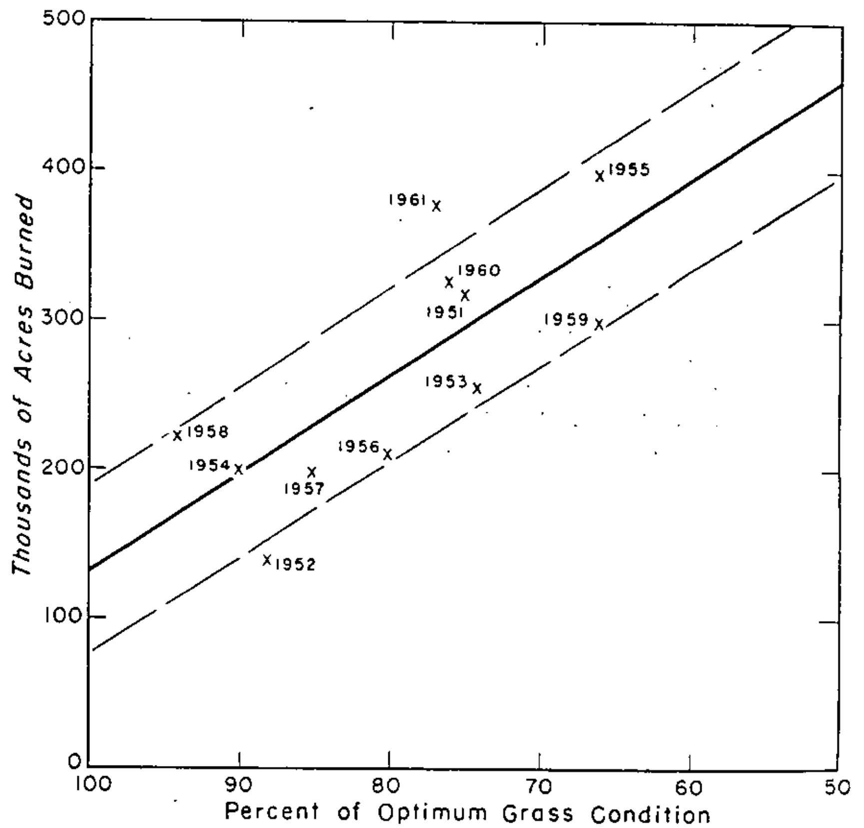
ARTHUR R. PIRSKO

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 U. S. Forest Service and California Division of Forestry reports. The amount of grass cover was taken from the May 1 Livestock, Pasture, and Range report of the California Crop and Livestock Reporting Service.[1] Grass ratings are subjective measures; 100 represents excellent grass condition; 90-99 very good; 80-89 good; 70-79 fair; 60-69 poor; 50-59 bad; 49 and less very bad. Both sets of data were for the 11 years, 1951–61.

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

Apparently, once a minimum grass cover is established to carry fire, the excess amount of grass is not an important factor in fire spread. At this point the controlling variables in fire spread are 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]

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Organized forest fire control has been in operation for more than 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

[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 is 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 2,000 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 per-

sonnel. 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.

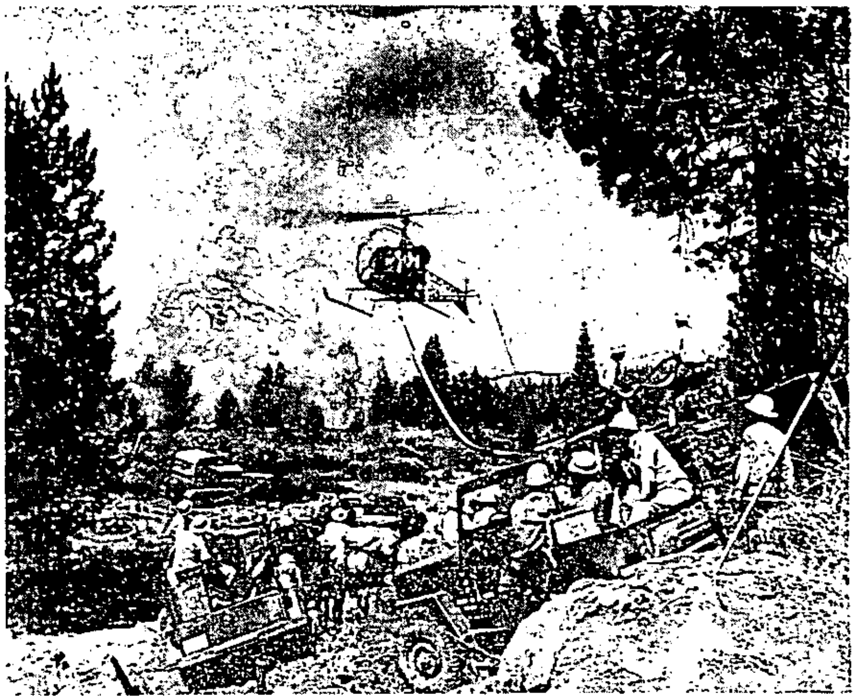
Fire Control

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.



Occasionally, the Laboratory is called on to test and evaluate new tools or procedures in fire suppression. In 1961 a sandcasting machine developed in Michigan as a cooperative project with the U.S. Forest Service was tested in some of Georgia's more hazardous fuels to evaluate the use of sand as an extinguishing or retarding agent. Although the machine exhibited certain limitations, the principle of sandcasting was judged sound and offers promise in the control of forest fires.

Fire Use: Prescribed Burning and Fire Effects

Although fire has been recognized as one of the first great forces employed by man, it has generally been considered an enemy of the forest. We know, however, that all use of fire in the woods is not bad. Properly prescribed, fire can accomplish planned benefits in the management of forest land. If we are to realize the maximum potential of a fire prescription, we need to know more 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. Nevertheless, air tankers alone seldom extinguish forest fires. They can only supplement a basic hand encounter on the fireline. Foresters are now looking for practical means of applying chemicals by ground tankers. Various State agencies and other fire organizations in the western United States have pioneered in this field by modifying existing tankers for mixing and pumping one or two firefighting chemicals, usually of the viscous water category. Very little work has been done on a basic unit capable of handling any chemical in present use. The Arcadia Equipment Development Center has designed and built a new tanker-mixer (fig. 1) that mixes, pumps, and applies any chemical, in current use, in a few minutes without the use of any other equipment.

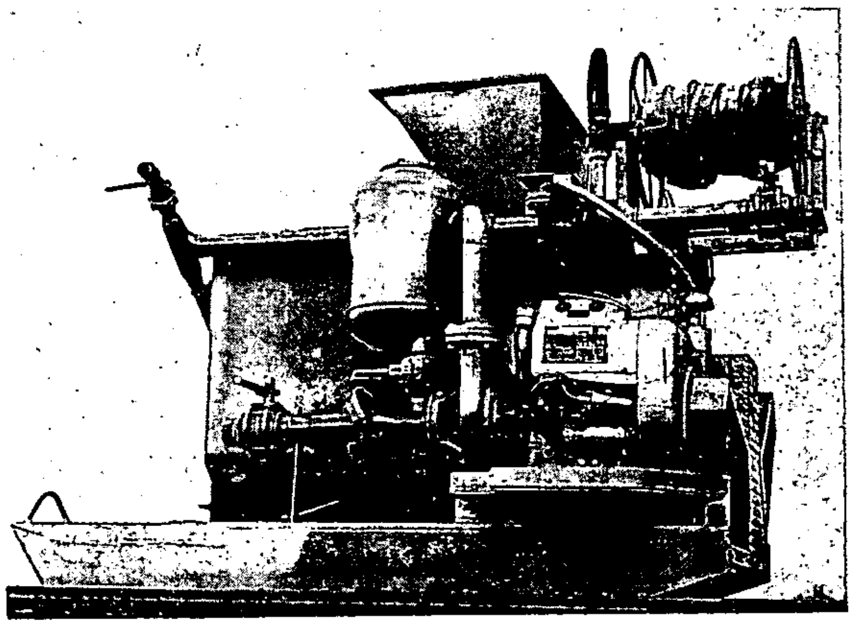


FIGURE 1.—Tanker-mixer designed and built at the Arcadia Equipment Development Center.

Purpose and Use

The tanker-mixer is a multipurpose slip-on unit that was designed for use on the ground, on heavy-duty trailers, and on flatbed 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 airport. It can be transported by ground crews to a helispot and used effectively as a mixer for helicopters. Basically, however, the tanker-mixer was designed for mixing and pumping firefighting chemicals on the fireline, for the pretreatment of roadside strips, and to confine slash disposal fires. When mounted on a heavy-duty trailer the tanker-mixer can be tractor drawn into areas that 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 engine, a pump, and a pump priming tank. The mixing tank houses a "side-entering" impeller assembly for mixing the chemical by agitation. Mounted on top of the mixing tank are the chemical hopper and the hose reel. The chemical hopper is large mouthed to facilitate pouring the chemical into the mixing tank. A knife edge is located at the mouth of the chemical hopper to cut the paper bag containing the chemical. Power is supplied to the unit by a 30-horsepower, air-cooled, 4-cylinder engine. The pump is 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 insure priming, a pump priming tank has been added, which also allows drafting from points lower than the unit. This allows the unit to be supplied with water from streams or lakes as well as from fire trucks, tanks, and mother tankers.

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

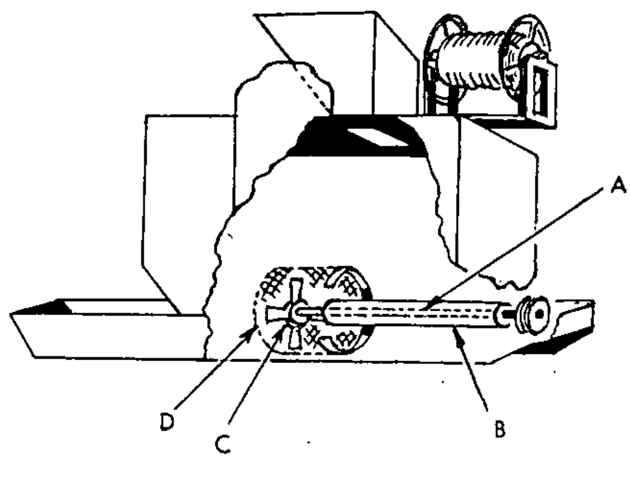


FIGURE 2.—Cutaway view of impeller assembly (*A*, 1 3/16-inch metal shaft; *B*, 3-inch galvanized pipe; *C*, impeller blade; *D*, metal shroud).

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.

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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 George Nunnelee and I were making routine equipment inspections in Covington County, Ala. At approximately 2:30 p.m., while on higher elevations in the north end of the county, I commented to Mr. Nunnelee that a tall smoke in the south end of the county had the appearance of a potential "blowup fire." "Blowup" seemed highly improbable because of the condition of vegetation following a 1/10-inch rain two nights before. My comment was based on the appearance of the smoke which to me indicated adverse wind patterns over a control fire approximately 21 miles due south of us.

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

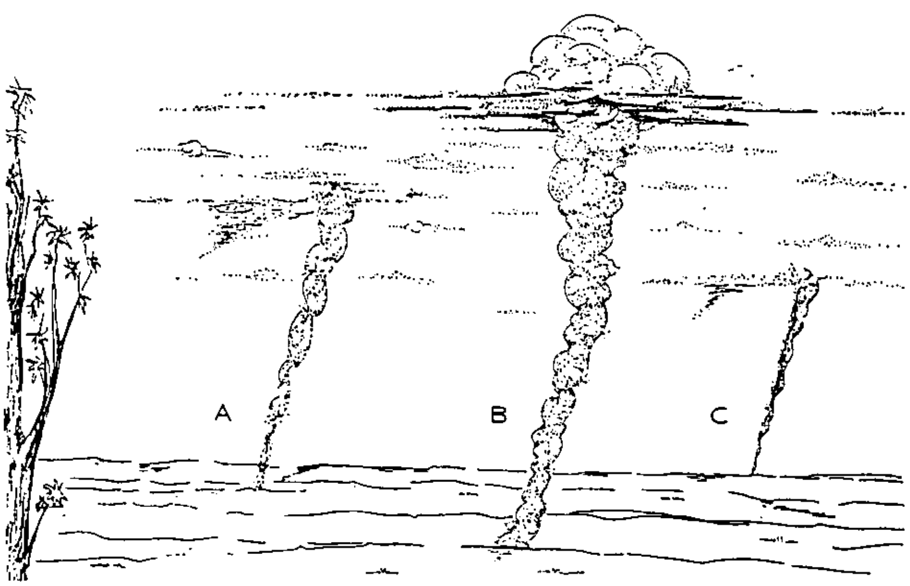

FIGURE 1.—Smoke columns over control fires as seen from a distance of 21 miles to the north. Column B is the smoke with which we came in direct contact. Columns A & C are from fires several miles from B.

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.

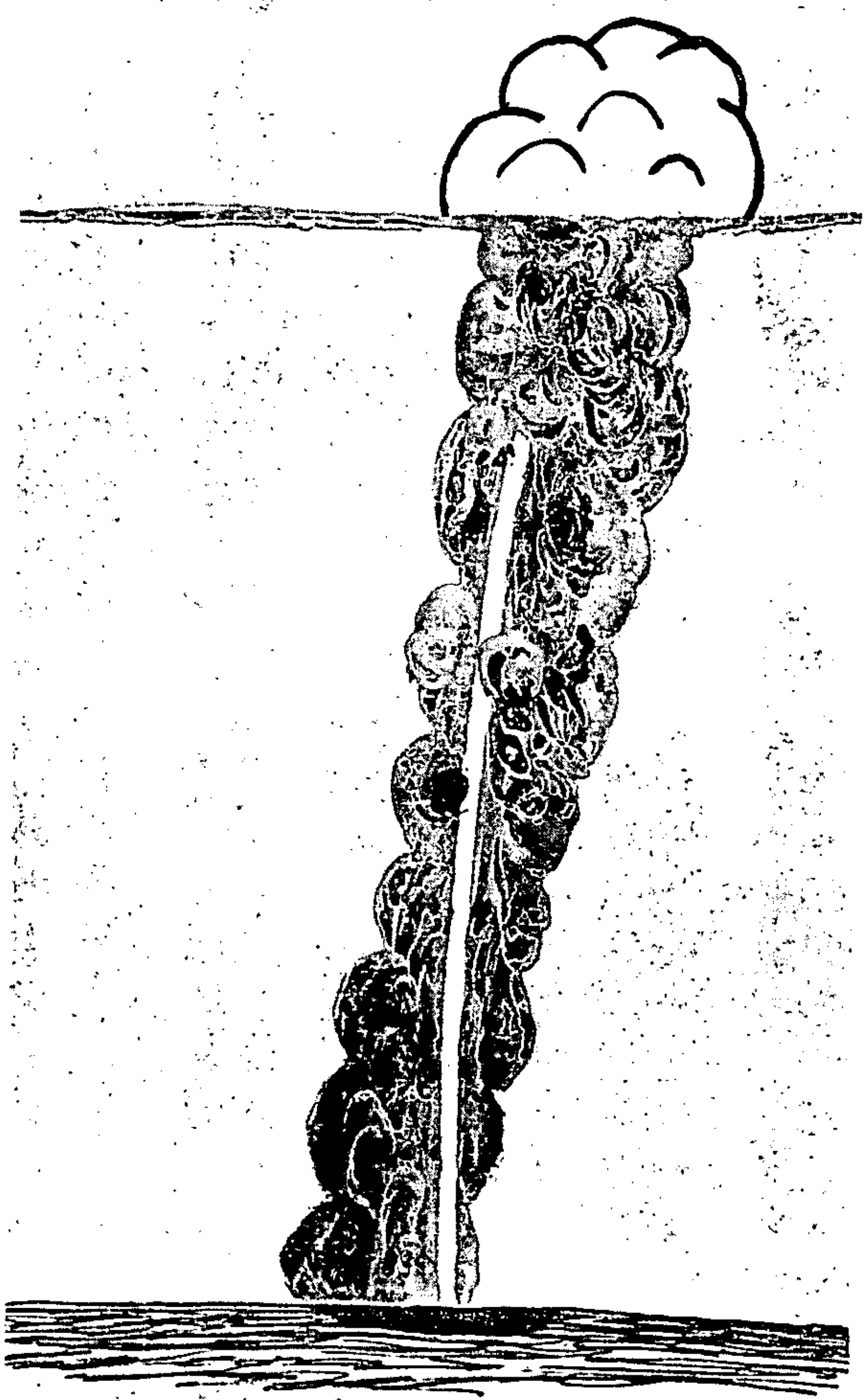

FIGURE 2.—Appearance of funnel as seen from the west.

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

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

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

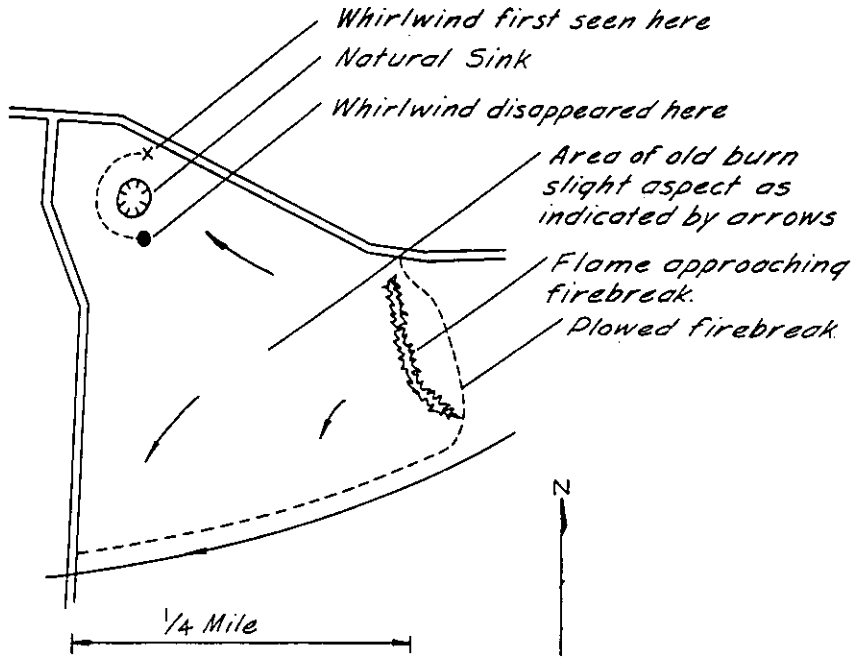

FIGURE 3.—Map of fire area.

While watching this whirlwind, I realized it was not the usual "firedevil" or "dustdevil" type often seen in or near forest fires; nevertheless, I had no idea that others had seen and reported similar 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 type from the small firewhirls produced on a model scale.[2]

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

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

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

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

On the 8-100 meter type fire danger rating station at nearby Lawrence Tower site, the buildup index was recorded as 34, the highest fuel moisture percent was 6.5, and the burning index was 12 in Fire Class 3.

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

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[2] Byram, George M., and Martin, Robert E. Fire-whirlwinds in the laboratory. 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.

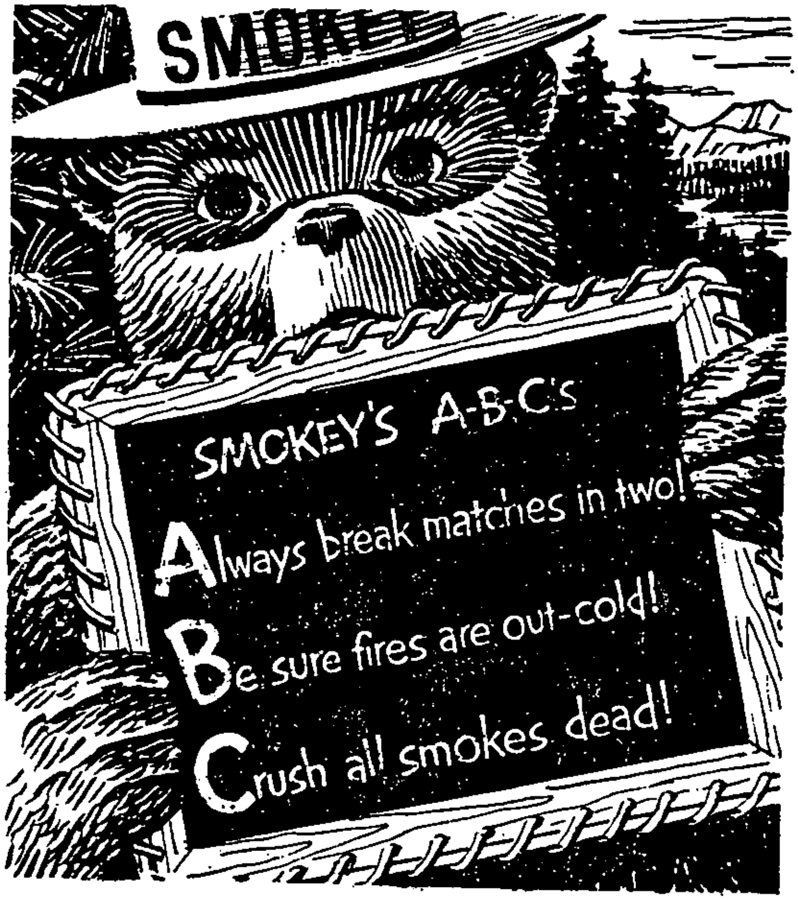
The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

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

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'S A-B-C's
Always break matches in two!
Be sure fires are out-cold!
Crush all smokes dead!