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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

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

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FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

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

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DROPPING ACCURACY—A LOGISTICS PROBLEM IN AIR ATTACK

LOYD M. LAMOIS, *Forester, Division of Forest Fire Research, U.S. Forest Service, Washington, D. C.*

Promising breakthroughs in technology are sometimes exploited at a pace which for a short period of time carries them ahead of underlying theories. Seldom, however, is this lop-sided race between practice and theory a long one. Sustained progress to high levels of achievement is a longer run—with basic theory setting the pace.

A case in point is the air attack of forest fires. In seeking for refinement and dependability in the air delivery of fire retardants we should pause to examine some fundamental aspects of the delivery process—aspects which not only will yield clues to more effective use of the tools we have at hand, but also will help us choose correctly from alternative approaches to the problems of designing new equipment.

Aside from the tactical decisions involved, the effectiveness of any single delivery of retardant to the fire site is a function of *pattern size* on the ground and the *accuracy* of placement. The interplay between these two variables defines the limits within which we must work. We cannot "engineer" larger patterns at too great a sacrifice in delivery accuracy. On the contrary, we dare not launch a program to develop pinpoint delivery if the mechanics threaten to restrict ground pattern size to that which would offset the gain in accuracy.

In the evaluation of a proposed delivery system, of course, the "effectiveness measure" of any single delivery must be considered along with the *costs* involved in operating the system. These three parameters, then, form the matrix of values within which our engineers must work to make the proper choice of delivery vehicle, aiming system, release mechanism, and operational tactics.

ACCURACY

Accuracy concepts are the logical starting point for much of the basic work to be done in the building of a sound air-attack methodology. The proper choice of equipment and its tactical use depend upon accuracy estimates which allow us to predict, with some degree of certainty, the ratio of probable successes to number of tries.

Unfortunately, we know very little about the accuracies we are obtaining with present equipment and present tactics. Experience has given us a general "feel" to serve as a rough guide; but we have few quantitative data on drop accuracies and precisely how they may vary with altitude, flight speed, tactical situation, human factors, etc. We have even less information on the level of accuracies obtainable with other modes of delivery such as high altitude drops of contained retardants, guided missiles, rocketry, etc.

To illustrate how such information might be of use to an air dispatcher, we will consider two tactical situations. The first is a mission to treat a lightning-struck snag which is smouldering and might become the start of a going fire if left unattended. The second is a line-building mission in which retardant is to be laid down in advance of a moving fire front or along an extended flank.

Against a background of considerations involving flying safety, time factors, and control tactics the dispatcher must answer two logistics questions immediately: (1) which delivery vehicle can best do the job? and, (2) how many drops can we expect to need in order to accomplish the mission? The following discussion illustrates an approach toward finding answers to these questions.

AIR DELIVERY TO A POINT TARGET

To evaluate the probability of success on any single delivery mission we must have some notion of how a number of similar deliveries are likely to be distributed about the target. Immediately we are forced to make an assumption that over a large number of similar drops the centers of the individual drop patterns on the ground will be clustered about the true target point, and not about a false point of aim significantly distant from the true target, i. e., we are dealing with random error.

This assumption is a logical one in the case of low-level glide water drops, where the pilot (as a flesh and blood servomechanism) is constantly adjusting his aim from the results of his previous drop. It also would be the logical assumption for a guided missile type of delivery, where true aim is assured and errors are purely mechanical ones inherent in the flight characteristics of the missile. This assumption would also hold true for high-altitude bombing with an accurate bomb sight and sources of systematic error, such as wind, taken care of.

In most situations this distribution of pattern centers will be such that the frequencies of occurrence, as one moves farther from the target, are arrayed according to the Gaussian or normal curve of errors.[1]

We need, however, more experimental data in order to safely assume random error where aiming is predominately a matter of judgment on the part of the pilot. We need, also, data upon which to base estimates of *mean absolute error* (average distance from

[1] In the case of low-level glide bombing this last assumption apparently does not hold true. Analysis of results involving 24 individual drops on a point target from a P-47 aircraft in Montana shows that the distribution of pattern centers about the target was predicted best from an exponential curve of errors. Successive corrections by the pilot in this type of action apparently results in early wide misses being quickly reduced to a high order of accuracy. The graph of frequencies becomes one in which a sharp peak of occurrence is centered on target, then falls off quite rapidly to the point of mean absolute error and extends far out in a long tail resulting from early large errors.

target to pattern center),[2] associated with various tactical situations, different delivery vehicles, and, in the case of manned aircraft, individual pilots.

Knowing the mean absolute error and assuming a given distribution of pattern centers about the target, one can calculate the probability of any single pattern center being within a specified distance from the target point. With the ground dimensions of effective pattern known, this probability data can be arrayed into graph or chart form that will yield the probability of any single delivery resulting in a ground pattern which includes the target point.

This has been done for both of the aforementioned error distributions. Table 1 assumes the normal distribution about the target. Table 2 assumes an exponential error distribution of the form

$$p = ae^{-ax} \text{ where } a = \frac{1}{\text{m.a.e.}} \text{ and } x = \text{distance from target.}$$

TABLE 1.—*Probability of target being covered by drop pattern*[1]

[Percent]

Mean absolute distance off target (feet)	Probability when dimension of drop pattern[2] in feet is—												
	15	20	25	30	40	50	60	80	100	160	240	320	400
10	44	57	68	77	89	95	98	99	99	—	—	—	—
20	22	30	37	44	57	68	77	89	95	99	99	—	—
30	15	19	24	30	40	49	57	71	82	96	98	—	—
40	11	15	18	22	30	37	44	57	68	89	98	99	99
50	09	12	15	18	24	30	35	47	57	80	94	98	98
60	—	10	13	15	19	24	30	40	49	71	89	96	97
80	—	—	09	11	15	18	22	30	37	57	77	89	95
100	—	—	—	09	12	15	18	24	30	47	66	80	89

[1] Assumes normal distribution of absolute errors.

[2] Dimension is pattern *length* when range error is under consideration. It is pattern *width* when considering deflection error. With circular patterns, dimension would simply be the pattern *diameter* in both cases.

When deflection errors are negligible (often the case with low-level glide bombing), the probability of target coverage is a matter of range error alone, and the table need be entered only once. When errors to the left or right of flight line are large enough for concern, the table must be entered twice—once for target coverage along the flight path and once for target coverage lateral to the flight path—and the resulting two probabilities multiplied to obtain net probability of target coverage.

A comparison between the two tables shows that the assumption of normal error distribution yields a more conservative estimate of success probabilities with pattern dimensions less than 300 feet. With pattern dimensions of more than 300 feet, probability values are approximately equal.

[2] Mean absolute error as used in this article is not the average *radial* distance from target to pattern center. It is, rather, the individual range component or deflection component as the case may be.

TABLE 2.—*Probability of target being covered by drop pattern*[1]

[Percent]

Mean absolute distance off target (feet)	Probability when dimension of drop pattern[2] in feet is—												
	15	20	25	30	40	50	60	80	100	160	240	320	400
10	53	63	71	77	86	91	95	98	99	—	—	—	—
20	31	39	46	53	63	71	77	86	91	98	—	—	—
30	22	28	34	39	49	56	63	73	80	93	98	99	99
40	17	22	27	31	39	46	53	63	71	86	95	98	99
50	13	18	22	26	33	39	45	55	63	80	90	96	98
60	11	15	18	22	28	34	39	49	56	73	86	93	96
80	—	11	14	17	22	27	31	39	46	63	78	86	91
100	—	09	11	13	18	22	26	33	39	55	69	80	86

[1] Assumes exponential distribution of absolute errors.

[2] Dimension is pattern *length* when range error is under consideration. It is pattern *width* when considering deflection error. With circular patterns, dimension would simply be the pattern *diameter* in both cases.

When the probability of target coverage is determined, it is possible to estimate the number of deliveries needed to assure success within certain confidence limits (table 3). This sort of logistics information could be of real value to a ground crew preparing to service a suppression mission and who would benefit from even a rough estimate of probable needs in the ways of gallons, missiles, aircraft, etc.

LAYING DOWN A FIRE BARRIER

The logistics of line building can be explored in a similar manner—a theoretical approach serving to lay a conceptual framework within which practical considerations might be examined.

One set of delivery assumptions from which we might begin could be the following:

1. Deflection error insignificant.
2. Range error known.
3. Absolute errors in range distributed normally about target point.

If our delivery system would allow us to build line by aiming at a succession of point targets laid out in advance of a fire, our above assumptions can tell us how these targets should be spaced and also indicate scheduling of drops on each target. For any given mean absolute error (range) and corresponding pattern length on the ground, table 4 lists the distance between successive target points that is necessary to be "95 percent sure" of overlap between drop patterns on the ground.

Table 4 displays two values in most cases. The upper value is the distance between successive targets when *one* delivery is made at each target point. The lower figure is the distance between successive targets when *two* deliveries are made at each target point. For any given accuracy value, the shorter pattern lengths on the ground demand at least *two* deliveries at each target point to allow for measured advance with 95 percent probability of no gaps in

TABLE 3.—*Estimated number of deliveries at a point target*

If your chances for success are—	Use this many tries to be 95 percent sure of at least one success	To be 99 percent sure, use this many tries
0.99-1.00	1	1
.95- .99	1	2
.90- .95	2	2
.80- .90	2	3
.70- .80	3	4
.60- .70	4	6
.50- .60	5	7
.45- .50	6	8
.40- .45	6	10
.35- .40	7	11
.30- .35	9	13
.25- .30	11	16
.22- .25	13	20
.20- .22	14	21
.18- .20	17	—
.15- .18	19	—
.13- .15	22	—
.10- .13	24	—

TABLE 4.—*Line-building aiming schedule for 95 percent probability of overlap*[1]

Mean absolute error (feet)	Distance in feet between successive target points[2] when pattern length in feet is—													
	20	30	40	50	60	80	100	120	160	200	250	300	350	400
20	—	—	2	12	22	42	62	82	122	162	212	262	312	362
	16	26	36	46	56	76	96	116	156	196	246	296	346	396
30	—	—	—	—	3	23	43	63	103	143	193	243	293	343
	14	24	34	44	54	74	94	114	154	194	244	294	344	394
40	—	—	—	—	—	4	24	44	84	124	174	224	274	324
	12	22	32	42	52	72	92	112	152	192	242	292	342	392
50	—	—	—	—	—	—	5	25	65	105	155	205	255	305
	10	20	30	40	50	70	90	110	150	190	240	290	340	390
60	—	—	—	—	—	—	—	6	46	86	136	186	236	286
	8	18	28	38	48	68	88	108	148	188	238	288	338	388
70	—	—	—	—	—	—	—	—	27	67	127	177	227	277
	6	16	26	36	46	66	86	106	146	186	236	286	336	386
80	—	—	—	—	—	—	—	—	8	48	98	148	198	248
	4	14	24	34	44	64	84	104	144	184	234	284	334	384
90	—	—	—	—	—	—	—	—	—	29	79	129	179	229
	2	12	22	32	42	62	82	102	142	182	232	282	332	382
100	—	—	—	—	—	—	—	—	—	10	60	110	160	210
	—	10	20	30	40	60	80	100	140	180	230	280	330	380

[1] Assumes *no* deflection error.

[2] Upper value indicates target advance with *one* delivery per target.
Lower value indicates target advance with *two* deliveries per target.

Within the boldfaced portion of the table the *net* rate of line building will be greater if single drops are used at each target. In the lightfaced portion of the table, two drops per target point are necessary for maximum progress in line construction. For extremely short ground patterns and large error in accuracy three drops per target would provide maximum rate of line building. Just where this is the case has not been defined in the present computations.

the line. As pattern lengths become larger, measured advance can be made allowing for only *one* delivery per target with equal likelihood of pattern overlap. At a certain minimum length of ground pattern (or a certain maximum error) it becomes advantageous to shift from a two-drop delivery schedule with accompanying larger shift in target points to a single-drop delivery schedule with an accompanying smaller advance of target point.

This aiming procedure is, of course, just one of several tactical approaches to line building. How would it compare in regard to efficiency with the alternative tactic of aiming each delivery at the end of the previous one on the ground is a question which might be answered by *simulation techniques*. Knowing the accuracy and pattern size on the ground it is possible to simulate, on paper, a line construction mission which assumes that aim is to be taken on the end of the previous drop pattern. A number of runs, or simulations, should provide a comparison of probable line-building rates between this and other alternative aiming schemes. The outcome of any comparison would depend, again, on the accuracies involved and the pattern size considered—with some combinations favoring one tactic and others favoring an alternative.

SUMMARY

The exploration of two tactical situations outlined in this paper merely illustrates an approach to the problems involved in air delivery of water and chemicals to the fire site. It does not represent an answer to any single problem. The tables, however, can be used as rough guides to the logistics of present-day air attack if full advantage is taken of what we already know about pattern sizes and drop accuracies.

We need more experience data on actual trials to round out a framework of theory upon which to base practical decisions. Specifically we need to know what order of accuracies are involved and how they vary with: speed of aircraft; altitude of aircraft; aiming systems and devices; human factors, including individual pilot reactions; the type of delivery missile, including self-propelled and self-guided.

A number of hypothetical situations which we may set up on paper might lead us to the conclusion that a system vastly different from the "seat-of-the-pants" style of free water drop we now use is the logical answer to safe and efficient delivery of water or other chemical to the fire site.

COOPERATIVE AIR ATTACK PROGRAM IN UTAH

RICHARD P. KLASON, *Assistant State Forester,*
Utah Department of Forestry & Fire Control

Early attempts at getting an air tanker program operating in Utah were made by our Department in 1958. During suppression operations on a large and stubborn brush fire at Camp Williams, a National Guard training camp south of Salt Lake City, a tank-equipped TBM plane was used to make several air drops. Results were not successful, for several reasons. Air-to-ground communication was lacking, water was being used as the suppression agent, funds for adequately equipping the program were unavailable, and trained personnel were lacking. The most important lesson we learned from the operation on the Camp Williams Fire was that a small agency such as ours would have trouble establishing a workable air attack program.

With the lesson learned at Camp Williams in mind, our Department discussed with the U.S. Forest Service, Bureau of Land Management, and local government agencies the need for and the best method of operating an aerial suppression program in Utah, especially on the Wasatch Front. As a result of these discussions a cooperative program was agreed upon and put into operation in June 1960. Three agencies were primarily responsible for the program, the U.S. Forest Service, Bureau of Land Management, and the Utah Department of Forestry & Fire Control.

These organizations negotiated with a Salt Lake flying concern to handle the actual flight operations. It was decided to have one tank-equipped TBM available on standby from June 15 to September 15. The plane was to be available 7 days a week from 10:00 a.m. to 6:00 p.m., airborne 10 minutes after being notified. A minimum guarantee of $2,500 was agreed upon to meet the operator's expense in the program. The U.S. Forest Service assumed responsibility for 50 percent of the guarantee, the Bureau of Land Management and the State Forestry Department each assumed 25 percent. It was further agreed that each agency would pay the mixing crews for their suppression time. The guarantee for the airplane was to be charged to the using agency at not more than $250 per hour of flight time. Any of the guarantee that was not used by the end of the season would be prorated among the three agencies. The State Forestry Department represented the interests of Salt Lake City's Water and Fire Department as well as the Salt Lake County Fire Department in the agreement.

Each of the using agencies was responsible for providing radio communications for the program when the plane was operating under a given agency's control. To accomplish this the plane was equipped for quick installation of a back-pack type portable radio with the using agency's frequency for air-to-ground control.

The mixing and loading site was established at the Salt Lake Municipal Airport, adjacent to our Department headquarters building. Telephone communications were extended from our office to the loading site to provide better control and alert the pilots. Our equipment supervisor was trained as "mixmaster" and was generally on hand to supervise mixing and loading operations.

The U.S. Forest Service provided much of the equipment necessary to begin operations. Initially, an injector-type portable bentonite mixer was used. Water for mixing was not a problem; a city fire hydrant stood approximately 100 yards from the mixing area. The mix was ¾ pound of bentonite to 1 gallon of water. To obtain sufficient water pressure to operate the mixer efficiently it was necessary to incorporate a booster pump into the system. The booster equipment, as well as the mixing crew, was provided by the Salt Lake City Fire Department and operated under the supervision of the "mixmaster."

Tank trailers were obtained to store the mixed slurry and one trailer was equipped with a high volume transfer pump to load planes. Later the U.S. Forest Service obtained a trailer-mounted bentonite slurry mixer. This unit had a self-contained pump which eliminated the need for the booster pump. In addition the unit would store approximately 1,000 gallons of bentonite slurry and was capable of loading planes. By the end of the season we had a storage capacity of 4,500 gallons of bentonite slurry on the operation site. Also, facilities were expanded so that it was possible to load two planes simultaneously. An additional supply of dry bentonite was stored on the site in a van-type trailer. Reserve supply of bentonite was always on hand at the U.S. Forest Service warehouse, approximately 2 miles from the operation.

As the fire season progressed it rapidly became more severe than normal. The contractor was able to equip two additional TBM's with tanks, increasing our striking force considerably. It became the practice to dispatch two planes on nearly all fire calls. This increased the expense but gave even greater increases in effectiveness in controlling the fires.

The program has proved to be quite effective. Plans are not complete for this season but it is hoped that the cooperative nature of the operation will be continued. In the discussion stage for next summer is a portable unit complete with a storage trailer that could be used in outlying areas. This appeals to all the cooperating agencies as areas that can be reached economically from the Salt Lake Airport are only a small portion of the total protection job in Utah.

OPERATION HANGAR DOOR

GEORGE ZAPPETTINI, *State Forester*; JOHN L. ARTZ, *Deputy State Forester*; and HOWARD REEDER, *Pilot; Nevada Division of Forestry*

The Toiyabe National Forest, the Bureau of Land Management, and the Nevada Division of Forestry work closely on fire protection and control, including operating air tankers. For the 1960 fire season, the Toiyabe and the BLM contracted for a 600-gallon TBM, with the Division furnishing its 300-gallon C-45. Both aircraft were stationed at the Carson City, Nev., airport for initial attack.

Under a joint Air Operations Cooperative Agreement each agency used both tankers, while using other planes for spotting and guiding. Large-scale fire operations were flown from the larger Minden Airport 11 miles south of Carson City. When required, additional tankers were brought in from out-of-State bases.

Within recent years, air tanker delivery of fire retardants has progressed beyond the pioneering stage. In our own region, western Nevada, the air tanker is most successful in initial attack. There is, however, no reason why the air operation should not be screened to find other air tanker uses—strategic as well as tactical.

If fire control people are to make continuing progress, a policy of research, critique, and training must be maintained. This is the thinking that motivated the annual joint training exercise conducted by the three agencies. When past fire season air operations were analyzed and certain problems were found to be worth further research, an early season air tanker training exercise was planned. Called Operation Hangar Door, it was to consist of a one day fly-out, graded and evaluated from the air and the ground, with all agencies participating.

A typical problem, one of many that were criteria for the research phase of the exercise, follows: The fire is on the north side of Genoa Canyon at 7,000 feet, fuel is second-growth pine, and the fire—grown to 5 acres—is moving rapidly. The terrain is rugged, with slopes of about 45°. It will take more than an hour to bring in ground crews.

The answer seems to be to commit air tankers; the order is given for their dispatch. Two C-45's make drops across the crest of the fire. One party, moving up the slopes, has reached this area and can contain the front; the tankers are ordered to the left flank. However, what was right for the tankers just a quarter mile to the east is proving troublesome on this downhill target. It seems the only approach is from over the higher ridge and straight down the inside face of the canyon. This is not so good for several reasons: Genoa Canyon is on the lee side of the Sierra Nevadas where westerly wind gusts at the ridgetop vary the tanker's air speed by as much as 50 miles per hour. The wind also flattens the convective smoke columns, trapping smoke within the canyon and producing near zero-zero visibility. Once across the ridge, the steep downhill course pushes the airplane to speeds "in the red" with about 2,000 gravity horsepower at work on the plane, even with its engines fully throttled.

The following questions are based on this problem. They are concerned with safety, economics of the air tanker as a tool under these circumstances, and morale of air and ground crews. These questions, and others extracted from other problems, were worked into the exercise by Jack Artz, Deputy State Forester; and Howard Reeder, Division First Pilot and Air Service Manager.

In the preceding problem, is it reasonable to expect accuracy of the pilot when his approach has been from beyond the ridge and, with the target in sight, he has only seconds to make his final alinement? Can he aline at all, with the visibility as it is? Isn't there a safer technique than to fly a plane at only 75 feet over a wooded ridge, at reduced flying speeds, under gusty conditions? Should the fire boss, out of regard for safety, ground the planes?

With this background and to simulate, as nearly as possible, the actual operational conditions of our rugged mountain area, a site for the exercise was selected in the upper bowl of Vicee Canyon, 5 miles west of Carson City. Three targets were marked with high-visibility bunting at an elevation of 8,000 feet. There is a higher ridge at about 9,000 feet, directly behind the target area.

Target One:—A small fire is burning uphill and spreading rapidly in heavy manzanita. A north-south jeep trail at the upper end offers a temporary fireline. The plane makes a drop on brush to the west side of the jeep trail in order to curb the fire before it reaches the jeep trail. Approach is from over an adjacent stand of trees, which are about 75 feet high. The drop is graded for uniformity, width, and length of coverage.

Target Two:—Lay a line between heavy manzanita fuel and adjacent stands of fir and pine. The drop, on the left flank of the fire, is slalomlike, downhill from west to east. It begins at the jeep trail 1,000 feet below the ridge, and continues down the 45° slope for another 500 feet. Grading criteria are as for target one, with special emphasis on maintaining airspeeds below 125 m.p.h. at drop.

Target Three:—This is a spot fire on a steep sidehill, set by lightning and consisting mainly of a burning snag. The drop is made in a manner that concentrates the entire load on the small area; it is graded accordingly.

The exercise was graded by properly stationed evaluators. We were fortunate that W. S. Swingler, Assistant Chief, U.S. Forest Service, Washington, D.C.; Dan Solari, District Manager, Bureau of Land Management; Lyle Smith, Fire Control Officer, Toiyabe National Forest; and Glenn Allaback, District Firewarden, Nevada Division of Forestry; were among those present to evaluate the exercise.

The exercise began at 7 a.m. when 18 men met at the Carson Airport for briefing. A preview of the exercise, including discussion of techniques proposed by the pilots to accomplish its aims, took almost 2 hours. There were three pilots taking part, with each pilot allowed four drops, one on each target and a fourth at his option. The observers would go to the target area, about an hour's drive by jeep. When dispatched, the aircraft would require 10 minutes for the climb-out to the target area. At the conclusion of the last drop, the evaluators would return to the airport to gather the day's data, bringing their grading sheets for the critique. Air-to-ground communications were used extensively.

In reaching for a common understanding of the goals set by the foresters for the exercise, the pilots described limitations of the aircraft during the pre-exercise briefing. It was revealed then that three techniques were possible for making the required drop on Target Two: (1) To approach from over the ridge, (2) to make a tight turn into the cul-de-sac and out, (3) to make a high approach, staying on the target side of the hill, and a slow, descending turn to aline with the drop. The third suggestion, if workable at all, would require the dissipation of considerable excess energy without gaining airspeed. It was proposed that stalling in would do this. Of these methods, it was the consensus that the tight turn was too dangerous. A proposal for Target Three was somewhat different from the usual technique: Loft the slurry out of a steep glide, making a slow, high approach similar to the third suggestion, making the drop at the point of beginning to a roundout from the glide.

The TBM was first. Approaching Target One from the north it made a beautiful drop along the jeep trail. Two more drops on Target One followed in order, with none of the three pilots gaining an advantage. The TBM was conceded to be superior in extent of line, due to its greater load-carrying capabilities. The C-45 (as it was to perform throughout the fire season) seemed to be able to climb, get in and out, and get back on the ground faster than the TBM.

Of the three drops graded on Target Two, two were made from approaches from over the ridge and one from the descending turn discussed earlier. The approaches that crossed the ridge were made at a minimum height and minimum airspeeds, with the planes being nosed down toward the target when over the spine. In these drops, landing gear was extended and full flaps were used, with the slowing aided by using closed-engine power settings. On one of these two drops, an S turn had to be made in split seconds to line up properly when the target was visible to the pilot. All three drops were considered effective, with the TBM again showing superiority in extent of line.

The results obtained by the three pilots as flown on Target Three were quite interesting. One drop was lined up dead center on the target but the line was strung out too long; only 10 percent of the fire retardant hit the circle. Another drop, by a C-45, similarly strung out, but missing the target completely, was the only drop of the twelve that was entirely ineffective. A third drop, also from a C-45, was made at the tangent line to a pull-out arc and the entire load was laid dead on the target (fig. 1). In the

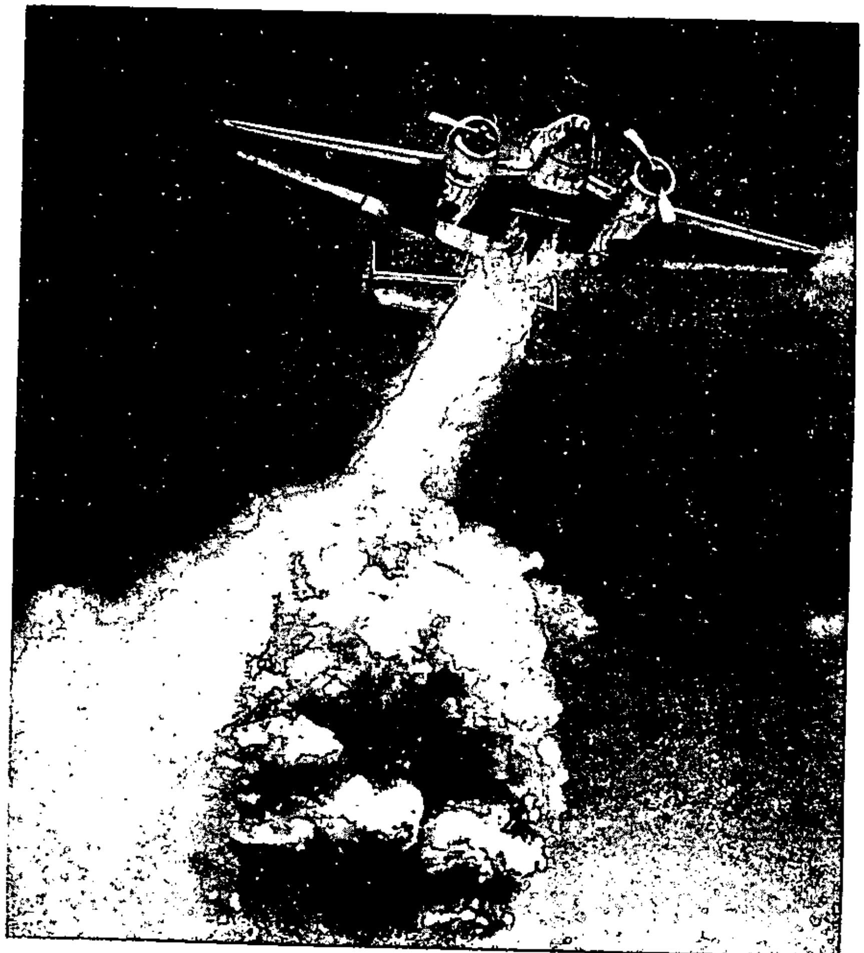

FIGURE 1.—A C-45 demonstrates one type of drop an air tanker can make: lofting the slurry—concentrating the entire load on a small area.

words of one evaluator, "there wasn't a pint wasted and the ground within a 30-foot diameter circle was soaking wet."

As for the technique of the stall approach, this way of getting into deep canyons was to be observed on several actual fires. It seemed to work well, was apparently safe, and resulted in getting in, when, with other methods, the target was out of reach.

Howard Reeder, the pilot responsible for suggesting using the stall approach, had this to say about it: "In respect to that descending-turn approach, I at first thought it might seem to be dangerous to deliberately reduce flying speeds when so heavily loaded; however, it is an effective way to lose altitude rapidly and safely when altitude control is maintained. The trick is to "mush," dissipating the energy of the high approach with "drag." Any tendency for vicious "snap" characteristics can be eliminated by keeping the craft dropping out from under the load—you know, the way it feels in an elevator.

"In the meantime, as a side effect of that slow descending turn, the target is always in sight. At the right moment—and there is a surprising latitude of timing—you merely dump the nose and the ship is back in flying trim. Right now! In contrast to the slow and low approach over a ridge (and I've tried it) I feel this technique to be much safer. Power failure, when at 50 feet over the trees, or severe turbulence, might bring you down. In the other case, there has been no time when I could not glide-out to a reasonably safe landing—even with both engines conked."

CONCLUSION

At the critique that concluded the exercise, pilots answered questions and ground observers reported their evaluations. All of this was condensed into a document for future study. The documentary movie of the exercise, in color and with sound, is now available on a limited basis.

The air tankers had shown a surprising facility for getting into a tight corner—the sidehill snag. In doing this, they proved their high value as an immediate dispatch tool. With an early arrival, the tanker could make a drop without delay. At the worst the tanker would be over the fire, to guide the walking crew in. The exercise was valuable in gaging the air tanker for local operations.

Good training is vital to the dependable employment of the air tanker. The tanker pilot is akin to the boxer in many respects; the better prepared and alert he is, the more successful will be his commitment when the chips are down. There is only one knockout punch in the air tanker. "Wishy-washying" into a fire attack situation can be dangerous. Good training can result in the right decisions and actions in crucial moments.

We have learned that the pilot has an ability to take care of himself in the pinches that is like the mountain goat's. We must, however, hold to the disciplines of safety and to the decision not to be wasteful. The operation must be policed for pilot proficiency, experience, and practice. We must require good maintenance and perfect air-to-ground communications. Above all, more training exercises should be required.

Incidentally, Operation Hangar Door, first scheduled for August 1, 1960, was postponed to August 10 because of the Stateline Fire on July 28. The instant commitment possible under the joint air operations agreement was instrumental in stopping this fire at 50 acres, although it had a disaster potential of thousands of acres.

By coincidence, the Division's C-45 was on a training mission preparing for Operation Hangar Door at the time of first report by Zephyr Lookout on the east shore of Lake Tahoe. With the fire location fixed only by the bearing from the lookout, the C-45 picked up the smoke, arrived over the fire in 4 minutes, scouted the access roads, and made the proper reports.

It then dropped its practice water on the fire and raced for the base at Carson Airport. In the next hour, the C-45 and the TBM carried 2,700 gallons of borate to the head of the fire. They flew from the airport on the east side of the Sierras at an elevation of 4,709 feet, over a 9,000-foot range, to the fire at 6,900 feet on the west side. The early action prompted Assistant Ranger Norman Anderson of the Tahoe National Forest to remark, "When we moved onto the ridge with our crews, we found that the borate had held the line long enough to let us get in." Cost of the air tanker support was $1,000. Total cost of suppression was $50,000.

AIR ATTACK COMES TO THE EAST COAST

STEPHEN C. AYRES, *Supervisory Airplane Pilot, Eastern Region, U.S. Forest Service*

A few years ago foresters noted the successful use of aircraft for delivering retardants on wildfires in the rugged slopes of the West, and speculated that such an operation would prove effective in the more moderate terrain of the Eastern States. The Eastern Region air attack program was started in late 1958 when one TBM, a navy torpedo bomber converted to carry 430 gallons of fire retardant, was acquired. After numerous air demonstrations of dropping retardants on fires before State and Federal land managers, a temporary base of operation was set up at Blacksburg, Va., on the Jefferson National Forest. An experienced airplane pilot was employed and trained for the air attack job.

The first air attack on a wildfire in Eastern Region national forests occurred during the spring fire season of 1959. This was on the Blacksburg District of the Jefferson National Forest, in western Virginia. This may also have been the first such air attack east of the Mississippi River. The tanker was also used by the North Carolina Division of Forestry on a large fire in the eastern part of that State. The tanker operated under a cooperative agreement, working out of the Coast Guard Station at Elizabeth City, N. C.

In September 1959 the air tanker dispatching and operational plan went into effect. This plan outlined the method of dispatch and control of the air tanker throughout the George Washington, Monongahela, Jefferson, and Cumberland National Forests in Virginia, West Virginia, and Kentucky, and the Southern Region of the Forest Service and the National Park Service. At the base airport, an office trailer was set up, and a dispatcher detailed to handle ground operations and dispatching. A retardant reloading base was established at Elkins, W. Va., which included one 1,600-gallon storage tank, a jet mixer, and transfer pumps. Another base is located at Weyers Cave, Va.; this base has two 1,300-gallon tanks, a jet mixer, and transfer pumps.

Air tanker operation moved permanently to the New River Valley Airport, Dublin, Va., in March 1960. Dublin Air Tanker Base has two 2,000-gallon storage trailers for both borate and bentonite fire retardant. The base has a jet mixer for borate and a circulating mixer especially designed for bentonite. Transfer pumps, hose, and a gasoline truck for refueling the air tanker are part of the equipment. Thirty tons of bentonite and ten tons of borate are in storage for immediate use.

The dispatcher's trailer is equipped with two-way radios and a telephone for communication. Forest and airway maps, plus a plotting chart, are available to pinpoint fire location when the tanker is requested. Fire-weather forecasts are received daily, in order to predict operations.

Since tanker operation began in the East, the Forest Service TBM has taken action on 14 going fires and has dropped 17,000 gallons of retardant. Reports show that it has been very effective in stopping fire spread and assisting ground crews in control.

Tanker planes are now available through commercial contractors. At present there are five Stearman-type aircraft each capable of carrying 150 gallons (fig. 1). Other operators are showing interest in air tanker operation. In the near future planes are expected to be available for all tanker bases, if fast initial attack action becomes necessary.

Additional tanker bases are being constructed. One base is being developed at Wise, Va., to serve the southern part of the Jefferson National Forest and surrounding area. The Cumberland

FIGURE 1.—Large drop door necessary to modify Stearman agriculture airplane for fire retardant dropping. Door hinges at front with locking mechanism at rear. Most doors can be closed and locked in flight.

National Forest is developing a base at Somerset, Ky., to support ground forces in problem areas and inaccessible terrain. By spring 1961 there will be five air tanker bases strategically located to cover all of the southern forests of the Eastern Region. Contract aircraft, both fixed wing and rotor type, will augment the present air attack organization.

Heliport and helispot location surveys are being made on all national forests in the region. The locations will utilize wildlife clearings or other areas where there is high-value land or high fire risk involved. Helicopters can be used for dropping fire retardant, for air patrol, and for passenger and cargo hauling. Air patrol routes are being established for fixed-wing aircraft to supplement lookout-tower detection.

State protection agencies are beginning to show interest in this new firefighting tool. Last year, one contract Stearman and one helicopter proved highly successful in supporting a State fire organization. A water-drop amphibian plane has had limited use in another State organization. It is anticipated that more protection agencies will make use of air attack in the coming fire season.

The acceptance of air attack methods, the buildup of retardant reloading bases, and the establishment of heliports will lead to the development of a highly mobile and hard hitting air attack force capable of swift movement throughout the eastern forested areas to detect and suppress wildfires.

FIRE COMMUNICATIONS, 1960

WILLIAM B. MORTON, *Electronic Engineer, Southwestern Region, U.S. Forest Service*

Two-way radio is no newcomer to the U.S. Forest Service. Radio networks on most national forests are in steady use to handle administrative communications of all kinds, from accounts through fire and payrolls to yucca plant reports. But the most spectacular, if not always the most frequent, use of radio is in providing communications for fire suppression activities.

It was in the field of fire suppression that radio communications had its major activity in 1960. And one of the outstanding features of radio this year was its sharply increased usage to provide communications with airborne firefighting equipment, particularly air tankers.

Air tanker drops of fire retardants have been in various stages of trial for several years. As soon as dropping retardants became a full-fledged tool, several regions recognized the requirements for radio communications with the aircraft concerned, and began to set up separate radio networks for this priority traffic. For some regions this was merely an expansion of existing networks for administration or aircraft dispatching for smokejumping.

When these networks were established, it soon became apparent that the use of aircraft for air tanker fire suppression work was no longer a local or regional affair. The trend was toward larger tankers with more range and load capacity. Air tanker operators took advantage of seasonal variations in fire suppression work by moving from one region to another, eventually covering the entire western half of the United States. But when air tankers converged on an area from widely separated points, they were then without communications, since the new area often used a different frequency.

This recognition of the interregional aspect of air tanker usage, and other problems, led to work in 1959 and early 1960 to establish common air net radio frequencies in the high VHF band for all regions west of the Mississippi, and a policy for interregional use of air tankers. Specifications were drawn up for procurement of air tanker radios, and radio networks were established or expanded or modified to fit.

It was almost as if this work had anticipated the 1960 fire season. Serious project fire situations in nearly all western regions called for interregional use of air tanker radios as never before. But even with the work done early in the season, some regions were unable to meet the increased demands for air net communication. Shortages of radio equipment, either fixed stations for air net control points such as new air tanker bases, portable equipment for ground-to-air communications, or aircraft type for tankers, required emergency procurement. Electronic technicians as well as air tankers were shuttled from region to region to meet increased demands for radio installation and maintenance during the emergency. Before the fire season ended, emergency demands severely tested an air net radio system which was only partially prepared at the start of the season. It met the test quite well, considering all.

The fire season ended with experience-bought plans to build up the necessary air net radio systems. Some network systems were changed; some equipment weaknesses developed, but in general the direction taken in 1959 remained as established.

The air net radio system probably would not have done as well if it had not been able to fall back on an existing, well-established communications organization. This organization has worked for years along general guidelines: (1) to obtain the best possible radio equipment, (2) to install that equipment in a system designed to best meet the need, and (3) to maintain equipment to high standards of performance by the electronic technician organization.

Radios are purchased under specifications designed for a planned radio system. Basic communications system design is done by regional electronic engineers. Existing forest radio networks are integrated with telephone systems to meet administrative needs. New systems such as air net are planned around the needs according to basic communications engineering principles. An example is the trend to high band (170 mc) systems because of periodic sunspot-caused interference on older low band (30-40 mc) systems. Long-range planning sometimes includes radioteletype network possibilities.

The backbone of the communications organization, however, is the electronic technician at the national-forest level. He installs and maintains the radios according to standards set at regional and national levels. He makes experience-born recommendations for system improvements. He tests new equipment as received from the factory for compliance with specifications. All this requires organizational work at regional and national levels such as revision of specifications, recruitment and training of competent technicians, and providing adequate test equipment with which to meet the standards.

These standards are in many cases higher than those set by industry in general, probably because of more exacting requirements of Forest Service communications. This, in turn, requires greater emphasis on training procedures, and in some cases developing new test techniques.

COOPERATIVE FIRE PROTECTION IN THE BLACK HILLS OF SOUTH DAKOTA

KENNETH SCHOLZ and JACK MCBRIDE[1]

The Black Hills in South Dakota and Wyoming, the only area of compact timbered mountainous terrain in the western Great Plains, is entirely surrounded by flat treeless prairies. Nearly all of this area is in South Dakota and is included in the Black Hills Fire Protective District. The district's approximately 2½ million acres of ponderosa pine forest are protected from fire by cooperative agreement between the South Dakota Department of Game, Fish, and Parks and the U.S. Forest Service, National Park Service, and U.S. Bureau of Land Management.

The district is crossed by routes U.S. 14 and U.S. 16 from east to west and by U.S. 85 and U.S. 385 from north to south. Most of the forested area can be reached by road.

Recreation use during the summer months is heavy. The Black Hills National Forest ranks sixth in recreation use among the 152 national forests; in 1960, 2,695,000 visitors were recorded. The National Park System in the Black Hills—Mount Rushmore National Monument, Wind Cave, and Jewel Cave—recorded over 1,900,000 visitors. Custer State Park, one of the largest state parks in the Nation, recorded 850,000 visitors. An estimated 3,000,000 additional people use the various highways for purposes other than recreation.

Fire occurrence is heavy and spread rather evenly throughout the year. Because of this, permits are always required for open fires. During the past 10 years there has been an average of 225 forest fires per year.

The district is susceptible to periodic occurrence of large disastrous fires. The larger burns are so severe that in many instances reforestation has been a serious problem. Because of more intensive fire protection and increased timber harvest, there has been a substantial increase in the acreage of dense ponderosa pine reproduction. With the hazard of crown fires in these young stands, larger acreage of more destructive burns may be expected.

The average annual precipitation in the area varies from less than 17 inches in the south to 28 inches in northern hills, with about 65 percent falling from May to September. February is usually the driest month. Many of the frequent thunderstorms of June, July, and August are without measurable moisture. Multiple fire ignitions are common.

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[1] Fire Control Officer, Black Hills National Forest, and Fire Control Forester, South Dakota Department of Game, Fish, and Parks, respectively.

With this fire situation, only a well-planned and coordinated fire control organization can provide the resource protection necessary for effective land-management practices.

Seeking such an organization, the men responsible for the management of these wildland resources wrote a fire cooperative agreement in 1945. The agreement was aimed at integrating and using most efficiently the fire control forces available in the area. With some modification, it has been in effect ever since.

The effectiveness of the cooperative effort was illustrated on August 22, 1960. With humidity less than 10 percent and temperatures 90 plus, fire dangers were extreme. A severe lightning storm started 28 forest fires. At least 12 were handled by local fire departments without Federal or State supervision. All had the same potential as the 3 that reached project size that day. The largest, a wild one, burned 10,000 acres from August 22 to 26.

These 3 project fires and 25 class ABC fires put the control facilities of all the cooperating agencies to a severe test. The Game, Fish, and Parks Department called in men from all over the State. The Forest Service called overhead from Wyoming, Colorado, Montana, and Nebraska. The Park Service and other Interior Department agencies made available nearly all their manpower and equipment.

The largest fire was handled cooperatively by the State and the Forest Service. The fireline was split into two divisions. The State provided overhead for the day and night shift on one; the Forest Service did the same on the other. Personnel from both units made up the headquarters. Communications were handled by the Game, Fish, and Parks Department on its radio network.

While coöperation on project fires is a valuable part of the agreement, there are other benefits. The State Forester has agreements with the boards of county commissioners of the six counties in the fire protection district. The counties receive financial and material aid under the C-M2 program.

The State Forester has carried out an aggressive program of acquiring and using military-surplus equipment. He donates it to the various counties for assignment to local fire departments for their use in fighting forest fires. This program has improved the speed and efficiency of initial attack and, probably equally important, has contributed much to the morale of the departments.

In the fire protective district are 26 organized volunteer departments that participate in this program. Under the program, these units have received 20 jeeps, 3 small tankers (pickups and small trucks), 14 large tankers, 4 jeep trailers, 5 complete rural fire trucks, and many other items. Direct purchase of equipment by State, County, and local fire departments has helped to round out each unit's equipment supply.

Each of the cooperating agencies except the Bureau of Land Management maintains a complete and up-to-date fire control organization of its own. The addition of the C-M2 units to the local fire departments makes it much easier to provide the supplies and equipment necessary for extraordinary fire situations.

Some problems have developed. Each agency maintains its own radio network and sometimes communications are a problem. To ease this situation, one State lookout, one national-forest lookout, and the national-forest dispatcher maintain a cross-monitoring system. These three have been able to provide the necessary cross-channel communication for the routine fire load. Additional cross-monitoring stations are set up if the need arises.

At least once each year all agencies meet to review the agreement and to work out methods by which the cooperation can be improved. Several districtwide training sessions are held each year.

Residents of the Black Hills are fire conscious. In an area where wildfire is a threat, this is understandable. It is one of the basic reasons why cooperative fire protection has been an outstanding success.

EVIDENCE IN FIRE TRESPASS CASES

Joseph Couch, Jr., *Forester, Division of Fire Control, Southern Region, U.S. Forest Service*

Comparisons of successful fire trespass cases often reveal that their beginnings were marked with a common factor: some initial bit of information on which to start. The hard fact, established by the experience of many investigators, is that the officer who opens a case with nothing to go on but a big area of blackened timber is working against long odds. Some professional investigators avoid such cases whenever possible—an understandable course if they feel compelled to maintain a high percentage of "hits."

Even unfavorable odds do not necessarily make fire investigations a poor investment. The values involved often make the cost of the most thorough investigations negligible by comparison; the money spent can bring important returns. For example, persons damaged by the negligent acts of others are entitled to be "made whole." Investigation serves as the foundation both for civil suits to recover damages and costs, and for criminal cases, in which the immediate objective is conviction of the offender. In *all* cases the ultimate prize is the prevention of future fires; whether or not damages are recovered or a conviction is obtained, a bulldogged investigation has a powerful prevention effect.

Neglect of law enforcement in favor of all-out suppression is sometimes justified with the argument that suppression is "an emergency," while the investigation "can wait." The emergency is conceded, but can we be satisfied with practices which fail to improve the situation? Sooner or later we must come to grips with the law-enforcement job to help carve the fire load down to size.

The investigating officer seeks to discover answers to the key questions, "Who, what, when, where, why, and how" regarding each violation, and to present the evidence so that a judge and jury can see and hear for themselves those things which make the story clear. In general, any object found at the scene which cannot be explained except with reference to the offense should be treated as evidence. The proof may be entirely circumstantial; while direct evidence is generally preferred, circumstances, in a chain well developed and linked together, can swing the balance.

The old fire chief's axiom, "The first 5 minutes are worth more than the next 2 hours," could have been said by an investigator. Delay is a bugbear to all fire personnel; it can multiply suppression problems, but it can completely destroy the investigator's case. It is disappointing to arrive at the fire's point of origin only to find that a bulldozer got there first. The fire's spread, falling of burned vegetation, work of heavy equipment, and movements of firefighters are quick to destroy physical evidence. Therefore, the foundation of the law-enforcement phase of the fire job—investigation—must come before, or at least with, suppression.

In high-occurrence areas, law-enforcement specialists are spread thinly. Usually, the initiation of a fire investigation is in the hands of the first-attack foreman. Many successful cases can be credited to a first-attack man who got to a fire with so little delay that he was able to observe a departing suspect or record his license number, rope off the point of origin, preserve a clear footprint or tire track, save the smouldering remains of an incendiary device, or clamp onto some other evanescent clue before it could vanish in smoke or churned-up soil.

Men who are required to collect evidence must know what to look for—and how to care for it. Selected individuals should be given specialized training in investigative work. *All* fire-going people need to be trained to observe significant events and to protect evidence.

Investigators should carry a kit containing—as a minimum—a photographic outfit; plaster outfit; cartons, pillboxes, bags, and envelopes; notebook, pencil and ballpoint pen; and a steel tape. When fire seasons are favorable and the kit goes unused for a time, the investigator should resist the temptation to leave it at the office. Like a snake-bite kit, when it's needed, it's *needed*!

The notebook and pencil are essential. Good investigators develop expertness in taking notes, making a detailed record of everything observed and done, with date and time entries, names, places, objects found, and sketches with measurements. Good notes are the backbone of the case. Cross-checking of the statements of witnesses and suspects, discovery of gaps in the case, completion of leads, preparation of the report, recall of details on the witness stand—all will require frequent reference to the notes. Businesslike documentation of the investigation helps develop a supportable case and makes the investigator a confident, impressive witness in court.

Fire investigators should have experience in taking photographs. With a little instruction, reading, and a generous amount of practice, any officer can produce clear pictures. In this work, challenging problems are the rule because of such situations as dim lighting or even darkness, poor contrast such as a charred object on blackened ground cover, or minute detail such as a nick in a horse track. Many investigators develop their own films, and make their prints, or use a Polaroid camera, to simplify on the witness stand the story of the photographs' handling and "unretouched" character. Juries can seldom visit crime scenes. Photographs of the general area, of important spots such as the point of origin, and of closeups of the evidence in place, will help jurors gain understanding. They also help the investigator in a pretrial review of the case.

The value of dental plaster of paris in making impressions of evidence is well known. Plaster-cast exhibits are ideal for court use. Suspects confronted with them sometimes admit their responsibility.

The nature of evidence is such that no allowance can be made for doubt. This dictates great care in handling, marking for future identification, and protecting from contamination or loss. Scientific examinations by laboratory experts can identify the sources of many items such as paint particles and tool marks. Careless handling may hinder the examination, or even destroy the value of the items as evidence.

The chain of possession of evidence must be complete. Ideally, a single witness would be able to testify that he personally found, marked for identification, kept in possession under lock and key, and is now handing to the court, the object of evidence under discussion. If possession must be transferred to others, as when evidence is mailed for laboratory examination, each change of hands should be covered by a signed receipt. The integrity of each item of evidence must be kept absolute.

On most investigations the major portion of time is spent interviewing witnesses and suspects. Obtaining information, especially from hostile witnesses and suspects, is seldom easy. It can be facilitated, however, by interviewing each person at the earliest possible moment, getting his testimony down on paper and having him sign the statement. This tends to prevent forgetting and the alteration of testimony.

Investigators should work with a partner, if possible. The second man is valuable as a witness, assistant, and if need be, an alternate.

Sheriffs or other professional police officers can be very helpful for the more specialized phases of criminal investigation. Close working relationships and understanding should be developed with these men and their advice and assistance sought when needed.

SUMMARY

Fire investigations pay off in their effect on fire prevention and often in damages recovered. Men responsible for investigations should be trained and equipped to locate and preserve evidence. All firefighting personnel should assist by being observant and by protecting points of origin. Delay is the investigator's principal enemy; work should begin before or with suppression. Detailed notes and sketches are the backbone of the case. Evidence must be carefully handled. All witnesses and suspects should be interviewed as early as possible and their testimony recorded in signed statements.

CAMP HALE FIRE COOPERATIVE CONTROL

JOHN P. BURKE, *Forest Ranger, Holy Cross District, White River National Forest*

The Camp Hale Fire started within the White River National Forest in Colorado on June 26, 1960. It was declared out on July 11. The combination of problems in this fire probably was without precedent. The fire started from operations of a military-research project on an area that was closed to all nonproject personnel—Army, Forest Service, and civilian—except for specified periods when neither security nor operations of the project would be interfered with. Without a fully coordinated effort by personnel of the U.S. Army, U.S. Forest Service, and the special project, it is likely that the fire would have escaped control and endangered personnel.

Contact with the Camp Hale Fire Department was made just after noon, June 27. It was believed that only test materials were being burned; the fire was reported to be very small and under control. Inspection by nonproject personnel at the time was impossible for security reasons.

Later that afternoon strong winds caused the fire to spread out of control, threatening a large area of timber and high-value watershed. The fire burned an area being used by the project as a weapons-impact area, known to contain duds—unexploded artillery shells. The burn was uneven and spotted over the area, which is rough and steep, marked with cliffs and talus slopes.

First control efforts, during the afternoon and evening of June 27, were by ground forces, thoroughly briefed on the hazards of topography and explosives. They worked to cold trail the outer perimeter and connect salient points. We then learned that the fire covered part of a larger impact area used by the Tenth Mountain Division in 1943 and 1944. The old duds were as dangerous as ever.

We attempted to locate a control line behind dud-free topographic barriers that would shield the ground from artillery fire. We continued on this basis for a day and a half. Then we learned that the artillery firing had included mortar firing, and all attempts to control the fire by usual ground methods were suspended. It was now evident that, except for a short stretch on the main fire and on one isolated spot, there was no safe place to locate the control line. Aerial control methods had to be employed.

Military research project activities were suspended in the immediate vicinity of the fire. But ground access to the fire was through the project area that was still active. Although the area could be cleared occasionally for nonproject travel, it was closed most of the time. Since six-place military helicopters were available, much of the early access to the base of the fire was by helicopter. It also was expedient to use the helicopters for reconnaissance, though the fire area was generally visible from a nearby restricted road.

Two of these helicopters continued to serve for reconnaissance and limited transportation. In addition they transported more than 100 men from base camp at 9,700 feet elevation to a helispot above timberline at 12,000 feet. From there the men walked down to the fireline, arriving fresh and alert. This operation was repeated the following day.

Two military helicopters, two civilian helicopters, and one civilian monoplane were employed to drop bentonite slurry. The helicopters were employed also for limited transportation as well as for considerable scouting to evaluate and plan slurry drops. In 403 drops, they delivered 19,955 gallons of slurry (figs. 1 and 2).

No ground-control forces were employed in the slurry-dropping stage except on one spot fire, which was isolated from both the main fire and the contaminated area. Even here two well-placed slurry drops held the fire from crossing to new fuel until ground crews could arrive. In the more than 30 minutes gained by these slurry drops it was possible to contain the spot fire within safe ground.

Final mopup of the few remaining smokes was done by project men, trained in detecting and handling duds, who were trained by the Forest Service in mopup. They were supplied wet water in backpack pumps lowered by rope from a helicopter.

In this fire the accident potential was unusually high because of the following problems:

1. The firefighters were soldiers, unfamiliar with either forest fires or mountainous terrain. There were as many as 150 soldiers employed at one time on several occasions.
2. The terrain is rough and precipitous—a hazard to ground and air operations.

FIGURE 1.—Helicopter with loaded 35-gallon slurry bag.

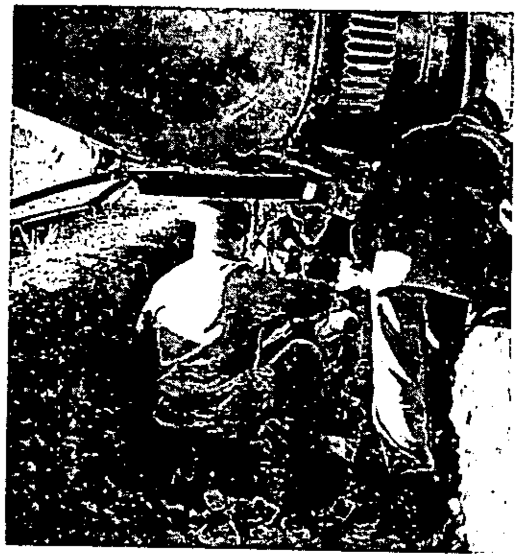

FIGURE 2.—Helicopter over slurry-loading pit.

3. In helicopter operations, especially in hauling personnel, loading slurry, and closely controlling slurry drops, there are inherent dangers.
4. Air traffic was heavy, with four helicopters and one monoplane dropping slurry in a limited area at the mouth of a canyon.
5. The fire area and surroundings were generally contaminated with unexploded artillery shells. Four of these duds were detonated by the fire during control operations.
6. Artillery was fired intermittently across the direct line between slurry-mixing depots and the fire.

These problems were met in the following ways:

1. Forest Service overhead, briefed regarding these hazards, maintained communication by portable radio. They assumed responsibility for the safety of their men.
2. Adequate headlamps were provided for a select crew the first night. Only daylight operations were conducted thereafter. Pilots were constantly consulted regarding the limitations of their aircraft and the dangers. One man, struck on the side by a falling rock, was sent to the doctor, with no disability or lost time. There were no other injuries.
3. The best possible landing spots were selected. Pilots were repeatedly consulted. We constantly reminded them that we depended on their judgment regarding aircraft safety. To get working space during loading operations helicopters were set down over pits and their motor speed was reduced.
4. Flight patterns of all aircraft were made known to pilots insofar as possible. A separate target area was assigned to the monoplane, and its time of departure and progress were given to all pilots either by radio or word of mouth.

A separate airstrip, with mixing station, also was assigned to it. Departures were delayed as necessary.

5. Plans of operation for ground control were changed, regardless of inconvenience or cost, when it was determined that an area might be contaminated with duds.
6. Close, continuous liaison was maintained between U.S. Forest Service personnel and the commanding officer of Camp Hale, who handled liaison with project personnel.

Slurry operations were not expected to extinguish deep-seated fires, though effort was made to get decisive results. Their purpose was to contain the fire and allow it to burn out and die out until mopup was reduced to the minimum.

Fuels varied from open hillsides with sparse grass cover and occasional decayed windfalls to heavy, full-crowned mature spruce and fir stands with many decayed windfalls.

The monoplane was effective in checking and preventing spread in sparse fuels in the less difficult target area. The necessary flying speed broke the slurry into a fine spray and some was lost in drifting mist. This plane made quicker trips and delivered larger loads, covering more ground than the helicopters. It was effective in the area assigned.

The helicopters made concentrated drops with excellent accuracy in the difficult target areas over sharp ridges, near cliffs and bluffs. These were areas of heavier fuels, and fire spread was effectively checked in spite of occasional flareups and spotting. The principal spot fire threatened to spread out of control into dud territory, but spread was promptly stopped by two precision drops made while a ground crew was being dispatched.

Slurry and wet water drops for 5 days wore the fire down to a few small smokes. The special mopup crew reported a 13-inch cover of bentonite slurry under timber in a particularly troublesome area of stumps and windfalls, some of which were still smouldering.

The slurry operation accomplished all that was expected of it, though it consumed much time and the cost was high. It contained the fire and reduced to the minimum the exposure of men to explosions of duds.

New problems for which we had no precedent—continually arose. Only one temporary partial injury occurred. Errors made were largely offset by the alert safety consciousness of nearly everyone connected with the fire. Cooperation by the pilots, Camp Hale, the project, and Forest Service officers contributed to a good safety record under very hazardous conditions.

FIRE RAKE SHIELD

LLOYD E. MYERS, *Fire Warden, Division of Forestry, Ohio Department of Natural Resources*

This shield covers the sharp teeth of the fire rake to protect other tools carried in tool boxes or on fire trucks. It can be made from discarded auto license plates 6 by 12 inches, or the plates can be cut to this size. Sheet metal, 18-gage, may be used.

Bend the metal to make a 3- by 12-inch piece with the letters turned out and the slot between less than the thickness of a rake tooth (fig. 1).

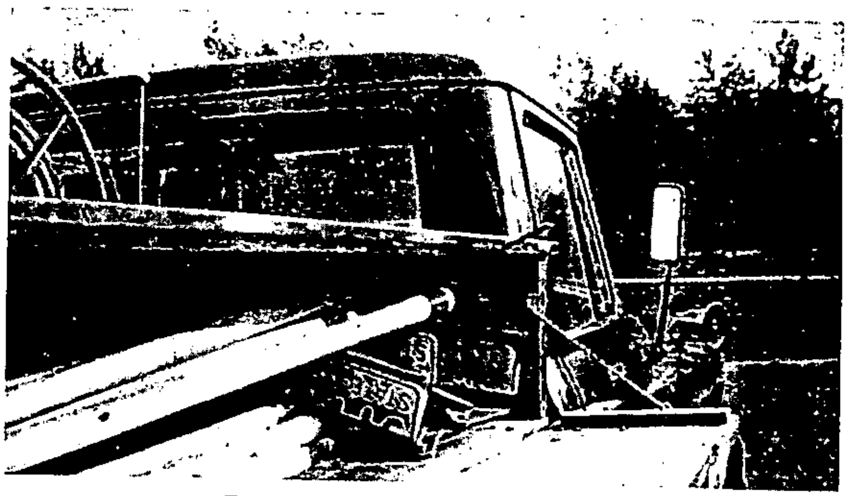

FIGURE 1.—Fire rake shields in use.

To put shield on rake, line up on teeth and strike rake lightly on the ground with the teeth down. Shield will slip tightly over rake. To take shield off, strike rake handle lightly near its eye over a stump or other object. Shield will fly off.

If shield gets bent or is too loose, put it on a flat surface, step on it, and it is ready for reuse.

THE WALLOWA-WHITMAN STORY—1960

O. B. CARY, *Fire Control Staff Officer,* and JOHN B. SMITH,
Forest Supervisor, Wallowa-Whitman National Forest

In 1960 the Wallowa-Whitman National Forest had its most disastrous fire year since 1910 and perhaps the most disastrous fire year since the forest was established. With good fire organization and improved facilities for fire suppression, why did this occur? Here is the story.

The Wallowa-Whitman includes an area of 2.36 million acres, of which 2.22 million are national-forest land. It is located in the Blue Mountains and Wallowa Mountains of northeastern Oregon. Elevations range from about 900 feet on Snake River to 10,000 feet in the Wallowa Mountains. Included is some of the roughest topography in North America in what is known as Hell's Canyon of the Snake River. Precipitation varies from 10 inches on the southeastern part of the forest to 40 or 50 inches in the higher elevations.

Cover types include cheatgrass and bunchgrass, brush, slash, ponderosa pine, mixed Douglas fir-true fir, lodgepole, and some alpine species. Commercial timber stands range up to 40 M board feet per acre in the mixed types.

The Wallowa-Whitman is one of the heavy fire forests in the Pacific Northwest Region. It has an average of about 100 lightning fires and 25 to 50 man-caused fires annually. A long summer period of severe fire weather is normal, but some years are much more severe than others. The daily burning index, on a scale of 100, averages about 25 to 30 in July, and 35 to 40 in August, with the daily index occasionally reaching 75 or higher.

The 1960 fire season was longer than usual. March, April, and early May were warm, resulting in heavy vegetative growth. The latter part of May, June, and July were dry, making a long period without significant precipitation. Measured fire danger for all of eastern Oregon was the most severe since 1931.

Forest officers recognized that the situation was very dangerous. On July 17, farm workers started a fire which ran away. It was readily accessible to firefighters, machinery, and aerial attack. Control action was fast, but it burned 140 acres in easy topography before being controlled.

Between July 9 and July 24, the burning index from a fairly representative lookout (Bald Mountain) ranged from 77 to 90, with only 3 days registering lower values. Fuel sticks measured 4 percent moisture content most of the time with little or no night recovery. On July 19, the burning index was 90 (fig. 1) and fuel sticks were 4.

The Supervisor's office in Baker, Oreg., had 104 degree temperature on July 19. This set a high temperature record unequalled

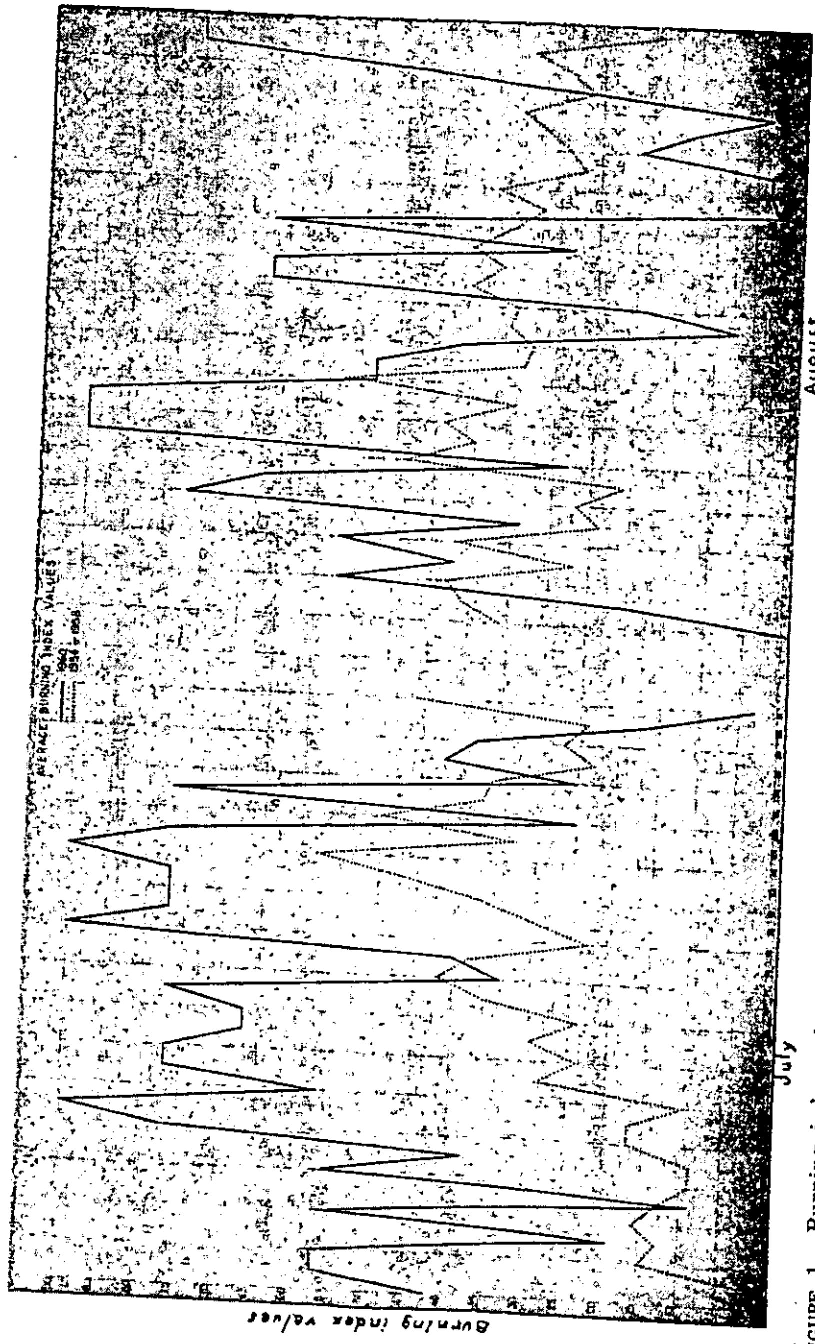

FIGURE 1.—Burning index values for July and August 1960 and average values 1954-1958 for Bald Mountain Lookout, Wallowa-Whitman National Forest.

in the past 70 years. A 40 percent chance of lightning was forecast the morning of July 19. By midafternoon, local observation indicated that a lightning storm was likely to occur. Normal forest work was stopped and all forest resources were readied for a severe fire situation.

Lightning started on the south end of the forest at 6:30 p.m. The storms moved northerly and northeasterly across the forest and the last lightning activity was reported about 9:30 p.m. No rain fell and fuel moisture recovery was only slight. More than 135 fires started and some spread rapidly. A few fires in light fuel types and rough topography had covered more than 600 acres by early morning of July 20. Logging and mill crews, construction crews, and all other available local manpower and equipment were recruited and quickly dispatched. Cooperation of the local lumber companies and individuals was excellent. Dispatching continued through the night. More than 700 firefighters and overhead were on fires or in the near vicinity enroute to fires by daylight. In addition, more than 25 bulldozers and numerous ground tankers were being used.

Aerial operations started at daylight July 20. Smokejumping and air tanker operations started simultaneously. By noon 45 jumpers had parachuted to 16 fires. By evening, a total of 69 smokejumpers were placed on fires, 24 of them on fires in the nearby Malheur and Umatilla National Forests. Air tanker operations started at daylight with three B-25's, one PV-2, and one PBY. By evening, one additional B-25 had arrived. Approximately 50,000 gallons of borate were used that day. Drops were made on small fires and on fast-spreading fire perimeters. Aerial observation and cargo dropping continued throughout the day.

One helicopter was used throughout the day. Additional helicopters could not be obtained because of major forest fires in many other parts of the West.

Most fires were under control by 10:00 a.m., July 20. That evening, 24 hours after the lightning storm started, there were 7 Class D and E fires burning. Several additional fires were in no better than a "corralled" status. Five smaller fires combined to form the large Anthony Fire which had covered about 7,500 acres of timbered lands and was spreading rapidly (fig. 2).

The North Fork of Burnt River Fire had covered 2,000 acres and was burning in grass and timber. The Cactus Mountain Fire (1,000 acres) and the Cow Creek Fire (1,000 acres) were burning in grass and timber in very difficult topography in the Lower Snake River Canyon. The Chesnimnus District had five Class C fires which were giving trouble. A 10,000-acre fire burning north of the forest boundary was a threat. The Imnaha-Snake District had the Waterspout Fire (700 acres) and the Pony Creek Fire (2,000 acres) which were difficult to control because of very rough topography. The Pine District had the Spring Creek Fire (2,500 acres) in the rugged Snake River Canyon.

Additional recruiting of overhead, manpower, and equipment was being carried on throughout the Pacific Northwest, and dispatching was prompt.

By July 24, reportable fires from the July 19 storm stood at 118. There were, or had been, 10 Class E, 4 Class D, and 4 Class C fires. Maximum buildup in manpower was reached on July 24 with 4,700 men, of which 800 were Forest Service overhead and organized Forest Service crews. The number of men decreased to 1,700 by July 29, and systematically diminished as the fires permitted release. There were 56 bulldozers, 25 ground tankers, 30 portable pumps, 80 power saws, 11 helicopters, 18 air tankers, and 20 other aircraft in use during this fire period. Three hundred and sixty-eight thousand gallons of borate were dropped.

Early in this emergency period, two staging areas, one at La Grande and one at Baker, were established. These two cities are transportation centers, and with the numerous fires forestwide, it was not known where men would be needed next. Manpower was brought into these staging depots, supplied with overhead, organized into crews, and then dispatched to where they were needed. In the staging areas the men were messed, rested, and controlled. Off-duty police in uniform were used to keep order and prevent the men from scattering. This system worked well, and few problems developed between townspeople and firefighters.

Other severe lightning storms occurred on July 26 and on August 9. The last major storm of the year, on September 11, set 29 fires. Fire occurrence for 1960 was as follows:

Period	*Lightning fires (number)*	*Man-caused fires (number)*	*Area burned (acres)*
Prior to July 19	48	20	221
July 19-25	118		45,886
July 26-August 8	40		234
August 9-September 10	21	18	2,710
September 11-October 31	29	35	962
Total	256	73	[1] 50,013

[1] Man-caused fires burned 1,184 acres.

To sum up, the Wallowa-Whitman had the most disastrous fire year of record. Fire weather was very severe and fire occurrence the highest of any year on record. The total was *329* statistical fires: 14 Class E, 7 Class D, 12 Class C, 75 Class B, and 221 Class A. Only 19 were extraperiod fires and uncontrolled within the first work period.

Extreme fire weather and extremely heavy fire occurrence seldom occur in combination to the extent they did on July 19. It was far beyond the capability of the forest's initial attack forces. A substantial buildup in forces was made to meet the threat of an extreme fire situation, but management did not foresee the abnormal numbers of fires that would start, or their wide distribution over the forest. While the storm was still in progress, local sources of manpower and equipment were called, and they responded well.

If disastrous losses are to be prevented during abnormal fire years, a complete review and revision of our fire control resources and facilities is necessary. One serious handicap was lack of helicopters. More smokejumpers would have been helpful in the early

FIGURE 2.—Anthony Fire in head of Anthony Creek. Anthony Lake in foreground.

stages. There were not nearly enough radios to provide the communication needed.

More highly skilled fire specialists were needed as were more trained crews. Twelve Forest Service crews were used on these fires. Their performance was good to excellent.

The disastrous losses which occurred in 1960 must not be allowed to occur again. The fire organization must be strengthened locally, and a strong flexible force must be available to back up the local organization when this "one in 50 years" occurs.

TRACTOR TANKS—DEVELOPMENT AND USE IN WISCONSIN

WILLIAM MEHARG, *Assistant Chief Forest Ranger, Wisconsin Conservation Department*

The development of water tanks on fire suppression crawler tractors in Wisconsin has been a lengthy process. It has added to the versatility of the fireline tractor-plow unit. Its value has been accepted by fire control forces and now all primary fire suppression tractors are equipped with tanks and pumps. Annual replacements of old-model tractors have tank installations as a part of the modification required to keep approximately 70 fire suppression tractors immediately available for use (fig. 1).

When tractor-plow units of a size adequate for fire suppression and in a weight class to be easily transported became readily available, they soon were an integral part of our initial attack effort on nearly all surface fires (fig. 2). As their use broadened and more power and speed became standard in newer models, an increase in the disparity between line constructed and line held

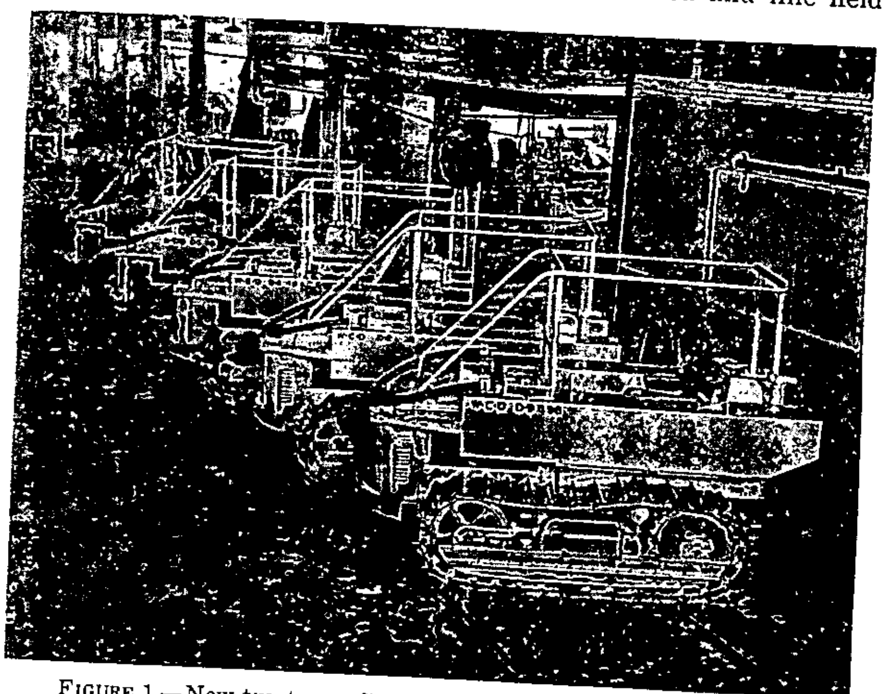

FIGURE 1.—New tractors, after modification, ready for distribution.

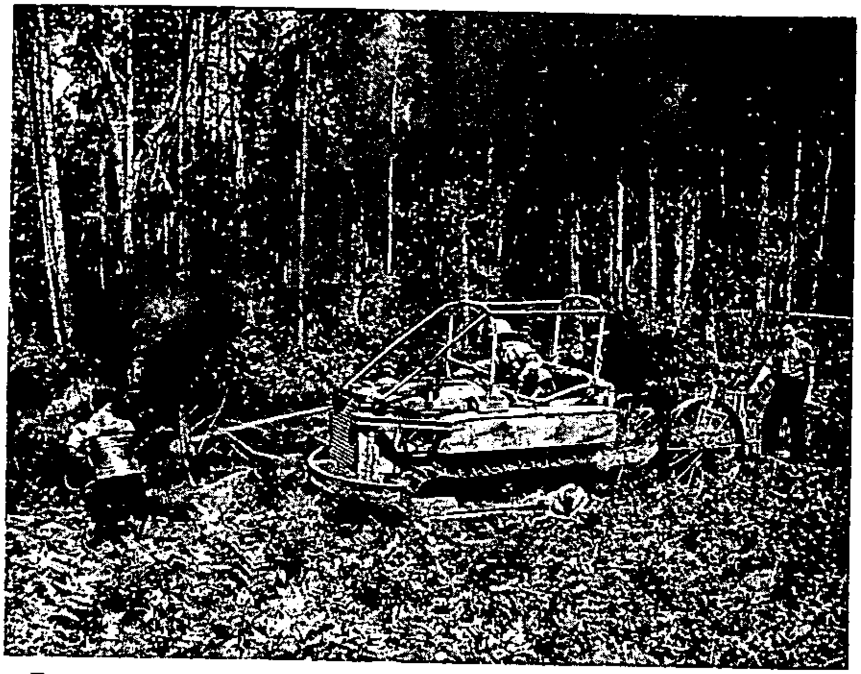

FIGURE 2.—Tractor-plow unit in use on fire, plowing and pumping water.

became more evident. The success of the units during severe burning conditions decreased somewhat partly as a result of the change in forest cover and partly because of expanded use in direct attack effort.

To increase the efficiency of tractor-plow units, water tanks were saddle-mounted directly over the tractor tracks. Over a considerable period of time, numerous adaptations were made and used. As an aid in controlling surface fires, their value soon became recognized, and more recently the installations have become standard (fig. 3). The capability of carrying and pumping water for use in critical situations has contributed to our ability to control approximately 90 percent of the fires to less than 10 acres burned.

The standard mounting now used is two tanks, each about 75-gallon capacity, connected together with a 1½-inch flexible line coupled to a flange-mounted pump driven by a rear power take-off. Operator guards and modifications to permit access to the tractor engine complete the installation.

On the fire, the tractor operator uses the pump at his discretion and handles the hose and nozzle. He determines when water use is necessary for control of the fire and with the capability of plowing and pumping simultaneously can determine how best and where to attempt control.

Any water source available to the tractor can be used to refill the tanks directly through the power take-off pump. Under cer-

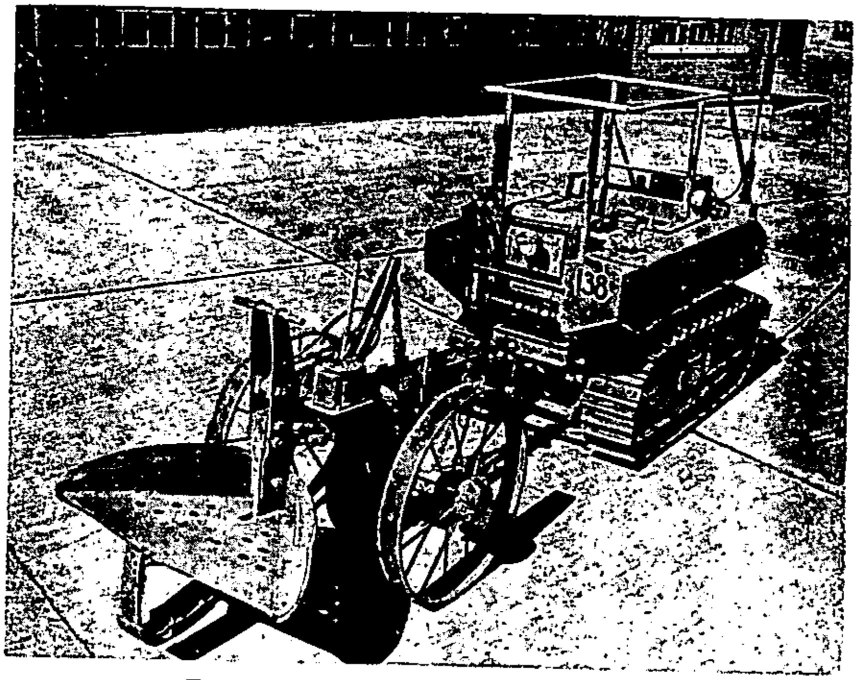

FIGURE 3.—Conventional tractor-plow unit.

tain conditions, we have found it practical to use a 250-gallon tank trailer instead of a plow and depend on the combined water supply to control the fire. Another attack combination is one tractor with tanks pulling a water trailer tanker, working directly ahead of a tractor-plow unit. This combination has been very successful on the severely burning flanks of a surface fire.

The tanks when full add about 1,500 pounds to the tractor weight and usually improve traction. The tanks also afford a measure of protection to the tractor operator. The obvious disadvantages are the added weight on soft ground and some little loss of stability. As a result of years of experience under many conditions, we believe the tractor tanks to be an asset and expect to continue this type of installation.

PORTABLE PUMPS FOR MORE EFFECTIVE CONTROL

L. J. McDONALD, *Superintendent, Ely Service Center, Superior National Forest*

In the early days of forest fire control in the North Central Region, the use of water was secondary to hand line construction. The water quite often was available but the means of applying it efficiently were not. Power pumps and hose were too heavy and cumbersome, breakdowns too frequent, and trained crews nonexistent. Today, in the North Central Region, and especially in its northern forests, water is generally in abundant supply and more often than not is depended upon for initial attack.

Throughout the years gasoline-driven, portable firefighting pumps have been greatly improved. Good construction and simple, reliable operation is now the rule. Weight has been reduced from well over 100 pounds to 35 to 75 pounds. Many of the pumps are capable of pressures up to 200 pounds and will deliver from 20 to 50 gallons per minute at 150 pounds pressure, depending upon make and model.

Hose improvement has kept pace with the manufacture of lighter, more durable, and trouble-free power pumps. Lightweight linen hose and plastic-lined hose in the 1-inch and 1½-inch sizes, capable of withstanding high pressures, are now available.

The accessories are as important as the power pump and hose. Here, too, much progress has been made with nozzles, valves, bleeders, and other accessories, to obtain precision and lighter weight. In addition, light-weight reservoir tanks of canvas and neoprene rubber, which can be quickly erected, have been developed for relaying water.

Improvements in laying hose to reduce or eliminate wrestling with heavy, cumbersome rolls and packsacks are being steadily made (fig. 1). The aim of all these improvements is to enable attack crews to use fewer precious minutes and thereby keep the perimeter of any fire to a minimum.

Because of these improvements and the action of well-trained "hot-shot" crews, the use of water is no longer secondary to other means for initial attack. Direct attack is not always possible with handtools alone. Water, quickly and properly applied, cools down the front, making direct attack possible. The judicious use of water enables a crew to secure much more rapid control and to hold greater lengths of line per man, more quickly and with less fatigue than before. The end result is smaller area burned and lower suppression cost.

At one time it was deemed advisable to have a one-size portable power pump that would meet all fire needs. Standard accessories would also be the rule. Such a development has not occurred

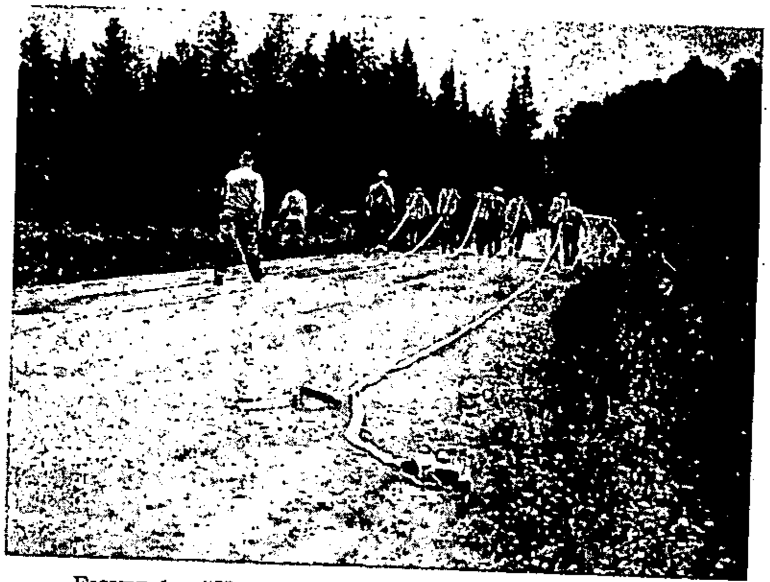

FIGURE 1.—"Hot-shot" crewmen practicing hose laying.

through the years and it is doubtful if it will now materialize. On the Superior National Forest it has been found that various size pumps and capacities are needed to meet the requirements of modern transportation, accessibility, and fast attack.

Weight of pump, hose, and accessories is very important to initial attack in the Boundary Waters Canoe Area of the Superior, where access is by seaplane or boat, canoe and portage. Whenever the burning index is 13 plus, a light-weight pump is carried in each of the two DeHavilland Beaver seaplanes. Pumps in the 35- to 40-pound weight class, with light-weight 1-inch linen hose and accessories, are a must. Pressures developed and the gallons per minute produced by a pump of this size are adequate in most instances, especially when attack is quick and fire perimeters small. When burning indexes are 25 plus, "hot-shot" pumper crews of three men accompany the pilots. When a forest fire is spotted, the seaplane lands at the closest lake and the crew takes off from there.

Heavier pumps of medium size or approximately 75 pounds weight, with increased pressure and more gallons per minute, are required for followup where speed of attack is no longer a factor but greater amounts of water are necessary. These pumps should also be used where they can be transported close to the fire and a water supply (fig. 2).

The large centrifugal pumps capable of producing 300 to 500 gallons per minute and mounted on two-wheel trailers, also have their place in fire suppression. These are used on large project fires where they can be pulled by truck or tractor direct to the source of water. They are usually powered by four-cylinder, gas-operated motors.

FIGURE 2.—Medium size pump and accessories, including 1½-inch linen hose.

Taking all of the above into consideration, the fire manager decides which pump to use: small, medium, or large. If initial attack fails, all three types of pump might possibly be found where a road system to the fire is available.

On the Superior National Forest, our newest tactical weapon in the use of water in fire suppression is the streamlined 125-gallon water tank mounted under the belly and between the floats of the DeHavilland Beaver seaplanes. As the seaplane taxis along the surface of a lake, water is forced into the tank through a pickup tube in the short period of 13-15 seconds. Quickly airborne, the plane proceeds to the fire and drops the load of water where it will do the most good. Quite often this is being done before the "hot-shot" crew arrives on the fire. Water dropping from the seaplane is not an attempt to extinguish the fire but only a holding action until the ground crew can take control.

Additional pumps, hose, gasoline, and tools, as needed by the ground forces, can be quickly dropped from the pontoons of the seaplanes.

JEEP WATER UNITS FOR FOREST FIRE SUPPRESSION IN MISSOURI

JERRY J. PRESLEY, *District Forester, Forestry Division, Missouri Conservation Commission*

There are ten State fire protection districts in Missouri. Fuel types in the areas under protection on most of the districts make it mandatory that some type of water unit be available for use in fire suppression work.

For several years the Forestry Division, Missouri Conservation Commission, has used jeep water units. The jeep tanker was first used around 1948 and additional units have been added until some districts may have as many as seven or eight in use during fire season (fig. 1). The jeep tanker has become an integral part of our fire suppression equipment.

The three basic components of the jeep tanker are the pump unit; the tank with fittings and hoses; and the half-cab jeep, on which the first two are mounted. The ¾-inch fan drive pump is mounted on the cylinder head of the jeep motor (fig. 2), and takes its power from the front end of the crankshaft through a long V-belt. Use of the additional belt is made possible by incorporating a double pulley on the crankshaft. The pump clutch (fig. 2) is operated from the dash by a flexible control rod that can be locked in the engaged position. The ¾-inch pump affords a working pressure of 135 pounds and delivers up to 25 gallons per minute of water volume at high motor speeds.

The jeep water unit provides a quick and easy means of controlling fires in fuel types where the time element is critical because of the fast rate of spread. A full load of water is carried at all times during fire season. During the spring fire season in Missouri temperatures low enough to make it necessary to drain the unit to prevent freezing are rarely encountered.

FIGURE 1.—This type of jeep tanker with L-shape tank is used extensively in fire suppression work.

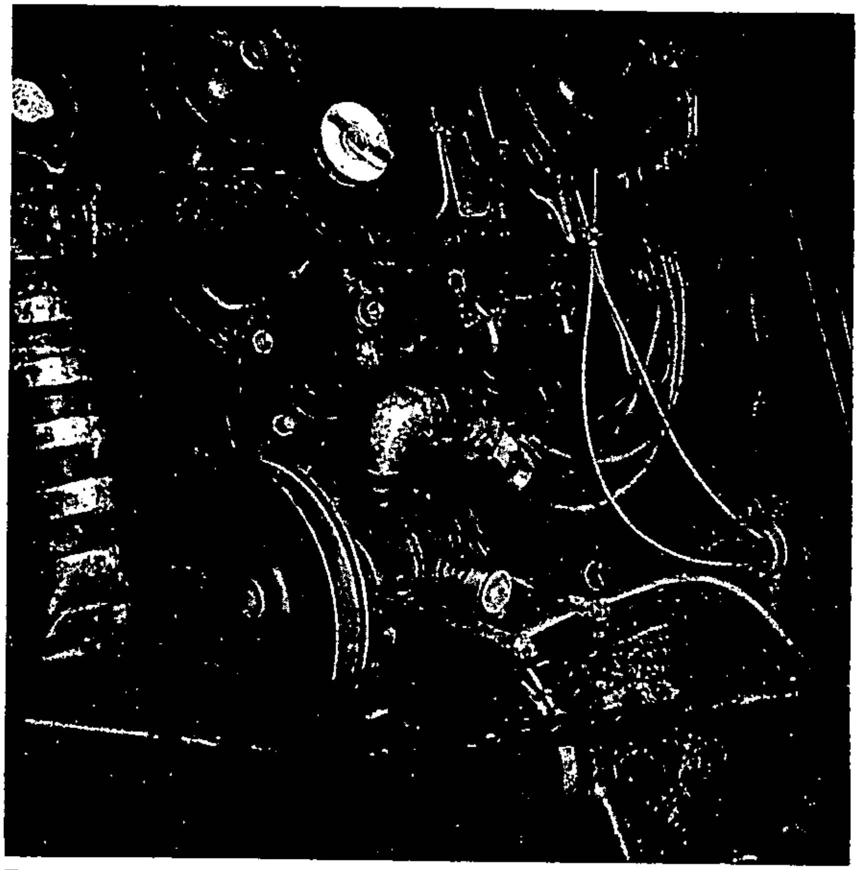

FIGURE 2.—Pump mounted on cylinder head of jeep motor, with flexible rod going through fire wall to dash mount for easy driver control.

Fires are best extinguished by 2- or 3-man crews with jeep tankers. Three-man crews are the optimum. Normally the driver operates the jeep while a second man uses the hose. The wise crew leader never tries to completely extinguish the fire (unless very small) but uses the water to cool and slow down rate of spread. A third man can follow the jeep and under most burning conditions easily control the fire with handtools or backpack pump. In some cases, the driver can operate both the vehicle and the discharge hose, thus allowing an additional man to follow with handtools.

On State Fire Protection Districts where large areas of flashy type fuels are present the jeep tanker provides (1) a quick means of attack on fires by enabling the driver in many cases to drive directly to the fire with his water supply, (2) actual suppression on small fires and a means of cooling off hot spots and heads of larger fires until additional help arrives, (3) a ready water supply for filling backpack pumps on fires where the use of the tanker itself is not practical.

THE ROLE OF THE SOUTHWEST FIREFIGHTERS

C. K. COLLINS, *Forester, Southwestern Region, U.S. Forest Service*

The organized Indian firefighters from the Southwest are widely known throughout the entire West for their part in fighting major western forest fires. Actually, they are not all Indians. Part of the organized units are Spanish-American from the villages of northern New Mexico which have been inhabited since the early days of the Spaniards.

Since both the Indians and the Spanish-Americans live in or adjacent to forest areas, they have been used on forest fires in the Southwestern Region on an emergency basis for many years. In 1949, however, permanent crews were organized and trained by the Forest Service and Indian Service, and as units, began to leave the region in 1950 to help fight fires in other regions. They did so well that additional calls came for such crews the following year. As a consequence there has been a yearly increase in the use of their services by not only the Forest Service but by the other cooperating agencies such as the Bureau of Land Management, National Park Service, and Indian Service.

Each crew is composed of 25 men, including 1 crew leader, and 3 squad bosses. Each firefighter has a physical examination and an identification card. When sending crews away from New Mexico or Arizona, the agency requesting the crews will send a qualified liaison officer with each crew to handle matters of health and welfare. A regional liaison officer will also be sent to any fire where 4 or more crews will be used. He works with the fire boss or plans chief in the overall use of the crews.

In the early 1950's it was considered wise not to organize more than 500 firefighters until we could determine more about the demand for them. We considered that the men would lose interest unless used on at least 1 or 2 fires a year. We now have over 1,000 firefighters organized and ready to go any place in the United States. The critical part of the fire season in the Southwest is generally about over when other western areas are having suppression problems. As a consequence there is not too much overlap between the Southwest and other western areas in requests for the organized crews.

The Indian crews are now from the Zuni, Hopi, Santo Domingos, Jemez, Zia, Taos, Navajo, and Mescalero-Apache reservations. The Spanish-American crews are from Pecos, Penasco, Questa, and El Rito, N. Mex.

The Southwestern Region of the Forest Service, the National Park Service regional office in Santa Fe, the Bureau of Land Management office in New Mexico, the Bureau of Indian Affairs, and recently the New Mexico State Forester are cooperating in the organization and administration of the program. Annual meetings are held with tribe or village officials to discuss the program with its current additions or changes.

The Forest Service does the dispatching for all the using agencies since the Forest Service uses more of the crews and probably is far better located in relation to recruiting the various units.

This service to other Forest Service regions and to other agencies outside of New Mexico and Arizona has reached a point where it has to be considered something beyond a casual venture in cooperation that could occur normally with one region helping another during a bad fire year. An analysis of the dispatching shows that it amounts to over 50 men fighting fire on the average of every single day of the year for the 6-year period 1954-59. This figure does not include the use made of the crews within the Southwestern Region of the Forest Service or by the cooperating agencies within New Mexico or Arizona, nor does it include the Forest Service or other agency personnel who accompany the crews.

Over 40,000 man-days of use were made of the organized firefighters outside the region during the months of July and August of 1960. This figure could have been much higher as we had orders at one time for about 3,000 men that could not be filled.

The question is often asked, "What do these crews have that cannot be developed in like crews from other areas?" At first glance it would appear that there is nothing special about the situation in the Southwest that could not be duplicated in other areas. However, after many years of successful use there appears to be a combination of circumstances that contribute to the overall continued success and demand for the crews. We can list them as follows:

1. Most of the Indians, such as the Zuni, Hopi, Santo Domingos, Jemez, Zias, and Taos live in pueblos or villages. Their form of government, customs, and religion tend to tie them much more closely together than the nomadic type of Indian or those who do not live in close association with one another.

2. They are taught discipline from birth.

3. They can be contacted and sent to fires in fast time considering the location of their homes.

4. They work together on their community and land projects and know how to use common tools. Many of their activities are communal in nature.

5. Their knowledge in using basic tools makes them better safety risks. The idea of doing things safely appeals to them and they learn such things fast. A safety report on their record by a California forest was received last year. A comparison was made between the organized Southwestern crews and other type firefighters and overhead on a fire. The record of the Southwestern firefighters in this case was astounding. It is especially good when the fact is considered that they do not get the easy and safe sections of fireline.

6. Due to the discipline factor they are orderly in camp and on the fire. They create no particular problem. They keep their camp

areas clean and clean up personally as well as can be expected on a fire. Their complaints are presented in an orderly way.

7. They work and stay together as a unit. They do not scatter out while in camp to a point where they cannot be assembled rapidly if needed.

8. They all live in depressed areas of the West and appreciate the work. The other units, including the Spanish-American crews, live in or near small communities where they can be recruited rapidly. These units also know they must perform as well as the Indians from the pueblos or they will not be used. As a result the competition has been keen for fire suppression work, and standards of performance have thus remained high.

INFORMATION FOR CONTRIBUTORS

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

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

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

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

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

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

There are so Many Reasons to Protect Your Forests