VOL. 4 APRIL 1940 NO. 2

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

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

Volume 4 Number 2

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the TECHNIQUE OF FIRE CONTROL

*

FIRE CONTROL NOTES is issued quarterly by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., 15 cents a copy, or by subscription at the rate of 50 cents per year. Postage stamps will not be accepted in payment.

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.

Address DIVISION OF FIRE CONTROL
Forest Service, Washington, D. C.

Fire Control Notes is printed with the approval of the Bureau of the Budget as required by Rule 42 of the Joint Committee on Printing

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1940

CONTENTS

THE 40-MAN CREW—A REPORT ON THE ACTIVITIES OF THE EXPERIMENTAL 40-MAN FIRE SUPPRESSION CREW

EDWARD P. CLIFF

Supervisor, Siskiyou National Forest, Region 6, U. S. Forest Service

and

ROLFE E. ANDERSON

Leader of the 40-Man Crew, Region 6, U. S. Forest Service

Region 6, throughout the summer season of 1939, conducted an experiment in organizing and operating a special 40-man suppression crew. With regard to this venture in an important field, Regional Forester Lyle F. Watts in his letter of January 9 states:

"The past season's experience has been valuable. All forests are enthusiastic about well organized, trained, and properly equipped mobile crews. Special instructions have been prepared for forests, so they can organize such crews from their own resources. The region is going to spend several thousand dollars for light beds and special equipment. Special overhead training is going to be handled as a project. New ideas in organizing and managing crews on the fire line are being developed and tried out. Reducing overhead costs, particularly behind the line, is almost daily talk on many forests. Costs on walking men to and from camps have been analyzed and discussed. The impetus to these and many other matters has, it is believed, been brought about in part, at least, by the use of the 40-man crew.

"If total expenditure for the 40-man crew, exclusive of the road and bridge construction, is prorated to each mile of fire line constructed, it cost $871 per mile. Long distance transportation, camp construction, etc., are all included. If only fire equipment, training, transportation, and suppression costs are included, the crew constructed each mile of fire line for $325. By comparison, it cost an average of $1,991 to construct and work each mile of 229 miles of fire line on six of our largest fires. If one-third of this was expended for mop-up and thus eliminated, the 40-man crew constructed line 35 percent cheaper, if all its costs are included; or over four times cheaper if only its fire costs are included, as compared to ordinary crews. Such a rough comparison does not tell the whole story as the 40-man crew in every case worked on the most inaccessible and difficult sections on fires, and time and expense of transportation were unusually high because of long distances traveled."

Mr. Watts' letter transmitted the comprehensive illustrated and charted report on the project. In addition to this detailed report, Messrs. Cliff and Anderson have prepared for publication in Fire Control Notes a most interesting condensed version.

Fire control men have realized for several years that the practice of recruiting untrained fire fighters for the suppression of large fires has proved inefficient and expensive. The 40-man fire suppression crew was organized in an effort to overcome apparent weaknesses in this important phase of forest management. Plans originating in Region 6 and the Washington office called for the organization, on an experimental basis, of a carefully selected, highly trained 40-man fire suppression crew equipped to sustain themselves for periods of at least 3 days in inaccessible back country where the work of ordinary

crews is inefficient. Each member of this crew was to be selected for his physical prowess and woodsmanship, hardened by work, and trained to use the correct technique in handling each foot of fire line without detailed supervision.

The Redwood Ranger Station on the Siskiyou National Forest was selected as the best location for the crew. This station was on the Redwood Highway, facilitating fast travel by paved routes to forest areas along the coast and Pacific highways, and forests east of the Cascade Range. In addition, this headquarters site was in the immediate proximity of needed project work, which would help finance the crew, and was located on a forest with large inaccessible areas and difficult fire problems.

Preparation and Training

Recruiting.—A junior forester with 10 seasons' experience in supervisory work on fires was chosen as leader. In an effort to choose qualified men for the crew in a limited time, the regional office requested each forest to submit the names of several qualified candidates. The crew members were selected from these candidates by the leader immediately after his assignment to the job. Most of the crew members reported for duty between June 16 and July 1, and the crew reached full strength by July 9. Eight additional men were recruited throughout the ensuing season to replace men found to be unqualified because of poor health, poor workmanship, and other deficiencies.

Four squad bosses were selected who were well qualified in the instruction and management of small crews on fires, in camp, and on work projects. In picking other members of the crew, men were selected who were not only capable fire fighters, but who also had specialties in other lines of work. The crew included 2 qualified first-aid men, 2 "cat skinners," one grader man, 10 fallers, and 3 men capable of doing fire line cooking. A professional cook and 2 flunkies were hired to prepare all meals for the crew while in camp. The leader and squad bosses were included as part of the total crew of 40 men. The kitchen force was in addition to the regular 40 men of the crew. Since the work of this crew was largely experimental in nature, a special recorder was added to insure obtaining necessary detailed records of the activities and accomplishments of the crew.

Salaries and Civil Service Status.—Members of the crew were hired as guards (CU–4) pending certification of eligibles, at an entrance salary of $110 per month. The squad bosses were given a CU–5 rating, with a salary of $125 per month. When away from Grants Pass. the crew members were supplied board and lodging by the Government.

Camp Site and Quarters.—A camp site was selected one-fourth mile from Redwood Ranger Station on the bank of the Illinois River. Eleven tents set up on tent frames provided comfortable living quarters for the crew. Two portable wooden buildings were constructed for use as a mess hall and bathhouse. A third portable building, loaned by the Siskiyou National Forest, was erected for use as a study hall, conference room, and office quarters.

Water was distributed to all parts of the camp by a pipe line tapping the ranger station water system. Electricity for camp light-

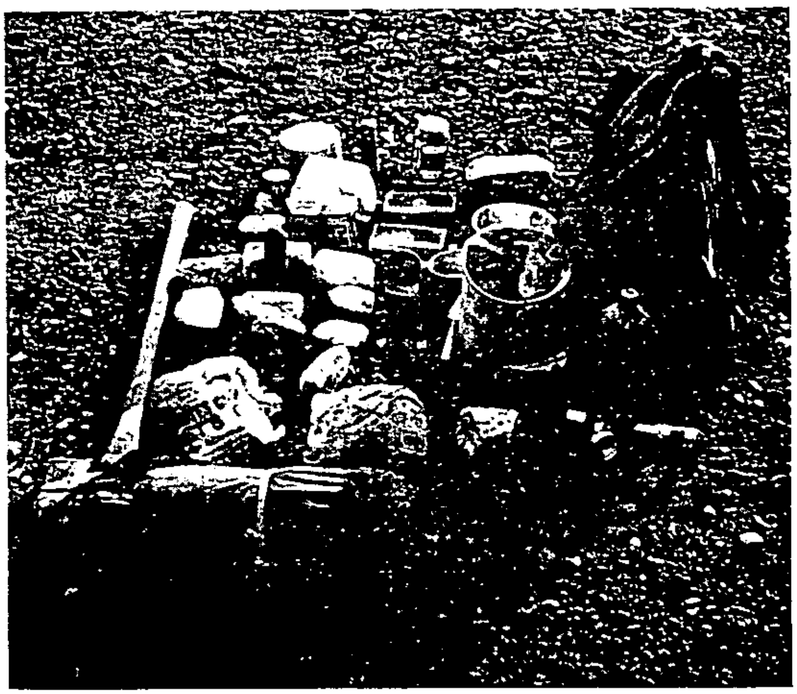
ing was purchased from a commercial power distributor. A grounded telephone line, 800 feet of road, and a 20-foot bridge were constructed by the crew to provide communication and access to the camp.

A number of recreational facilities were provided to occupy the leisure time of the men closely confined to camp. A gravel dam was thrown up across the river to form a small lake for swimming. A soft-ball diamond and volley-ball and horseshoe courts were cleared and leveled for the enjoyment and conditioning of the men.

The cost of constructing and maintaining the camp and supplying fuel amounted to $6,245, which includes the value of the time devoted by the 40-man crew to these activities.

Equipment and Supplies.—The objective in equipping the 40-man crew was to select tools, bedding, and rations which would convert the crew into an effective fire-fighting unit, self-sustained for a minimum period of 72 hours, and which at the same time could be carried over trails and rough country at a creditable speed without unduly tiring the men. This objective was met by building up packs which included essential fire tools, concentrated rations consisting mainly of dehydrated food, and lightweight, goose-down sleeping bags which rolled into bundles 13 inches long and 7 inches in diameter. These compact bags, well tailored, with zipper on both inner bag and cover, proved sufficiently warm for summer use.

Table 1 shows the content and weight of an average pack with essential equipment. The complete list of fire tools carried to and used on all fires upon which the 40-man crew took action is shown in table 2.



Contents of 40-man pack.

TABLE 1.—*Contents of an average 40-man-crew pack*

Number	Item	Weight in pounds
1	Pack board, Trapper Nelson	5½
1	Headlight w/3 extra batteries	1½
1	Canteen w/water (to hang on belt)	2½
1	Sleeping bag, lightweight	5½
2	Lunches in cloth sack (to hang on belt)	1½
1	Rations, 3 days	11
	Cook and mess outfit or extra equipment	2
	Personal effects	2
	Tool, fire (average weight)	4
	Average weight per man, total	35½

TABLE 2.—*Fire tools carried to and used on fires by the 40-man crew*

Number	Item	Weight in pounds (each)
4	Axes, cruiser's	2½
6	Axes, swamping	3½
10	Pulaskis	3½
10	Hoes, hazel	3½
10	Shovels, baby (6 carried by last 6 hoe men)	2
12	Fusees (for burning out)	½
2	Saws, falling, w/handles	10
1	Back-pack bag, w/pump	6½
4	Axes, falling	4
2	Oil cans, 1-pint	1
4	Wedges, wooden	½
10	Axestones, carborundum	½
10	Files, 10-inch	¼
4	Bags, water, 2½-gallon	½
1	Bag, water, 5-gallon	1

Surplus saws, axes, steel wedges, sledges, hoes, and shovels were always carried on the fire truck for use in case the regular tools were not sufficient. During the season no use was made of this extra equipment except in the exchange of dull tools for sharp ones.

Equipment used by this crew and found to be especially adaptable included hardwood wedges which can be driven with the side of an ax, and fusees for backfiring. Fusees were particularly adaptable for this crew because of their lightweight, which made it possible to carry enough to enable several men to backfire at one time.

Special equipment such as radio, compasses, and first-aid kits was used by the crew on all fires.

Various kinds of concentrated food were tried by the 40-man crew on the fire line. Table 3 lists items of food by weight and calorie content which proved to be the most satisfactory combination. It is felt that through further study, however, it might be possible to devise a lighter ration with equal nutritive value.

On going to a fire each man carried two lunches on his belt so that no time would be lost in preparing meals during the first shift on the fire line.

TABLE 3.—*Ration list, 1 man 3 days*

No.	Item	Weight in pounds	Calorie content	Where to obtain
1	Eggs, powdered	½	1,330	Eddie Bauer, 2d and Seneca Sts., Seattle, Wash., or Sports Craft Inc., 512 Southeast Yamhill St., Portland, Oreg.
2	Cervelot	1	1,800	Nearly all grocers.
3	Bacon, canned	1	2,600	Do.
4	Soup concentrate	½	2,500	Eddie Bauer, 2d and Seneca Sts., Seattle, Wash.
5	Potatoes, dehydrated	½	1,800	Do.
6	Rice, white	1	1,600	Any grocer.
7	Apple concentrate	½	1,500	Columbia Fruit Processors, Inc., Pateros, Wash.
8	Sugar	½	900	Any grocer.
9	Tomato juice	½	100	Do.
10	Hardtack	1	1,600	Do.
11	Coffee	¼	----	Do.
12	Lemon drops	½	850	Any confectionery.
13	Anchovy paste	⅛	600	Any grocer.
14	Dates	1	1,600	Do.
15	Figs	1	1,400	Do.
16	Salt	⅛	----	Do.
17	Butter, canned	½	3,500	Order through grocer.
18	Milk, powdered	½	2,300	Any grocer.
	Total	11	25,980	

According to dietitians, hard manual labor requires 3 calories per pound per hour. A 180-pound man working and/or hiking 16 hours per day for 3 days requires 25,920 calories. Therefore, the ration listed in table 3 is ample, and the 2 lunches carried by the men on the first shift offer a large margin of safety.

Based on the experience of 1939, it is advisable for the leader of the crew to make out a basic menu with a choice of substitutes of about equal weight and calorie content. The men may be allowed to choose any substitute listed in table 4. This will assure a balanced food ration. It was found that a free individual choice usually does not result in a balanced menu.

TABLE 4.—*Desirable substitutes for 40-man-crew ration*

No.	Item	Weight	Substitute for—	Where to obtain
1	Dried beef	----	Cervelot	Any meat market.
2	Lemon juice	12 ounces	Tomato juice	Any grocer.
3	Grapefruit juice	do	do	Do.
4	Raisins	do	Dates	Do.
5	Cheese, dried	8 ounces	Anchovy paste	Do.
6	Peaches, dried	1 pound	Figs	Do.
7	Apricots, dried	do	do	Do.
8	Spaghetti	2 pounds	Rice	Do.
9	Oatmeal	do	do	Do.

Cooking on the fire line.

Transportation.—Three 1939 model, 1½-ton Chevrolet trucks were used for transportation of crew, supplies, and equipment to and from most of the fires and on work projects. Two of these trucks were equipped with comfortable, upholstered seats for hauling the men, and one was used for supplies and fire packs.

On the longer and more tiring trips such as the 360-mile trip to the Big Cow Creek fire on the Malheur and Whitman National Forests, commercial busses were used. These busses added greatly to the comfort of the men and made it possible for them to rest en route, and arrive on the fire in better condition than if they had traveled by truck.

Personnel Management.—Some restrictions were required in order to keep the men constantly within fire call. Camp rules were established, outlining the responsibilities of the crew members as to fire duty, fire calls, camp police duties, and personal conduct and appearance. Only a few instances of infringement of these rules occurred during the season. Tension of stand-by duty was lessened considerably by frequent fire suppression jobs.

Opportunity was given each member of the crew to leave camp periodically to purchase tobacco and other personal effects and to attend the local theater once or twice weekly, provided they signed out and agreed to stay in a group going to and returning from the theater. Excursion trips were made under the same arrangement.

Softball and volleyball teams were organized, and weekly games with Cave Junction and the Oregon Caves CCC Camp were played through the early part of the summer. Swimming, horseshoe pitching, and punching-bag work-outs also absorbed no small amount of surplus energy. Some leisure time was devoted to study of the handbooks, bulletins, and periodicals contained in the 40-man-crew library. Leisure time classes in first-aid, lifesaving, and safety were conducted by qualified crew members.

Because of the seriousness of the fire season and the shortage of manpower caused by sickness and injury, only a small amount of annual leave was given during the main part of the fire season. Two more men were added to the crew during the latter part of the season so that accumulated leave could be granted and still maintain the crew strength at 40 men.

Fire Training.—Fire training was started June 20, immediately after the first large influx of recruits. Frequent training sessions continued up to July 21, when the crew was called on the first fire. An occasional training period was given subsequently for the benefit of new recruits.

In the first training periods emphasis was placed on fire line organization and construction so that the crew would be in readiness for immediate call. Training continued with practice hikes and drills in unloading fire packs from trucks and reloading them again so that a certain speed and precision was acquired in performing these routine jobs. Conferences were held on methods of line construction, fire behavior, and fire strategy in various fuel types, in conjunction with the field training sessions.

Special training was given selected crew members in radio operation, fuel type mapping, and first aid by qualified instructors.

Work Projects.—Two work projects, located 9 miles from camp, were selected to utilize the time and energy of the crew members when they were not occupied with training or fire fighting or engaged in camp construction activities. The purpose was threefold—namely, to keep the men in good physical condition, to help finance the crew, and to accomplish useful and needed work. The construction of the Illinois River Bridge and the Eight Dollar Mountain Road were the two projects selected. The bridge was a creosoted wood, Howe truss structure, with a main span of 137½ feet and an approach on one end of 52 feet. This bridge was completed by the crew in the fall of 1939. A total of 815 man-days was spent on the project.

The crew spent a total of 672 man-days on the Eight Dollar Mountain Road and brought a 2-mile section to about 75 percent of completion.

Action on Fires

The 40-man crew worked on 8 class C or larger fires located on 5 national forests in Region 6 between July 21 and September 2, 1939. The two periods worked by this crew on the Saddle Mountain fire were counted as two fires since they were analyzed separately and were widely divergent in location and time. The fires on which the 40-man crew worked and the time and travel chargeable to these fires are listed in table 5.

TABLE 5.—*Fires worked upon by the 40-man crew in 1939*

No.	Name of fire	Forest	Dates	Days on fire (including travel)	Miles traveled (truck or bus)
1	Horseshoe Bend	Siskiyou	July 21 to July 26	5½	80
2	Blue River	Willamette	July 27 to July 28	2	421
3	Wheeler Creek	Siskiyou	August 7 to August 8	2	150
4	Saddle Mountain (east side).	Siuslaw	August 10 to August 13	4	300
5	Willard	Columbia	August 14 to August 17	4	543
6	Eagle Creek	Siskiyou	August 18 to August 21	4	127
7	Saddle Mountain (west side).	Siuslaw	August 22 to August 26	6	663
8	Big Cow Creek	Whitman	August 28 to September 2.	6	725
	Total			33½	3,009

Get-Away Action.—Get-away time on fires varied from 31 to 75 minutes, according to circumstances at the time of the call. The crew was dispatched from their headquarters camp on four occasions. Three of these calls came in the late afternoon before supper and the fourth immediately after breakfast. On two occasions the crew was working on the road project 9 miles away, and it was necessary to assemble them at camp before leaving.

If the call came near mealtime and the meal was practically prepared, the men were usually fed before leaving. Assembling and feeding the men resulted in rather slow get-away time on several occasions. However, it is believed that the practice of feeding the men before leaving is justified, particularly if a long trip of several hundred miles is involved, because it avoids making a meal stop en route and the men arrive in better condition than if they travel without food.

Experience in 1939 brought out that the following considerations should govern action looking toward faster get-away time:

1. Keep all members of crew in direct telephone communication at all times. Use large extension bells, sirens, and other signals where necessary.

2. Order lunches or prepared meals ahead on route of travel if time can be saved in this way.

3. If dinner is prepared at camp at the time of the call, the crew should be allowed to eat before leaving in order to avoid losing time en route.

Meals and Stops En Route.—One or more meals were usually eaten en route to the more distant fires. In all but a few cases, a dependable restaurant was notified by phone in advance and no time was lost in the preparation of the meals.

Time Distribution on Fires.—Table 6 shows the distribution of fire time for the 40-man crew, based on data recorded on the eight fires upon which the crew worked. These computations include time from start of work to completion of control line on all fires or sectors of fires handled by the crew.

40-man crew hiking to a fire.

TABLE 6.—*Time distribution of 40-man crew on fires*

Time element	Total hours	Percent of time
Foot travel	12. 31	4. 1
Worktime on fire line	176. 58	58. 2
Time eating, sleeping, and resting	114. 36	37. 7
Total	303. 25	100. 0

Distribution of time as recorded above is shown graphically in the chart on page 56.

No comparable figures are available for other crews, but it is believed that this table shows plainly the advantages of using self-sustaining crews on inaccessible sectors of fires. Foot travel to and from such sectors by ordinary crews serviced in established base or line camps usually consumes a great deal more than 4 percent of the time of fire fighters and saps a tremendous amount of energy of men who are unaccustomed to hiking in rough country. The usual practice of camping on or near the fire line wherever night overtook the crew insured the effective use of a large proportion of the day with a minimum of lost motion. Truck- and foot-travel time to the fires from the time the crew was dispatched up to the point control action was started is not included in these figures. However, when determining the distance practicable to dispatch such a crew, it should be considered that more than one-quarter of the total time charged to fires was consumed in travel by truck and on foot to the fires.

TIME DISTRIBUTION CHART

Organization and Method Used in Line Construction.—A progressive method of line construction, which in reality is a variation of the one-lick method, was used successfully by the 40-man crew on all fire suppression work.

The progressive method used has the advantages of the one-lick method; namely, the elimination of lost time occasioned by men passing each other in the line and the enthusiasm and unity of effort generated by rapid and continuous progress. It is superior to the one-lick method in that men can do more effective work by taking a stance and completing a unit of work and each man can be held accountable for a given segment of line. The form of organization is illustrated in the diagram on page 57.

A description of the organization of the men on the line and their duties under the progressive system follows:

1. A scout from the crew was used when no outside scout was provided. When not scouting, this man worked as an axman.

2. The line locator selected the location and blazed the way. He was directed from time to time by the crew leader as information was received from the scout or direct observations of the fire were made.

3. Nine axmen, using three cruiser's axes and six 3½-pound swamping axes, followed the locator. Ordinarily the ax crew did from 50 to 100 percent of the clearing, depending on the relative amount of clearing to be done as compared with digging and holding.

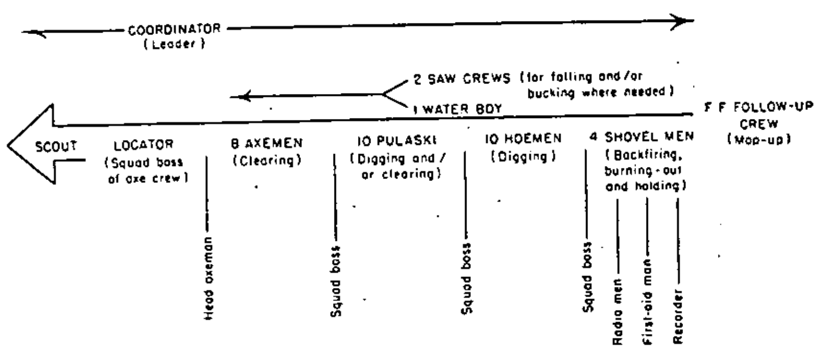
4. Ten pulaski men worked behind the axmen and cleared or dug line as the needs justified. The pulaski men hold a unique and vital position on the line. By using the cutting edge of the tool for clearing they may speed the clearing and slow the hoe work, and by turning over the same tool the opposite effect can be accomplished. The versatility of the pulaski men enabled the crew to adapt itself to a great variety of cover types without changing the line-up of tools.

5. Ten hoe men followed the pulaski men and completed the line digging. In favorable types one or more Kortich tools were substituted for hoes. Six of the hoe men carried extra shovels to the point of attack so as to have them when needed to assist in holding and mopping up the line. These extra shovels were called into action on almost every fire in order to take care of the emergency "break-overs" and spot fires which the usual shovel crew could not handle. After arrival on the fire, the spare shovels were carried by the shovel men in an extra pack sack with the fusees and other miscellaneous items. By following this practice, the hoe men were not burdened with an extra tool while working.

6. Four regular shovel men were on hand at all times to do the burning-out and holding the line behind the line construction men.

7. Two sets of fallers equipped with falling tools worked as and where needed for falling or bucking. They were usually directed by the coordinator.

DIAGRAM OF PROGRESSIVE METHOD OF LINE CONSTRUCTION USED BY THE 40-MAN CREW



8. One man was always used to carry water, and two were so employed when needed.

The crew leader controlled the movement of the squads in such a way as to effect the highest rate of held-line production. A qualified squad boss was used as a line locator. When not engaged in locating he was in charge of the ax crew. Where considered of vital importance the leader did his own locating. The second squad boss was in charge of the pulaski crew. It was his responsibility to keep a balance of work between clearing and digging by shifting his men from one operation to the other as the needs arose. The third squad boss was in charge of the hoe crew. It was his function to complete the line and cooperate with the burning-out and holding crew, dropping men from his crew to the holding crew when needed. The fourth squad boss supervised the burning out and holding of the completed line until it was taken over by the follow-up crew.

Numbering of Men and Packs.—Each man of the crew was given a number, according to his place in the line and, except for a few changes, each man kept this number throughout the summer. Each fire pack was also numbered from 1 to 40, corresponding to the number of the man carrying the pack.

Building fire line.

Unloading from the trucks and hiking to the fire front was done in sequence of numbers. Upon returning from the fire the packs were placed in the truck in reverse order from which they were taken out—that is, number 40 pack was the first to be loaded. This system of unloading and loading made for speed and precision. A quick deployment of men in working positions was facilitated by arriving at the point of attack in regular formation.

Foot Travel.—Upon reaching the end of motor transportation, each man received his pack and the crew was led over trail or rough country in single file formation to the point of attack. Rest stops were made during hikes as needed. Average rate of foot travel was computed at 2.5 miles per hour, including rest stops of less than 30 minutes.

Deployment of the Crew on Fire.—Upon arrival on the fire, a quick size-up was made and, if necessary, the 40-man crew scout was sent out to look over the country immediately ahead. Scouting was usually done by scouts not attached to the 40-man crew. If the entire crew worked as one unit, they fell to work in line in the regular unloading and hiking order. If the crew was split into two units, as was occasionally done, the even-numbered men went one way and the odds another. This resulted in the even division of both men and tools. Unless the direct method was used, the burning-out crew followed and kept apace, but at a short distance behind the hoe crew. If a follow-up crew was worked immediately behind, the burning-out crew was usually able to keep up without

additional help. If adequate follow-up was not provided, however, it became necessary to drop more and more men from line construction work to burning out and holding.

The practice of splitting the crew into two or three work units worked out very satisfactorily on spot fires and in cover having low to medium resistance-to-control factors. The gain in splitting of crews, of course, is brought about by a saving in total time devoted to walking. In high resistance-to-control types, however, the relative saving in walking time is much reduced, and it is believed the advantage is negligible in an extreme resistance-to-control type. Another advantage of a split crew is that work can often begin at the head of a fire, and one unit can work each way to effect a faster control.

The greatest disadvantage in the division of the unit was the difficulty of giving adequate supervision. This disadvantage can be overcome by careful training of overhead. In the heavy resistance-to-control types found on three fires in 1939 the crew worked to greatest advantage as one unit.

Packing on the Fire Line.—An ever-existing problem was that of keeping the fire packs up with the men. This problem was solved by using a variety of methods as follows:

1. By intersecting the fire at a central point so that the crew can work both ways from the starting point. Upon arrival at a fire it was often possible to predict where the crew would stop work at the end of the shift and drop the packs there.
2. By leaving packs at the point where work began and returning after them when an opportunity permitted.
3. By delegating the burning-out crew to take charge of moving the packs forward as the line progressed.
4. By delegating an FF or CCC crew to carry packs ahead from time to time. Horse packing was not feasible on account of the inaccessibility of the country in which the 40-man crew worked. Horses were utilized but once during the season.

Follow-Up.—One of the biggest problems which confronted the 40-man crew was securing adequate follow-up action. Almost every forest on which the crew worked showed a readiness to cooperate by sending ample follow-up behind the 40-man crew. The failures usually arose from not making certain that the men arrived when and where they were needed. For example, on one fire a night crew was sent out, but they were poorly guided and did not arrive. On another fire they worked on a "cold" line to the neglect of a mile of "hot" line. In each instance it was necessary for the 40-man crew to put in a double shift in order to prevent the loss of line they had constructed. It is recognized that the ordinary follow-up crew hiking in from a central camp each day, is under a tremendous handicap. After the second or third day behind the 40-man crew, the follow-up crew spends more and more time walking to and from work, which progressively reduces the amount of time and energy available for effective action on the line. The solution to this problem apparently lies in equipping the follow-up crew with light sleeping bags and condensed rations so that they too can stay out on the line.

Cover Types.—Several cover types were encountered by the 40-man crew, including high and low brush, Douglas fir timber, lodgepole deadenings, and ponderosa pine types and snag areas. The progressive method of line construction, with slight variations, worked well in all these types, and the crew proved to be a versatile unit and readily adapted itself to the various conditions encountered. The tools carried by the crew adequately met the needs in all types encountered. The pulaski tools are the "balance wheels" which made it possible to work efficiently in the various types with the same equipment. Experience during 1939 indicates that a trained crew of 40 men is about the proper size for work in moderate and high resistance-to-control types such as are encountered over most of the Douglas fir region, and that smaller units of about 20 men will work more efficiently in the low resistance-to-control cover which is characteristic of ponderosa pine forests.

Accomplishments

A careful record was made of the action of the crew and rate of line construction on each fire. At the completion of the fire season a detailed review was made of each fire by the leader of the crew. Space will not allow these records or reviews to be presented here. By way of summary, however, two measurements of the efficiency of the crew are given by comparing its rate of held-line production with the Region 6 standards and with average production of other crews on large fires in this region.

The comparison of rate of line construction by the 40-man crew with the Region 6 standard was made by computing the length of time that it would take to build under regional standards the same line as was constructed by the 40-man crew on the various fires. In making these computations due weight was given to the proportion or length of line on each fire in the different resistance-to-control classes. Complete data for this comparison were taken on six fires and are summarized in table 7.

TABLE 7.—*Held line production, 40-man crew 1939, compared to Region 6 standard*

Name of fire [1]	Resistance to control rating — Chains: Low	Medium	High	Total line worked: Chains [2]	Hours	40-man production held line per man-hour chains	Region 6 standard same held line per man-hour chains
1. Horseshoe Bend	51	42	19	112	67.4	1.66	0.53
2. Wheeler Creek	15	25	22	62	46.5	1.33	.45
3. Saddle Mountain (east side)	55	30	9	94	87.1	1.08	.62
4. Willard	32	20	7	59	42.5	1.39	.56
5. Eagle Creek	40	124	63	227	319.8	.72	.42
6. Big Cow Creek	97	39	4	140	100.5	1.39	.73
Total or average	290	280	124	694	663.8	1.04	.51

[1] Accurate data were available only on 6 fires.
[2] This figure includes only length of recorded held line. About ⅓ of held line built was recorded and given resistance-to-control ratings. A total of 28 miles of control line was worked in 1939, in addition to a large amount of unmeasured work on spot fires.

The comparison of the accomplishments of the 40-man crew with other crews shows that throughout the season it attained an average rate of held-line production of 0.34 chains per man-hour as compared with 0.07 chains per man-hour for large crews working in Region 6 on fires 300 acres or larger from 1936 to 1938, inclusive. The data for these large crews were taken from the July 1939 issue of Fire Control Notes. It may be noted that the rate of line production in this second comparison is less than that shown in table 7. This is accounted for by the fact that burning out, holding, and mop-up, as well as travel time while on a fire or sector of a fire, were included when computing this average in order to make the 40-man crew rates comparable to those listed in Fire Control Notes.

These figures show that the 40-man crew produced line at twice the speed set up by Region 6 standards and about five times the rate produced by other crews on all large fires in Region 6 over the last 3 years. Even so, these figures do not give a true picture of the efficiency of the 40-man crew in comparison with other crews because of the following factors:

1. In the first comparison the regional standards are based on small as well as large fires, and accomplishments on small fires are usually greater than on fires of the size acted upon by the 40-man crew.

2. The 40-man unit was in most cases dispatched to the most rugged and remote sectors of the fires in which the fatigue factor of travel is more pronounced than for crews working near the road.

3. The 40-man unit was sometimes used as "pinch hitters" on sectors difficult for other crews to hold. On these sectors the 40-man crew was valuable chiefly as a holding crew and line production was a secondary factor. After hours of difficult holding under heavy smoke conditions, the crew was in poor condition for high production on the line.

Weak Points

The 40-man crew was organized and trained as a line-building crew. Plans were made for the 40-man crew to burn out and hold their own line for about 2 hours after construction, after which time the line would be taken over by an FF or CCC crew. The men were told that they would be expected to work at a fast rate of speed for a definite shift of 8 to 10 hours and that mop-up and holding would be taken over by another crew. To work a longer shift would definitely call for a slower pace.

As it actually worked on many of the fires, the men walked long distances, then worked on line construction at a fast pace for 8 to 10 hours; but instead of being relieved it was necessary for the crew to do their own mop-up and patrol for long periods after the line was constructed. This worked the men excessively long hours. In one case the crew was engaged more than 20 hours in continuous work and travel with only short intervals of rest. It is not physically possible to continue at a fast pace for such long periods, and the men will consciously slow their pace to avoid complete fatigue.

The ultimate results of this practice, if continued, will be to slow down the rate of line production. The men will expect to stay out on the line for excessive hours and will work at a speed commensurate

213278—40——3

with those hours in order to sustain themselves throughout the day. In working excessive hours day after day, we have lost sight of that part of our objective of maintaining a fire-fighting crew capable of working at unprecedented speed to stop the first run of fire, burn out the line, and turn the mop-up over to a relief crew.

Costs

A total allotment of $35,090 was set up to the forest to finance the 40-man crew from the time of recruiting to the end of the fiscal year 1940. This allotment was planned to cover all costs of camp construction, subsistence, transportation, and wages throughout the work season, including fire suppression and project work. It was planned that a contingent of $7,000 should be carried over to finance the crew in the spring of 1940.

Actual expenditures for the crew through the season of 1939 totaled $30,914. Of this amount $2,642 was spent on overhead and $5,491 was used for the subsistence of the crew. The entire cost of camp construction and maintenance totaled $6,245, and fire training was recorded at $1,082. The contribution to fire suppression work by the 40-man crew amounted to $6,742. All other cost, including labor, cost of transportation to and from work on the bridge and road projects, and other miscellaneous items of cost, totaled $8,712. The work of the crew on these two projects was appraised at $5,000 at the close of the season.

The balance in the available allotment, plus the unexpended F. R. D. earnings, amounts to $9,176, which will be available to pay the salary of the leader during the balance of the present fiscal year and finance the crew for approximately 2 months next spring.

Conclusions

It is felt that the 40-man crew experiment was successful in achieving the purpose for which it was conceived. The careful selection and methodical training of personnel and the choice of lightweight equipment, including concentrated rations, featherweight beds, and up-to-date fire tools, combined to make a sturdy fire-fighting unit of great mobility, which was able to sustain itself in inaccessible country for periods of 72 hours or more and take effective independent action on the most remote sectors of a fire. The merits of this form of organization are obviously shown in the records of rate of line construction contained herein.

It is believed that this system can be applied to other crews organized from picked CCC enrollees and the personnel of construction crews. Units so organized will probably not measure up to the 40-man crew in physical development, but would have the advantages of mobility and self-reliance made possible by the use of lightweight beds, concentrated rations, and a judicious balance of tools.

It is also believed that the special equipment can be used to advantage by crews of untrained pick-up laborers by enabling them to stay out on the fire line, thus reducing the large expenditure of time and energy used in walking to and from established camps and curtailing the expense of servicing fire fighters in inaccessible country.

LESSONS OF THE McVEY FIRE, BLACK HILLS NATIONAL FOREST

A. A. Brown
Fire Control, Region 2, U. S. Forest Service

Making a pretty complete kill on 22,000 acres of highly productive country, where every cubic foot of timber that can be grown is needed to sustain the dependent communities, the McVey fire was easily the worst fire of the 1939 year. To find and follow through the clues leading to increasing mastery of such fires offers the sharpest possible challenge to fire-control students. Such losses are intolerable, but it will take more than our usual insight and methods of study to find out why they occur. When we find the answers, it will take more than our usual forms of training to get the essential principles of control so embedded in the minds of enough men that these principles will be applied in future crises.

At 11 p. m., 9 hours after the arrival of the first 68 men on the fire, those in charge recognized for the first time that they "were up against a fire that wouldn't act according to rule." The fire had spread less than 250 acres in the previous 5 hours and had reached a total of approximately 1,600 acres. Wind from 7 to 10 p. m. had been "nearly imperceptible." Completion of the control line in the early morning hours "appeared certain" long before the time required by the first work-period policy. But about 11 p. m. the wind freshened a little and the fire marched out through the unworked gap of "less than half a mile" and started a spread which was not corralled until 34 hours later. The surge of the fire at about 11 p. m. the first day was the result of recognizable causes or it was not. Can we discover why this and similar fires behave the way they did? Whether, like a rattler, they actually gave a warning which we might learn to recognize in future before it is too late?

The data submitted by Staff Technician Skinner shows that at 6 p. m. on the first day, 5½ hours after discovery and 4 hours and 40 minutes after arrival of the first cooperator crew, the fire had a perimeter of 10.2 miles (including a 25 percent addition to a machine count of map miles). Of this total, 4.6 miles were in the same location as when the fire was finally corralled—mostly on or close to roads, fields, and prairies; and 2.3 miles were held until 9 a. m. the next morning. The spread from 6 p. m. of the first day to 9 a. m. of the second day came, therefore, from not over 3.3 miles of front as of 6 p. m. on the first day. The author's figure of 10 miles to build as of 6 p. m. evidently considers expected spread after that time, but does not include the 6.9 miles of line or edge as of 6 p. m. which was in the same place at 9 a. m. the next morning.

Output of held line up to the completion of the final control line was 0.1 chain per man-hour—which again falls within our semistandard of 0.06 to 0.16 of a chain per man-hour. No figure is available on lost line. Spotting was naturally very bad. Can't we develop better ideas for dealing with spot fires? As a simple example, how can we get men to watch and comb the places where spot fires may start instead of watching the fire from which the sparks come? Sounds easy, doesn't it?

Before the first crew arrived, two post cutters working nearby saw and tried to stop this fire. They failed and had difficulty in escaping. They were suspected of starting the fire, but it was later proved to be a hang-over lightning fire.

The heading under which this must be written, and its implied purpose, impose an automatic censorship on its contents. A lesson

in fire control to be of interregional interest should introduce something new, or should at least give new emphasis to principles or to aspects of their application that have not yet been fully learned. Whether or not any experience qualifies on either of these two counts depends on the class of individual.

A list of the lessons learned by the CCC boys on the McVey fire would have a very different content from the list that would be most appropriate for their foremen. Similarly, some of the lessons learned by members of the supervisors' staffs of the Harney and Black Hills Forests would sound trite to a southern California fire fighter, although other features of the job might have considerable thought-provoking challenge to outsiders.

The following comments represent an attempt to sort out experiences of the McVey fire from which lessons may be drawn that are of interest to officers concerned with fire-control strategy on big fires. For the most part they do not represent anything new in principles of fire control.

The McVey fire itself was a conflagration in flashy fuels, in rolling topography, with variable winds. This combination is designed to test the resources of any fire boss. Rates of forward spread on wide fronts up to 120 chains per hour occurred. Direction of spread varied, and rate of increase in terms of acreage burned went as high as 2,900 acres per hour during the run of Tuesday, July 11. The cover type of the whole area was ponderosa pine, interspersed with small meadows. Over two-thirds of the area burned consisted of thinned stands of ponderosa pine, in which the thinning slash formed a continuous layer of fuel of varying density and stages of decay, dating from 1933.

Although this fire reached a total area of 22,000 acres, it was controlled as a second-period fire with a total of 46 miles of held line. Because of the blow-up on July 11, only 10 miles of line were still held by 8 p. m. of that day. The additional 36 miles were built in one work period, from 8 p. m. Tuesday night to 9:15 a. m. Wednesday. The rate at which the fire burned out was remarkable for a timber fire. Once the entire perimeter was controlled, the whole area went cold almost overnight. This seems to have been due, in a large part, to the absence of heavy dry material, to the burning out done on all fire lines, and to the extreme heat produced by the slash on the ground.

The lessons to be learned from this fire for the local organization have the usual and familiar character of lessons in fire strategy, in organization, in speed of attack, in methods of attack, and in fire prevention and preparedness. All of these have been discussed at some length, and most of them on which it was agreed that something definite and constructive could be done locally have been duly listed in the conclusions of the Board of Fire Review. For the most part, they will not be repeated here, but an attempt will be made to go back a little further in a consideration of the significance of facts brought out by fires such as this one.

One of the first things that seems important to recognize is the inadequacy of existing fire-fighting methods to meet and overcome all kinds of fires. A 1-acre fire may be only a smoldering spot or it may already be as dynamic as a small tornado.

Most of our theory of fire-control tactics is based on a two-dimension idea, and the control of a fire is usually pictured as the solution of a problem in plane geometry. It seems to me that this type of thinking has carried over too far into ideas of application on the job, so that the experienced fire foreman himself comes nearer to a full realization of the potentialities of a given fire in the third dimension than does the so-called fire-control expert.

This of course, sums up to our inability to cope with crown fires. It is not a new subject but it has been rather studiously ignored in discussions of fire fighting. Certainly, this one factor looms large in the history of the McVey fire.

Assuming that nothing could be done during the height of the spread of this fire through the crowns, there were lulls during which it might have been controlled if certain things could have been done quickly enough. These "ifs" comprise debatable points from which some lessons may be drawn. During the first afternoon and evening, from 6 p. m. to 11 p. m., the fire dropped out of the crowns and stayed relatively quiet. There were 10 miles of fire line to build, which it was expected would be complete by 2 a. m. As it turned out, this would have been completed, probably by midnight, but the blow-up at 11 p. m. with less than one-half mile of line still to build resulted in losing nearly all that had been accomplished. A plan of attack designed to complete the job before 11 p. m. might have saved the day.

It has long been realized that it is unsafe to stake everything on the assumption that a fire will slow down at night. Yet fires do so so commonly that both the forester's and the regional policy are based on overnight action which is judged to be adequate on a big fire if sufficient manpower and facilities are mobilized to control a more or less static fire perimeter before 10 a. m. of the next day. On the McVey fire, forest officers allowed themselves a large safety margin, but as it turned out, not enough, since they did not foresee the critical necessity of a safe perimeter that could be held against all odds by 11 p. m. of the first night.

Regardless of how feasible such an accomplishment might have been on this particular fire, it, of course, presents a very real question in the case of future fires. Will it ever be possible to predict the behavior of an exceptional fire far enough in advance to insure the exceptional intensity of attack required? Ways in which Region 2 officers believe such foresight might be improved are: Through improved fire-danger ratings, improved fire-weather forecasting, and through better recognition of potentialities of local fuel hazards.

The next lesson of critical import and perhaps the one of most constructive value of all is that of the strategy of control in an aggressive fire such as this. Although the main head or heads of the fire took one direction, then another, during its run, prevailing winds and past experience with such fires in this locality have revealed that the odds are four to one that the greatest conflagration threat will be to country to the east and northeast of the fire. This was well known, yet the timing of control effort was such that the most northerly and westerly extensions of the fire were the last to be controlled. As a result the blow-up here flanked all the hard-won

control line to the east. This was a question of judgment at the time and not as obvious a failure as it may sound in review. The worst fuels and the most aggressive head of the fire were given first attention, and the hardest part of the fight seemed already won when the fire made its new drive northward on its west flank. This extension set the stage for the final run eastward on a front of conflagration proportions. The west flank of the fire had already burned out to a wide expanse of noninflammable grassland which gave a strategic advantage. Had the progression of safe-control line been entirely from the grassland eastward along the north flank and from the completed south line northwestward along the east flank, the investment in fire-control line would have been better protected against loss and the same blow-up with the same amount of uncontrolled perimeter farther east at 11 p. m. would have been far less disastrous, in terms of both a narrower new head and less lost line. This lesson in importance of sound strategy would not have become apparent at all had the fire remained quiet an hour longer or had the fresh crews scheduled for this sector been the first to arrive and start work instead of the last. Similarly, more manpower or increased efficiency in line construction, sufficient to complete all control line before 11 p. m., might have resulted in success with the timing used.

After the fire had made its run northward another lull occurred between the hours of 2 and 7 a. m. of the morning following. Forces were reorganized and a fresh attack was made during this period which carried considerable promise of success in spite of a greatly increased perimeter. In this case little fault can be found with the strategy planned, but its execution failed from circumstances which may also carry some lessons.

The critical sector of the new line was being pushed rapidly from both ends by experienced fire foremen using the one-lick method and burning their line clean as they went. Follow-up crews were organized to guard the hot line and to control spot fires. The latter failed to accomplish this. No one knows exactly why, except that this job turned out to be far more exacting and required far more supervision and more ingenuity and action than did the construction of a reasonably safe control line alone. Both on this occasion and at other times during the fire the rate of production of a reasonably acceptable control line, including burning out, did not represent the rate at which the fire was being controlled. This raises a question of tactics where fire line is being built rapidly. The job of holding the line built calls for far more than is implied by either the term patrol or mop-up. It represents on a fast-running fire a desperate defense action, since the advance crew cannot wait to see the fire finally die down behind it, but must pass on to the follow-up crews the responsibility of making good the advantage gained. When 2 to 3 miles of such line is handed to a sector boss he must drastically change the approved method of organizing the job, which was based on mopping up a dying fire edge. Apparently this was not well enough done. The conclusion then is that organization of crews must be handled on a very different basis than the conventional mop-up or patrol action when fire line is put in rapidly by an advance crew or by mechanical means.

A further experience on the McVey fire that was baffling to sector bosses was the tendency of backfires to spread inward toward the oncoming crown fire in the surface litter just as intended, and to go into the crowns just before reaching the main fire. But when the two met they seemed to "bounce" right back through the unburned crowns toward the fire line without any noticeable drop in intensity. This did not always occur but happened so often as to make backfiring ineffective at close range and very risky at longer distances. Apparently the nature and force of the convection drafts is the deciding factor. It is a challenge to backfiring theory and strategy.

Out of these experiences there may be resolved several points of challenge to existing fire-fighting theory and practice. These points, rather than the lessons discussed, will be listed in the form of questions.

1. How can forest fire-fighting theory and practice take better account of fire as a force to be dealt with which varies as a problem not only with the area involved but also with the varying rate at which heat units are being released and with the convection forces being generated?

2. How can the requirements of successful control action for each individual fire be predicted more successfully?

3. What principles of fire-control strategy can be defined and set up for general application?

4. What changes in crew organization should be adopted to insure holding long stretches of fire-control line built rapidly along the perimeter of an active fire?

5. How can the use of backfiring be reduced to a dependable practice in combating crown fires?

Ax Handle Treatment.—In an effort to reduce the large number of loose ax handles which result when axes are stored in rather arid portions of some of the forests on the coast, we requested the Kelly Ax Co. to make a few experiments. The experiment consisted of nothing more than reducing the moisture content of the eye portion of the ax handle considerably below that required by the specification, the theory being that after driving the handles home the portion within the eye will, because of its hygroscopic nature, pick up enough additional moisture to equalize with the rest of the handle and produce a normally tight fit.

By placing the eye end of the handle in a drier, the moisture content was reduced to between 8 and 9 percent back to the point where the handle leaves the eye. This removes some of the moisture, but it also drives some of the moisture back into the body of the handle, and after the handle is driven in it is believed that some of the moisture goes back into the eye portion and thereby prevents undesirable brittleness.

Six axes so treated were sent to the Los Padres National Forest and placed on the north end of the forest where they would be subjected to very low humidity practically all of the summer season. No looseness has developed in the handles, and the forest has continued to use the axes along with other axes which were not so treated in the handling process. In the latter group looseness did develop.—Region 5.

SEPARATING THE GOOD PEOPLE FROM THE CARELESS

A. G. LINDH

Division of Fire Control, Region 1, U. S. Forest Service

This is indeed a brave and ambitious title. So also is the entire concept of the article. The author proposes a scheme which may look radical as a whole, but so did closures when they were first proposed. The actual procedure and system involved may seem heavy, but the results might be more per dollar of money and hour of time than obtained from other forms of fire-prevention effort. It is an idea that calls for incisive thought. There should be discussion of the workability of the scheme and the practical values it may have; certainly we can overlook no new device which offers any chance to improve the prevention record.

For as many years as there has been organized fire protection on the national forests, we have carried on a fire-prevention campaign aimed at educating all people who use the forests. As the years went by, progress could be noted. We have not anywhere near approached the point of diminishing returns, if for no other reason than young people continue to replenish the stock of those who have not been educated.

Through the years and even up to this day, we have discovered that we could not educate 100 percent of the people effectively, since a small minority will continue to be careless, thoughtless, or malicious. Because of the existence of this minority, we have each year found it necessary to close certain areas of high hazard and heavy use to travel and enjoyment by all people. We have rather uniformly informed the people that while the closures had to exclude all people it was necessitated only by the careless, the thoughtless, or the malicious few. Since we had no means of segregating this small minority, it followed that we unjustly had to exclude the careful, or thoughtful, and well-meaning majority.

In many instances we have failed to close areas of high hazard and heavy use, when from the standpoint of good management in fire protection, we should have closed them simply because we knew we would be excluding the vast majority of people who are careful. As a result, we allowed the small minority freedom in such areas when, by rights, they should have had no freedom.

Analytical thought on the problems indicated leads one to the conclusion that we should at least start thinking deeply about a method of segregating the sheep from the goats. If we could segregate the two groups, even along broad lines, then we could increase the number of closures against the minority and decrease the areas closed against the majority. As a starter, to stir up our thinking on this problem, the following plan is suggested:

1. Develop regionally a small textbook on the arts and sciences of being a good woodsman. This would serve as the first step in a training program. This would enable our forest users to grow in their knowledge of the essentials of woodsmanship necessary to make them safe as occupants of even the most hazardous areas. There would be developed at the same time for regional use the outline for an examination to be given at every point throughout the field to all local candidates for a certificate of skill in fire-prevention woodcraft. This would be an examination somewhat similar to the automobile driving tests given applicants in most States for drivers' licenses. It would include sufficient practical tests to insure that the candidate had more than "book larnin."

2. Applications for fire-prevention woodcraft certificates would be submitted through the local forest officer. He would furnish the applicant with a textbook and outline of what was expected of him.

3. On a designated date to be set locally, the forest officer would conduct examinations, both written and practical field tests, with a rigid efficiency requirement before we would give the candidate an unlimited certificate of merit.

4. Cards or certificates would be issued by the regional forester (who must necessarily maintain a master card list) only after the graded examination papers were submitted by the local forest officer with a statement concerning the candidate's fitness.

5. A card or certificate of merit in fire-prevention woodcraft when issued would be a passport for that citizen into any part of any national forest in this region at any time. In other words, the owner of such a card would be entitled to entry into hazardous, closed areas established for the purpose of keeping the careless people out during seasons of high danger. The card would bear the fire-prevention code.

6. The card would be canceled upon presentation to the regional forester of sworn statements by two forest officers that the owner of the card had violated the fire-prevention code. When a card was thus canceled, the owner would have the right of appeal and trial before a jury of forest officers.

Discussion.—One specific purpose of this system would be to enable fully qualified local people to enjoy freely the privileges in any part of the forests which would be opened to all people if all people were careful. It would remove the objection, now chiefly arising from local people, to the closing of areas which we are now forced to close if we are to meet our public responsibility in the handling of critical fire situations.

The plan would set up a definite objective in education of the people who use the forests. Such training, if properly handled, would be popular with them. If we extend our education and examination efforts only to an average of 20 people per ranger district per year, we would still be able to handle the majority of our local forest users within 5 years in Region 1. In some large population centers we might have to detail several forest officers every spring to hold training courses and subsequent examinations. We could no doubt get the cooperation of sportsmen's groups and such groups as the American Legion in handling the educational work. This would require the time of forest officers only to give the examinations.

213278—40——4

The adoption of the suggested plan might require the making of a new regulation by the Secretary of Agriculture, and the chances are it would spread nationally if it were adopted in one region.

Considerable careful work would be required to outline the textbook and the practical and written test. I believe, however, this would be justified. The subjects that appear highest in priority for such training would be:

1. Location, building, and putting out of several campfires under a variety of conditions.

2. Proper smoking habits and a carefully worked-out smoker's code.

3. Ax, shovel, and bucket requirement and a demonstration of proficiency in the use of the articles in suppressing fires.

4. The careful outlining of the requirement that the applicant must know how to put out small fires and report them promptly. (He probably should be required to take such suppression action if he is to continue holding his card.)

5. A knowledge of miscellaneous fire risks such as bottles, or other glass, automobile exhausts in dry grass, sparks from stovepipes, danger of spontaneous combustion, etc., and how to avoid them.

6. How to build and maintain a clean and sanitary camp.

7. Obligations in the care and maintenance of signboards.

8. Respect for other people's rights and property.

9. What to do if lost.

10. The obligation to educate and advise others who are not skilled in woodsmanship, within the limits that the man himself sets as a code of conduct in dealing with his neighbor.

11. Knowing how to increase care with all sorts of fire risks when conditions get extremely critical. (The textbook might contain a brief guide as to the effect of temperature and humidity on fuel moistures and the resultant ease of ignition.)

This tentative plan is outlined to encourage discussion with the objective of doing something more effective in the way of fire prevention. In other words, this is written up to shoot at.

TECHNICAL REPORT ON THE PARACHUTE JUMPING EXPERIMENT

David P. Godwin

Division of Fire Control, U. S. Forest Service, Washington, D. C.

Because of its spectacular nature, the parachute-jumping experiment conducted last fall on the Chelan National Forest in Northern Washington drew more attention from the press, the magazines, and the movies than any other one Forest Service activity in 1939.

On the date of this writing (January 16) as the manuscript of this April issue is about to be cleared from the Division of Fire Control, the well-arranged, well-written, and very comprehensive technical report on the project was received from Region 6. Counting typewritten text, illustrations, and appendix, it consists of 146 pages and is a guidebook containing all the technical information on this subject.

Its table of contents indicates the scope of the work:

PART I. Historical:
- Introduction.
- Initial action.
- Approval and finance.
- Contract.
- Personnel.

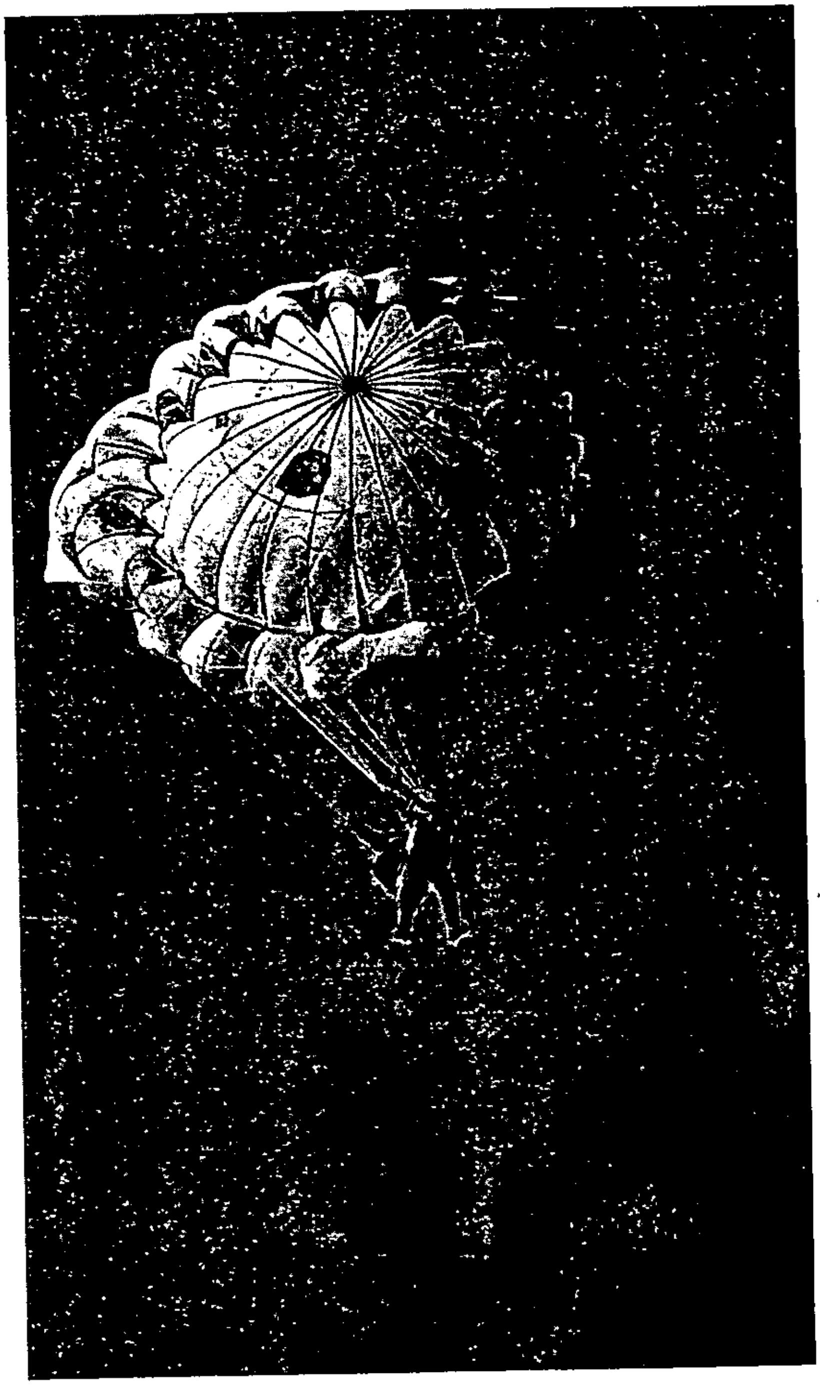
Part II. Equipment:
- Airplane.
- Parachutes.
- Trial parachutes.
- Dummy parachutes.
- Live-jump parachute training outfits.
- Repair equipment.
- Timber jumper's equipment.
- Radio equipment.
- Fireman's outfit.

Part III. Conduct of project:
- Project base.
- Preparation for the experiment.
- Experiment procedure:
  - Trial parachute tests.
  - Dummy parachute tests.
  - Live jumps.
- Techniques used:
  - Getting the jumper ready.
  - Air technique in letting out jumpers.
  - Jumper's approach to exit.
  - Jumper's "take-off" from airplane.
  - Jumper's descent to ground.
  - Preparation for landing.
  - Let-down out of trees.
  - Retrieving the parachute.
  - Tools to smoke chaser.

Part IV. Observations.

PART V. Conclusions.

Appendix:
- Airport equipment.
- Rolling the trial chute.
- Training smoke jumpers.
- Rough sketch of proposed training tower.
- Loft equipment for servicing 16 men.
- Smoke jumper's suit and equipment.
- Fireman's tools (proposed) for timber jumpers.
- Weights of component parts of the equipment.
- Dummy parachute tests (field notes).
- Live jumps (field notes).
- Mental and physical reactions to free fall in space.



After eliminating part of the appendix, the report will shortly be duplicated and distributed to the field force of the Forest Service. In addition, effort will be made to provide limited distribution to other agencies engaged in fire-control activities.

Much thought and study must be given, this winter, to the organizational aspects of this new technique so that a better understanding may be had of its practicability. But the results of the field work are so promising it is proposed to set up working units, integrated with the fire-control organizations in two western regions.

COMPETITIVE EVENTS FOR FOREST FIRE FIGHTERS

Anne C. Allen

State District Forest Fire Warden, Rhode Island

On a Saturday in August of 1939 there was held at East Greenwich, R. I., the first "Southern New England Forest Fire Fighters Field Day." In all respects it was a great success. As a builder of esprit de corps such an event is invaluable and is worthy of emulation, on larger or smaller scale, wherever fire-fighting groups exist. The author provides us with a lively program.

New England has always believed in competition, leading the race for efficiency. The old-time Handtub Musters or Squirts, where the competition of firemen reached its highest peak, originated in New England. Early in the game of fire fighting the outstanding value of these musters in building up efficiency, teamwork, and company spirit, through the guise of muster practice and actual competition, became self-evident. Musters flourished and the annual championship became a mighty big thing.

Training in forest fire fighting in New England, however, has been haphazard at its best. But following the hurricane of September 1938 the entrance into New England of Forest Service trainers with a systematic scheme of training in forest fire fighting technique for CCC crews, State and town crews alike, forest fire fighting reached a uniformly high level never before attained. After the intensive winter and spring training, it was thought worth while to arrange a field day, so that the results of the training might be brought to public attention and, at the same time, serve to create healthy competition between crews.

At first it was hoped the field day would take in all of New England. Technical difficulties arose, however, and the event was finally staged as the "Southern New England Forest Fire Fighters Field Day," the States of Massachusetts, Rhode Island, and Connecticut competing. The State of New Hampshire later put on a "Paul Bunyan Day," with State-wide competition in forest fire fighting and logging. The slack period between spring and fall fire seasons was chosen as a good time for the field days.

The Rhode Island Department of Agriculture and Conservation, with the cooperation of the Forest Service, sponsored the Southern New England Field Day. M. L. Holst of the Forest Service and A. C. Allen of the Rhode Island Forest Fire Service were asked to map out a program of contests in forest-fire fighting techniques and to compile the rules and regulations. The New Hampshire Field Day used these same contests. They are outlined here with the hope that they may become standard throughout all forest-fire-fighting outfits that may have occasion to put on such events. They have been proved by actual use to be extremely workable.

Crew Contests

Hand-Tool Fire Line Construction Contest.—

1. Contest limited to a 20-man crew and foreman. No patrolmen will be left on line.
2. Contest will consist of constructing to mineral soil a fire line 12 inches wide and 1,000 feet long, using the progressive line construction method.
3. Contestants will be aboard truck. At signal from starter they will unload, receive tools, and start line construction. Line will be considered finished when last man passes the 1,000-foot mark.
4. Tools for contest will be furnished on the grounds. Record time for event: 3 minutes and 45 seconds.

Portable Power Pump Line Construction Contest.—

1. Event limited to 10-man crew.
2. Gasoline tank, intake and discharge hose must be connected to pump, after pump has been set up at water source.
3. Hose to be dry 1½-inch linen forestry type.
4. Hose may be laid from rolls, reels, backboards, or packsacks.
5. Event will consist of constructing 500 feet of water trench as follows: Pump and hose to be on truck; at signal from starter crew will set up pump, lay 300 feet of hose to site of fire, and there construct 500 feet of water trench. Contest will be considered completed when nozzleman passes the 500-foot mark. Trench must be so constructed that the water penetrates to mineral soil. Record time for event: 4 minutes and 53¾ seconds. Recommended scoring card for judges of the two events just described:

	Percent
1. Time	40
2. Quality of line	40
3. Spacing of men	10
4. Safety	5
5. Spirit of crew	5
Total	100

Portable Power Pump Efficiency Contest.—

1. Event limited to 10-man crew.
2. Event will consist of setting up pump, laying hose, and tripping target.
3. At signal from starter crew will unload pump from truck, carry same 100 feet to source of water, connect fuel tank, intake, and discharge hose, lay 300 feet of fire hose, install siamese and lay 300 feet more hose on each connection of siamese to nozzles, fill hose with water and trip 2 targets at a distance of 30 feet from the nozzles. Contest will be considered finished when both targets have been tripped.
4. Hose to be dry 1½-inch linen forestry type. Record time for event: 1 minute and 49 seconds.

Motor Forest Fire Tank Truck Efficiency Contest.—

1. Crews limited to 7 men.
2. Hose may be carried in any manner—laid in body, reels, pack-sacks, backboards, etc.
3. Hose to be 1½-inch.
4. Discharge ports of pumper must not be more than 4 feet over the starting line towards nozzle end of hose when pumping.
5. Truck to be placed with front wheels on white line and motor running. At starting signal (whistle) truck to run 150 feet to starting line. Crew proceeds to lay two 200-foot lengths of hose in parallel lines, place nozzles on lines, connect lines of hose to discharge of pump, and pump water through hose and nozzles, from tank on truck, and trip targets (2) 30 feet from nozzles. Starting time to be taken when front wheels of truck cross a timing line 50 feet from the starting line. Finish time to be taken when water trips both targets. Record time for event, using linen forestry hose: 46 seconds.

Individual Contests

Back-pack Pump Contest.—

1. Back-pack pumps to be furnished on grounds.
2. Full pumps to be located on white line.
3. Contestants to be lined up on starting line 100 feet in rear of pump cans. At signal, contestants will run to pump, pick it up and place it on back, proceed 200 feet to stone wall or log barrier at least 3 feet high, cross barrier and continue 200 feet to white line, then by the use of the pump, fill a 1-quart, No. 3 tall can, two-thirds full of water from a distance of 10 feet. Record time for event: 2 minutes and 25 seconds.

The customary log chopping, log bucking, and log burling (if a pond is available) events round out a very satisfactory field day program. Two other events that the crowd seems to enjoy most heartily are an ax-throwing contest, using the standard Pulaski tool, and a water fight between portable pump crews, using a 30-inch rubber beach ball.

The results of the two field days held in New England indicate that events of this kind are one of the best means of selling fire prevention to the general public.

A Better Nozzle for Back-Pack Pumps.—A little over a year ago the D. B. Smith Co., of Utica, N. Y., made available a new design nozzle for back-pack outfits. Essentially, it is nothing more than a midget Boston garden hose nozzle, the same as the one we all use to water our lawns and gardens. The same range of streams is available as in the garden variety. After having been tested for over a year, we can report that the field considers it a much more practical nozzle than any heretofore available. An interesting sidelight on this device: About 10 years ago we tried, unsuccessfully, to induce the Smith Co. and others to manufacture this nozzle. After a lapse of 9 years, and without urge, the device is made available. Test one. You will be pleasantly surprised.—F. W. Funke, *Region 5.*

CHECK OF CENTRAL STATES FIRE-DANGER METER

R. R. Reynolds
Associate Forest Economist
and
David Bruce
Junior Forester
Southern Forest Experiment Station, New Orleans, La.

Since November 17, 1936, the Southern Forest Experiment Station has been collecting daily weather data at the Crossett Experimental Forest for use in determining fire-danger ratings. The measurements made include temperature, relative humidity, wind velocity, and rainfall. A continuous record of humidity and temperature is obtained; wind velocity is measured twice a day, 7 a. m. and 12 m.; and rainfall is measured once a day, at 5 p. m.

Twice daily, at 8 a. m. and 12 m., these readings are given to the dispatcher of Arkansas Forestry Commission District No. 1 and to J. C. Ross, district ranger in charge of the local unit, who have used them to supplement general opinions of fire danger and to estimate the approximate size of the suppression force needed at any given time.

Since November 16, 1936, the district ranger has kept a daily record of the weather readings furnished by the Crossett Experimental Forest, and opposite these readings has noted the number and size of all fires occurring within the local unit, which consists of about 605,000 acres of second-growth shortleaf-loblolly pine-hardwood timberland. It is therefore possible to compare weather readings with number and size of fires.

The Lake States Forest Experiment Station has furnished a copy of their "Central States fire-danger meter" for use in this comparison. By use of this meter, which rates fire danger on the bases of (1) wind velocity, (2) relative humidity, (3) days since rain, and (4) condition of vegetation, the daily fire-danger rating was determined at Crossett, Ark., for the period of 752 days for which weather and fire data were available. In this check the daily rating was based on the 12 m. weather reading, since the maximum fire danger occurs shortly after noon, and since contact with fire wardens and suppression men is made usually at this time.

As one of its measures of fire danger, the Central States meter uses relative humidity, which indicates the moisture content of the fuel and hence the ease with which the fuel will ignite and burn. In evaluating fire danger, this meter also uses three different conditions of vegetation—(1) green, (2) curing, and (3) dead. In this check, because of local conditions, vegetation was assumed to be

"curing" during the early part of the growing season (April–June), and for the rest of the year it was assumed to be "dead." Therefore, this check should be considered to be on a *modified* Central States meter.

The danger rating, which was determined from the meter, as outlined, was placed opposite the fire and weather data, which were then summarized by grouping all days with the same fire-danger rating. Since a summary of the weather data would show only the average conditions that determined the danger ratings, and since actual conditions for a given day are used in determining fire danger, these data are omitted.

Table 1, which summarizes the fire data, is interesting because it shows a relationship between the danger rating when using this meter and (*a*) number of fires per day and (*b*) acreage burned. Average number of fires per day was determined by dividing the total number of fires on days with a given danger rating by the number of days on which this rating occurred. This figure indicates the frequency of fires for days with the given danger rating during the period of the check. As will be noted in the table under danger rating 1 (first line), the value of 0.1 fire per day indicates that there was 1 fire for every 10 days that had this rating at 12 o'clock noon. Similarly, a fire every third day with a rating of 2; a fire every second day with a rating of 3; and so on up to 8 fires a day with a rating of 6. These values can be used as the probable number of fires to expect for the various danger ratings in estimating the necessary suppression force. Also, since the suppression crew must extinguish perimeter of a fire, a rough estimate was made of the average perimeter per day.

The information summarized in the table shows that there is a definite increase in the number of acres burned per fire as the danger rating increases. It is also interesting to note that the number of fires per day increases with the increase in danger rating. The total loss of acreage per day can be obtained by dividing the total acreage burned in any danger class by the number of days in that class. It is entered in the summary. The average acreage loss per day for a given rating is perhaps of greatest interest in estimating amount of damage.

TABLE 1.—*Comparison of fire-danger ratings with occurrence and size of forest fires in Crossett district, Nov. 17, 1936, to Jan. 1, 1939*

Central States meter danger rating	Number of days	Total number of fires	Greatest number of fires per day	Number of days without fire	Percent of days without fire	Total acreage burned	Average number of acres per fire	Average number of fires per day	Average number of acres burned per day	Estimated average perimeter burned per day
1	173	18	3	160	92	29	1.6	0.1	0.2	1
2	101	38	6	82	81	133	3.5	.4	1.3	11
3	216	131	8	160	74	716	5.7	.6	3.5	23
4	193	314	25	104	54	2,135	6.8	1.6	11.2	65
5	67	224	14	20	30	1,865	8.3	3.3	27.8	160
6	2	16	15	0	0	1,447	90.4	8.0	723.5	1,200
Total	752	741	25	526	70	6,355	8.6	1.0	8.5	....

The danger classification of the Central States fire-danger meter might be improved for use in this locality. As generally used, the lowest danger-class on any meter indicates weather conditions during which fires will not occur. Since 18 fires have occurred here on days of danger-class 1, as this meter is now graduated, the meter should be regraduated so that class 2 will include these days. Also on most danger meters, only about 1 day in 100 is in the highest danger class. Since, as used here, there were no days in danger-class 7 and only two class 6 days in a total of 752, a regraduation should be made also in the other end of the scale.

Even with a meter in which the upper and lower danger classes are improved as described, there is need for local administrative judgement in determining the action to be taken for a given fire-danger rating. The practice of burning the woods by local inhabitants, and the tendency of reduced visibility to increase the discovery time of fires, must be considered in planning the action to take for given danger ratings. The results of the present check, however, indicate that a well-designed fire-danger meter will be of great value in many phases of fire-control work on this and similar areas, and that its correct use permits the forest administrator to save money in protecting his forest. Before a fire is discovered, it will serve as a basis for varying the presuppression organization; and when a fire is discovered, it will serve as a guide to the dispatcher in estimating the size of suppression crew required. Also it will act as a guide for the regulation of debris burning. These uses alone should make an accurate fire-danger meter of great value to those in charge of fire protection in this region.

Family Forestry.—Dwellers in nonforested regions are pretty well convinced—when they don't forget—that fires are bad business for the country as a whole. But how about the one class that is responsible for so many of our fires—the local settler? We haven't made enough headway in selling him the idea, mainly, I think, because we are using a sales talk that sounds good to us rather than one that sounds good to him.

Let's look at a more or less typical settler down in the southern woods. He has 80 acres, a mule, a cow, 2 sows, a sack of flour, $4 in money, a wife, and 8 kids. He's doing the best he knows how but "jest can't seem to git no place." He's living 1 day at a time with no prospects of things getting better. God knows, he wants his kids to have some of the things other kids have, but they'll be danged lucky if they get enough to eat come spring.

His timber isn't bringing him in anything. If it wasn't there he'd have more pasture and more plow land. No use telling him that in 10 or 20 years he can crop a thousand dollars off that timber. His family has to eat right now. Ten years from now they can look out for themselves. No use generalizing about timber depletion. If all the lumber companies in the world go busted—what of it. Besides they are rich anyway. Suppose a bunch of woods workers do lose their jobs. They'll just have to look out for themselves same as he has to do. Anyway, they are probably rich; they have jobs. He can't even get a job.

If we want to sell this man on forestry, we will have to do it in terms of more food and clothes now, not 20 years from now, nor even 1 year from now.

I believe it can be done. Probably not on a basis of sawlogs or pulpwood, but rather through forest byproducts. It must be something in which the whole family can take a hand. It means showing this settler what to produce and then showing him how and where to market it. Some of the possibilities (depending on location) are: Berry picking, gathering roots and herbs, seed collection, ferns and foliage for florists, hand-made wood products such as ax handles, etc., insect and plant collecting for wholesalers of school and laboratory supplies, favors and novelties—the list is almost endless. The point is that any time the kids can drag in $10 or $20 a year out of the brush, pa is going to keep that patch of timber working and keep the fire out of it.—A. G. Simson, *radio engineer*.

USE OF THE McLEOD TOOL

ALLEN S. DAKAN

Project Superintendent, Camp F–64–C, Pike National Forest, Region 2

McLeod tools may not be new to the Forest Service generally, but my introduction to them has been quite recent. Last Spring we assisted L. P. Brown in preparing for his ranger-training school at Manitou Park. He brought forth two of these peculiar rake-and-hoe combinations to be painted according to fire-tool standards. We looked them over and tried them out on a few short stretches of line around the camp. They seemed effective in the light grass and duff of open ponderosa stands which are common on the Pike National Forest. A short time later, 8 of the tools were ordered for equipment in the fire-tool boxes at the main camp and side camps. The standard 20-man cache was equipped with 4 and the side camp 10-man boxes with 2 each.

During this fire season we have used the McLeod tools on practically every fire which we worked. Most of these fires have been located in the open ponderosa types where the duff cover varies from nothing to as much as 6 inches deep. The soil has been mostly loose, disintegrated granite. On sites of this nature the McLeod tool was ideal for both line building and mop-up. When using the "one-lick" method, four men could be lined out on small fires, preceded by the foreman marking and clearing line and followed by one or two men with shovels for clean-up. The speed at which line could be built was surprising.

On one fire, the first on which the tools were used, we built line using the one-lick method and McLeod tools. Five men built 23 chains of line in 30 minutes, or, for that short period, at the rate of 9 chains per man-hour. This was on the average site with duff as much as 4 inches thick in places, some rocky ground, and some down timber that had to be cut. The fire was especially hot and had started to run up several trees when we first hit it. In this instance we found that working at right angles to the line using the hoe side of the tool was most effective and fastest, especially in the heavy duff. The line could be cut at the very edge of the fire with a minimum danger of throwing fire outside, and the duff thrown out could be scattered most effectively. On other fires, the tools have been equally satisfactory.

For mop-up, the rake end of the tool is excellent. Two men with McLeod tools and one with back-pack pump can rake a hot spot while it is being sprinkled, doing a very effective and rapid job of puddling. This was much faster and easier than the same work when done with shovels.

We are thoroughly sold on this tool for use in this type of country. Even though a little awkward to use in rocky ground, it is not much if any worse than a shovel.

NEW PRACTICE IN BURN TREATMENT

Fred C. Mills

Director, Health and Safety Service, Boy Scouts of America

As a result of a visit to the Washington office last fall by Fred C. Mills of the Boy Scouts of America, a cordial cooperative relation has been established with the national headquarters of that important organization. Mr. Mills' major interest naturally lies in the field of health and safety, and the highly developed practices of the organization are largely the result of his efficient efforts. This article is an abstract from his letter concerning what is known as the Harborview Hospital burn treatment which was developed by Dr. Hilton W. Rose, in charge of the burn service at that Seattle institution, now King County Hospital.

When I first went to the Harborview Hospital, Dr. Rose was not there, but I talked with the house doctor and he explained the burn treatment in considerable detail. The following day I called on Dr. Rose and he gave me more of the background and some additional data. Briefly, the treatment, which seems to be extremely practical, is as follows:

The patient, when brought to the hospital, was immediately immersed in a tub of 60° temperature water without attempting to remove the clothing. The temperature is gradually raised to blood heat. The reason for putting him in cold water first is that the burned tissue, according to Dr. Rose, is microscopically exactly the same as frozen tissue. It is a well-established fact that when the blood is too rapidly put back into circulation in frozen tissue, that tissue is broken down, which is likely to cause considerable destruction and may result in a gangrenous condition. As the circulation is gradually brought back to normal, shock is diminished, particularly as a result of the oxygen being excluded from the burned surfaces. The patient remains in the tub about 4 hours. When his condition is such as to permit it, the clothing is removed and the burned surface is cleaned with green soap applied with gauze. Narcotics are administered, the patient is removed from the tub, dried thoroughly under lights, and coated with a ferric chloride or silver nitrate. He is then placed in a bed where the top bed clothing is supported by framework and lights are maintained in order to keep the wounded surface dry.

In burn cases much of the fluid in the blood stream is absorbed by the tissues, seriously depleting the supply of the circulatory system, sometimes as much as one-half. This condition itself may be fatal unless the balance is corrected. Dr. Rose claims that this system does help to correct this condition. A saline solution is given when found necessary in order to increase the blood volume. Dr. Rose works on the theory that a burn is a wound, plus shock. He does not believe that there is any poison from protein absorption. This, I believe, is in line with the best information available. He does not

use tannic acid because of the very thick eschar which is formed by it and which makes the location of an infected area which may develop beneath it difficult. This is not true with ferric chloride which forms a thin coating.

Dr. Rose's treatment sounds extremely practical to a layman. I have talked it over with several surgeons here and they are interested, particularly in his theory of delaying the return of blood to the damaged area. Dr. Kennedy, a member of our National Health and Safety Committee, chairman of the Fracture Committee of the American College of Surgeons, and head of Surgery, Beekman Street Hospital, is a little dubious about putting the patient in a tub even of sterile water while still clothed. He thinks that it might cause infection to develop.

The Fruits of Their Labor.—Bordering the east boundary of the Mt. Hood National Forest and within District Rangers Walters, Gordon, and Lynch's zone of influence, live a great people. These folk are farmers, ranchers, woods workers, and small-businessmen. They represent a good cross section of western America's rural and urban population. Their patriotism, citizenship, and interest in public affairs are outstandingly high. Their acts are not confined to lip service but to deeds which speak much louder than words. Community interest in their national forest is not exceeded anywhere.

Their interest, loyalty, and confidence in forestry is best expressed in their attitude toward fire prevention and suppression, and in timber management. In this area of 900 square miles live approximately 25,000 people. From among these people the district rangers have enlisted nearly 400 men in organized and trained fire-fighting crews, many of whom for 15 years have been going to forest fires at the call of their district ranger and many times without waiting for the call. Logging and sawmill operators, farmers, and stockmen have closed down their operations and their mills, and interrupted the work of their threshing-machine and harvesting crews that their men may go to a fire burning on their forest. County officials have purchased radio-equipped fire tanker trucks with pumps, fire hose, and fire-fighting tools, and manned them with trained operators who are on duty day and night throughout the fire season. They have announced their intention of harvesting county-owned timber under the selective-logging system advocated by the Forest Service. Loggers, millmen, woodcutters, and others whose business it is to work in the timber have requested the Forest Service to keep them advised on burning conditions in order that they may close down when it is unsafe to work. Farmers operate fire-danger stations with equipment furnished by the district ranger and report their recordings faithfully to him. County courts and individuals pay the Forest Service to dispose of their slash in order that it may be done safely and without injury to standing trees. Schools, churches, American Legion, Grange locals, and other organizations carry on campaigns of fire prevention and for better forest practices in the management of privately owned timber.

There are no State laws for eastern Oregon to regulate woods operations such as apply on the western slope, yet these people voluntarily impose upon themselves comparable restrictions. Incendiarism is unknown here and the new settler is quickly educated by his neighbors to be careful with fire in the woods.

Why are these people so forestry-minded and so fire-conscious? Is it a local economic influence? Or is it the result of carefully planted seed sown in fertile soil over a period of 30 years by patient foresters with a vision and with confidence in their cause?—Foster Steele, *assistant supervisor, Mt. Hood National Forest (Six-Twenty-Six).*

DWELLING SPARK ARRESTERS

F. W. Funke

Specialist in Fire Control Equipment, Region 5, U. S. Forest Service

Underwriters' statistics show that over 11 million roof fires occur each year, principally because of the lack of effective spark arresters. Despite the pressing need for devices which would reduce this tremendous loss, little has been done. The California region particularly has suffered from disastrous fires caused by embers being siphoned through house flues during periods of high wind. The Reginald Denny fire in the San Bernardino National Forest in 1926, was an outstanding example.

Early in 1928 the writer conducted a series of experiments in the laboratory with various types of house flues. Action of the flue gas and sparks was studied under a wide range of conditions. The study was incidental to other activity, however, and made slow progress. With the advent of the expanded work program in 1933 the work was shelved and not brought to the fore, until 1938, this time as a separate project financed by the Washington Office of Fire Control, M. Fram, junior mechanical engineer, being assigned to the project. The study was concluded in December 1939.

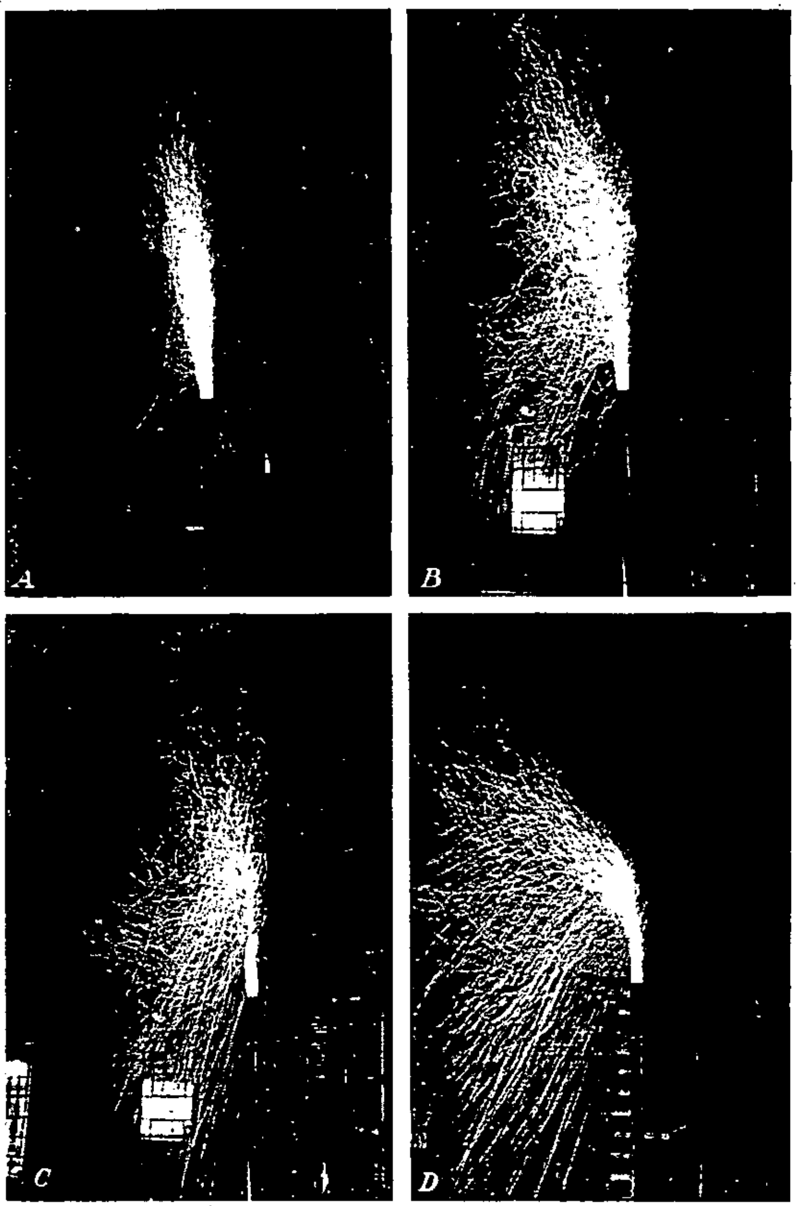
During the course of the studies looking toward development of an efficient and practical spark arrester, numerous arrangements of test flues were examined; actual test set-ups were studied; in fact, every conceivable application was considered. Spark particles were graded as to hazard or fire-setting qualities. Experimental types of arresters were built and tested under flue-gas velocities ranging from 10 feet per minute to 26 feet per second. The best features of the various arresters were included in a compromise design which, through field and laboratory tests, indicates that it is effective and practical for nearly all installations.

A report has been prepared which contains the data secured in the study. It is available to interested agencies upon request.

It would be misleading to convey the idea that all the answers dealing with spark arresters have been obtained in the study. Our search was directed to the design of a simple and practicable arrester which would be effective and serve our needs with a minimum of maintenance. Such a design is now available.

A very interesting photographic record was made of the spark paths. The exposure covers a period of 8 seconds, during which the individual path followed by each of the larger sparks is clearly shown. A standard cast-iron wood heater with an 11-foot smoke pipe was used during the tests. Graded sizes of sparks were injected into the gas stream.

It was determined by experiment that the efficiency, i. e., combustion loss and effectiveness of the arrester, is so closely related to definite proportional characteristics that for all practical purposes it can be stated: For any given size arrester of this design a proportionate



A, Small sparks of the nondangerous type. Practically all are consumed in the gas stream. B, Mixture of nondangerous and slightly dangerous size sparks. Paths of latter are clearly shown. C, High percentage of dangerous sparks. Small sparks broken during transit through flue are shown being consumed above stack. D, Heavier charge of sparks of the same grade as in C.

increase in size must exist between the inlet and outlet. This is clearly indicated on the plate.

The arrester may be installed at the top of the stack or at any intermediate point between the stove and the stack outlet. When installed near the stove, the arrester functions somewhat similarly to an automatic damper, restricting high-velocity gases produced by intense fires, and at the other end of the curve aiding gas flow from a low fire by permitting faster cooling and increased viscosity of the gas above the arrester. In passing, it may be worthy of note that the friction loss introduced by the arrester is the equivalent of a half length of 6-inch stove pipe.

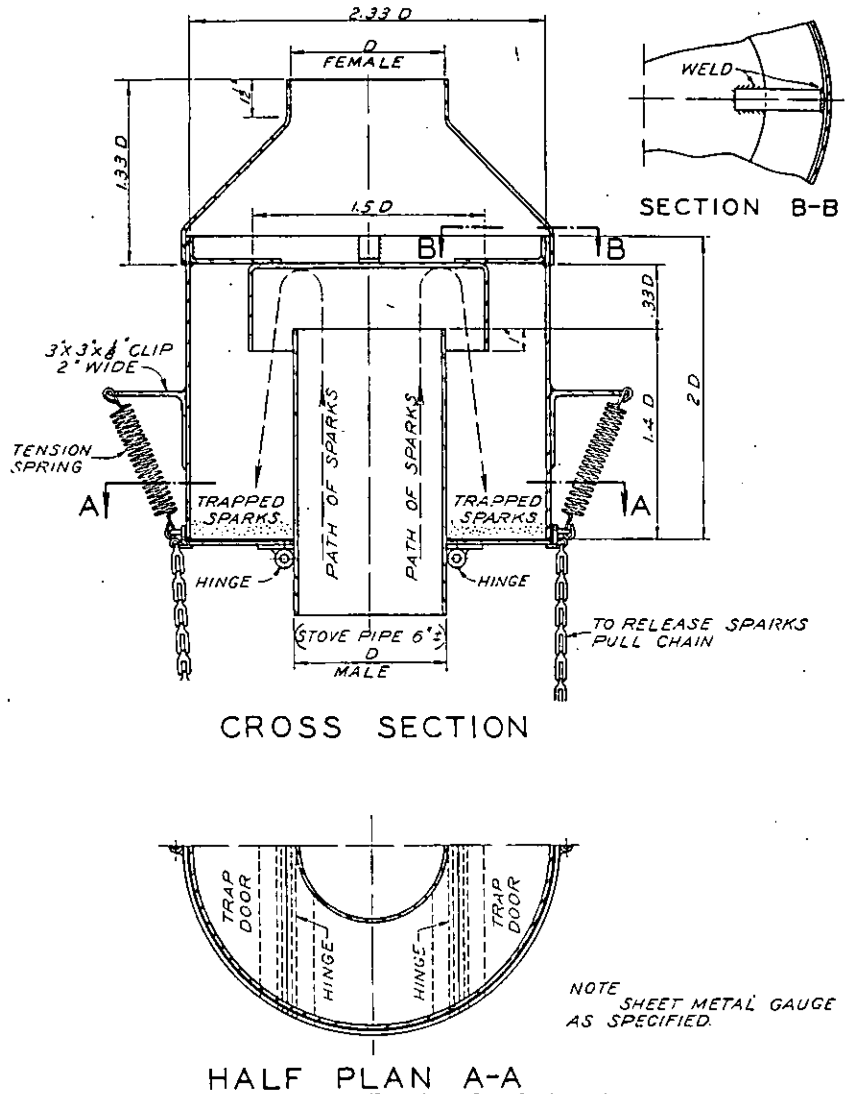
Sparks of a size which will almost invariably start a fire if permitted to land on inflammable material.

Maintenance required by the arrester will depend entirely on the kind of fuel used. Ordinarily it should not be necessary to clean out the spark trap more often than once each 60 days. This is done by attaching a wire or chain to the trap doors on the bottom of the arrester, the lower end of chain to be fastened at some point ouside the house within easy reach. By permitting the doors to jar heavily on closing, practically all trapped material will be shaken down and permitted to pass out to the wind. If the spark trap is not cleaned periodically, the gas opening in the arrester will gradually choke, causing the stove to smoke.

As to material, little need be suggested. Individual preference can have full sway. If the arrester is at least 22 feet removed from the stove on a flue having at least one elbow, a galvanized iron arrester will give good service for many years. If the flue is straight, there should be at least 30 feet between stove and the galvanized arrester if it is to stand up for any length of time. Black copper bearing iron will probably be used for most installations even though rust from the arrester streaks the stack. Cadmium plate might be substituted for the galvanized iron under similar conditions.

Metal gage will, of course, depend on the size of the arrester, amount of heat to which it will be subjected, as well as numerous other influences. For the average installation where it is expected to secure at least 10 years of service, arresters up to 8 inches in size should be of not less than 24-gage metal. Larger sizes should be proportionately heavier to secure strength as well as weight of metal.

No tests have been made of rectangular flues, but it is believed that if at least one round section of standard length pipe is used before the gas enters the arrester, no turbulence will result which will reduce the efficiency of the arrester.



Region Five Dwelling Spark Arrester

The arrester as designed has a streamlined cap with a female end on top so that it can be installed at any point in the flue. This cap is not necessary to the efficiency of the arrester, but it does prevent accumulations of wind-borne litter in the arrester. Drainage of water in the arrester is automatically provided by the loose-fitting trap doors. It might be desirable in some localities to install a cap over the arrester to prevent snow clogging. Any type of cap can be used as long as it does not restrict the flow of gas from the stack.

OCCURRENCE OF MAN-CAUSED FIRES ON SUNDAYS AND HOLIDAYS VERSUS WEEKDAYS IN THE NORTH PACIFIC REGION

JOHN C. WILKINSON

Pacific Northwest Forest Experiment Station, Portland, Oreg.

In fire-prevention work, fire-danger rating, and other phases of fire control, it is important to know whether chance of man-caused fires is greater on Sundays and holidays than on other days. The wide variation in opinion among forest officers indicates the need of studying this subject. Herein are made available some facts about fire occurrence as related to days of the week and holidays and different causes and classes of people, obtained from a study of the fire reports made at the Pacific Northwest Forest and Range Experiment Station.

All man-caused fires on all the national forests in Washington and Oregon from May to October, inclusive, and for the years 1931–38, inclusive, were tabulated by day of the week or holiday on which they occurred and by different causes and classes of people. Hunters' fires were broken down into fires occurring during the day before plus the first 2 days of the legal hunting season and fires occurring during the succeeding days of the season. The original tabulations were made by forests, groups of forests, and months, but the most reliable comparisons come from the summaries prepared for the entire region and for the entire period.

Out of the total of 5,717 man-caused fires studied for the 8-year period, 1,091 fires occurred on Sundays, compared to an average of 771 fires per day on the other days of the week. There was a total of 4,115 smoker and camper fires, and of these 891 occurred on Sundays and only 537 per day on other days of the week. This shows that there were about 1.7 times as many fires per day on Sundays as on weekdays and indicates the magnitude of the fire load on Sundays as compared to other days. The Fourth of July and Labor Day appeared to have about the same rate of occurrence as Sundays, but Memorial Day and the opening days of the hunting season did not appear to have a higher rate than other days.

Since the number of people in the forests is much greater on Sundays and holidays than on other days, full credit should be given to prevention measures for keeping the number of fires on the days of heaviest use so nearly on the same level as on the days of ordinary use. Thus the relationship between prevention and fire occurrence, whatever it may be, is an important consideration to be kept in mind when interpreting the results of this study. The fire reports offer the only measure of occurrence, but they record the fires that happened in spite of prevention. There is no way of predicting what the fire-occurrence rate would be with more or with less prevention.

Looking at individual causes and classes of people responsible, it is apparent that smoker-fisherman and camper-fisherman fires show

the strongest tendency to be concentrated on Sundays, and this seemed to be true in all parts of the region. This tendency is strongest early in the season. Debris-burning fires of the bonfire and trash-burning type (but not including land-clearing fires), smoker or camper fires attributed to travelers, hunters, and berry pickers, and camper-stockman and camper-rancher fires were found to have a slight tendency to occur most frequently on Sunday; but smoker or camper fires started by miners, and land-clearing, railroad, and miscellaneous fires seem to occur at about the same average rate on all days of the week. Lumbering and incendiary fires show a slight decrease on Sunday.

Although this study indicates that Sundays, the Fourth of July, and Labor Day have a somewhat higher occurrence rate than ordinary days, nevertheless the maximum number of fires to be expected on any one ranger district even on a Sunday or these holidays seldom exceeds 1 or 2 (as many as 5 man-caused fires have occurred in 1 day on 1 ranger district, but this is very exceptional), as compared to lightning storms, which commonly start 10 or 20, or more, fires on 1 district in 1 day. All things considered, it appears that the increase in man-caused fire occurrence on Sundays and holidays can be taken care of by the protection force required for other days of similar burning conditions (fuel, moisture, wind, and herbaceous stage) and visibility conditions. There may be a few localized exceptions to this statement, as on districts having the heaviest load of Sunday visitors or Sunday fires. Possibly the most important way to use the results of this study will be as a guide in determining where, when, and to whom additional prevention measures should be applied.

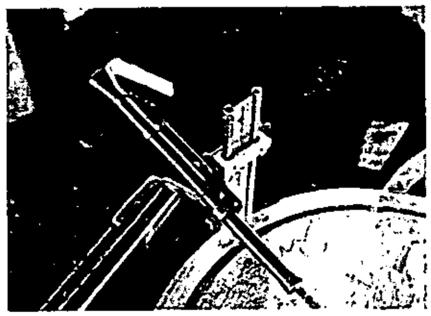
TELESCOPIC SIGHTS FOR LOOKOUTS

Karl E. Moessner

Junior Forester, Superior National Forest, Region 9, U. S. Forest Service

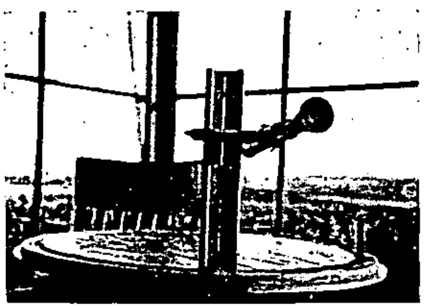
Telescopic rifle sights, mounted on standard Osborne fire finders, were tried out during the last field season by three Superior Forest lookouts and appeared to have marked advantages over the customary open sights.

The illustrations with this article show the manner of attaching the telescope to the rear posts of the fire finder by a simple mounting which allows sighting on near or distant smokes and holds the scope in a vertical position when not in use.



Top view of scope, mounted on fire finder by means of trial wooden mounting.

By adjusting the micrometer screws while sighting at a distant object the telescope is made to parallel the line of the open sights, facilitating instant use of either scope or peep. This alternate use nullifies any disadvantage which might be experienced because of the somewhat smaller field or the magnification of smoke or haze.



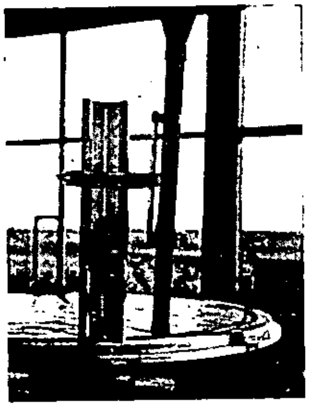
Scope on fire finder ready for use.

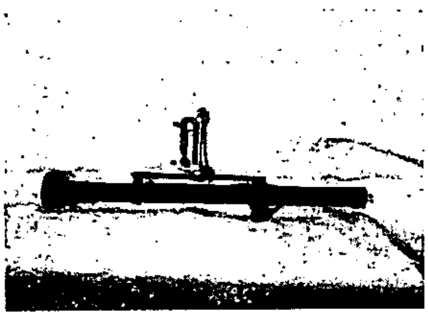
Although the manner of mounting prevents use of the scope when reading vertical angles, this proves of little importance in nonmountainous regions.

A few advantages credited to the improved sight are:

1. Horizontal readings to small or distant smokes are made with greater accuracy in much less time.
2. Estimates of the size of small fires are more accurate, since the sight makes reading both edges of the smoke column entirely feasible.
3. Locations of one-shot fires are more accurate, since the sight brings out folds in the terrain and details of cover invisible to the naked eye, yet requisite to careful estimates.

Although it has many of the advantages usually associated with binoculars the sight is relatively inexpensive. Satisfactory four-power scopes are available at less than $5, while the mounting, as finally designed, can be constructed of bronze for a few cents.





Left: Scope in rest position, vertical and out of the way. Right: Bronze mounting as finally designed. Note that the normal sight is unobstructed.

The 20-Hour Day.—In a recent issue of Fire Control Notes it was remarked that 10 hours should be the maximum number per day on fire fighting. Most of us, remembering the custom of the past, and the instructions of the present, say at first glance: "It is impossible to divide the day up in such a way."

This set-up, however, ties in with a system we have used whenever a fire arrives on the patrol, and mop-up basis, in the following manner: The day crew gets up at 6 a. m. and is on the fire line at 7 or 8 a. m. The night crew gets into camp at 9 or 10 a. m. They "try" to get in 4 or 6 hours sleep (slumber, in this case, versus ants, big, little and small, flies, heat, dust, the power grinder, public address system, and stories told by the forest officers called for in the "perfect camp set-up") before they are called for supper at 4 p. m. They are then out on the line by 6 p. m. so that the day crew can return to camp before dark. (Already I can hear protests from the experts.) The night crew gets in several good hours mopping up before midnight. They eat their lunch and fall asleep shortly after. Here is where the boss says: "Well boys, you can sleep from now until 4 a. m. if at that time you get up and hit the ball until the day crew arrives." (This legalizes the sleep they will take anyhow.) By this time, the fires in small materials have died out, the snags have cooled down and can be felled during daylight hours, with men who are refreshed.

The day crew gets a fair night's sleep, and instead of being tired and sleepy by noon, they are able to be alert when they are needed most, and fresh enough to tackle a break if one should occur.

During the night, naturally, it will be necessary to have a few good men to patrol on underslung line and where snags are apt to fall.

In this way, we can cut the day to 20 hours of work. There will still be some overlapping of time, because of travel time.

We know that the method described works with good results, since we have used it numerous times, and compared the results with those obtained on forests where they still believe in awakening the day crew at 3 a. m., when the fire is on a patrol basis.

This same system works well on a cold trail job. In fact, both night and day crews can be used, if conditions warrant, during the "golden hours of fire fighting."—Edward G. Madsen, *forest ranger, Sierra National Forest, Region 5, U. S. Forest Service.*

LESSONS FROM LARGER FIRES OF 1939 IN THE NORTH CENTRAL REGION

Clark—Jake Fire—340 acres.—Suppression action was satisfactory. Therefore the important task is that of prevention. Although fires set for the purpose of burning over lands, not owned by the person who sets the fire, are classified as incendiary, the fact that these may be set for a purpose which the individual feels is justified makes the prevention problem far different from those where fires are set with purely malicious intent.

There is need for constant effort on the part of the ranger and other regular forest officers to prevent this type of fire. This must be attacked indirectly so as to secure for the Forest Service the good will and confidence of the individual. In many cases a direct approach may antagonize.—Paul D. Kelleter, *forest supervisor.*

Clark—Malice Fire—548 acres.—The fact that this fire was discovered by a patrol unit and suppression was begun immediately further confirms the use of such units, particularly during periods of high danger and low visibility. Had there been no patrol unit and additional stand-by units available, the burned area would very probably have exceeded 1,200 acres.

The same comments in regard to fire prevention apply in this case as those given in the statements concerning the Jake fire.—Paul D. Kelleter, *forest supervisor.*

Clark—Dandy Fire—1,042 acres.—Even though the suppression of this fire was well executed, the need for a better scouting method was evidenced. With numerous sets scattered for 2 to 3 miles and burning conditions such as to cause very rapid spread, it is necessary to have a scouting system which uses the nearest observation points for obtaining information, with radio communication to the fire headquarters.

An intensive patrol for periods of high fire danger during bad fire weather and low visibility might have resulted in an earlier discovery of this fire.

Again the matter of fire prevention is emphasized. Our past programs have resulted in bringing the reasons for and benefits from preventing forest fires to the attention of probably every forest resident. An important method of attacking the prevention of this type of fire is through the continued efforts of rangers and other regular Forest Service personnel. This will likely best be done in a very indirect manner; the various forms of timber use offer a facilitating means for such efforts.—Paul D. Kelleter, *forest supervisor.*

Manistee—Northridge Fire No. 1—358 acres.—(This smoker fire was one-tenth of an acre in size when discovered, eight-tenths of an acre and spreading slowly in grass, leaves, and slash when first reached by 5 men, 53 minutes after known time of origin. Discovery time 14 minutes. Report time 11 minutes. Get-away 3 minutes.

Travel time, 7 miles by truck, 24 minutes. Travel delayed by road barricaded by deadfalls, fence, and trees, because of a local row. Wind of 4–7 miles upon arrival soon went gusty and changeable. Notes by foremen show 10 major wind changes. One drove fire directly at tanker when motor was stopped while district ranger was out directing crew. This run covered 600 feet in 2 minutes, damaging tanker and severely burning district ranger who could not start tanker motor.—Ed.)

One lesson learned from this fire is that additional stand-by fire equipment is necessary if we are to meet our fire suppression standards. The most urgently needed item is tanker trucks. * * * In this case, too much reliance was undoubtedly placed on the tanker truck based on our successes with it on about 40 previous fires.— E. S. Iversen, *district ranger*.

Experience had taught that in this particular set of circumstances the most urgent need was speed of effective attack. The most useful suppression instrument available was a three-quarter-ton tank truck equipped with radio. The development of this tank truck was so recent that only the district ranger possessed, at the moment the fire broke out, sufficient knowledge and skill to make the most effective use of the machine. Since speed was so important, the ranger, therefore, made the best use of the machine he could, believing it to be more effective than the larger crew of men which might have been mobilized in a little longer time.

The actual result was that the shifting character of the wind neutralized to a great extent the effectiveness of the tanker which was eventually put out of commission by being partially burned. The ranger was severely burned and put out of commission at the same time. As a result, the other features of the fire suppression suffered through lack of the ranger's skilled supervision.

The principal lesson to be learned is that the tanker should be in charge of a guard or someone other than the ranger, who has been highly trained and is skilled in its use, so that the man who is the logical fire boss will not have his attention absorbed in any piece of machinery. A further factor in the loss of time was the fact that the roads leading to the fire were blocked at the points where they crossed private lands. This situation has been known for some time and efforts been taken to correct it, but the fact that it has not been corrected and the resultant loss of time have certainly resulted in an unnecessary burning of a number of acres.—Quoted from supervisor's memorandum by G. K. Fenger, *acting regional forester*.

TRAIL TRACTOR AND TRAILMOBILE

Thomas A. Rice
Division of Engineering, Region 6, U. S. Forest Service

The Trail Tractor

The trail tractor was developed in the Forest Service Experimental Equipment Laboratory at Portland during 1937 and 1938, primarily for the purpose of reducing trail-construction costs. The experimental model was used on trail construction on the Willamette National Forest during 1938 with satisfactory results, both as regards work accomplished and testing of the machine itself.

On the basis of the 1938 tests, five additional tractors were built for Region 6 during the winter of 1938–39, one for Region 4, one for the State of Washington, and two for the British Columbia Forest Service, a total of nine. One weakness in the rear-end assembly was brought to light in these machines during 1939, and was fully corrected in September and October 1939 by replacements in all units put out to date. The Canadian tractors were tied up early in the season because of the war. The Region 4 machine, it is understood, was used mainly on terracing work. The Region 6 units were placed on three west-side forests to determine what they could do under moderate to severe conditions of side slope, rock, and clearing.

Trail tractor in action.

The data on the following pages have been compiled from reports submitted by the Siskiyou, Umpqua, and Willamette National Forests.[1]

SPECIFICATIONS U. S. F. S. SPECIAL TRAIL TRACTOR

Detail:

Drawbar horsepower	19.0
Drawbar pounds pull, level, first gear	5,000
Drawbar pounds pull, level, second gear	2,640
Drawbar pounds pull, level, third gear	1,445
Drawbar pounds pull, level, fourth gear	855
Belt horsepower	22.5
Bore and stroke, inches	3¾ by 4
Number of cylinders	4
Revolutions per minute	1,500
Piston displacement, cubic inches	133
Speeds, miles per hour, first gear, forward	1.35
Speeds, miles per hour, second gear, forward	2.56
Speeds, miles per hour, third gear, forward	4.66
Speeds, miles per hour, fourth gear, forward	7.9
Speeds, miles per hour, first gear, reverse	1.56
Speeds, miles per hour, second gear, reverse	2.98
Speeds, miles per hour, third gear, reverse	5.45
Speeds, miles per hour, fourth gear, reverse	8.35
Number of lower track wheels each side	6
Track shoe length, center to center pins, inches	3.075
Track shoe width, inches	7½
Length track on ground, inches	52½
Total ground contact area, square inches	788
Width over all, inches	36⅛
Under height, inches	44
Clearance with grousers, inches	5
Center to center track (gage), inches	28⅝
Ground pressure, pounds per square inch bare tractor	3.59
Rear power take-off, revolutions per minute, first gear, forward	161
Rear power take-off, revolutions per minute, second gear, forward	307
Rear power take-off, revolutions per minute, third gear, forward	560
Rear power take-off, revolutions per minute, fourth gear, forward	950
Rear power take-off, revolutions per minute, first gear, reverse	187
Rear power take-off, revolutions per minute, second gear, reverse	357
Rear power take-off, revolutions per minute, third gear, reverse	651
Rear power take-off, revolutions per minute, fourth gear, reverse	1,000
Weight in pounds, bare tractor	2,830
Weight in pounds, with bulldozer	3,650
Weight in pounds, with bulldozer and hoist	3,970

Attachments available:

- 2-way hydraulic bulldozer with convertible blade.
- 4-speed reversible drum hoist with maximum 10,000 pounds line pull in low speed.
- 100-gallon per minute high-pressure water pump can be attached in place of hoist.
- 2-wheel trailer carts of 1,500-pound capacity trailed from drawbar.
- Trencher plow, pulled from drawbar.

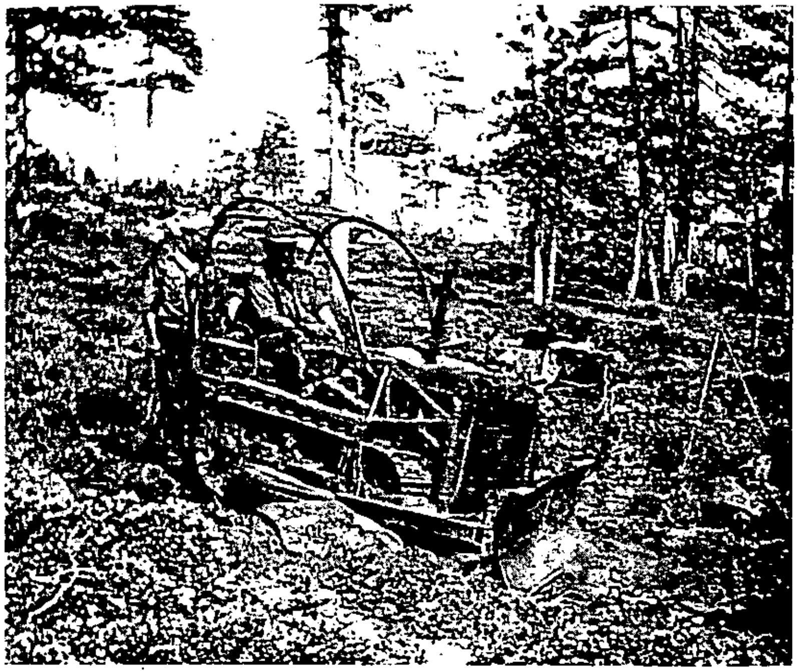
Costs:

- Bare tractor in lots of 5, $1,700; lots of 10, $1,600.
- Tractor with bulldozer, in lots of 5, $2,350; lots of 10, $2,200.
- Tractor with bulldozer and hoist, in lots of 5, $2,650; lots of 10, $2,475.

Because of special reversible clutch and special power take-off, the cost of bare tractor is a little greater than Cletrac's small model, but when U. S. F. S. machine is equipped with bulldozer, the combined cost is less than any commercial model.

---

[1] The region is indebted to the supervisor, forest engineer, and field organizations of the three forests for excellent work on the job, good cost figures, photographs, and write-ups of their 1939 trail tractor projects.



Side view of trail tractor

Transportation of supplies by the trail tractor with trailer. Travel time of this outfit when loaded was approximately 4 miles per hour, and of course reduced the working time of the trail tractor accordingly.

SUMMARY

A summarized statement of tractor trail constructed during calendar year 1939 is as follows:

Forest	Project	Miles constructed	Average cost per mile	Estimated cost per mile for secondary trail using hand labor
Siskiyou	Chetco Divide:			
	Page district	4. 88	$493. 85	$600
	Chetco district	5. 77	417. 00	500
Umpqua	Red Butte	4. 50	238. 04	350
Willamette	Scar Mountain	2. 33	443. 77	550
Total		17. 48	362. 16	495

It is estimated that trail construction by hand methods in similar country on the Siskiyou approximates $600 per mile. The trail tractor average for the 10.65 miles of trail construction was $455 per mile. These costs can be expected to be reduced by better organization, the use of the trailmobile for transportation, and as experience is gained from operations.

Trail constructed by trail tractor.

Another trail constructed by trail tractor.

The Trailmobile

As trail-tractor operations advanced, the question of hauling supplies for machine and camp by other means than a trailer hitched to the trail machine, or pack stock, became important. A vehicle with gage to operate on the trails as constructed, with power and speed sufficient to transport the loads was needed to relieve the trail tractor from hauling supplies and permit it to follow the more important grading and construction work.

As an experiment, the construction of a miniature automobile fashioned after a pick-up or stake truck was undertaken.

The finished vehicle has specifications as below:

Motor, four-cylinder Hercules 1 XB.
Wheelbase, 60 inches.
Tread, 35 inches.
Weight, 1,400 pounds.
Minimum turning radius, 17 feet.
Top speed, 30 miles per hour.
Bed of box, 36 by 53 by 15 inches.
Load capacity, approximately 2,000 pounds.
Tires, outside diameter 20 inches, mounted on 4.50 by 12 rims.

Salvaged parts from a model A pick-up were used in the construction.

The cost of the trailmobile, using salvaged items, new motor, and labor is estimated as $569.

Comments from the supervisor as to the machine's value and comparative capacity follow:

The trailmobile was put into service too late to allow time for development of records.

The trailmobile.

Trailmobile transporting supplies on completed trail.

Its capacity is equal to a seven-horse pack string, and it can maintain a hauling speed of 8 miles per hour. Estimated that hauling costs should not exceed 5 cents per ton mile, while like costs with the trailer-tractor combination are estimated as 18 cents per ton mile and pack-string costs approximately $1.50 per ton mile.

This machine was developed entirely by the personnel of the Siskiyou National Forest under the supervision of Supervisor E. P. Cliff.

CONCLUSIONS

The work done in 1939 brought out the following points:

1. The trail tractor is a workable and economical tool for trail construction. Although further refinements are possible (and probable), it may be considered as out of the experimental stage.

2. Trail can be economically built by machine on side slopes to 80 percent, with considerable ledge rock and boulders, heavy timber, and dense brush. The use of more powder than used originally in loosening rock and heavy stumps was found to speed up progress and reduce costs.

3. A trail tread of 58 inches after machine work, shrinking to approximately 54 inches after 1 year's settlement, is secured with the trail tractor. In Region 6 this is not objectionable from the maintenance standpoint.

4. Costs are lower than for hand work on standard secondary trails.

5. After tractor trail is completed, transportation of fire and other supplies can be accomplished at considerably lower cost by use of either the trail tractor with trailer carts or the trailmobile, than by pack stock. The trail tractor can pull two trailer carts with a pay load of up to 3,000 pounds at speeds of 3 to 5 miles per hour. The trailmobile can haul a pay load of 1,200 pounds at 6 to 8 miles per hour. A reasonably smooth trail grade is necessary, which presupposes annual blade maintenance.

INFORMATION FOR CONTRIBUTORS

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

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

If there is any introductory or explanatory information, it should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Text for illustrations should be typed on strip of paper and attached to illustrations. All diagrams should be drawn with the type page proportions in mind, and lettered so as to reduce well. In mailing illustrations, place between cardboards held together with rubber bands. Paper slips should never be used.

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

The approximate position that illustrations bear to the printed text should be indicated in the manuscript. This position is usually directly following the first reference to the illustration.