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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

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Volume 3 Number 4

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the TECHNIQUE OF FIRE CONTROL

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The value of this publication will be determined by what Forest Service officers, State forestry workers, and private operators 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, personnel management, 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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CONTENTS

THE USE OF CHEMICALS IN FOREST-FIRE CONTROL

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The Forest Service made its first test of chemicals for fire suppression in 1911 when carbon tetrachloride, a popular material for commercial extinguishers, was found to have no superiority over water in forest fire suppression. The World War led many men to believe that "chemical bombs" could be used effectively on forest fires. In response to this belief, the Chemical Warfare Division of the Army conducted an inquiry. Nothing happened. But the desire to make use of chemistry in fire control persisted. The author reports on the latest and most comprehensive attempt along this line. As a result of a 3-year research project, over 3½ tons of monoammonium phosphate with a 5 percent admixture of sodium dichromate to prevent corrosion of equipment, have been distributed to national forests for the conclusive test—in the hands of fire crews on actual fires as they occur. The current cost of this chemical mixture—17 cents per pound, plus about 2 cents for freight—may prevent its extensive use except in aerial attack, if that venture should prove successful. Foam producing solutions are also in experimental use on national forests, but the special equipment required for their use in man-pack cans is not satisfactory.

Research studies were undertaken in 1936 by the United States Forest Service, with the objective of learning whether chemicals could be used to advantage in forest-fire control and suppression. Studies (*1*, *5*, *8*)[2] of limited extent had been made at various times in the past, but no continuous and comprehensive investigation had ever before been attempted in this country. The use of chemicals as extinguishers for other classes of fires and under other conditions has stimulated the interest of both the public and those responsible for the protection of forest areas from fire in the possibilities of their use in forest-fire suppression. To the chemist, familiar with combustion and its control, the possibility of finding a material that is outstandingly superior to water or to existing chemical extinguishers has not seemed particularly promising. To the fire fighter, who has an understanding of conditions surrounding forest fires, the use of chemicals as an agent in control and suppression has perhaps been more of a hope than an expected development. However, the desire to employ all available ways and means of combating forest fires and to discover, if possible, any new materials of value, led the Forest Service to undertake a study of the possibility of making effective use of chemicals.

[1] Acknowledgment is made to the Division of Fire Control for financing this investigation; to the various forest experiment stations and administrative units of the Forest Service and the Michigan Department of Conservation for cooperation and assistance in making the field tests; and to members of the Forest Products Laboratory, particularly George M. Hunt, Arthur Van Kleeck, Howard D. Tyner, and Bruce G. Heebink, who participated actively in the investigation.

[2] Numbers in parenthesis refer to list of references at the end of this report.

It was recognized at the beginning that forest fires present a situation not at all analagous to the type of fires and the conditions under which chemical extinguishers are now largely employed. The principal characteristics of forest fires as related to the possible use of chemicals are: (*a*) They occur in the open with an abundant supply of oxygen for combustion and frequently under substantial wind velocities or air drafts. (*b*) The fuels are almost entirely cellulosic, with a wide range in form, size, and arrangement. Heavy timbers, grasses, leaves and needles, limbs and branches, rotten wood and peat are but a few of the types of materials involved. (*c*) A large percentage of forest fires occur in more or less inaccessible areas where transportation is difficult, water is often scarce, and the only equipment available during the early stages of attack are hand tools, such as shovels, axes, and back packs for water.

The purpose of this paper is to present the results of the investigation begun at the Forest Products Laboratory in 1936 and continued through 1937 and 1938. The results pertain primarily to the use of chemicals in water solutions, although the results of some tests on chemical foams are included. The data are from laboratory investigations and from field tests on fuels in several forest regions of the country.

Method of Investigation

The investigation involved three steps: (*a*) Review of the literature and search for promising materials, (*b*) laboratory tests to compare the effects of various compounds and to study variables in extinguishing fires in wood, and (*c*) field tests to compare results of the more promising materials on natural fuels of different types and arrangement.

The survey of the literature covered some 440 papers, patents, and other references, and indicated that a large number of materials in one form or another have been proposed or tried as extinguishing agents or retardants to combustion. Most of these may be classified as (*a*) gases, which alone or in mixtures with air of proper concentrations will not support combustion, for example, carbon dioxide; (*b*) liquids, which may be a single component, such as carbon tetrachloride, or water solutions of one or more chemicals; (*c*) solids, such as dry sodium bicarbonate; and (*d*) foams, most of which are a mixture of water, chemicals, and carbon dioxide gas. Some materials may occur in two or more forms, for example, carbon dioxide which is available as gas, liquid, or solid.

The usefulness of gases as extinguishing agents is generally considered to be limited to fires in inflammable liquids or to other burning materials in confined spaces where the fuel can be covered or surrounded by the necessary concentration of gas to prohibit combustion. This involves maintaining a layer of gas over the fuel until it has cooled below the combustion temperature. For materials burning in the open and in deeply glowing fuels where a considerable accumulation of heat exists, this condition is generally impractical to obtain. For these reasons, gases, which are effective under special situations, do not appear to offer promise as forest-fire extinguishers.

Solids have been suggested primarily because of their smothering effects. This may result from a liberation of combustion-retarding gases or from the air-excluding action of inert materials combined with their mass cooling effect. The bicarbonates, some of which liberate carbon dioxide at fire temperatures, and dusts of heat-resistant compounds illustrate this type of material. The action of finely divided soil (dust) is familiar to most forest-fire fighters.

The blanketing action of foams, which is of value on burning oils, is generally regarded as of less significance on fuels of the type involved in forest fires. While foam-type extinguishers are recognized as of value for fires in wood, paper, textiles, and the like, they are not necessarily considered superior to water or solutions containing large percentages of water (*6, 10*). However, the increase in volume of foams over the original chemical solutions, as a result of entrapped carbon dioxide, seemed to offer large theoretical advantages and stimulated considerable interest in their possible use in forest-fire suppression.

Based on a consideration of the types of fuels involved, the conditions surrounding forest fires, the extinguishing action and limitations of various chemical agents, and the equipment and problems involved in use, it was decided to confine the investigation primarily to water solutions of chemicals. Water is now used extensively, and it seemed possible that chemical solutions might be used in the same equipment. Some tests were included on foams in order to compare them with the more promising chemical solutions and water, although the use of foams would obviously entail special equipment.

The choice of chemicals for test in water solutions was based in large part upon the work of previous investigators, but a few were included because of theoretical or other considerations. Barrett (*1*), Mitchell (*5*), Stickel (*8*), and others in the Forest Service had gotten some encouraging results with potassium carbonate and calcium chloride a number of years ago. Thomas and Hochwalt (*9*) had reported marked effects for solutions of potassium and sodium salts in extinguishing gasoline fires. Work at the Forest Products Laboratory had compared the fire retarding action of a large number of chemicals when impregnated into wood (*3*). Russian investigators (*7*), in 1932 and subsequent years, had investigated several chemicals to determine their value in forest-fire control. From these various sources and others the list of chemicals for test was prepared.

Laboratory Studies

Laboratory tests were used as a method of getting within a limited time the comparative extinguishing properties of a considerable number of chemicals in water solutions of different concentrations. More than 800 standardized and controlled small-scale, fire-extinction tests were made with different chemical compounds and concentrations of solutions. The usual procedure was to make extinction tests on a standard wood fire with a 25 to 30 percent (by weight) water solution of a given chemical, and, if it showed appreciably higher effectiveness than water and was otherwise promising, additional tests at lower concentrations were made.

The method of test was an adaptation of that used by Folke (*2*), a Danish investigator, in a study of the factors involved in fire extinction. The standard fuel pile consisted of 18 pieces, 1 by 1 by 6 inches in size, of clear, surfaced, southern pine wood. After conditioning to 6 to 7 percent moisture content, the pieces were selected by density to give a total weight of approximately 990 grams (2.18 pounds) for the 18 pieces. The pieces were arranged in the form of a crib—3 in a layer and 6 layers high on a wire screen attached to the platform of a scale that permitted continuous reading of the weight during test. The wood was ignited by means of a battery of 4 gas flames placed directly beneath the crib for 1 minute. The burning was allowed to progress until 50 percent of the original weight of the crib was lost, at which time extinguishing began. The liquid was applied as a small jet from a glass nozzle at a predetermined and controlled rate.

Data were recorded of the volume of liquid used for flame extinction and for total extinction (including glow), of elapsed time for flame and for total extinction, and of the crib residue remaining after complete extinction. A series of several tests was made with each chemical solution and concentration. Similar tests were made using water as the extinguishing agent, to afford a basis for evaluating the effectiveness of the chemical solutions.

The comparison of the various chemical solutions and water was made at a constant rate of application of solution and under quiet air conditions. Tests were made later on the standard fire, using different rates of application of extinguisher and under varying horizontal wind velocities.

Results of Laboratory Tests

Of the data obtained, the volume of liquid required for extinguishing the fire was considered the most reliable and probably most significant indication of effectiveness. The time required for extinction paralleled rather closely the volume used, but since the application was intermittent during the later stages of extinguishing (suppression of glow) the elapsed time was considered less accurate than volume of liquid used. The amounts of fuel consumed during extinguishing, as determined by the residual weights of cribs, also indicated comparative effectiveness and gave the same general conclusions as did the relative amounts of liquids used. The effectiveness of the chemical solution was expressed, for convenience, as a "superiority factor," determined by dividing the volume of water (as a standard) by the volume of chemical solution used. Values were determined separately for flame extinction and for total extinction, including both flame and glow.

The results obtained with various chemical solutions of about 25 to 30 percent concentration are shown in table 1. The effectiveness, expressed as superiority factors, ranged from less than one (less effective than water) to more than two (twice as effective as water). Examples of chemical solutions that were less effective than water are citric acid, tartaric acid, and ammonium nitrate. Examples of solutions showing two or more times the effectiveness of water for total extinction are phosphoric acid and the ammonium salts of phosphoric acid. For extinction of flame alone, the acetate, bicarbonate, and carbonate of potassium showed the highest effectiveness of the materials tested. Monoammonium phosphate, which showed little superiority over water for flame extinction in quiet air, showed high superiority for both flame and total extinction in a later series of tests made under substantial wind velocities.

TABLE 1.—*Extinguishing properties of concentrated water solutions of chemicals compared with water*

[Tests made under quiet air conditions, liquid applied at rate of 26 cc. per minute]

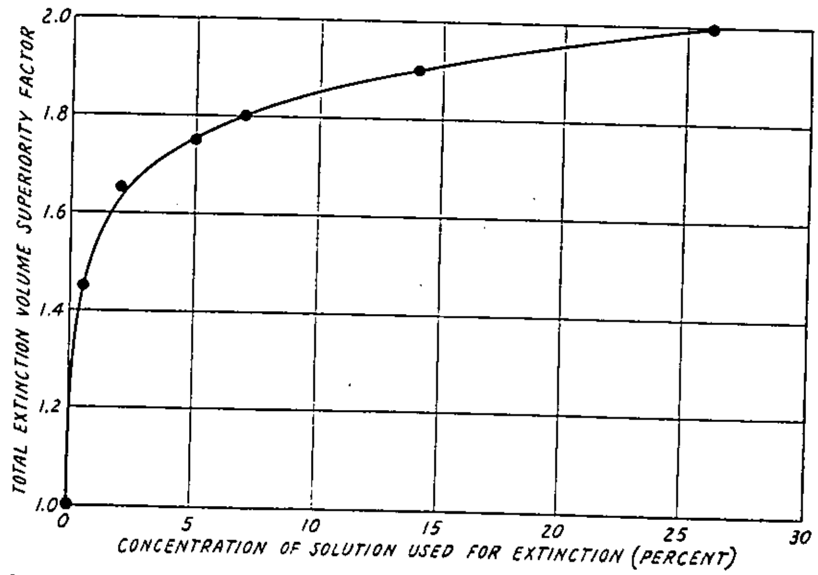
Chemical	Concentration of solution by weight	Superiority factor[1] based on volumes used for—	
		Flame extinction	Total extinction
	Percent		
Acid, citric	25	0.90	0.75
Acid, phosphoric	26	1.50	2.40
Acid, tartaric	25	.75	.60
Aluminum sulphate	23	1.00	1.40
Ammonium carbonate	28	1.10	1.40
Ammonium chloride	28	.95	1.50
Ammonium nitrate	25	.80	.80
Ammonium nitrate	29	1.10	1.00
Ammonium phosphate, di-	26	1.30	2.10
Ammonium phosphate, mono-	26	1.20	2.00
Ammonium sulphate	26	1.10	1.70
Calcium chloride	26	1.10	1.50
Cobaltous chloride	25	1.00	1.30
Lithium chloride	27	1.25	1.80
Magnesium chloride	25	1.20	1.70
Magnesium sulphate	30	1.10	1.30
Potassium acetate	30	1.75	1.80
Potassium bicarbonate	25	1.70	1.55
Potassium carbonate	25	1.90	1.70
Potassium chloride	25	.90	1.20
Sodium acetate	27	1.50	1.60
Sodium chloride	25	1.10	1.00
Sodium phosphate, mono-	24	1.00	1.50
Sodium silicate	22	1.00	1.20
Stannous chloride	25	1.10	1.50
Zinc chloride	30	1.30	1.70

[1] Calculated by dividing the average volume of water by the average volume of chemical solution used in extinguishing similar fires.

Boric acid, hydrochloric acid, oxalic acid, ammonium borate, ammonium oxalate, and sodium sulphate were tested also, but only at substantially lower concentrations of solutions. Of these, only boric acid showed appreciable superiority over water. At 5 percent concentration, which was about the maximum obtainable with boric acid, its effectiveness compared favorably with that of phosphoric acid or of the mono- and dibasic ammonium phosphates at similar concentration. Tests were also made on combinations of two chemicals in the same solution, but the results indicated no advantage over the single chemicals at the same total concentration.

With a number of the more effective chemical compounds, tests were made on solutions of lower concentration to study the relation of concentration to effectiveness. The tests were made under quiet air conditions and at the same rate of application as used in the comparative series on various chemicals. Figure 1 shows the results obtained for monoammonium phosphate, plotted to show the relation between concentration and total extinction effectiveness. It is evident that a large percentage of the superiority of the chemical solution over water is obtained with 1 to 2 percent concentrations and that the increase in effectiveness is less rapid for concentrations above 2 percent.

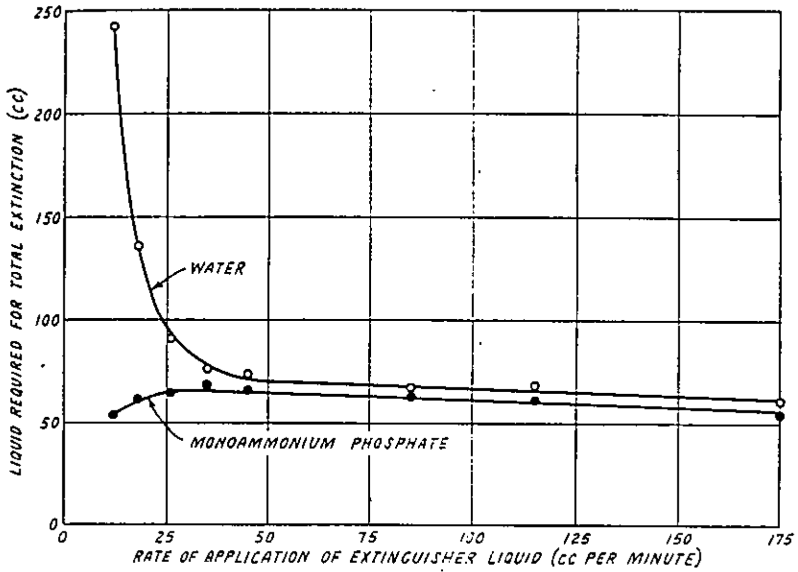
A third series of tests was made to study the effect of varied rates of application of extinguisher. A 10-percent solution of monoammonium phosphate was compared with water on standard fires under quiet air conditions with rates of application of from 12 to 710 cc. per minute. The actual volumes of water and chemical solution required for total extinction, for rates of application within the range of 12 to 175 cc. per minute, are shown graphically in figure 2. The comparison of various chemical solutions shown in table 1 was made at a rate of 26 cc. per minute. At a rate of application of about 40 cc. per minute and above, the advantage of the chemical solution over



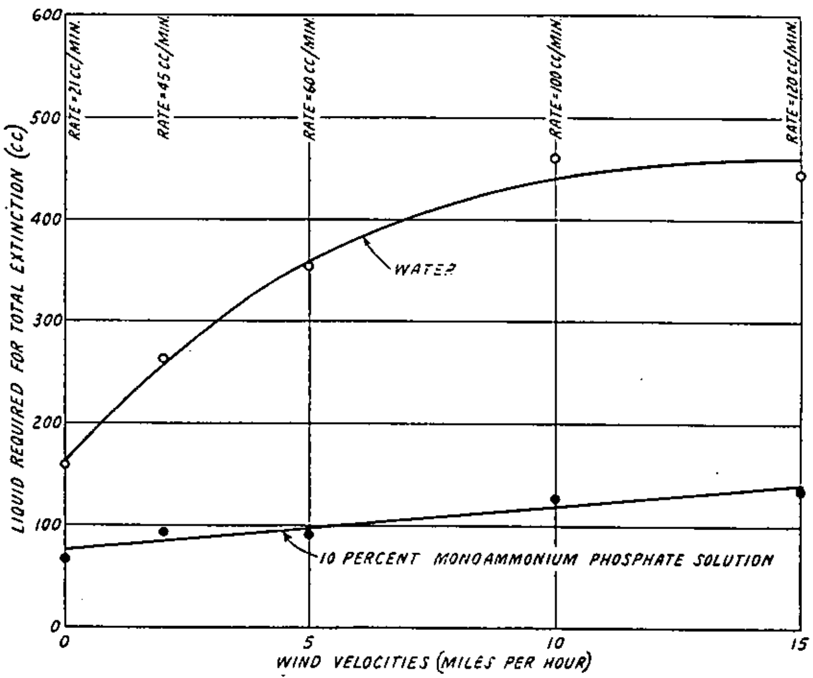
Relation between total extinction volume superiority factors and the concentration of monoammonium phosphate solution.

water is small and fairly constant. With lower rates of application the amount of water required for total extinction increases rapidly, whereas the amount of chemical solution decreases slightly. At the lowest rate of application, more than four times as much water as 10 percent monoammonium phosphate was used for total extinction. At still lower rates it was impossible to extinguish the fire with water before the crib collapsed. This series of tests shows rather clearly that the superiority of a chemical solution over water is not a constant, but is related to the rate of application of extinguisher for a relatively constant size and severity of fire.

It became evident during the course of the investigation, particularly in the field tests, that wind velocity was an important factor in extinguishing and that the relative effectiveness of chemical solutions and water might change when tested under substantial wind conditions. Consequently, late in the course of the study, some laboratory tests were made under constant and controlled horizontal wind velocities. A 10-percent solution of monoammonium phosphate



The variation in volume of 10 percent monoammonium phosphate solution and water required for total extinction, with change in rate of application.



Average amount of water and of 10 percent monoammonium phosphate solution required for total extinction at different wind velocities.

was compared with water on wood crib fires under wind velocities of 0, 2, 5, 10, and 15 miles per hour. With increasing wind velocities, it became necessary to increase the rate of application of liquid in order to extinguish the fire. The rates of application used in one series of tests were selected, after some preliminary work, to obtain approximately the same weights of crib residues (amount of fuel remaining after extinguishing). In the other series of tests a relatively high rate of application was used throughout. The results are shown in table 2 and a part are presented graphically in figure 3, in which the volumes of liquid required for total extinction are plotted against wind velocity.

TABLE 2.—*Effect of wind velocity on fire extinction superiority of 10 percent monoammonium phosphate solution over water*

Number of tests averaged	Wind velocity	Rate of application	Superiority, factors		Crib residue (percent of original crib weight)	
			Flame extinction	Total extinction	Extinguishing agent: water	Extinguishing agent: chemical
	Miles per hour	*Cc. per minute*			*Percent*	*Percent*
5	15	120	4.5	3.3	31	38
5	10	100	4.3	3.6	32	42
5	5	60	3.3	3.7	32	42
5	2	45	2.3	3.1	31	39
5	0	21	1.3	2.1	23	34
5	15	100	5.0	4.0	18	37
5	10	100	4.3	3.6	32	42
----------	0	100	1.0	1.1	47	49

It is at once apparent that the superiority of the monoammonium phosphate solution over water increases with an increase in wind velocity. With velocities of 10 and 15 miles per hour it required some three and one-half to four times as much water as chemical solution to extinguish the fire. Had it been possible to extinguish the fires with water at lower rates of application the superiority of the chemical solution would doubtless have been still larger.

This series of tests indicates that wind velocity has a major effect on the size of superiority factors of chemical solutions over water, and that values obtained for the various chemicals tested in quiet air (table 2) do not apply under appreciable wind velocities. A considerable number of the chemicals tested, particularly those that showed high total (flame and glow) extinction properties, as illustrated by monoammonium phosphate, would be expected to show increased effectiveness with increased wind velocities. Apparently the flame extinction superiority of chemical is related to its glow extinction property under substantial wind velocities. Although flame may be temporarily extinguished, the glowing fuel is quickly fanned into flame again by a substantial wind, unless the chemical exhibits marked glow extinction properties. Since field fires are commonly accompanied by strong air currents, it appears that the superiority for total extinction is of much greater practical significance for most field fires than superiority in flame extinction alone.

During the progress of the investigations it was learned that Metz (4) working in Germany and using similar laboratory test procedure, had tested a group of 10 chemicals that were included in the Forest

Products Laboratory tests. A comparison of the results of the two independent investigations shows a similar order of effectiveness for the 10 chemicals. Metz also found ammonium phosphate the most effective of the several materials tried.

Field Tests

The laboratory tests gave valuable indications of the comparative effectiveness of a considerable number of chemicals under rather carefully controlled conditions. In the laboratory it was possible to vary the rate of application to the size and severity of the standard fire, to approach the minimum rate and quantity required for extinction without danger of the fire getting out of control, and to apply all liquids to fires similarly and with little waste; objectives which could not be attained so well under field conditions.

The laboratory tests, however, were confined to a single type, size, and arrangement of fuel of approximately uniform moisture content. Consequently, it was considered desirable to check the laboratory results for a few of the most promising chemicals on the more important forest fuels and as much as possible in their natural arrangement and condition, by different methods of application.

A total of more than 2,000 field tests were made on grass and palmetto-grass fuels of the South; hardwood leaf litter of the Appalachian region; slashings of the Lake States, Appalachian, and Pacific Northwest; logs and branches, bracken, and rotten wood of the Pacific Northwest; and pine duff and brush of California. In each of these various regions, the local Forest Service experiment stations and administrative units cooperated in making the field tests.

Where it was feasible and practicable, the fires were set in the fuels in their natural arrangement and condition. This was true for all tests in grass, palmetto-grass, hardwood leaf litter, pine duff, and brush. Slashings, logs and branches, bracken, and rotten wood were artificially arranged, however, either because of their nonuniform natural distribution or on account of the danger connected with burning them in their natural arrangement under the conditions prevailing at the time of test.

Chemicals for field tests were selected on the basis of their showing in the laboratory tests. Phosphoric acid and its monoammonium and diammonium salts had shown the highest total extinction effectiveness through a wide range of concentration. Of this group the monoammonium phosphate was used on all fuels tested in the field. Ammonium sulphate was included in the field tests on a number of fuels because of its moderate effectiveness and low cost. Either the bicarbonate or the carbonate of potassium, both of which had shown high flame extinction properties in the laboratory, was used on those fuels in which the flaming type of combustion seemed to predominate. In the later series of tests some work was done with foams. Field tests on ene or more fuels were also made with calcium chloride, boric acid, phosphoric acid, and sodium acetate.

The procedure used in the field tests was modified from time to time as the work progressed, experience was gained, and additional equipment became available. For most of the tests an experimental unit, consisting essentially of a small air compressor, pressure tanks for liquids, hose and nozzles, was employed. A number of types of nozzles were used, but one adjustable over a wide range in rate of flow of liquid was employed extensively in the field tests. In some tests back packs were used, and in a few tests power pump equipment was employed. These were all included in a portable field laboratory containing a variety of equipment for preparing and applying solutions and foams and taking the measurements and data required.

In the early field tests, alternate fires were extinguished with chemical solution and water, respectively. Considerable difficulty was experienced, however, in obtaining successive fires of equal severity, because of wind conditions at the time of test and other factors. A method of making two tests simultaneously—one with chemical solution and one with water—was finally evolved in the later experiments. This method overcame the irregularity due to wind. The two fires started at the same time were extinguished simultaneously by two operators with similar equipment, one using water and the other chemical solution. For succeeding tests, the operators alternated water and chemical solution regularly, each extinguishing the same number of fires with each liquid in a series of tests.

The data taken varied somewhat from one series of tests to the next. However, in all tests the quantities of liquids used for knocking-down the flame and mopping-up the glow, and the elapsed time occurring during extinction were recorded. In the naturally arranged fuels, measurements were commonly made of the length of the extinguished line or the areas burned. Readings were also made of weather conditions, including temperature, relative humidity, and wind velocity and direction. In some cases, moisture contents of fuels were determined.

Considerable care was exercised to have fires of comparable size and severity for extinguishing with water and chemical solution. Areas of naturally arranged fuels were selected to obtain as much uniformity as possible. Artificially piled fuels were selected to get uniform kinds and quantities of material and to have them arranged in like manner for corresponding water and chemicals fires. With all the care used, however, it was felt that large differences were common in the test fires, particularly in the naturally arranged fuels. Furthermore, no constant relation between rate of application of liquid and size of successive fires could be attained, and the wind velocity and direction fluctuated considerably, both during a single test and from one fire to the next. These variations caused wide fluctuations in the results in successive tests and series of tests that were intended to be alike.

In table 3 are shown the average results obtained in the numerous field tests on different fuels with several chemical solutions and foams. The values, shown as superiority factors, are similar to those used to express the results of the laboratory tests, and represent the ratios of quantities of water and chemical solution required for total extinction of test fires. For example, a factor of 1.5 indicates that 50 percent more water was used than chemical solution in extinguishing the test fires. A range of values, as 1.2 to 1.6, indicates that the results varied as shown in different series of tests made at different times and under somewhat different conditions.

While there are definite limitations to the data because of non-uniform test conditions, certain important indications are nevertheless evident. Chemical solutions and foams show different results on different fuels. The flame extinguishing types of chemicals, such as the bicarbonate and carbonate of potassium, made their best showing on the flashy types of fuels, like standing grass and loose hardwood leaves, and were of little or no benefit on the glowing types of fuels, like slashings and closely compacted pine duff. On the other hand, the pronounced glow-retardant chemicals, of which monoammonium phosphate was selected as representative, were most effective on the glowing types or combinations of glowing and flashy types of fuels, such as fresh pine slashings, but showed substantially increased effectiveness over water on all fuels tried, except rotten wood. Foams were of most value on logs and branches and rotten wood, where the burning surfaces could be coated with a continuous layer of the foam. In green slashings, bracken, and similar materials, where the fuel is thick and matted, the foam cannot be applied readily to the burning surfaces and has little or no advantage over water. In general, the best results with foam were obtained when the combined foam-forming and fire-retardant chemical solutions were expelled as a liquid or as a partially expanded foam. Considering the range of fuels and concentrations of solutions tested, monoammonium phosphate was the most effective material tested. Furthermore, it is moderate in cost, appears to be otherwise suitable, and is the most widely applicable.

TABLE 3.—*Comparative effectiveness of chemical solutions and foams in direct extinction field tests*

Extinguisher		Superiority factors [1] based on volumes of water and chemical solutions used for total extinction on—								
Chemical	Concentration	Grass	Palmetto-grass	Hardwood leaves	Pine duff	Coniferous slashings	Logs and branches	Bracken	Brush	Rotten wood
	Pct.									
Ammonium phosphate, mono-.	2.5	1.2		1.3		1.2–1.6				
	5.0	1.3–1.5	1.6	1.4		1.4–2.1				
	7.5	1.4				1.5				
	10.0	1.5		1.5	1.8	1.5–2.4	1.3–1.5	1.4	1.5	1.1
Ammonium sulphate	5.0	1.3		1.2		1.3				
	10.0	1.1	1.2	1.3	1.3	1.4–1.6				
	15.0					1.5				
Boric acid	2.5					1.2				
	4.0					1.4				
Calcium chloride	10.0			1.3		1.3				
	20.0					1.8				
Phosphoric acid	5.0	1.4								
Potassium bicarbonate	5.0	1.2			.6					
	10.0	1.4								
Potassium carbonate	5.0	1.2	1.3	1.3		1.0				
	10.0									
Sodium acetate	5.0	1.2								
Foam not loaded [2] expelled as a liquid	9.0						1.2			
Foam loaded [2] expelled fully expanded	16.4				.5–.8	.7	.7			
Foam loaded [2] expelled as a liquid	16.4				1.1	1.1	1.6	1.1	1.4	1.6
Foam, Kempak (loaded)	18.8				1.2–1.5	1.3	1.3			

[1] Superiority factors calculated by dividing volume of water by volume of chemical solution used in totally extinguishing similar fires. Different procedures were employed in conducting tests on the different fuels so that the values shown are not entirely comparable in all cases.

[2] "Not loaded" foam contained only foam-forming chemicals; "loaded" foams contained approximately equal amounts of foam-forming chemicals and fire-retardant chemicals.

Pretreatment Tests

Field tests were also made in which the fuels were pretreated in advance of an oncoming fire. These tests were made in several ways to determine the value of chemicals in holding a line from which to backfire, or as a barrier or firebreak. Of the chemicals tried, phosphoric acid and its ammonium salts were found most effective. In pretreated strips of grass and pine duff, in which the water was allowed to evaporate before test, moderately severe fires were completely stopped by the fire-retardant chemical. Lines, freshly treated with monoammonium phosphate solution and from which back fires were set, were much more easily held than lines treated with water alone.

Summary

The results of both laboratory and field tests show that the extinguishing capacity of water can be increased or reinforced materially by the addition of certain chemicals, the increase depending upon both the kind of chemical and its concentration in the solution.

The superiority of a given chemical and concentration of solution over water is not a constant, but varies with a number of factors, of which (*a*) the rate of application in relation to the size and severity of the fire, (*b*) the wind velocity, and (*c*) the kind and arrangement of fuel are important. Dependent upon the conditions prevailing, the amount of chemical solution required may range from approximately the same as water to only a small part of the amount of water required to extinguish a fire.

Of the various chemicals and foams tested, monoammonium phosphate solution appears thus far to be the most practical and promising, all things considered, for most types of forest fuels.

Where an abundant supply of water is available and can be used, chemicals are not considered to have any worthwhile application. Where water is scarce or difficult to get to the fire, or where the available equipment is scarcely adequate to cope with the fire, the intelligent use of chemicals can yield important advantages. In border-line cases, chemical solution may control or hold a fire where water fails, and chemicals may, in such cases, make all the difference between success and failure in an attack upon a forest fire. The use of chemicals appears most important in the early or initial stages of attack, through the use of back packs and tankers, and they probably have little if any application on large going fires, unless for use when back firing.

It is realized that only a few of the many chemical materials and methods of application have been investigated and that further research in the field may yield valuable results. However, miraculous results with chemicals are not to be expected nor are chemicals equally effective under all forest fire conditions. Furthermore, to utilize present known fire-retarding and extinguishing chemicals efficiently, further studies are needed to develop or adapt apparatus and methods for their application. It is believed, however, that the work thus far points the way to a new and useful weapon for the forest-fire fighter that will ultimately assist him in his never-ending fight against fire.

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Quick Get-Aways.—At F-32, C. C. C. camp at Mayhill on the Lincoln National Forest recently a group was walking back to the camp office when without warning Superintendent Ray Craig turned loose a series of shrill blasts on his whistle. A dozen enrollees came pouring out of the camp shops, from off a camp trailer under construction nearby, from around nearby buildings, some hatless, others with shirt-tails flapping, but all with one objective—to get up the steps and into the fire truck. In less than 30 seconds by the watch the driver was in the seat, the motor turning over, and in just 45 seconds Project Assistant Ray Stoddard had latched up the tail gate, grabbed the open door of the cab and the truck rolled out, with its trained fire crew, its full equipment of tools and rations for 20 men, and its red flags at all four corners warning road traffic that the Mayhill fire truck was on its way to keep another Sacramento Mountain fire in class A. The next morning another demonstration, this time a real fire up the Penasco, saw the big Dodge stake body truck hit the camp exit in about 55 seconds. Said the regional office visitor, "Huh, I'd have been a sucker to have bet even a hat band against that outfit on as little as a 1-minute getaway."—Region 3 Daily Bulletin.

RANDOM NEWS NOTES FROM THE FOREST SERVICE RADIO LABORATORY

Contacts with forest officers generally indicate that even those within the region where the Radio Laboratory is located have little idea of the proposed and current work and progress of this Service-wide project. It is planned, therefore, to include in each issue of Fire Control Notes a news letter from the Radio Laboratory, as a means of distributing information of value to users of radio. It should also prove useful in communication planning and in anticipating the application of new designs and improvements.

Automatic Ultra High Frequency Relaying

It is now common knowledge among Forest Service radio users that transmission by ultra high frequency radio (represented by the types A, S, SV, T, and U) is largely limited by topographic barriers. The radio-minded individual, when standing on top of a mountain or other prominence, will usually visualize the tremendous communication possibilities from such a point with even the lowest powered type of ultra high frequency radio transmitter. For general communication purposes it is seldom possible to take advantage of these ideal topographic conditions. Over four years ago the Radio Laboratory decided that something should be done to permit the use of these ideal locations even when not regularly occupied by lookouts or firemen.

The best possibility of making use of these ideal topographic spots would be to equip them with some form of automatic relaying device which would permit picking up messages from portable stations in the field and retransmitting the message to some distant terminal station in sight of the relay point. Such an arrangement would add tremendously to the possibility of applying ultra high frequency equipment to general communication needs.

Because of the complications involved and the relatively heavy battery drains necessary to operate such an automatic relay system, the idea was not actively investigated until early in 1939. Commercial systems employing the automatic relay feature have been in operation for several years. All of these rely upon commercial power, however, and they are so complicated and their mode of operation is such that they are entirely unsuited to Forest Service use.

Since practically all points which are best suited for the establishment of an automatic relay station would be without commercial power, one of the prime requisites of such a system for field use is reduction of dry battery consumption to an absolute minimum. Recent developments in the field of commercial vacuum tubes have permitted exceptionally large savings along this line, and the first automatic unit is now under test at the Radio Laboratory. Naturally many of the solutions of problems encountered in considering other ultra high frequency problems have been applied to this test unit with the result that the automatic portion of the device is much simpler than might be expected. Several improvements must yet be made before the system will operate with a high degree of reliability, however, and it is not expected that the automatic relay will be ready for release to the field for at least 1 year.

The present type S radiophones cannot be satisfactorily used to work into an automatic relay system, because, in order to talk through the relay station it is, of course, necessary to transmit on the frequency to which the relay receiver is tuned. It has been generally agreed by field technicians that the type S radiophone should be revised in several minor points, and in making these revisions some method of tuning the transmitter will be provided to permit working into the proposed automatic system as well as to simplify the method now necessary in calling the new type T model D radiophone.

For those interested in the technicalities of the proposed relay device, a brief discussion of the functioning of the unit now undergoing test is given.

The transmitter and receiver proper of the test unit are fundamentally duplicates of those portions of the new type T model D radiophone. Each part, however, has been built as a separate unit to facilitate experimental alterations. The local oscillator of the superheterodyne receiver has been crystal controlled on the standby frequency. The automatic control device is mounted on a third unit and consists of an open chassis about 6 by 8 by 2 inches, which carries three tubes and five relays.

In order to conserve batteries to the utmost, the receiver does not operate continuously, but is turned on for 5 seconds out of each half minute by means of a weight driven clock. If a carrier of 6 microvolts or greater is present on the receiver standby frequency during the 5-second "on" period, the receiver automatically locks into continuous operation and the relay transmitter comes on the air retransmitting any signal which may be coming into the receiver.

In order that the entire circuit shall not be interrupted during the switchover time between terminal stations, when operating simplex, a time delay of 10 seconds has been provided; i. e., the relay station remains in operation for 10 seconds after the incoming signal has been discontinued. This arrangement allows adequate time for each terminal station to come on the air and hold the relay system in operation without waiting for the receiver to recycle each half minute.

The total battery drain during each 5-second period is 200 ma. at 3 volts, 50 ma. at 1.5 volts, and 18 ma. at 180 volts. Without an incoming signal the relay station consumes the above battery power for a total time of only 4 hours out of every 24.

Unless the relay circuit is required to handle an exceptionally large amount of traffic, it is estimated that the device should operate for a period of from 2 to 3 months without attention or replacement of batteries.

Current Projects—Radio Laboratory

Design of mobile ultra high frequency receiver.—A thorough investigation of commercial receivers for mobile service in this frequency range has failed to disclose a satisfactory unit. The principal problems of this project are the production of a receiver having a tuning range of from 31.5 to 39 megacycles, yet one which is not critical of adjustment over this relatively wide range; the reduction of ignition interference below an objectionable level both from the car in which the receiver is mounted and from other vehicles on the road; the development of a receiver which will permit reception of equipment such as the type S radiophone (standard commercial superheterodyne receivers cannot be used to receive the type S because of frequency modulation of the transmitter); and the creation of a mechanical design which will retain adjustment of all circuits when the receiver is subjected to severe road vibration.

Design of a substitute for the present type U radiophone.—A greater number of AC operated ultra high frequency radiophones are needed in the field, but because of the relatively high cost of the present type U the purchase of this unit can seldom be justified. The new type U will be similar in appearance to the newest type M and will incorporate a special receiver based on the design of the mobile receiver referred to above. The receiver will be equipped with an automatic calling device, which will eliminate the need of a noisy loudspeaker in constant operation for stand-by.

Preparation of data on five questions of the CCIR Stockholm meeting 1940.—This project involves making numerous technical performance measurements on Forest Service type radiophones. Such data are being submitted by the Department of Agriculture to the United States delegation to the International meeting at Stockholm in 1940. This material, together with that accumulated from other agencies, is used in the basic consideration of radio frequency assignments and performance standards throughout the world.

Design of a metal detecting device for use on saw timber.—The NETSA in New England has a serious problem in milling timber in which are embedded numerous metal objects which have destroyed saws and endangered the lives of sawyers and other head rig workers. The laboratory is investigating the possibility of producing a suitable detector to locate such embedded metal.

Projects for Early Attention—Radio Laboratory

Redesign type S radiophone.—Field technicians have generally agreed that the type S radiophone should be redesigned in several minor points. In addition to several technical alterations, it is proposed to repackage the type S to permit easier and more convenient handling in the field. The new type S will also incorporate some form of transmitter frequency control or monitoring which will permit setting the radiophone on some predetermined frequency. This latter feature is essential for operation into such equipment as the proposed automatic relay and will expedite calls to the new type T. Such a frequency marker device will also be useful in establishing contact with other type S or SV sets.

Antenna and transmission line investigation for UHF.—This is a continuing project, and any improvements in this part of a radio system can be considered equivalent to increasing the power of a transmitter or improving the sensitivity of a receiver. Special low angle arrays of rugged and simple construction will be one of the important considerations investigated.

Honorable Mention Department.—The absence of the Clark National Forest in the list of forests having fires over 300 acres in 1938 was immediately noticed in Washington. In 1936 this forest had 15 fires over 500 acres burning a total of 18,350. In 1937 there were 8 fires over 300 acres burning 4,975 acres. In 1938 not one single fire over 300 acres!

BI-STATE BODY PLANS CAMPAIGN TO REDUCE FOREST-FIRE LOSSES

Woods and mill workers have not been without some appreciation of what forest protection means to them. In many cases they have been more conscious of their stake in forest-fire control and sustained yield than were timberland owners. But organizations of woods and mill workers have seldom given aggressive support to the movement to preserve and renew the raw material on which the security of their members depends. The following clipping from the Union Register, a labor paper of Seattle, sent in by Assistant Regional Forester John C. Kuhns, may therefore have a far reaching significance. It is hard to imagine a more potent force for fire prevention than a great body of organized workers fully conscious of how much forest protection means to their class and determined that carelessness and neglect shall not jeopardize the forest on which their future security depends.

Reforestation and perpetuation of the lumber industry have become in recent years one of the major concerns of the Lumber and Sawmill Workers Union. The men in the mills and woods are becoming increasingly cognizant of need for building not only for the present but also for the future.

Fire has always been the greatest threat to perpetuation of our vast timber resources. Unless fire is curbed, all the efforts to establish sustained yield, selective logging, strip logging, or reforestation are nullified. Forest fires must be held to a minimum if Washington and Oregon are to escape the fate of Michigan and the Lake States which have become barren scrub-covered areas instead of heavily timbered, lumber producing States.

The Oregon-Washington Council of Lumber and Sawmill Workers is taking the initiative in working out a program to stamp out the terrific annual toll due to forest fires. Through the Union Register, through posters, and windshield stickers, the bi-State body is going to impress on the public the necessity of reducing the number of forest fires.

The campaign will be carried on all summer. Lumber workers will be urged to help educate the general public in the need for more care in the woods.

Tangible results are expected to be forthcoming this summer, although the campaign is laid out on a long term basis. Over a period of years, the efforts of the Oregon-Washington Council will undoubtedly do much to help reduce the huge annual losses due to carelessness in the woods.

Boy Scouts as Carriers of Fire Prevention.—Mr. Hugh Fleming, Jr., now with the New England Forest Emergency organization, writes from Boston that 70,000 Boy Scouts will each spend a week in camp during the summer. Every Sunday morning when a group is being sent home, a short talk on fire prevention is given by the Scout Master and two or more Flagg posters are given each boy—one for himself, and one or more to put up in his home town where he thinks it will do the most good. The Boy Scout organization is divided into regions similar to Forest Service regions, and anyone interested in promoting a similar movement can get in touch with the regional officials of the Boy Scouts by inquiring from the nearest Boy Scout Master.

SEEN-AREA MAPPING—AN IMPROVED TECHNIQUE

Karl E. Moessner

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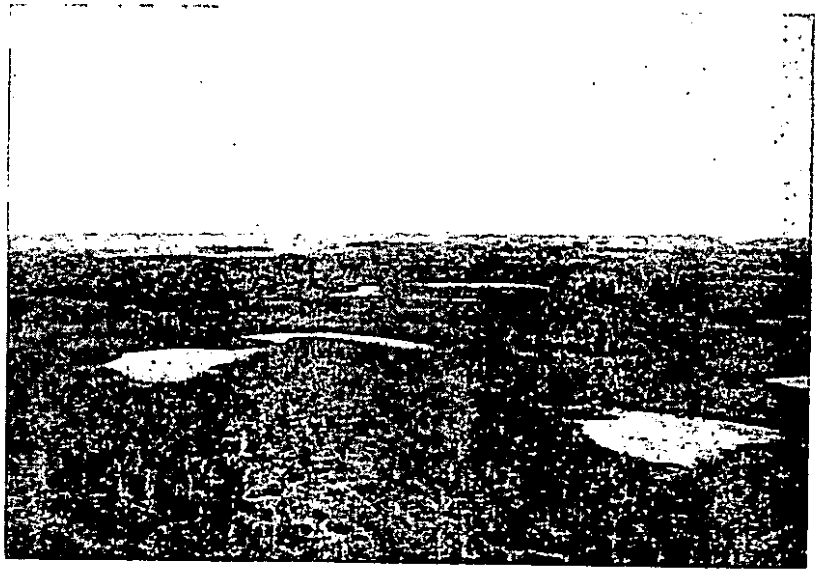
A technique of seen-area [1] mapping, making use of a cover-type map, the Osborne fire finder or a vertical angle measuring alidade, binoculars, and an elevation—unseen-space scale, has been tried out on the Upper Michigan National Forest and found to produce astonishingly accurate and consistent results.

On this forest a lack of contour maps and a semiflat topography makes profile plotting, whether in the office or in the field, unfeasible. Through necessity, sketching from the tower is the only method used, all work heretofore being done on ½-inch = 1 mile scale base maps.



View northwest from Tie Hill Tower, Upper Michigan National Forest. The hills in the immediate foreground are 250 feet above the lakes, those in the background nearly as high. Note the landmarks, cover types, and lakes.

Past experience indicates that these maps lacks detail necessary in seen-area mapping. Their use has produced annually a crop of sketches so optimistic as to be valueless in detection planning.

Since admitting the weaknesses of our detection system is the first step in correcting its faults, the present technique is designed to map as unseen all areas not *surely* seen. At the same time, no attempt is made in the field to speculate on the relative depth of the unseen

[1] Seen area, throughout this article, means any portion of a 10-mile circle visible to the lookout and may consist of treetops, low shrubs, or ground cover. Any area hidden from the lookout, by being below his line of sight, regardless of how far, is technically unseen.

areas, since without contour maps this would degenerate into pure guesswork. Rather, the mapper shows as nearly as possible what he sees, not what he thinks, in order that the planner may *start* with facts.

Four things have been found necessary to good seen-area mapping:

1. A detailed map giving the accurate [2] location of a large number of landmarks easily recognized from a fire tower. Topographic symbols, or some indication of topography, are vitally necessary.

2. An instrument, either the Osborne fire finder or an alidade, to enable the observer to sketch the width of the unseen areas, and measure vertical angles.

3. Binoculars, to aid the observer in noting and locating ridges or other masks [3] and in recognizing landmarks.

4. A method for determining the length of the unseen area, which will work in semiflat topography and which does not require contour maps.

On Upper Michigan the forest inventory township plats have proved the most suitable map for this work. These plats indicate all cover types over 2½ acres, carry base from aerial photographs, road and lake traverses, and, in addition, show many hills, ridges, and other topographical features.

Normally, these maps are on a scale of 4 inches=1 mile, but for this purpose, photostatic blue-line prints, on a scale of 1 inch=1 mile, have been obtained. These prints are mounted on cloth to form a mosaic for each tower or point mapped. In actual practice the mosaic is trimmed to a circle with a 10-mile radius and temporarily mounted on the fire finder by means of Scotch tape.

This preference for timber-type maps as a base in seen-area mapping should perhaps be further explained.

Since the topography in this part of the country is relatively flat, in many parts of the forest a stand of timber 70 feet high may prove as much of a mask as a hill or may double the height of an existing hill. It is, therefore, imperative to be able to locate on the map all stands of mature timber.

Timber types on this forest consist of a number of coniferous and deciduous associations which change character at a slight variation in soil or moisture, but which appear consistently in the same topographical locations. While this natural ecology may be somewhat altered by cutting and fire, it can be accepted that a species characteristic of a swamp will not usually be found in large numbers on a ridge. Since most field men can be trained to recognize through binoculars characteristic species at several miles distance, a good type map not only furnishes the location of many recognizable landmarks but offers an excellent key to the topography.

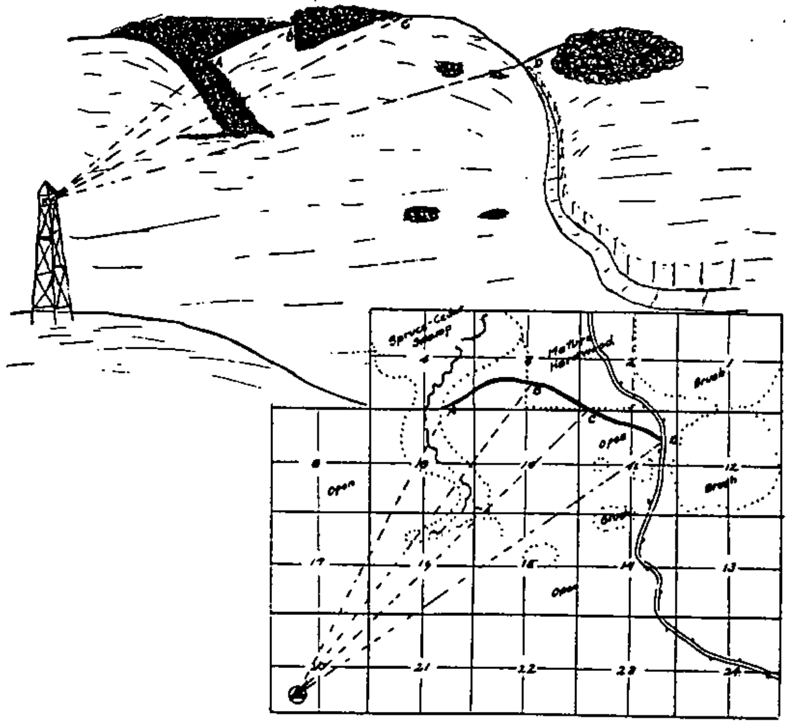
The illustration on page 20 represents the procedure which might be followed in determining the location of a mask and the width of its unseen area, using a type map.

The upper sketch represents the appearance of the landscape to the mapper, the lower the type map.

[2] While this term is relative, base features should be located within 200 feet of their true position.

[3] For the purpose of this article, the word "mask" may be taken to mean any hill, timber, or other feature obstructing the observer's view.

A represents the point where the hill appears to come in contact with the swamp along the creek, *B* the left edge of a block of mature hardwood near the crest, *C* the point where the timber disappears over the hill, and *D* the spot where the road comes around the right edge of the hill. By sighting on each point and drawing rays as indicated to the known landmarks, the crest of the hill line *ABCD* is plotted. The outer rays *OA* and *OD*, projected, mark the extreme width of the unseen area.



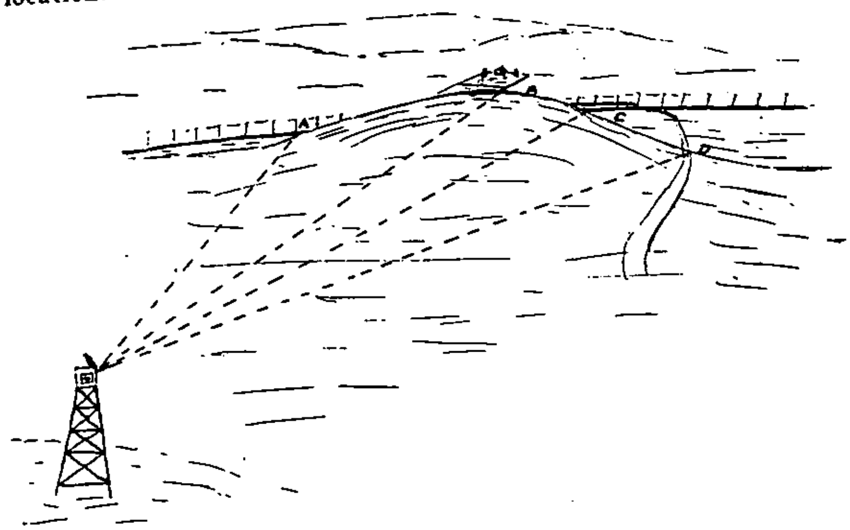
Sketch and map illustrating use of type map in locating crest of ridges.

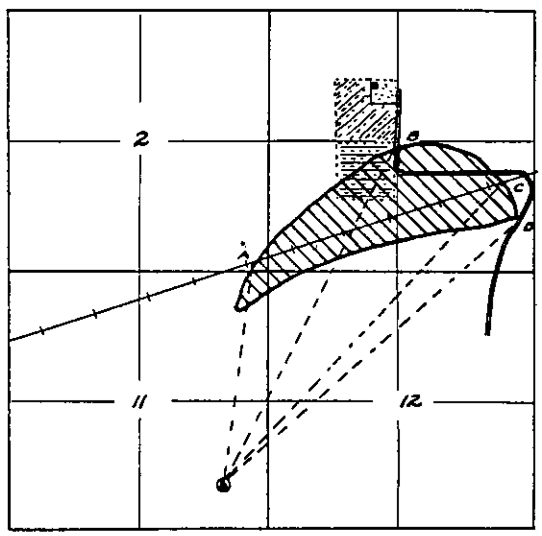
But the determination of the length [4] of the unseen area is not quite so simple. One method commonly used may be called the landmark method. The observer in this case, having located the crest of the hill, picks out a landmark which appears directly above it. This landmark, building, road, lake, or other feature, marks the extreme edge of the unseen area. (See illustration, p. 21.) In this sketch, *A* indicates the junction of the unseen area and the railroad, *B* the edge of a field appearing just over the crest of the mask, *C* the point where the left edge of the unseen area crosses the railroad and *D* the intersection of the hill and road. On the map the crosshatched area *ABCD* indicates the unseen area as it would be shown.

In timbered country the type map unquestionably offers the best means of locating a large number of landmarks necessary to the system described, while in settled areas it proves almost as valuable in showing the location of scattered woodlots. In addition, it offers this further check: if the observer in a country where hardwood

[4] The distance unseen behind the hill.

ridges and coniferous swamps exist is able to see only the tops of hardwood trees from the tower, he may surmise that part of the area is unseen, yet not know what part. On the other hand, equip him with a type map and he will know how much is unseen and its location.

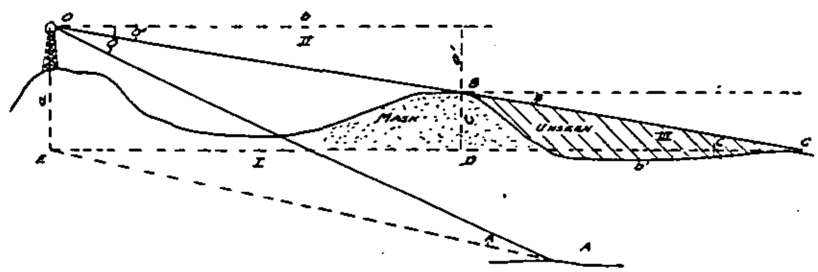




Sketch and map illustrating the landmark method of determining outlines of unseen area behind a mask.

Needless to say, binoculars are indispensable to accurate work. Frequently an area which appears solid to the naked eye may show up as a series of rounded ridges when viewed through the glasses. We cannot afford to let the optical illusions created by the lack of proper equipment influence the planning of our detection system.

In all of this work the fire finder or the alidade must be used continually to locate points and to plot edges of masks and the resulting unseen areas. But there is another important use for these instruments: the reading of vertical angles. For, ideal as the landmark system may appear to be it fails miserably in some circumstances. Where unseen areas fall on jackpine-blueberry plains, cedar-spruce swamps, muskegs, or consistent level hardwood stands, the monotonous landscape offers few effective landmarks. Here the mapper has a choice of guessing at the length of the unseen area, or attempting to work out some effective means of calculating the distance.



Mathematical explanation and proof of the angle-of-site method.

Let *O* be the observation point.

B be the crest of a mask, at a known location.

C be the unknown point where the observer's line of sight intersects the ground or ground cover.

A be a landmark of known location whose elevation is approximately that of *C*.

Vertical lines are constructed through points *O* and *B* and horizontal (level) lines constructed through *O*, *A*, *B*, and *C*, forming right triangles I, II, and III, with angle *A* equal to angle *O*, and angles *B* and *C* equal to angle *O'*.

Angles *O* and *O'* are negative vertical angles measurable from the tower. Lines *EA* and *b* are scaled directly from the map.

(1) Then $A = \frac{EA}{CotA} = \frac{EA}{CotO}$

(2) And $o' = \frac{b}{CotO'}$

(3) And $c = a' - o'$.

(4) And $b' = cCotC = cCotO'$.

(5) Therefore $b' = \left(\frac{EA}{CotO} - \frac{b}{CotO'}\right) CotO'$ = length of the blind area.

Where the height of the mask (c) can be estimated, length of the blind area = $cCotO'$.

In this proof the curvature of the earth has not been considered, since it was felt that this would be a negligible factor even at 10 miles distance.

Past experience on Upper Michigan has proved that the human eye is not an effective instrument for calculating horizontal distances where angles of less than 5° are involved. Since in this type of topography 90 percent of the vertical angles measured from any one tower are less than 2°, the chances of any individual training himself to consistently estimate the length of the unseen area behind hills of varying height at different distances are exceedingly remote.

Yet, at the same, time, these hills all rise less than 500 feet above the surrounding plains, in fact the average is closer to 100 feet. How much more effective would it then be for the observer to estimate the height of the hill (to the nearest 20 feet, let us say) and calculate by trigonometry the horizontal leg of the triangle? Roughly, on a hill 100 feet high with a vertical angle of 20 minutes the chances of an accurate guess would be 3,000 to 1 in favor of the latter method. Then if we further improve the technique by calculating the height of the hill, is it not likely that the method would prove the most accurate possible?

The angle-of-site method [5] developed on Upper Michigan calculates by trigonometric right triangle formulas the relative elevation of the top of the mask and the ground level behind it, then determines the length of the unseen area as one leg of a right triangle whose base is the difference in the above elevations and whose apex angle is equal to the negative angle of the top of the mask, read from the tower.

The illustration on p. 22, with its accompanying explanation, covers the formulae and procedure used in this mathematical solution. But accurate as this method is, it has one rather obvious weakness, the time required to complete the computations. Even if every field man called upon to make a seen-area map were a mathematical genius, the necessary time plus the possibility of arithmetical error would seriously discount the value of the system.

Realizing the necessity of making this technique practical, a simple scale was developed which reduces the procedure to the mere reading of vertical angles and the laying off of distances upon the map.

The above elevation—unseen space scale, shown above, consists of:

1. A 1 inch=1 mile scale[6] graduated in miles and quarter miles.
2. A 1 inch=1 mile space scale reading elevation in feet over unseen distance in miles for angles of 10 minute variation.

In using this scale on a typical problem (see illustration on p. 25), the mapper would:

1. Plot lines from tower at *O* to points *A*, *B*, *C*, *D*, *X*, and *Y* as shown, extending line *OB* beyond unknown point *E* at the far side of the unseen area. (Point *D* is located on a definite landmark, whose elevation is approximately the same as the level ground in the vicinity of *E*.)
2. Sketch the crest of the mask as line *XBY*.
3. Measure the negative vertical angles to *D* and *B*, recording them as 40 minutes and 30 minutes, respectively.
4. On the 40-minute scale (see fig. 5) lay off the map distance *OD* and read 210 feet, the elevation difference of the observing point and the landmark *D*.
5. On the 30-minute scale lay off the map distance *OB* and read 100 feet, the elevation difference of the observing point and the crest of the mask at *B*.
6. Since *E* and *D* were assumed to be of equal elevation the height of *B* above *E* equals 210−100=110 feet.
7. From the 30-minute scale obtain the distance equal to 100 feet and lay this off on the map as line *BE*, the length of the unseen area.
8. The cross-hatched unseen area *AXBYCE* would then be outlined.

In actual practice, a number of shots must be made for every mask, but the procedure followed is identical, except that the elevation of the mask can sometimes be estimated allowing the observer to cut out steps 4, 5, and 6.

[5] So called because of its resemblance to the technique employed by the field artillery in computing the angle of site of a target hidden from the battery, but visible to the observers, in country where no contour maps exist.

[6] Field mapping on Upper Michigan was done on a 1 inch=1 mile scale map. The scale and the map must be the same.

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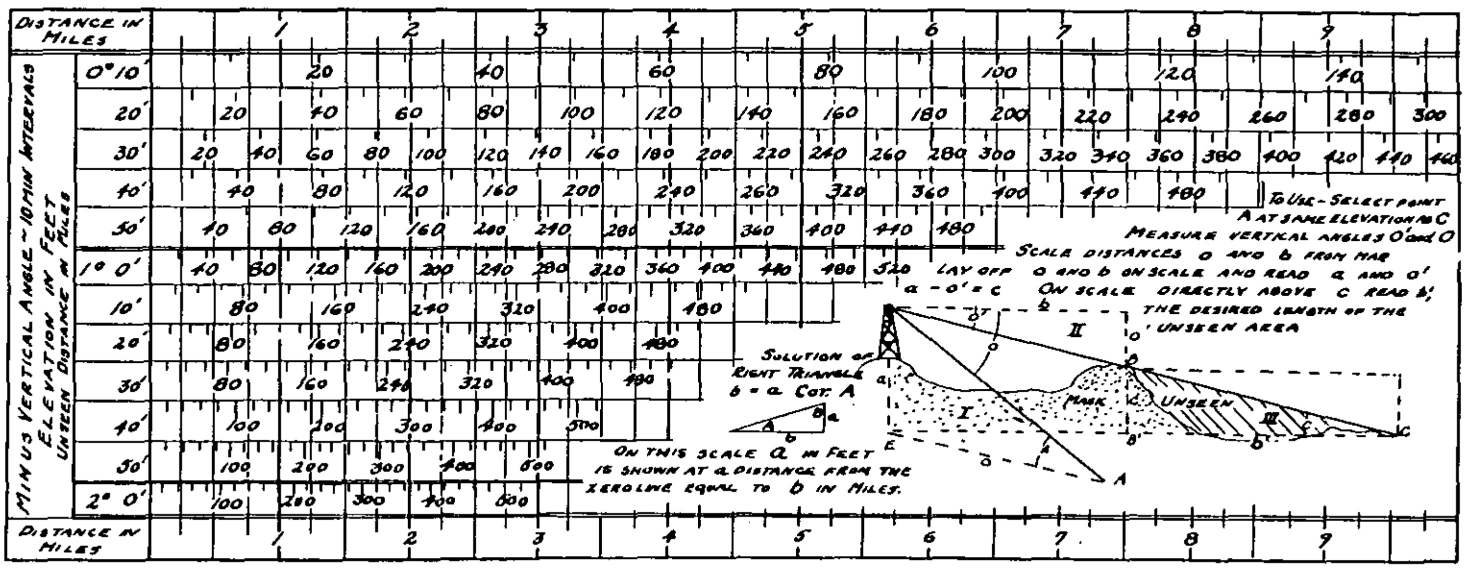
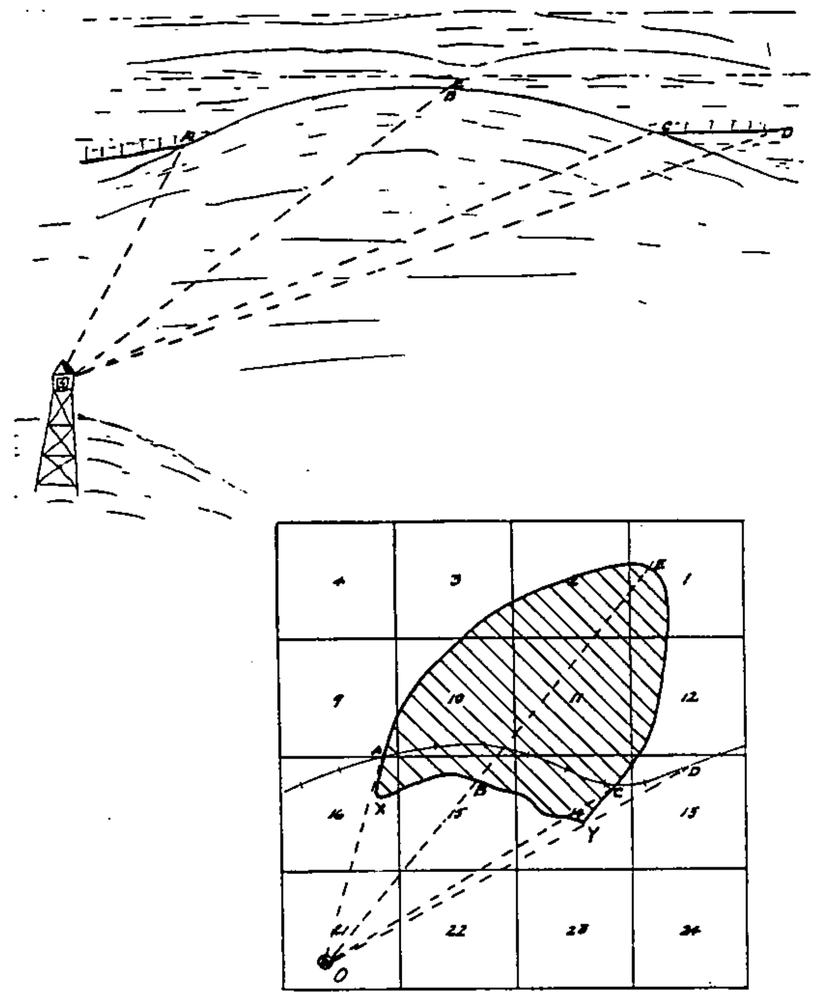
ELEVATION-UNSEEN SPACE SCALE

CONSISTS OF – A 1 INCH = 1 MILE SCALE GRADUATED IN MILES AND QUARTER MILES.
A 1 INCH = 1 MILE SPACE SCALE READING ELEVATION IN FEET OVER DISTANCE IN MILES



Elevation—unseen space scale developed on Upper Michigan. This scale was actually compiled for all angles up to 5°, but field trials proved most angles to be less than 2°, and nearly all hills less than 500 feet.



Sketch and map illustrating use of the elevation—unseen space scale as an aid to the angle-of-site method.

The angle-of-site method is designed to accomplish by mathematical means the work which profile plotting does graphically. In so doing it proves to be far more adaptable, since:

1. It can be used where no contour maps are available; the observer calculates his own relative elevations.

2. It is unaffected by the mechanical difficulties of plotting 10-and 20-minute angles, and for this reason is entirely workable in flat country.

3. When used with a detailed type and base map it takes into consideration *all* masks whether topography, timber, or buildings.

4. It is a mechanical method, it is easily taught, and consistent even when used by relatively inexperienced mappers.

AN EFFORT TO MAKE AERIAL SCOUTING SOMETHING BESIDES AN EMOTIONAL ESCAPE FOR THE EXECUTIVE

CLAYTON S. CROCKER

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Some 3 or 4 years ago I heard someone remark that one of the stumbling blocks in the quick organization of suppression forces was the lack of detailed scouting information. This has been true on all the fires I have known.

In attempts to speed up and to perfect scouting, we have spent much time and money, but still our scout maps and data reach the dispatcher and organizer far too late to be of most value. Usually the data obtained is inaccurate and incomplete. Something better is needed, and here's what has been done lately.

We have six office men in Missoula trained to take pictures, develop the negatives, and make prints while in an airplane over a fire. We have developed a home-made kit for doing this work and have converted an old 5 by 7 Graflex into a foolproof scout camera. The whole outfit weighs about 75 pounds.

Experiments show that inexperienced men on their first trip in the air can take, develop, print, and drop the pictures in 18 minutes. Some have done it in much less time than this.

While we haven't had a chance to try this out on a real fire, I am confident it will prove valuable. Advantages are as follows:

1. Our scout plane and a photographer can reach most fires in the region and put pictures into the hands of firemen, rangers, and supervisors before the local ground scout could hike around the fire.
2. Pictures tell a story in detail not possible to obtain from maps and notes. They eliminate chances for discrepancies inherent in any attempt to correctly visualize conditions described through the eyes of another person.
3. Pictures give the fire boss or the dispatcher up-to-date information. The ground scout can't.
4. Series of pictures taken periodically will provide data for rate of spread studies, and should be worth while for study by Board of Review.

Some prints made by trainees are enclosed.[1] These are the first attempted and in most instances were taken too high above ground. However, it will give an idea of the quality of picture obtained.

The plan is to take a series as follows:

1. From a distance to define location, major topography, etc.
2. Close enough to get the entire fire or sector. This to give details of size, perimeter, and intensity of burning.
3. Very close to show details of fuel, ground cover, etc.

If the thing is worth it, I shall be glad to write it up in detail for other regions. It has taken 3 years to get this to a stage where we could say it is feasible and simple.

[1] The prints are interesting, but since two of them show no actual fires and all of them would suffer greatly by transfer to a printed page, they are not reproduced herein.—Ed.

HOSE SCRUBBING MACHINE

K. G. Sedgwick
Project Superintendent
and
K. M. Macdonald
Fire Assistant, Nicolet National Forest, Region 9, U. S. Forest Service

Faced with the necessity of washing 6 miles of dirty hose after one of last summer's fires, members of the Nicolet personnel cast about for a quick, cheap way to clean the hose. The result was that Ken Sedgwick designed and constructed a machine to do the work. A patent, to be dedicated to the public, has been applied for.

During a period of 2 days of continuous operation (16 hours) the machine washed 26,600 feet of hose, with a crew of five men operating the machine and handling the hose. The crew consisted of a man to feed the hose in, one to draw it through, one to wash the ends near the couplings, and another to operate the machine. If the machine were to operate continuously, one or two extra men might be needed to carry the hose to the machine and unroll it.

The five-man crew was made up of FF men, paid at an hourly rate of $0.25. Labor cost figures came to $0.075 per hundred feet of hose. Average speed of the hose through the machine was 27.7 feet per minute, including time lost in placing the hose in the machine and removing it. Actual speed of the hose through the machine was approximately 40 feet per minute.

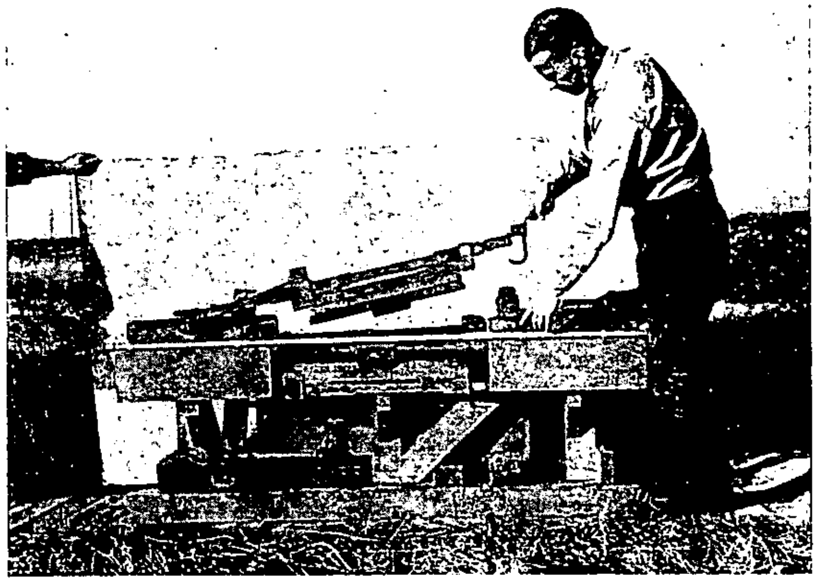
The costs for washing hose in this way are considerably lower, it is believed, than they would be if hose were washed by hand, although check figures on hand scrubbing time and cost are not available. The results are better than those obtained by hand scrubbing. The machine does not seem to damage the hose in the scrubbing process, although it tends to accentuate the folded edge which results from rolling the hose, but not appreciably more than hand scrubbing does.

In operation, the hose is rolled up at the fire and brought in to the ranger station, where the machine is placed at the lower end of the hose drying rack. The hose is then run through the machine and drawn directly up on to the rack, where it is allowed to dry. It is then rerolled and stored.

The machine itself consists of a wood frame on which are mounted two sliding brush carriers, one above the other, each carrying two regular floor scrubbing brushes placed end to end. The lower carrier has the brushes on its top side, with the bristles extending upward. The upper carrier has its brushes on the bottom, bristles down. The hose is drawn by hand between the brushes, while the carriers are driven in an endwise reciprocating motion by a small gasoline engine. The stroke of the brushes is 2 inches, and the speed is 300 complete (forth and back) strokes per minute. The two brush carriers move in opposite directions.

Before going between the brushes the hose passes through a trough 19 inches long in which it is thoroughly wet by water spraying from holes in a ½-inch pipe. The spraying is continued as the hose goes through the brushes and then through another trough where it is rinsed off before leaving the machine. On the Nicolet, water for the spray is supplied by a garden hose connected to the ranger station water system.

The upper brush carrier is so arranged that it may be raised while the machine is in operation, thus allowing the hose to be threaded through the machine without stopping the engine. The carrier is then clamped down and the hose drawn through by hand. The machine will not wash the hose right up to the couplings at the ends, so that in operation a man with a pail of water and a scrubbing brush washes by hand about 1 foot of hose next to the couplings.



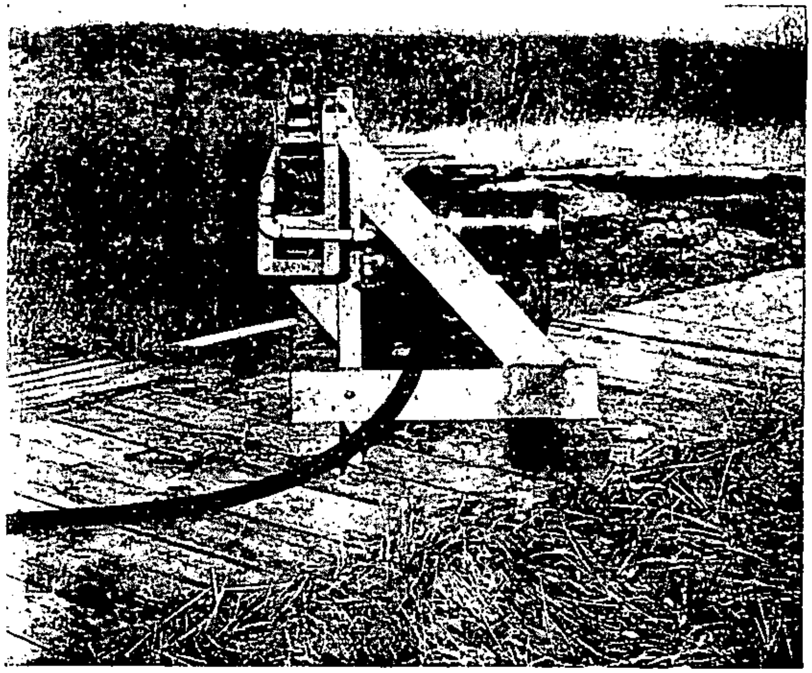
Front view of hose-scrubbing machine. Inventor holding the upper brush and pointing to places where hose is inserted.

In some cases the edges of the flat linen hose were not properly washed, so a pair of small vegetable brushes were mounted on the sides of the carriers, with their bristles extending horizontally inward. These remedied the trouble, but as the bristles were soft and wore out very quickly, brushes with stiffer bristles have been ordered. A set of regular scrubbing brushes is worn out in about 2 days of operation. They are easily renewed, however, as they are held in place with wood screws.

Motive power is supplied by a 1 horsepower 1,750 revolutions per minute Lawson single-cylinder gas engine, taken from a Forest Service portable power grinder. Power is transmitted to a crankshaft by means of a grooved pulley and V-belt. A connecting rod runs horizontally from the crankshaft to the lower end of a vertical wooden lever which is pivoted at a point about one-third its length from the top. A link from the top of this lever and another from a point two-thirds of the distance from the top connect with the brush carriers and transform the oscillatory motion of the lever into a reciprocating motion of the carriers.

The machine is 5 feet 5 inches long, 1 foot 11½ inches wide, and 2 feet high. Its weight is 282 pounds, including the motor, which is mounted directly on the frame.

The frame of the machine is made of 4 by 4 and 2 by 4 white pine, securely bolted together. The troughs, lever, and carriers are of 1⅝-inch yellow birch. No nails were used in its construction. All



View of right end of hose-scrubbing machine, showing locking clamp in raised position, hose connection and piping, motor, splash guard, brushes, and trough.

metal work was done by a Forest Service blacksmith. The crankshaft is carried in a pair of ball bearings from a tractor transmission. A sheet metal shield is installed between the brush carriers and the motor to protect the motor from water.

It is estimated that this machine can be built for approximately $160, exclusive of the engine which supplies the power, although the designers' original model cost somewhat more. Power for the machine can be supplied from any available source.

A Simple Hose Reel.—Mr. Godden has developed an ingenious hose reel for winding hose to take it in after the fire is out or to move it to a new location. Very simply made from half-inch pipe, the reel is very portable and can be operated by one man. When the hose is reeled up tight, one side can be slipped off after the hose is tied, and the hose is easily removed.—From the article "Ready for the 1939 Fire Season," in the May 1939 issue of the West Coast Lumberman, which carries a picture of the hose reel.

LESSONS FROM LARGER FIRES OF 1938

Roy Headley

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The July number of Fire Control Notes included an article on larger fires on the national forests. "Lessons learned" from these fires were quoted from reports when they seemed interesting and suggestive. Quotations from reports on 1938 fires are continued in this issue. The fact that a "lesson" is quoted does not necessarily mean that the editors agree with the conclusions. Experience of individual men on individual fires should contribute to the body of knowledge and ideas shared by all who may have to manage large fires. Whether this particular method is the best way of making "lessons learned" available to all, is doubtful. Criticisms and suggestions are invited. Would you get more from full case histories and complete comments on a few larger fires? Or do you get more from these brief pointed statements of what men have learned from many specific situations? Remember that we are now limited to four 40-page issues of Fire Control Notes per year.

California Region—Continued

Trinity—Glennison Fire—370 acres.—This fire reached the size it did as a direct result of crowning through the unburned canopy on the day following control. Past records will show that this is a common occurrence on fires in the Canyon Creek areas, and a special effort had been made to mop up the entire fire before the burning period of the day following control.

In spite of the efforts of 65 men with backpack pumps and a power pumper, the fire flared up from inside and crowned out in the unburned canopy of live oak.

If there is any lesson to be learned from this experience, I believe it is the necessity of having enough men with water equipment to cover the entire fire before the beginning of the next burning period. This is a rather difficult and costly procedure, especially when control is not achieved before daylight. The flare up on this fire began at 12 noon, which did not allow much time to cover the entire fire. Also, it is not advisable to send men into the burn before it has had time to cool sufficiently to allow them to work safely.

Control of this fire the day following was achieved by following the above procedure to a large extent. However, weather conditions were more favorable until the late afternoon, which allowed more time to mop up.

In summarizing the above, perhaps the most important point is to achieve control as early as possible the first night so that the fire will cool down before daylight, and allow more time for mop up.

Trinity—Little Bear Wallow Fire—2,200 acres.—C. C. C. enrollees are ineffective on a fire when not thoroughly trained in fire suppression, and they must be accustomed to hard hiking in rugged country and able to do effective work after arriving at the fire. In the case of this fire, the initial attack was made by an experienced guard and two green enrollees. The boys, who were transferred here with a New York company a day or so previously, were soft, untrained, and not accustomed to hiking, and not only slowed down the guard's travel time to the fire, but were useless after arriving there.

Pack stock was badly needed in the early stages of this fire. The absence of pack stock prevented the setting up of a dry fire camp to which food and water would have to be packed. Such a camp would have eliminated a long hard hike by fire fighters to and from the fire line.

The district dispatcher should be furnished adequate help both in the office and in the warehouse during a large going fire. He should not work over 20 hours on one shift.

Adequately trained men should be available to keep accurate records of all overhead and manpower on the fire line, or in the fire camps, and also to handle time slips and commissary supplies.

North Pacific Region

Siskiyou—Cedar Camp (Chetco) Fire—34,627 acres.—Something must be done to stop incendiary fires from being started to keep large fires burning. On the division in which I worked, it is a positive fact that one fire was set, and I am relatively sure that others were set in the same area. By way of a solution, the use of C. C. C. would probably be first, but in this case the C. C. C. was not available in sufficient numbers. Another solution, I believe, would be to use no crew not thoroughly supervised, even if it means using less men. For supervision, I believe that every straw boss unit should be led by a known straw boss. This would probably mean assigning many short term employees from other forests in cases of large fires.

Take the local man's advice as to fire behavior and wind drafts if he is reliable.

Reliable local men are indispensable as scouts, especially in unfamiliar country.

All trails should be brought up to at least secondary standards.

More roads are needed in inaccessible areas.

Division bosses should travel more on saddle horses than on foot, to prevent fatigue.

After the first few days, do not work the men more than 10 hours, as little is accomplished after that period.

Two weeks of hard fire fighting is about all the crews or overhead can stand. They should be relieved for a rest period if possible.

Discharge camp agitators immediately.

Provide comfortable and clean camps for the men. Better output of work will result.

Food for the camps should not be ordered from an itemized list as this clutters up the air for a long period of time when the channels should be free for other fire business. Order by the standard ration list.

Select dependable men for night patrol. Many hours of hard work are often lost through incompetent night patrol.

Adequate commissary should be provided the men, especially tobacco and socks.

Make a written record of all orders given and keep carbon copies.

Pack trains were more dependable than airplane service in smoky weather.

Airplane servicing proved itself on this fire especially where camps had to be located where no trails existed. Food and supplies could be furnished immediately or ahead of the men.

The importance of radio communication cannot be overstressed. It played a vital part in the control of this fire. The ultra-high S sets were indispensable to the scouting units. Their compact size and the ease of operation make them a very practical aid in fire fighting.

As a presuppression measure, I feel that in the future when a lightning storm is reported near the district during critical fire weather, that at least a 25-man crew should be held in stand-by for immediate attack. Due to a policy of not hiring local men for fire fighting, much time is lost in obtaining outside help.

On the actual suppression of the fire, the following defects were noted: The service of supply was not able to keep up with the number of men placed on the fire line. The men were worked too many hours per day for efficient work. Some of the fire line was not burned out soon enough, resulting in loss of line. More efficient bosses were needed on the line to keep the men working. Many of the men hired were physically unfit or not properly clothed for fire fighting. Greater care should be taken in the hiring of the men. These comments are offered not in criticism but for guidance in the future. In general, as compared to other project fires which I have been on, I feel that this one was handled exceptionally well.

Siskiyou—Nome Fire—5,800 acres.—Planes proved to be an excellent means of supplying fire camps both from the standpoint of speed and economy. Camps were serviced that otherwise would have had to be supplied by man pack, as was done for several days when planes were grounded, which required 8 hours of hard packing by good men to get 40 pounds of supplies into camp.

Planes will not eliminate the use of horses. During the time that this fire was burning the smoke became so dense the planes were grounded for several days, which clearly brought out the fact that pack stock must be relied upon at times.

Training given short term employees paid big dividends. The experience brought out the fact that we have a thoroughly competent, industrious, and efficient short term organization. It is believed that more could and should be done to give these men longer employment.

The lack of enough dependable foremen was in evidence. It is believed that more short term employees from other forests should be assigned for foremen and straw boss jobs on large fires, particularly in this area. (Both sides of this gamble must be considered. Sometimes the district loaning men has suffered.—Ed.)

Because of lack of trails in the area in which this fire burned, it was impossible to get enough men in to the fire in time to keep it from becoming a conflagration. At one time it was necessary to shift a camp 2 miles airline distance. Because of lack of trails and the rough country, it was necessary to hike the men 18 miles and truck them 6 miles.

It is useless to send men unless they are accompanied by a competent foreman in the proportion of not less than 1 foreman to 25 men. Practically all the errors on this fire can be traced definitely to lack of competent foremen overhead.

More use should be made of the indirect method of control on fires of this size and in this type of topography. There is always the human aversion to burned area that is continually cropping up on fires of this kind. Men work too close to the fire, thus sacrificing time and labor.

More satisfactory results can be obtained by dropping back and taking advantage of natural breaks in topography.

A stream, unless it is large and clear of brush, makes a poor fire line. The variable winds up and down streams, the possibility of rolling logs and falling snags, and the rapid spread of a fire up the slope once it crosses a stream, makes it exceedingly dangerous to use.

Siskiyou—Old Diggins Fire—4,207 acres.—On back country fires, the available pack stock for supplying crews must be given consideration hand in hand with the calculation of probabilities and the ordering of men to meet this calculation. Very difficult situations arise because of inability to supply crews on the line.

Strength-of-force plans for the district should be revised so as to include more intensive control during periods of bad fire weather and low visibility. This pertains particularly to areas where incendiarism is recurrent.

There is a need for a lighter, more compact backfiring tool to be included in our smaller fire fighting units.

For areas where incendiarism is a problem, funds should be available for hiring small crews for work on roads and trails, so that they will be available and close at hand for suppression.

Siskiyou—Siskiyou Fork Fire—1,396 acres.—The fatigue factor from walking long distances through brush and over rough ground must be considered in predicting output when men reach the fire. Such men on the initial attack will not do the work per hour fresh men or those transported to a fire will do.

Observations made from the air are often misleading, as it is difficult to tell accurately the actual conditions or resistances to control encountered on the fire line.

Siuslaw—Smith River Fire—27,500 acres (mostly outside).—The necessity and practicability of camping fire crews on the job, even if water must be packed by man power, was emphasized.

In some cases the fire line was constructed on the fire slope of a ridge instead of the opposite slope, which resulted in a difficult job of burning out.

Fremont—Bonanza Fire—9,155 acres.—The large area and rapid spread of this fire was due entirely to the dense and continuous stand of "cheat grass" (*bromus tectorum*) with very little timber overstory. Consequently, the usual "forest" fire standards are not fully applicable. However, the following was learned about this particular country.

1. Must keep roads cleared as fire breaks.
2. Must construct additional cross roads.
3. Must make definite plans for suppression (outline prepared).
4. Overhead, in general, needs more "mop up" training.
5. C. C. C. enrollees must be shown "how" by fire foremen and straw bosses.
6. On very large fires it is better to use machinery for trench construction at the sacrifice of some acreage than to depend on hand work too close to the fires.

Investigation of the cause of break-over on August 26 showed that while a good trench and clean burn had been obtained on the extreme southeast corner of the fire, and mop up had been carried back of the line an adequate distance for ordinary circumstances, the crowning of a small green pine tree on a low ridge about 300 feet inside the line threw sparks into the thick cheat grass and juniper timber which quickly crowned and spread under the brisk breeze. Men working in the vicinity of the break took action almost immediately, but were unable to cope with the heat of the crowning junipers and did not have time to use the indirect method.

Olympic—Green Mountain Fire—1,500 acres.—The lookout covering this area was on a patrol trip to a supplementary point and did not discover the fire until 15 minutes after it had been reported by the operator. It is always possible that this 15 minutes might have saved the day; however, due to an east wind and the fact that 15 men were unable to hold the fire a few minutes later, this too is doubtful.

There is also the possibility that had the pumper been put into use immediately upon arrival of the first crew, that they might have been able to drown this fire.

Rogue River—Trail Fire—1,089 acres.—Each sector boss should have a competent scout who is an experienced fire fighter to assist in locating lines and scouting ahead and who is responsible to him only. Other scouts working for the fire boss work at large and are often of no value to the sector boss who needs information on the line.

Scouts should not be men who merely know how to map and hike, but should be the best fire fighters available—men who know fire behavior from experience and can realize dangerous situations.

The camp manager should be a man who not only knows clerical work, but a man who knows fire fighting and requirements on the fire lines. This man should be the next important man to the fire boss.

A property or tool man charged with the responsibility of checking tools in and out and supervising the reconditioning of tools should be assigned each fire camp.

Related to the above is a question as to whether men should carry their tools back from fires, leave them on the line, or release them to relief crews. I am of the opinion that hand tools should generally be carried out for the following reasons:

1. Allows better control to prevent loss and theft.
2. Enables reconditioning of tools and means better tools on line.
3. Not apt to have tools one place and men another.
4. Prevents mixing of tools owned by different agencies.

On this fire the C. C. C. carried their tools out and the locals did not, and some of the above points were well illustrated.

A "camp boss at large" over three fire camps and assisted by a camp boss at each fire camp proved to be a good idea. In this way there was good correlation of activities between the various camps. All supplies were ordered through this man from the SOS unit.

Rocky Mountain Region

Roosevelt—Jenny Lind Fire—664 acres.—I believe the most important point to be noted is the great difficulty of insuring adequate initial action on a very aggressive fire in its initial stages. (Three miners, 100 feet away, saw fire and attacked it 5 minutes after it started. District ranger with one man arrived at fire 35 minutes after it started. But larger crews did not reach fire in time to prevent 39- to 54-mile wind from starting fire on its first run. Probably most important lesson to be learned is that on a forest not provided with regular detection and other facilities common western fire forests, a fire starting in slash in a gale of wind could be and was stopped at 664 acres.—Ed.)

Almost uniformly there was too much tendency to bury burning material along the fireline in such a way that it only prolonged the burning and the mop-up period. The correct use of dirt has been so much emphasized that there are few if any of the foremen ignorant of the undesirability of partially burying heavy material; but there seemed to be great difficulty in getting this particular fault corrected.

A common fault which was perhaps the most serious was that of inclosing ragged fire perimeter inside a line without taking any measures to clean burn. This needs to be given a great deal of emphasis on all forests.

Southwestern Region

Gila—Canyon Creek Fire—502 acres.—This fire was started by a new employee of Mr. Adams, who was reputed to be a very careful man with fire. This emphasizes the need for personal contact with the permittees and employees which the rangers do carry out on this forest. The Gila rangers make a concentrated effort to contact all permittees through the whitling medium which I feel is the best method for this class of case. (But good as "whitling" is, it can't be done with everyone whose tendency to be careful with fire needs strengthening. Often there is time for no more than a few words—but those words need to carry ideas which will stick like cockle burs. For the benefit of readers, who will suggest such ideas, phrases, slogans which will stick, for use in the quick contacts which are so often the only ones possible?—Ed.)

Gila—Lookout Ridge Fire—575 acres.—Class 6 burning conditions prevailed and were not recognized. The fuels were very dry and the wind was strong. The lesson learned here is that a fire danger station would have furnished a definite check on burning conditions, and this could then have been promptly followed by proper stgenrthening of the guard force to meet class 6 or emergency conditions. (This forest is now supplied with a fully equipped station. Danger stations and danger ratings are designed to avoid just this sort of failure to recognize changes in fire danger.—Ed.)

Poor line location due primarily to trying to hold fire to a minimum acreage with subsequent loss of excess acreage was an important factor. This is merely a matter of training in suppression. (Yes, but training in judgment, which is the most difficult and most backward field of training.—Ed.)

Gila—Iron Creek Fire—2,318 acres.—Here again class 6 burning conditions existed unrecognized.

Too much line was lost by working too close to the fire. (Understand that this fire and this weakness were used by the region for training by the case method.—Ed.)

Width of fire lines must be governed by (*a*) fuel on ground; (*b*) steepness of slope; (*c*) wind velocity. In the past, fire lines have been entirely too narrow for safety in handling backfiring in windy weather. (Importance of training in judgment again emphasized. More common error is to make fire lines wider than need be for backfiring.—Ed.)

Intermountain Region

Wasatch—Shepherd Creek Fire—960 acres.—Particularly significant is that the fire, carried by a high wind, spread over 700 acres within 2 hours after it started. It traveled so fast that the fire truck, plow unit, and men could not keep pace. Forty men were on the fire within 20 minutes after it started, and, with our fire truck which suppressed a mile of fire edge, and the plow unit that made over 3,000 feet of fire line, it was impossible to cope with the high rate of fire spread. (But the wind dropped and the fire died down, after which the crews had a chance and did not muff it. An important principle is that the front of a fast running fire is often untouchable. But a lull always comes. The job is to be sure to grab it for keeps during that first lull.—Ed.)

Eastern Region

George Washington—Panther Gap No. 2 Fire—478 acres.—Fires had previously occurred along this portion of the C. & O. Railroad track. Inspection in February 1938 showed that the right-of-way was in very poor condition. This was brought to the attention of the section foreman personally and to the division superintendent by mail. No follow-up inspection was made.

Action on this fire, which was on a mountainside and almost entirely visible from the road, indicates that the hard and fast rule of requiring the district ranger (fire boss) to remain on the fire line is not always satisfactory. By remaining on the road with the whole fire spread out before him and with an adequate messenger staff, it was possible for him to know more about what was actually going on and be able to take quicker action than he could have on the actual fire line. In my opinion, the definite rule that the fire boss must remain on the fire line, in many cases, results in failure of suppression forces to take prompt action at critical points due to the very inaccessibility of the fire boss by putting him up in the front line trenches when he should be in a position where he can control the actual movement of his forces, both combatant and reserve, on the basis of what is happening on all points rather than just the local hot sector where he happens to be at the time a decision must be made. (This poses a problem which calls for more attention, more critical experience, and more carefully recorded experience for the benefit of all. Here is the dilemma on those fires where there is any real choice as to the method the fire boss follows in this respect. If he goes on the line, he will get the feel of the job in a way which cannot possibly be done through others. He can therefore, act more intelligently on the particular fire, and will also increase his priceless fund of direct fire experience. But as Supervisor Howard brings out in the above quotation, he will lose some control of the work on the job as a whole. Some men who have managed fires from a base camp with the aid of scouts, messengers, and a map laid out in the dust, are enthusiastic in favor of that method. Others say that a competent fire boss makes plans and issues general instructions; that frequent decisions are likely to gum things up; and that the fire boss can work through messengers and scouts while moving around the fire, as well as from a central point. If it is a matter of skillful discrimination between fires which call for one or the other of the two methods, what criteria may be set up to enable a fire boss to judge quickly and accurately which method is best for a particular fire?—Ed.)

Southern Region

Conecuh—"Boss" Fire—496 acres.—The fire area was about 30 acres on arrival. This can only be reduced under the prevailing conditions, by closer placement of suppression equipment. Maximum travel distance now 10 miles. To halve this distance would quadruple the number of fire crews. Question: How much can we afford to spend to reduce area on arrival? Certainly 30 acres is too large. (Since this fire only burned 64 acres within the protection boundary, it did not come within the definition of fires of over 300 acres; but it is included here because it raised in the minds of forest executives a question of such fundamental importance to socially-minded management of fire control.—Ed.)

Conecuh—"Big Fire"—576 acres.—In the attack on this fire, as in most other fires on the Conecuh, (wire-grass type of ground cover), everything depended upon the success or failure of the tank truck. From the time of attack with this truck until the water supply was exhausted (15 minutes) 19 chains of line were built. A reorganization has been made to provide for replenishment of the supply of water for the tank truck.

The fact that the first crew boss on the fire did not assume the role of fire boss contributed to confusion and loss of acreage. Intensive training in the duties of a fire boss is being given all crew bosses.

A whirlwind picked up burning material from as far as 100 yards inside the line and dropped it outside in the rough, resulting immediately in a break-over of large proportions. On at least two occasions whirlwinds hit the fire line while suppression was being carried on with tank trucks, resulting in loss of short lengths of line and excessive use of water. Variability of wind direction and prevalence of whirlwinds are factors not ordinarily considered in danger rating.

Evidence indicates there was time to have cut a line and backfired across the head. This would have speeded up control and promised better chance of holding to a smaller acreage.

Conecuh—Long Fire—442 acres.—The more basic problem, the elimination of the grazing fire as an element of risk, is, of course, being attacked from the educational angle, and some progress has been made in convincing stockman of the advantages of rough woods. However, the problem is intimately tied up with the regulation of grazing on the forests and warrants much study as well as administrative attention. The risk of stockmen's fires will likely be present on the Conecuh for some years. (The 1938 record on the Conecuh is so much better than for previous years as to suggest that progress has indeed been made on this outstanding problem of the grazing fire.—Ed.)

Conecuh—Bradley Fire—792 acres.—The education of local residents has not yet reached the point where they can be depended upon to follow all accepted principles in respect to debris burning. In this case, a line was plowed around a field and the fire set to burn into the wind. But the rancher failed to realize the high danger involved when burning at 10:30 a. m. Had this burning been deferred until late in the afternoon, there is no doubt but what the fire could have easily been confined to the field being burned.

It must be admitted that we do not yet have on the Conecuh equipment capable of stopping a large fire under severe burning conditions. Since the occurrence of this fire, our tank trucks have been improved somewhat by the use of a larger nozzle opening. This increases water consumption, but permits attack on a somewhat hotter fire. On later fires the use of two tank trucks abreast has been tried with some success. There is also a possibility of delivering more water from one truck by the use of two hoses.

There is a definite need for a mobile tractor-plow suppression unit, capable of rapidly plowing a line from which backfiring could be done. This type of equipment appears to offer the only practicable means for stopping the head of the occasional bad fire short of natural breaks.

The relative humidity on the day of the fire (December 3) did not reach a point that could be called low. This shows that relative humidity, in itself, cannot be relied upon as an indicator of fire danger.

Ocala—Pleasant Flat Fire—2,161 acres.—Our means of transporting men and equipment in the conventional type truck is unsatisfactory for the sandy roads on the Ocala. We plan to overcome this obstacle by replacing our conventional fire trucks with four-wheel drive trucks as rapidly as funds become available.

The ground of the timber type through which this fire burned is generally covered with water during periods of normal weather, but dries out several times a year so that it becomes inflammable. Since it is not very accessible by tank trucks, the construction of permanent meandering 8-foot firebreaks on the higher ground within the type will prove very helpful in suppression of any future fires which may occur.

This fire was also the first on which we used the new Mathis or Columbia two-disk plow equipped with a rolling colter. This equipment proved very effective, and with minor changes will become an important piece of suppression equipment.

Summarizing, I would say that the most important thing this fire showed was the inability of the ranger to make efficient use of the manpower and equipment that was available at the time of the fire. The matters of new and better equipment are secondary. (The ranger may take comfort from the fact that many others, including big shots in fire control, suffer from the same inability—but this should not deter him from seeking to be mentally prepared for efficient management of the next fire.—Ed.)

Choctawhatchee—Sandy Mountain Fire—2,381 acres.—The equipment we were using was in poor, worn-out condition and failed on the fire line. This has since been corrected by a new tank truck which has been built and equipped with a power take-off and centrifugal-type pump.

Burning the boundary biannually is not sufficient to cope with the control problem of exterior fires. To remedy this we plan to burn a strip having a minimum width of 300 feet around the north and east boundaries each year; this will give us a 300-foot strip freshly burned adjacent to a 300-foot strip with a 1-year rough, and it is felt that this will form an adequate base from which a backfire can be set.

The fire-training meeting that followed this fire indicated that our previous method of handling fire-training meetings was not reaching its objective. The most effective means of discussing strategy in fire control we found to be the drawing of an actual fire on the blackboard by one member of the group, picturing the fire as it was when he arrived. He wrote on the board all of the actual conditions, that is, men and equipment that he had, size of fire, condition of fuel, direction and velocity of wind, time of day, land status, etc. In other words, I wanted to eliminate from the very start the pet answer, "it all depends." Each member had an opportunity to describe or to lead a discussion on one or more fires that he had been on in the past several years. After placing all the information on the board portraying the fire as it was when he arrived, he would then ask different members of the group what they would do under like conditions. After the fire had been thoroughly discussed, the leader of the group would then tell them what he did and what the results were.

I felt that this was probably one of the most effective fire-training meetings I had ever attended because every member was eager to describe his experiences and to criticize the action that had been taken on the other fires by other persons, and the opinion of the group after the meeting seemed to indicate that they had all gotten quite a bit out of the meeting.

Kisatchie—Big Fire—650 acres.—It takes considerable training and actual fire fighting to get C. C. C. crews up to the output of 6 chains per man-hour which was attained on this fire. To insure such an output for the future, all C. C. C. members of companies used for fire suppression must be put through an intensive 3-day fire school at least four times a year. The rapid turn-over of enrollees makes the quarterly fire school absolutely necessary. If enrollees are properly trained and well led, 6 chains per man-hour can be maintained without any undue trouble. (More power to Supervisor Bryan, the author of these brave words. The weighted average output per man-hour on the 25 larger fires in region 8 in 1938 was 1.67 chains.—Ed.)

This was a man-caused fire set for grazing purposes. It probably was not the intention of the trespassers to burn Government land. However, the fact that it did burn Government land did not worry them very much as it was just additional burn for their stock to graze upon. Fires originating outside of our fire and national-forest boundaries are, as a rule, more dangerous than those arising inside. The reason for this is simply that they are farther from the centrally located source of manpower, and by the time a crew reaches them they are so large that control is exceedingly difficult. The Kitsatchie Forest had five 300-acre and larger burns during the 1938 season. Three of these fires originated from so-called grazing sets which occurred outside of the national-forest boundary. When one considers that 90 percent of the land immediately outside of our boundaries burns at least annually, it is not surprising that some of these fires will cross the boundary and burn national-forest land. State fire laws are not enforced, and the area outside has no protection except that afforded by its proximity to national-forest land.

It is the opinion of this forest that the outside fires will never be completely solved until the outside area is placed under protection. The grazing of cattle, horses, sheep, and goats conflicts directly with fire control. Regardless of who owns the land, stockmen, as a general rule, are going to burn in the spring if they think they can get away with it. We can, in a measure, stop them from burning outside by fire-prevention talks, law enforcement when the fires set endanger Government land, and general educational programs. However, the real solution for outside fires is protection for that area.

This forest in the past spent most of its time and money on fire prevention within the boundaries. The number of fires within the boundaries have been steadily decreasing, and it is now our problem to stop the setting of those fires around our boundary which could possibly creep over to Government land. This is a large job, as our boundaries are long and a large number of people live just outside. It will take several years to make much headway, and the problem will never be settled until this outside land is put under adequate protection from fire.

Kisatchie—Honey Fire—1,092 acres.—In this case the fault lies with the fire boss in his failure to recognize extreme fire conditions that existed on January 25, and to modify his attack to fit these extreme conditions. If he had realized, or had had means other than his general knowledge and experience to guide him in selecting the correct method of attack, the fire would have been controlled much easier, and with a somewhat smaller acreage. Instead of attempting a direct attack, had he backfired all existing roads and firebreaks facing the oncoming fire, the fire would have been controlled at about 700 acres and the slash-pine plantation inside of the fence would have been saved. The amount of held line per man-hour would have been at least tripled. One answer is a well-constructed fire-danger meter which will leave as little as possible to the judgment of the fire boss on the fire line.

The only method of controlling this fire at a smaller acreage after it had started would have been an immediate attack by the indirect method of backfiring. Under such conditions, tank trucks and specialized equipment are of very little value. A strip of burned ground at least 400 feet wide is necessary to stop the heads of such a fire.

The fire was started by the L. & A. Railroad train which was temporarily stalled at the point of origin. The Louisiana State law requires that the railroad free their right-of-way from combustible material. The forest has never been able to force the L. & A. to do this. The railroad officials have been warned, both in person and by letter, many times. Also, they have paid suppression cost and damages for other fires caused by their railroad. Railroad business is rather poor, and the officials took the attitude that they could not afford to keep rights-of-way clear as required by law. Reimbursement for damages and suppression costs amounting to $2,160.62 has been asked for.

Since this fire occurred, however, the railroad officials have decided it is cheaper to clear the right-of-way than to pay damage and suppression costs. Both the L. & A. Railroad and Missouri-Pacific Railroad Cos. have cleared their rights-of-way of combustible material within the forest boundary. For the first time in the history of the Kisatchie Forest, we will enter the 1938-39 fire season without the constant hazard of railroad fires.

Fusees used for backfiring in some of the tool boxes had absorbed enough moisture from the air to be worthless. The wet or damp fusees could not be detected by casual examination. Some delay in backfiring was caused by these dud fusees. Fusees cost only about 9 cents a piece, and this failure could have been eliminated by simply replacing old fusees with new ones every 30 days.

Kisatchie—Slash fire—407 acres.—Two hundred and ten acres of the fire had only recently been planted to slash pine. The slash pine of course was totally destroyed. The rough was composed of wire grass, broomsedge, and a fairly heavy carpet of hardwood leaves. The rough was of 5 years' accumulation, and can be considered heavy for longleaf type.

Investigation revealed that the fire was handled very well by the lookout men and the dispatcher. The discovery, report, and get-away times are excellent. However, the decision of the superintendent to send only 6 men with the junior foreman in a pickup to check on the fire was sadly at fault. The day was not an extremely bad one; however, a fresh south wind was blowing and any fire located within a quarter or a half mile south of the boundary certainly should have merited both the fire truck (tank truck and Panama pump) and a full 16-man crew with the standard fire-fighting tool box. If the junior foreman had had a full 16-man crew and fire truck he would have unquestionably held the fire with only an acre or so of national-forest land burned.

Kisatchie—Cactus Fire—488 acres.—The C. C. C. enrollees from the State camp had only been at Fullerton Side Camp about 10 days at the time of the fire. They had been transferred there to assist in the heavy planting program. These men were absolutely inexperienced in fire fighting and, consequently, had only what training could be given them in this time. It is little wonder that they became panic-stricken on a fire such as this, not having had the chance to gain the experience necessary on fires of lesser severity.

The seat of this lies in the decision of Superintendent Warner to keep his men separate from the enrollees of the home company. This was a wise decision from the standpoint of supervision of the men on the planting job, but left a woefully weak point in the fire-fighting organization.

When it is necessary to augment our regular camps with additional men for a heavy planting program during the fire season, there will be a split of men in such a way that we will be assured of a good sprinkling of well-trained men in every crew. This will be an addition to an intensive training program for all new men.

Kisatchie—Boom Fire—877 acres.—This was an incendiary fire and was the result of four separate sets. These fires were not set by local residents. The area is grazed heavily only in the spring and early summer when cattle are driven out of the swamps by the backwater of the Mississippi River. Many of the stockowners who graze their cattle on the forest at that time live and normally graze 30 or 40 miles away. These men are not interested in growing trees, but are solely interested in good grazing for their stock. They firmly believe that a fresh burn is much better than a rough at that time of the year, and many of them will resort to nearly any measure to get the burn desired. Better law enforcement is one of the answers. Control of grazing by fencing and issuing permits is another. Fire-prevention contacts with stockmen will also help. Next winter the forest plans to have at least one man roaming this area on foot or horseback for the sole purpose of apprehending at least one trespasser. One conviction on a criminal charge of wilfully setting fire will unquestionably do more real prevention work than anything else.

DeSoto—Saucier Fire—685 acres.—The weather conditions made the hazard extreme. There had been no rain for 3 days. The relative humidity was 33 at noon. Wind velocity varied from 8 to 16 miles per hour during the fire. The ground cover was broomsedge grass. The flames had a range of 40 to 60 feet, crowning at times and spotting ahead.

Instructions were to backfire from a fire lane on the west side. This firebreak had been constructed 2 years ago and had not been maintained since this time. As a result, it was grown over and offered no effective barrier from which to backfire. The extreme weather conditions made it improbable that even if the firebreak had been recently maintained, the crew would have been able to hold their backfire on this narrow line.

DeSoto—Hell Hole Creek Fire—509 acres.—This fire emphasized how immediate and continued work on the flanks of a large fire can keep the acreage to a minimum and prevent new heads from forming when the wind shifts. Crews worked the flanks continually so that when the head was finally stopped the entire fire was corralled within a very few minutes.

The head of this fire presented a wall of flames 20 feet high, with a range of 30 to 40 feet. It was burning in a 5-year rough. Several of the fire fighters had narrow escapes while attempting to stop the head. Two different pump men were forced to abandon their pumps in order to outrun the fire.

This fire, as well as other large ones on the DeSoto, shows that in extreme weather conditions a great deal depends on the dispatcher's judgment in placing crews, not only for the head but for work on the flanks. The speed at which these fires travel offers little opportunity to correct tactical mistakes on the fire line.

North Central Region

Chippewa—Lundeen Fire—370 acres.—Training plans must be flexible enough to provide for abnormal years. Training plans called for the training of the dispatcher and lookout men prior to our normal fire season, but as the spring fires started 25 days prior to our normal season the dispatcher and lookout men were inadequately trained. It is believed that this fire would not have reached this size had the men been given more thorough training. The area when reached was estimated at 60 acres.

Areas of this type should be burned over in the spring when conditions are safe and snow is present on the high land, as areas of this type are used for pasture by local settlers. If not burned, they will be set by the local settlers when weather conditions are favorable for burning.

The action by the suppression forces was satisfactory, with the exception that a scout should have been used to reconnoiter the fire and secure any clews or evidence as to the individual or individuals responsible for setting the fires.

Gardner—Tower Fire—489 acres.—This was one of a series of 25 fires burning on the district on this date. The fire danger was class 6 and the wind velocity was 20 miles per hour. The fire spread rapidly in highly inflammable leaf and grass fuel. Topography was rugged with steep slopes, which accelerated the rate of spread. Winds shifted frequently and small whirlwinds occurred along the fire front. As a result the fire had a number of heads, with one traveling along the top of each main ridge. The fire advanced in a solid sheet of flame, leaping 6 feet high in most places, and the men could not get near the fire because of the intense heat. Spot fires, jumping in many cases over 100 feet ahead of the main fire, were common. There was 2 to 3 years accumulation of leaves on the area.

When Assistant Ranger Barry arrived, he took charge of the fire immediately. He made a quick size-up of the situation, determined that direct attack was ineffective (It had already failed.—Ed.), and directed the crews to drop back several hundred feet from the fire edge to construct line. The technique used, which consisted of raking a line and backfiring from it, was considered satisfactory under the circumstances. This dropping back was essential because whirlwind conditions caused fires to spot 100 to 200 feet ahead of the main fire.

Knowing the conditions as are known now, fire management could have been improved by backfiring from the truck trail and keeping the fire from crossing it. However, the use of this technique would have required at least 25 additional men as there were separate heads traveling toward the road.

The district personnel feel that bloodhounds could be effectively used in tracking down trespassers; merely the knowledge that bloodhounds were being used for this purpose would make the local residents less apt to set wild fires. When this matter was taken up with the regional office however, the use of bloodhounds was opposed for several reasons, the principle being that bloodhounds are usually associated with running down murderers, kidnappers, and other criminals in that category, and should not be used as a deterrent medium for reduction of man-caused fires. (But after years of fairly successful use of bloodhounds in a small way, the southern region feels that the use of dogs for this purpose should be greatly enlarged.—Ed.)

The general belief that all fires in Missouri hardwoods can be handled by direct or parallel methods is false. On certain days, conditions are such that the only practical method is to drop back to natural or cultural barriers, such as the road in this case, and sacrifice some burned acreage in order to insure control.

A more extensive use of water should be resorted to on such days. On this fire three men could not control a 5-foot spot fire by use of rakes. A marine pump would have saved the first line built on this fire.

Gardner—Flat Fire—302 acres.—This was the only fire burning at the time, and most of the enrollees were in camp and available. Therefore, in view of the available manpower, wind velocity, darkness, and possibility of multiple sets, the dispatcher was justified in sending 31 men instead of the usual smaller initial attack crew. It is our policy to send more men to night fires during hazardous periods, since experience has shown that travel time is slower and held line production is usually very low.

Gardner—Brookshire Fire—412 acres.—As a result of our experience on this fire, an organization of fireguards and suppression squads paid from P. & M., F. C., and F. F. was set up at strategic points to supplement C. C. C. during critical days.

The held line constructed per man-hour on this fire was three chains. During periods of class 6 danger, with a wind of 20 miles per hour, held line construction is necessarily slow because of the need for a wide line and careful patrol immediately behind the crew to keep the burning leaves from spreading across.

This fire was set and tended by local residents. They were intent only on burning their own land and claimed to be unaware that any Government land was inside their fence. A contact with Mr. Brookshire warning him before the fire was started might have prevented it. However, he was taken before a justice court and pleaded guilty. This action should have a very desirable effect in the locality for fire prevention.

Gardner—Thurman Junction Fire—412 acres.—The slopes on most of the burned area were between 40 and 50 percent, and in some cases much steeper. A strong wind prevailed, as was evidenced by a large number of tree tops broken during the time the fire was burning. At least 60 different places were set afire along the bottom of a deep dry ravine for about 1¼ miles. The fire spread rapidly up both slopes. The change in tactics used by the person setting this fire is of extreme importance in this locality. Previously, sets have been made by following the ridges. In this case, sets were made in the bottom of a deep hollow in the most blind place possible. As to prevention, controlled grazing with definite allotments would probably have eliminated this fire.

Superior—Sand Creek Fire—329 acres.—Most of the line was made with a tractor and plow. Need was emphasized for a foreman with good judgment to direct the furrowing crew in line construction. This is necessary to shorten the amount of line by cutting across burning points, and burning out, especially where low timber values are involved. (Why use up a foreman on line location at which he may or may not be expert? Why not train a cat-skinner to locate his own line, or when that is not practicable, have him directed by a man who, while not a foreman, is skilled and trained in the art of line location?—Ed.) This point was very outstanding on the fire as the furrowed line followed the fire and no burning out had been done, hence a sinuous line of great length and loss of line in the northeast corner due to lack of burning out directly behind the plow unit.

Crew foremen need more training in burning out to the furrowed or trenched line. This fault was very pronounced on the south half of the fire. The foreman would not burn out and I had to do the job myself in order to get it done. Also, the foremen did not stay with their crews, directing their work, but left them with leaders and assistant leaders in charge. This fault possibly results from lack of knowledge of the ability of individual foremen and rating them too high on the fire roster.

I noticed a great deal of wasted human effort through the lack of training or knowledge in what constitutes a fire hazard. When large living aspen is cut down close to the fire line as a hazard, I believe more training is necessary to correct this error in judgment.

Extract from a Board of Review Report—Name of region, forest, and fire withheld.—This fire became large primarily because of ineffectual control work by green, slip-shod C. C. C. crews used in initial attack. Subsequent losses of line appeared to be due chiefly to reburns caused by failure to burn the moss from trees. The story is well covered in the Forest Board of Review write-up and accompanying conclusions for this fire.

The use of trail builders in building a truck trail into the fire allowed the largest construction job on a fire yet undertaken to be completed rapidly and when needed. Radio was also advantageously used.

The weaknesses that showed up are enumerated below as a check-list for action to avoid repetition in future:

1. Water supply for men on top of ridge was not made available until close to the end of the campaign.
2. There was lack of knowledge of the situation at various times on the part of directing heads. Also failure to calculate size of job and manpower needed.
3. Shortage of right tools at the right time and place.
4. Men were instructed to get tools from forces they were relieving, resulting in failure to contact and no tools for relief forces.
5. Moss on the trees was not burned off.
6. After fire was lost, men tried to fight too close for about 2 days.
7. Backfiring delayed; might easily have resulted in disaster.
8. Pessimistic outlook and manning for worst possible situation rather than existing.
9. Excessive manpower and overhead. Current manpower organization records were not maintained.
10. Weak line organization; high-caliber men in camp and not enough of this type on line.
11. Lack of prearrangements as to crews, trucks, and rations.
12. Insufficient and lack of proper handling of property; failure to check invoices of supplies resulted in considerable loss.
13. Wage rate and time-keeping difficulties, resulting in minor labor troubles. Standard crew-boss time records would have helped.
14. Records not adequate, not coordinated or properly checked, resulting in duplicate orders for men and equipment and supplies.
15. Off-shift men, especially overhead, did not go to bed when possible in many cases.
16. Lack of transportation from camp to line, etc.
17. Outside pack stock could have been ordered earlier.
18. Crews got lost. Adequate guide service needed.
19. Definite marking of station locations on the line and on a duplicator map would have prevented crews or bosses getting on wrong sectors.
20. Excessive costs on this fire. Records of charges to fire not kept currently so that reasonably accurate charges could be made. Arbitrary prorating of costs distorted picture of costs on this and the other fires.

(Aside from the foregoing the management of this fire was all right. But before you set this instance down as a horrible example of what could not happen in your territory, consider two questions: (1) Do you know, and have you faced what really happens on your own jobs, and (2) have your larger fires over been subjected to the type of honest and searching forests and regional inquiry from which the foregoing resulted? Good management of larger fires is probably more exacting than any other management job except the direction of a battle in human warfare. Blunders, wastes, failures cannot be wholly eliminated. But they can be reduced. The analysis in this case has what it takes to do just that.—Ed.)

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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 technology may flow to and from every worker in the field of forest fire control.