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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.

Volume 8 Number 1

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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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RESULTS FROM MECHANICAL FIRE LINE CONSTRUCTION

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Paralleling the coast from North Carolina to Texas is an area of approximately 250,000 square miles, or 160,000,000 acres, grading from flat coastal plain to rolling uplands. The greater part of this area is forest land, about 62,000,000 acres in the longleaf-slash pine type, and most of the remainder a mixture of shortleaf-loblolly pine and hardwoods.

Following the cutting of the heavy original timber stands, the shortleaf, loblolly, and slash pines tended to prolific reproduction, limited by the frequency of wild fires. The longleaf pine, which has infrequent seed years, came back in fair but understocked stands where team logging left small or defective but seed producing trees. Where clear-cutting and railroad skidders, tearing down all but an occasional sapling, were used and followed by intense logging debris fires, there are today large areas with only scattered clumps of reproduction.

With fire protection, the potential timber capacity of this entire forest region is tremendous. Because of the long growing season, favorable climate and soils, both pines and hardwoods will grow with almost unbelievable rapidity. On large blocks of the better sites protected from fire annual growths of 400 to 600 board feet per acre per year are common; 150 to 200 board feet per acre is common to the poorer sites. Stands of 20,000 board feet per acre are frequent on land that someone tried to farm 40 years ago.

Also, accessibility and unsurpassed market conditions combine to create a forester's dream. Heavy demands for fence posts, pulpwood, poles, piling, and sawlogs give opportunity to practice a succession of good silvicultural thinnings and cuttings, each at a profit. All products enjoy exceptionally high stumpage values.

The Fire Problem in the Southeast

The one thing standing in the way is uncontrolled fire.

From the days of the earliest settlers, light burning, annual or biannual, has developed into accepted custom and tradition; in some sections it reached the dignity of a civic duty. In the longleaf areas the wire, sedge, and other grasses with their high, luxuriant growth generate a real conflict between the stockman and the tree man. Large numbers of cattle and sheep graze the piney woods. By tradition, unfenced lands are "open range" for any stock owner. A person can

easily make a fair living by running a herd without cost on the other fellow's land. The grasses make pretty fair forage in the summer and cure after frost into a dense mat of natural hay on which the stock winters. The conflict comes in the early spring when stock needs fresh grass. The new sprouts are buried under the dead growth which will accumulate from year to year. If a fire removes this cover, a luxuriant new growth of grasses is available for grazing in a matter of days.

Years of steady work by many agencies toward overcoming this hereditary practice of burning has won the majority to the side of protection, but there remains among the rural residents a large aggregate of citizens who still feel the urge to draw their matches at the drop of a leaf. The problem of the land managers and fire control agencies is to squeeze the area that can be burned by these often well-meaning fire setters.

The deep mat of dead grass, augmented by needles, leaves, and shrubs, continuous over great stretches of woods, sets up a high fire potential. Such fuel is flash, burns explosively, and produces hot, high flames that often go into the crowns of the trees. The fires spread with extreme rapidity. Before the high gusty winds, common to the region in early spring, heads of fires frequently run in the speed range of 2 to 3 miles per hour.

State foresters and individual owners tried to interfere with the spread of these fires, but their meager forces with hand tools often could do little more than keep them from crossing roads, streams, or like barriers. Various fire-control men reached the conclusion that a reasonably good job of suppression in the flatwoods could not be done by hand. They were handicapped by both lack of funds and lack of equipment, but they did develop tankers and made a start on heavy plows.

CCC Hand Control

The picture changed with the advent of the CCC program in which this section enjoyed a large share. Camps on State, private, and national forest lands placed around 75,000 young men in these woods. They were organized in crews with their foremen, supplied with transportation and plenty of hand tools, were well trained, and always available in numbers for a quick getaway to a fire. At the height of CCC the South was in a favorable position to control fires efficiently with manpower, if men and hand tools could do the job.

The CCC boys did a man's job, but it became more and more evident that their efforts were out of proportion to the results. In the easier fire weather they did pretty well. During bad fire weather, with rakes, flaps, and back-pumps, they fought valiantly, frequently to exhaustion, only to have fires get away from them. There were such instances as a fire being attacked when small, receiving a plentiful concentration of fresh crews, but still, a few hours later, reaching 10,000 acres.

Foremen shook their heads over the brutal work they were requiring of their men. State foresters, rangers, and supervisors who were observant became convinced that this was the wrong answer. The man with the match was still master of the suppression forces.

Building of Mechanical Units

As time went on the future prospects of hand-tool suppression looked even darker. Despite the handicaps and limitations, the aggregate of control efforts had resulted in a marked reduction in the frequency with which many areas were burned—large areas were protected with but small percentages of burned acreage over a number of years. With this protection, suppression became more difficult year by year as the amount of fuel on the ground increased. Seedlings lived and grew into dense stands of advanced reproduction, but thickets of bushes and brushy growth also thrived. On the better growing sites, unburned for 10 or 12 years, the fuel and brush accumulations became so heavy as to make hand tools entirely too slow and ineffective. Field men also realized that CCC must sooner or later end and fire crews would have to come from slowly gathered farmers, loggers, or distant town labor.

In those days they began moving toward mechanical fire-line building. The only fire plows in sight were a pusher type developed by the Arkansas State Forester and those being built by Mathis and Rome. Powered by 35- and 50-horsepower crawler-type tractors, they built a good line about 5 feet wide through the heavy palmetto-gallberry sod cover. As more and more of these units were placed in operation, their value was quickly established. When they could be gotten to a fire, they built a line at a rate of about 1 mile per hour, a line which would hold on the flanks and which could be backfired to stop a head fire. They made suppression surer and faster.

The weakness of these heavy units was the difficulty and long elapsed time required to get them to a fire. The four-disc-type plow weighed 3,600 pounds; the two-disc type about 2,400 pounds. The smallest tractor that could successfully pull the two-disc plow weighed 12,000 pounds. Transporting these units to a fire required a heavy truck-trailer which carried the tractor and towed the plow. On ordinary roads the loaded outfit traveled 10 to 12 miles per hour, with travel rate becoming slower after turning into back-country or woods roads. The point beyond which the heavy truck could not travel was often reached while still far from the fire, necessitating "walking in" the tractor for two or more miles. These units were quite helpful, but the limitation of slow, ponderous travel made their time of arrival disappointingly late. In the fast-burning fuel types, fires often reached class D size before a plow could be put to work. The plows stopped some fires at a reasonable size, but in the main their role was to help keep already large fires from getting much larger.

Brief study of the situation pointed out the necessity for a line-building unit that could be delivered on the fire at a speed which would appreciably reduce the critical and all-controlling elapsed time between start of fire and effective attack. We knew speed of travel would have to be bought through the sacrifice of some of the valuable characteristics of the heavy units. The hope was that a unit could be developed which would build the least line one could get by on, translating the weight saving into travel speed—a unit that could control a fire in medium fire weather, and in bad fire weather could get on a fire while it was still small and hold it until a heavy plow could get there.

The controlling specification was a tractor-plow unit that could be transported on a 1½-ton stake body truck. In the spring of 1944, a Clarkair tractor weighing 3,175 pounds was obtained for experimental purposes. The engineers and mechanics went to work and created a light plow. A series of field trials and alterations resulted in the plow known as the Rangers Pal, weighing 465 pounds. The total 3,600-pound unit would not seriously overload a 1½-ton truck and could travel at 50 miles per hour on good roads.

The small Pal plow, used where there are no stones, is 7 feet long and 28 inches wide. Mounted on a central beam front to rear are: A three-height tractor hitch; an 18-inch rolling coulter; a middle buster plow point; two 20-inch discs; a worm gear depth adjusting device; two short wings to roll back the overcast; and two wheels with 4.00 x 8 tires which ride within the plowed furrow. This plow builds a furrow 28 inches wide at the bottom. With side slopes and overcast of dirt, the total width of mineral soil line is 48 to 54 inches, depending upon the nature of the soil and the depth to which the plow is set to cut. In fire line plowing it works best at a speed of 1½ to 2 miles an hour on level ground, but will plow up to 3 miles per hour.

In the summer of 1944 the HG Cletrac became available. Its wider tread, greater clearance, and less weight (3,000 pounds) made it more desirable for plow use than the Clarkair. Seventeen of these HG tractors were purchased; our equipment shops built 15 Pal plows and 2 middle buster plows. These last were for use on stony ground found in the Talladega Mountains in Alabama. Stake trucks were rigged for fast loading and unloading. These units were distributed to our most critical fire districts and used on the season's fires. To the extent that sets were available, these units were equipped with radio. The suppression results from these plows far surpassed our expectations. They hit fires very quickly and built line with a speed that prevented build-up and demonstrated that they could handle a fire on a class 5 day.

In 1945, 12 more of these units were constructed and radios installed on all but a few of them. Radio is vital toward getting the most out of a unit. It enables the ranger during bad fire weather to distribute his plows at strategic locations, start them off immediately upon discovery of a smoke, and give the crews directions while traveling. When the units are finished with one fire, they are dispatched to another without loss of time.

With the great variations of soil and ground cover there can, of course, be no one all-purpose weapon. It is presently estimated that our conditions call for three distinct sizes of units: The light Pal plow for use in the grassy, more open longleaf type; an equal weight unit with a middle buster type plow for the hill country up to 30 percent slope; and the heavy two-disc Mathis type plow in the luxuriant and dense cover found in Florida and the Carolina coastal areas. Middle weight plow units have been built for use in the heavy but less dense cover found in the inland loblolly type. These middle weight plows follow the same general design as the Pal plow but weigh around 900 pounds, are raised and lowered by a hydraulic jack, and are pulled by a T–6 tractor weighing 6,750 pounds. For these, special carriers were designed, consisting of a Hi-Low semitrailer with a 1½-ton truck for a prime mover. These carriers will make 40 miles per hour on good

roads. To speed up travel and increase their range, Hi-Low semi-trailers have been built to carry both the heavy Mathis plow and its tractor. The prime movers are 2½-ton 6×6 (Army type) trucks for the heavy going, and 2-ton 4×4 (Army type) trucks elsewhere.

Method of Use of Mechanical Units

The size of the crew with each plow unit is varied with type of country and existing class of fire weather. A typical crew is composed of a lead man, tractor driver, backfiring torchman, and follow-up man with back-pack pump and flap. Such a crew has successfully suppressed 6 successive fires in one class 5 day. One famed crew on a Mississippi district handled 72 fires last spring by themselves. If it appears that there will be much of a mop-up job, a hand-tool crew is dispatched to take over that part of the work and release the plow crew for another fire.

Attack by a single plow unit is an undesirable tactic. Because there were not enough units available for the job at hand it was necessary on all but a few of the fires studied. (Seven more Pal units are under construction and some doubling up can be practiced next spring.) On a number of occasions ranger districts had more going fires than plows. Attack was delayed on too many fires. They got pretty big before plows could be disengaged from other fires. On days of lower fire occurrence, two plows attacked some fires and there were a few opportunities to use three. The rapidity of suppression under such attacks was so striking as to indicate that the desirable action and the key to obtaining a reasonably small percent of burned acreage is to dispatch two plows to many of the class 3 day and to all class 4 day fires; three plows on all class 5 days or to any incendiary fire with numerous sets on any class fire day. The secret of success is the elimination of each fire in the shortest possible time. Then, all units are available for assignment to other fires. Another factor makes time important. On bad windy days heads run rapidly and produce a long cigar-shaped burn. Winds frequently make a 90° shift. The longer the time before both sides are controlled, the greater the risk that wind shift will turn one or the other flank into a broad front head fire.

A plow unit requires an appreciable investment of funds. The national forests in Region 8 have within their protection boundaries approximately 10,000,000 acres where tractor plows will work to advantage. State foresters and large lumber and pulp companies have as their long-time objective, as funds and facilities become available, adequate protection of an estimated 100,000,000 acres of potential "plow country." The State organizations have been adding tractor plows to their forces as their funds will permit and some units have been acquired by industrial landowners. Two fundamental protection questions to be resolved are: "What method of fire line building gives the best combination of effectiveness and economy?" and, if the advantage is with the plows, "To what extent will investments in mechanized units pay off?"

Comparison of Results

A preliminary study was made this summer to assess and compare the results so far obtained. We wanted to know whether our present

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investment in plow units had been good business and, if so, to obtain indications as to the extent we are justified in making further investments and to give guidance to other fire protection agencies who are considering trying or expanding mechanical fire line building.

An analysis was made of 315 fire reports for the calendar year 1940 from the Catahoula, Evangeline, Kisatchie, and Vernon units in Louisiana, and for the year 1941 from the Leaf River, Chickasawhay, and Biloxi Ranger Districts in Mississippi.

The area protected within these particular ranger districts is 1,132,926 acres. On and around them is found the highest concentration of man-caused fires in the United States. This group of ranger districts enjoys the dubious honor of a 5-year average of 752 man-caused fires per year. Besides the bare figures of high occurrence, other factors contributed to the severity under which the plow units were tested. Most of the fires are incendiary, planned by men who know the areas intimately, choose the time of day, weather, and burning conditions, and place numbers of sets, all calculated to give fire every possible advantage. The fire setters make it a little rougher by crowding large numbers of fires into particular days. There were 2 separate days last spring when the Chickasawhay District had 26 fires, and 4 days with concentrations of 15 to 20 fires.

In the years 1940 and 1941 the 7 districts had no fire plows but conditions were about as advantageous as could be for good hand-tool results. The areas studied then had 8 CCC camps, or about 1,200 active young men organized in crews with their foremen, transportation, and some light tankers. The boys were well trained, crews could be gotten together and started quickly, and on bad fire days were often placed out on standby. Fires were usually attacked with a truck load or more of men with followup available. The results obtained by these CCC crews must be considered as quite good for hand-tool suppression, and far superior to what could be expected from equal sized crews gathered from farms, sawmills, or towns.

For comparison, the actions on 526 plow-fought fires on these same districts in the spring season of 1946 were analyzed. There were 6 heavy Mathis type plows and 11 Ranger Pal plows on these districts during the early part of the fire season, and 6 more Pal units were added during the course of the fire season.

To prevent distortion, we threw out of the study those outside fires which were simply cut off near the boundary, class 2 day fires because they were so inoffensive as to give no test to suppression methods, and fires under 5 acres in final size. A fire in the flatwoods during strong burning weather that is suppressed with hand tools at less than 5 acres usually represents special circumstances, such as being held by roads, streams, or fields.

Table 1 shows the comparative results from hand-tool crews and tractor-plow crews under like burning conditions.

Table 2 gives the percent of fires which became class D size (100 to 300 acres) and class E size (over 300 acres) under each method of suppression. The test of a method is rather well measured by its results under bad conditions. Historically, this region has lost the big part of its burned acreage from those few fires that were not well held; fires that on severe fire days were too much for the available manpower.

Table 3 shows the complete cost of each of the three sizes of plow units. Because much of our equipment was Army surplus and some old CCC surplus, these costs are considerably below the expenditure probably required to obtain similar items under present market conditions.

TABLE 1.—*Size of fires, and work required to control them by hand tools and by plows*

Class fire day	Average size of fires						Average time on line building		Average maximum men per fire (includes mop-up)		Average length of held line	
	Hand-tool control			Plow control								
	Beginning of attack	Final	Increase	Beginning of attack	Final	Increase	Hand tools	Plows	Hand tools	Plows	Hand tools	Plows
	Acres	*Acres*	*Percent*	*Acres*	*Acres*	*Percent*	*Man-hrs.*	*Man-hrs.*	*Number*	*Number*	*Chains*	*Chains*
3	23.0	57.2	149	14.4	28.7	101	20.15	5.37	18.0	5.6	75.2	57.1
4	45.6	93.7	105	17.7	36.5	112	24.99	5.86	22.6	6.4	83.2	67.7
5	49.8	422.2	748	22.1	67.9	207	52.51	10.40	30.3	8.2	160.3	83.0

TABLE 2.—*Percent of total fires reaching class D and class E size, by hand-tool and plow suppression*

Class fire day	Class D size (100 to 300 acres)		Class E size (over 300 acres)		Total over 100 acres	
	Hand tools	Plows	Hand tools	Plows	Hand tools	Plows
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
3	18.6	2.6	2.0	0.0	20.6	2.6
4	11.2	5.1	4.0	0.4	15.2	5.5
5	22.5	11.2	16.9	2.8	39.4	14.0

TABLE 3.—*Cost of plow units*

Part	Heavy plow unit		Medium weight unit		Light plow unit	
Truck	(2½-ton, 6 x 6)	$2,000	(2-ton, 4 x 4)	$1,800	(1½-ton)	$800
Hi-Low trailer		800		800		
Tractor	(D-4)	4,000	(T-6)	2,400	(HG Cletrac)	1,400
Plow		750		700		275
Radio		450		450		450
Total		8,000		6,150		2,925

The 526 (analyzed) plow-fought fires, if suppressed by hand, (figuring costs upon the manpower required to suppress with hand tools the 1940 and 1941 fires and the wage rates prevailing here last spring) would have cost an average of about $57 each for suppression labor and crew bosses, or around $30,000. Although our cost accounting system does not provide for exact identification of costs by individual fires, by totaling the manpower and equipment time from the fire reports and applying current wage rates and our standard costs of

equipment, operation, and depreciation, it was found that the cost of suppressing these 526 fires was approximately $6,800, an average of about $13 per fire. Thus, there is an indicated saving of $23,200 or $44 per fire in suppression costs.

Table 1 demonstrates the reduction in acres burned per fire, under the different fire weather conditions, when fought by tractor plows instead of hand tools. The most significant figure is the reduction in the size of area burned under plow control on the worst fire days. What the losses from fire damage to reproduction and timber would have been on the acres which probably would have burned except for the plows is too speculative to reduce to reliable figures. The study did tell us the 315 hand-tool suppressed fires burned 47,523 acres, whereas 526 plow-fought fires burned 18,015 acres. Hand-tool controlled fires averaged 150.8 acres per fire as compared with 34.2 acres per plowed fire. Further studies may show that these averages will vary both ways from year to year or according to the types of country, but the spread is so significant as to assume the position of major importance.

Conclusions

Reduction in the amount of damage from fire is the primary objective of a fire control organization. Whatever the average damage per acre resulting from wildfire in any given stand, it seems axiomatic that a mechanical method of suppression which gives promise of saving well over two-thirds of the former losses, besides the reduced cost of operation, will have paid its way after a very few fires.

It is also our judgment that mechanical suppression will prove to be a firm base for far better fire prevention. In a section of the country where so many people lean toward promiscuous burning, they will give really serious consideration to the teachings of foresters only after it is well demonstrated to them by stopping fires with dispatch that the foresters mean business. When they see us, the preachers of fire prevention, fighting fire ineptly, permitting what they judge to be unnecessarily large burns, they question the real sincerity of our talk. Where suppression action has not been too good, we even encounter the idea among the residents that under all the talk, the fire organizations really want quite a bit of fire in order to keep their jobs alive.

From the true incendiary, the fellow who sets out to burn a large piece of the other man's lands to save himself from buying spring feed for his stock, we expect a considerable increase, for a while, in the number of fires. The stockman usually has in his mind some certain size burn as an objective. He can often get such a burn from one fire fought by hand tools. If a tractor plow suppresses his fire at small size, he will repeat his fire settings again and again on other days, trying to get the size burn he originally wanted. This will be annoying at the time, but those actions tend to segregate and identify these burners. They follow predictable patterns of action until it becomes more and more probable that properly placed guards will be able to apprehend them in the act. With some court convictions and the increased risk of being caught, we believe that fast suppression will gradually discourage this worst source of fires.

Another major source of fires on the national forests of this Region has been the "job fire." When money was short, it was very common to have a scattering of fires set so the boys in a community could get some work putting them out. In ground cover where large crews are required to keep fires from reaching critical size, these "gravy train" set-ups have the ranger in a bad defensive position. With fast mechanical units employing only a few reliable men, each unit easily more effective than 25 good men, the "job fire" people find that they have lost their power, the ranger is independent of them, and they are not hired. They soon discover that the cause of their temptation is gone.

Another important gain from mechanical suppression not brought out by statistics is the reduction of the "fatigue factor." The physical demands placed on hand crews by fast-spreading hot fires can be so great that men frequently play out before completing suppression of one fire, and they are seldom in condition to be assigned to a new fire without a long rest. Plow suppression does not overfatigue the crew, and the men are able to act energetically on successive fires all day long if needed.

The big question is, Does mechanical fire line construction pay? We conclude from the data at hand that an organization with any appreciable area of "plow country" to protect cannot justify the large suppression bills and heavier damage losses that occur without such equipment.

How far can one go in investing in equipment? In the first place, it has required the current condition of the lumber market and the price lists to bring home not only to the general public but to a lot of people in the business that we have become a chronic "have not enough" lumber nation. Our timber stands and vulnerable reproduction have attained a monetary value and a place of economic importance that jolts us all. Fire damage from now on will have to be calculated a lot higher than when it was thought "there is plenty more."

There can be no simple formula applicable to different areas. There are some good guides.

Depending upon the local rate of fire spread, there needs to be an outfit within a travel time permitting attack before the fire gets to critical size. Critical size would be governed by the values at stake where the fire is burning and the threatened values where the fire is heading.

The frequency of fires, the number that will have to be fought per year in a given area, is a part of the equation.

In the area studied, with one fire per year for each 1,500 acres, our speculative calculations indicate that we can afford a small unit for each 30,000 acres of our reasonably well stocked stands. That would mean an initial investment of about $0.10 per acre. It costs around $12 per acre to plant trees on denuded land. Our pine stands have an annual growth value of $1.50 to $5 per acre with growing stock on the ground which will bring from $20 to $75 per acre in the lumber market. The investment in mechanical equipment for fire line construction looks like pretty cheap fire insurance.

HIGH LIGHTS FROM RESULTS OF HELICOPTER TESTS

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Operation

Since October 1945, the testing of performance of Army Air Force helicopters in mountainous areas has been conducted on the Angeles and San Bernardino National Forests, Region 5, in cooperation with the 62d AAF Base Unit (Air Rescue Service), March Field, Calif. The first ships furnished the test project were the Sikorsky R-6 model.

Helicopter R 5–A on approach for landing on Cajon Ridge, with nose up to reduce forward speed. Altitude, 3,800 feet above sea level.

This small two-place craft was soon found to be inadequate in pay-load capacity and altitude range for Forest Service work. Tests on the Sikorsky R 5–A equipped with standard rotor blades were initiated at March Field in April 1946. Considerable was learned about helicopter operation in mountainous areas with this ship. But the R 5–A also lacked the ability to carry the necessary pay load in spot landings and take-offs at elevations over 3,000 feet with summer temperatures.

In July 1946, a set of new high lift blades was furnished the project by Sikorsky. Although the performance data given below are primarily for the R 5–A with these high lift blades, certain data for the same helicopter with standard blades are shown for comparative purposes. All data would apply to the R 5–D or S–51 models when equipped with the same blades.

Effect of Temperature

All aircraft performance specifications and all performance data included in this article are for N. A. C. A. Standard Air. Altitudes under N. A. C. A. Standard Air conditions are called density altitudes.

Table 1 may be used for converting measured elevations or altitudes to density altitudes (N. A. C. A. Standard Air) or vice versa. Since no correction for variation in barometric pressure at sea level is made in this table, precision is to the nearest 150 feet. Example: A landing spot has a measured elevation of 7,000 feet as determined from the topographic map. Weather records show that during the summer, temperatures at this landing spot may often reach 90° F. From table 1 the approximate density altitude at this landing spot would be 10,700 feet at 90° F. The helicopter would perform under these conditions as though it were at an altitude of 10,700 feet. Interpolation of values given in the table may be necessary in many cases.

TABLE 1.—*Approximate density altitude (N. A. C. A. Standard Air)*[1]

Measured elevation above sea level (feet)	Density altitude when air temperature at actual elevation is—					
	30° F.	45° F.	60° F.	75° F.	90° F.	105° F.
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
1,000	−500	400	1,200	2,200	3,200	4,100
2,000	700	1,500	2,400	3,500	4,400	5,300
3,000	1,900	2,900	3,700	4,700	5,700	6,600
4,000	3,200	4,100	5,000	6,000	6,900	7,800
5,000	4,500	5,400	6,300	7,300	8,200	9,000
6,000	5,700	6,600	7,500	8,500	9,400	10,300
7,000	7,000	7,800	8,800	9,800	10,700	11,500
8,000	8,300	9,100	10,000	11,000	12,000	12,800

[1] Assuming a barometric pressure at sea level of 29.92″ Hg.

Specifications and Performance

The specifications and performance of the Sikorsky R–5 (S–51) helicopter are given in the following tabulation. Manufacturer's data were obtained from tests performed for C. A. A. All altitudes given are density altitudes under N. A. C. A. Standard Air conditions.

Specifications

Weight:
- Gross, Model R 5–A — 4,900 pounds
  - Model S–51 — 4,985 pounds
- Empty, Model R 5–A with standard equipment — 3,760 pounds
- Empty, Model R 5–A or S–51 stripped of nonessential covering and auxiliary equipment — 3,500 pounds

Seating capacity:
- R 5–A — 1 passenger and 1 pilot.
- R 5–D and S–51 — 3 passengers and 1 pilot.

Fuel capacity — 100 gallons.

Oil capacity — 8 gallons.

Engine: Pratt-Whitney Wasp Junior R–985–AN–5.
- Normal rating — 450 b. hp. at 2,300 r. p. m. at sea level.
- Take-off rating — 450 b. hp. at 2,300 r. p. m. at 2,300 feet altitude.
- Fuel — Grade 91 octane.
- Oil — Grade SAE 60 Summer, SAE 50 Winter.

Dimensions:
- Length, over-all (blades extended) — 58′ 0½″
- Length, over-all (blades removed) — 44′ 11½″
- Height, over-all — 12′ 11″
- Main rotor diameter — 48′ 0″

Specifications—Continued

Dimensions—Continued

Tail rotor diameter	8′ 5″
Alighting gear tread	12′ 0″
Cabin width, pilot's (S-51)	4′ 5″
Cabin width, passengers' (S-51)	5′ 2″
Cabin height, floor to ceiling	4′ 5½″

Performance

	High lift blades	*Standard blades*
Gross weight, 4,900 pounds:		
Maximum speed placarded by C. A. A. (3,900 ft.)	103 m. p. h.	103 m. p. h.
Cruising speed at 65 percent b. hp. at sea level	80 m. p. h.	80 m. p. h.
Minimum flying speed (up to hovering ceiling)	0 m. p. h.	0 m. p. h.
Fuel consumption (cruising), approx	28 gal./hr.	28 gal./hr.
Gross weight, 4,985 pounds:		
Maximum rate of climb at sea level	1,370 ft./min.	1,230 ft./min.
Hovering ceiling without ground effect	6,200 ft.	3,200 ft.
Hovering ceiling with ground effect	8,000 ft.	6,800 ft.
Absolute ceiling	17,250 ft.	14,900 ft.
Gross weight, 5,180 pounds: Ceiling	16,200 ft.	11,000 ft.

The data shown in tables 2 and 3 were obtained from actual tests on the Angeles and San Bernardino National Forests. Successful landings and take-offs were made in mountain terrain with the loads shown at the altitude indicated, except that no tests were run at density altitudes greater than 9,300 ft.

The net pay load shown was computed as the difference between the gross weight of the machine and the weight of the stripped machine when serviced for a 125-mile operating range as shown in table 2.

TABLE 2.—*Maximum gross weight and net pay load for spot landing and take-off at various density altitudes* [1]

Dimensions—Continued Density altitude, N. A. C. A. Standard Air (feet)	Gross weight		Net paid load	
	High lift blades	Standard blades	High lift blades	Standard blades
	Pounds	*Pounds*	*Pounds*	*Pounds*
1,000	5, 600+	5, 460	1, 500	1, 360
2,000	5, 600+	5, 300	1, 500	1, 200
3,000	5, 520	5, 140	1, 420	1, 040
4,000	5, 380	4, 980	1, 280	880
5,000	5, 250	4, 820	1, 150	720
6,000	5, 110	4, 660	1, 010	560
7,000	4, 970	4, 510	870	410
8,000	4, 830	4, 340	730	240
9,000	4, 700	4, 190	600	90
10,000	4, 560	----------	460	----------
11,000	4, 420	----------	320	----------
12,000	4, 280	----------	180	----------

[1] Wind velocity at 20 feet above landing spot, 0 to 5 m. p. h.; full throttle; engine speed, 2,300 r. p. m., except 2,400 r. p. m. while breaking ground and approaching for landing. Minimum clearance while hovering at 2,300 r. p. m. and full throttle, 3 feet.

It should be noted that while the helicopter is capable of operating successfully at a gross weight considerably in excess of 4,900 pounds, this is forbidden in actual operations as C. A. A. does not permit loads in excess of the designed gross.

For practical purposes, therefore, it is necessary to reduce the fuel load in order to carry the maximum pay load and still keep within the designed gross weight. This may be accomplished as follows:

	Pounds
Weight, empty (stripped)	3,500
Pilot (1)	170
Residual fuel and oil	30
Oil (6.7 gallons)	50
Fuel (58.3 gallons for 1 hour 33 minutes, including 15 gallons reserve)—sufficient for 125-mile range	350
Operating weight (no pay load)	4,100
Pay load	800
Gross weight	4,900

It may be seen then from table 2, that the maximum density altitude to which the maximum pay load may be carried is 7,500 feet for the high lift blades, and 4,500 feet for the standard blades.

While the machine may not be used to carry the loads it is capable of handling at the lower altitudes, it is obvious that the load reduction will result in progressively increased performance as the altitude is decreased. This is shown in terms of rate of climb in table 3.

TABLE 3.—*Rate of climb of helicopter with high lift blades* [1]

Density altitude (feet)	Rate of climb	Manifold pressure	Density altitude (feet)	Rate of climb	Manifold pressure
	Feet per minute	*Inches Hg*		*Feet per minute*	*Inches Hg*
3,000	1,210	35	8,000	600	30½
4,000	1,040	35	9,000	520	29
5,000	900	34	10,000	440	28
6,000	800	33	11,000	350	27
7,000	700	31½	12,000	270	26

[1] Gross weight, 4,900 pounds; engine, 2,300 r. p. m.; air speed, 60 m. p. h. Best rate of climb speed is approximately 50 m. p. h.

Hovering

Hovering is one of the most important types of operation. Theoretically, a helicopter can climb vertically to its hovering ceiling (without ground effect). This is not practical, however, as it places undue strain on ship and engine, and pilots find it easier to climb with forward speed. Hovering between 30 and 300 feet above the ground is considered hazardous, since in case of engine failure, a successful autorotation landing may not be made. The hovering ceiling (without ground effect) is the maximum density altitude at which the helicopter can maintain altitude with zero air speed.

When hovering close to the ground (12 feet wheel clearance for R–5 or S–51), an air cushion is built up between the rotor and the ground. This cushion provides additional lift and the operation is called hovering *with* ground effect. The hovering ceiling with ground effect is slightly higher than the maximum density altitude at which spot landing and take-off with a given gross weight can be made with normal power settings.

Vertical descents are not normally made except within the ground cushion.

Landing and Take-Off

Normal landing and take-off paths for the helicopter are similar to those for a light airplane, except no run on the ground is required for the helicopter and the helicopter climbs and descends more steeply.

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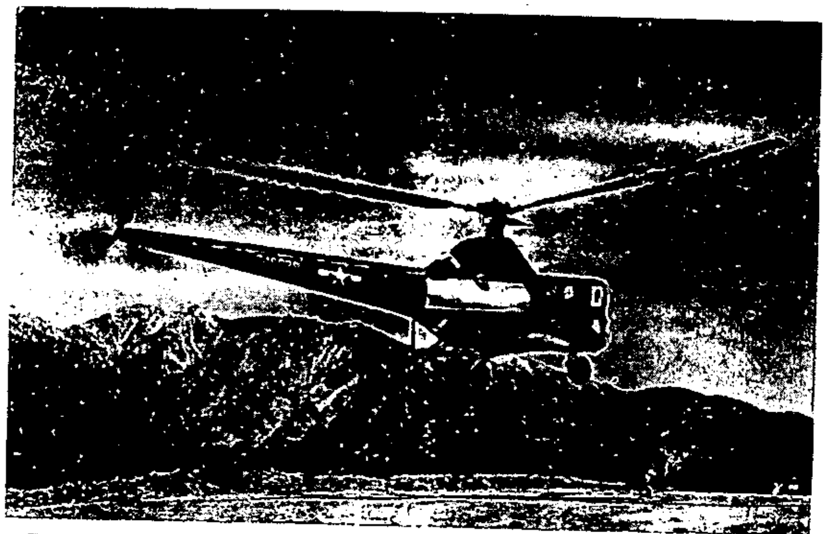

R 5–A at moment of final hovering before landing on Cajon Ridge, Calif.

Specifications for Spot Landing Areas for R–5 (S–51) Helicopter With High Lift Blades

1. Landing-area requirements for spot landings and take-offs of the helicopter are the same for all elevations. Terrain should slope gently away from the landing spot for about 500 feet. Landing areas located on ridge-top knolls are most desirable. The ridge-top location is preferred to one in a canyon because normally less clearing is required, and in take-offs, flying speed may be more quickly gained by losing altitude. Also, ridge-top landing areas require little maintenance and special drainage.

2. Landing areas in accordance with these specifications are considered safe for normal spot landings and take-offs, but if the area is to be used for autorotation landing the obstacle height should be lowered 25 feet from that shown in the tabulation below.

3. The minimum landing spot should be 200 feet in diameter, level and graded.

4. Clearing for landing approach and take-off paths should be located so helicopters can land and take off into the wind. Satisfactory cross-wind landings and take-offs are difficult when wind is gusty.

Distance from center of landing spot	Maximum permissible height above landing spot of obstacles in take-off and landing approach paths
Feet	*Feet*
100	0
200	3
300	14
400	29
500	47
600	63
700	79

Although exceptionally large and high obstacles between 700 and 2,000 feet from the landing spot and along the take-off or landing approach path are undesirable, clearing beyond 700 feet is unnecessary since the helicopter can take off or land in a continuous turn over a 700-foot diameter area.

With maximum gross weights, the helicopter travels on take-off from 75 to 100 feet on the ground cushion before it gains sufficient speed to leave the cushion, and climb with translational lift. Upon normal approach for landing its speed is checked and a ground cushion picked up as it comes within 200 to 300 feet of the landing spot. The helicopter is then eased over the spot and let down from hovering to the ground.

If the helicopter is equipped with high lift blades, suitable landing gear and brakes, running landings and take-off could be made with full design gross weight (4,900 pounds) up to density altitudes of 10,000 feet. This would require a landing strip, but a much shorter one than required for conventional airplanes.

First Use of Helicopter in Fire Suppression

Although it has been verbally reported that previous use has been made of a helicopter to patrol fires in Florida swamp lands, its first recorded use on a going fire by the Forest Service, as part of the scouting and transportation facilities, is now part of the record of the Castaic Fire, Angeles National Forest, Region 5.

On the third day of the fire, September 9, 1946, a Sikorsky R 5–A with standard blades, furnished by the 62d AAF Base Unit, March Field Detachment, and piloted by Lts. Chuddars and Frost, arrived at the fire just in time to carry George Reynolds, Angeles Forest Engineer, on a scouting and mapping expedition of an 800-acre break-over into the rugged and inaccessible Red Rock Mountain area. Within less than three quarters of an hour the helicopter was landed in a 200-foot clearing at the fire camp (abandoned Castaic CCC Camp) in the bottom of Castaic Canyon, and an unusually detailed and accurate map of the fire situation was delivered to the fire boss. With any other means, including conventional aircraft, much more time would have been required and considerable important detail could not have been obtained.

Several additional flights were made from the fire camp during the remainder of the afternoon, and information continued to be reported from the helicopter by radio. Because of high obstacles adjacent to three sides of the landing spot, all landings and take-offs were made from one side quartering into the wind.

On the morning of September 10, work in establishing a fly camp on the summit near Red Rock Mountain was begun. This camp was to be dropped in and supplied by air. Elevation was 4,000 feet (density altitude approximately 7,000 feet). Since the helicopter was not stripped and not equipped with the new high lift blades, it could not land with a reasonable pay load at the dropping area. However, Lieutenant Frost and B. O. Hughes (Assistant Regional Forester, Region 5) succeeded in delivering cargo which was released free fall close to the ground and at speeds under 15 miles per hour. Later in the day, Lieutenants Frost and Reynolds dropped clean socks literally at the feet of the weary firefighters.

Throughout September 10, helicopter reconnaissance of the perimeter of the break-over continued until all hot spots were manned. During all flights the helicopter was subjected to severe gustiness, updrafts, and downdrafts. Reports from pilots and passengers indicate that the helicopter was far less affected by these severe air currents than the twin-motored Beechcraft (AT–11) used in cargo dropping for the same fly camp.

Helicopter vs. Conventional Aircraft in Cargo Delivery

During the period of September 10 and 11, on the same Castaic Fire, 8,361 pounds of cargo (including chute and packaging) were dropped by the twin-motored Beechcraft (AT–11), which had been modified especially for this work. It required 9 flights averaging over 40 minutes each to deliver this cargo. From 5 to 7 passes of the dropping area were made to discharge each load. The average load was 929 pounds. It is estimated that approximately 800 pounds of each load consisted of equipment and supplies.

It is interesting to note the probable relative efficiency of a helicopter in this operation. Since the dropping area was a natural ridge top helicopter landing spot with density altitude of 7,000 feet, we find from table 2 that a stripped version of the R–5 (or S–51) with high lift blades could have easily carried 800 pounds of equipment and supplies on each flight and landed at the dropping area. By moving the air supply point from Newhall airport to the fire camp (Castaic CCC Camp), the flying time plus unloading time for the helicopter would have been from 15 to 20 minutes per 800 pound load. Besides the total time saved in delivering the supplies and in flying time costs, a considerable saving would have been made in packaging, cargo chutes, and preventing losses. At least five chutes did not open or failed during this operation, and equipment dropped free fall scattered considerably down the steep slopes.

Returning the fly camp equipment to a truck head is a costly pack animal project. A suitable helicopter could have transported it back to the main fire camp in approximately four 20-minute round trips. The transportation of men and supplies by suitable helicopter to the fire line is not discussed here. Such possibilities, however, were unlimited on more than 75 percent of the fire line for this particular fire.

Future of Helicopters in Forest Work

Although the information given in this article is insufficient for complete planning in the use of the helicopter, it is hoped that it will be inspiring to those who have long hoped for a successful machine. There is no doubt that there will soon be available helicopters suitable for forest fire control activities. Helicopters that will carry an adequate pay-load to the elevations with which we are concerned, and perform satisfactorily, have been field tested. It is expected that the several mechanical "bugs" now hindering the continuous operation of these ships will soon be eliminated. When this is done, the helicopter for forest-fire work will be ready to serve you.

Novel Method of Fire Area Measurement.—Region 5 reports a very ingenious method of measuring the size of a fire developed by one of their pilots. While flying across the fire at 120 miles per hour the observer presses his face against the window watching the trailing edge of the wing strut. As the strut crosses into the burn the observer calls "now" and another passenger begins timing with the second hand of his watch. When the other edge of the fire is reached the observer again calls "now" and the timing is stopped. Two flights are made in each direction to compensate for wind. In a case which was cited the data obtained was an average of 12 seconds one way and 6 seconds on the cross trip. With the speed of the plane at 120 miles per hour, 2 miles per minute, or 2.67 chains per second, it was determined that the fire was 32 chains long and 16 chains in average width. This indicated that the fire had spread over an area of 51 acres.

PRESCRIBED BURNING IN THE FLORIDA FLATWOODS

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This discussion of prescribed burning is based on experience and studies of the use of fire as a tool in the elimination of hazardous fuels in the longleaf-slash pine forests of the flatwoods section of Georgia and Florida. It does not cover other uses of fire in the silvicultural control of diseases in pure longleaf pine and other southern forest types. Most of the practices described will, however, be found applicable to other types of prescribed burning.

By definition prescribed burning is a distinctly technical measure and a potentially dangerous tool. Mr. Arthur W. Hartman, Chief of Fire Control in the Southern Region, sounds a note of caution when he says this employment of burning is "the application of fire to land under such conditions of weather, soil moisture, time of day, and other factors as presumably will result in the intensity of heat and spread required to accomplish specific silvicultural, wildlife, grazing, or fire hazard reduction purposes." Consequently, fires set for any other purposes or set without expert knowledge of fire behavior under existing conditions of weather, soil moisture, time of day, probable wind, etc., are definitely to be avoided. Uninformed and misguided efforts to burn are almost certain to produce disastrous results.

Successful fire protection in the long-leaf-slash pine forests of the southeastern flatwoods markedly changes the composition of the stand. Under protection, slash pine, instead of remaining confined to ponds and swamp margins, reproduces vigorously and invades drier sites formerly occupied almost exclusively by open stands of longleaf pine. The stand is thus converted from nearly pure longleaf pine to one in which slash pine predominates. This change in composition is sought and welcomed by most owners and operators of forest land because of the rapid growth of slash pine and its high value for naval stores and other products.

Unfortunately, increase in fire hazard accompanies this beneficial conversion to slash pine. Under fire exclusion the grass roughs become heavy. Needles and twigs add to the inflammability, while the gallberry and palmetto undergrowth increases in size and density. Conditions often become particularly hazardous in dense stands of slash pine 10 to 15 years of age, where dead needles may be draped over the high gallberry undergrowth and the lower dead branches in an almost continuous screen from the ground to the living crown 15 to 20 feet above.

When a fire starts in stands unburned 10 or more years it spreads rapidly and is hard to control. Such fires often cause extensive and

[1] Forester, Northeastern Forest Experiment Station (formerly of Southern Forest Experiment Station).
[2] Forester, Naval Stores Conservation Program (formerly District Ranger, Osceola National Forest).

severe damage and become so much of a threat to the landowner that he is likely to give up the idea of growing timber on his land.

To decrease the threat of such fires, many foresters and landowners in this section have resorted to prescribed burning of accumulated fuels at intervals under carefully selected weather conditions. Slash pine about 6 feet in height and longleaf over one year in age can stand slow-burning prescribed fires during the dormant season. Experience demonstrates that burns carefully planned and executed in this season may temporarily eliminate the hazard of accumulated fuels without serious injury to the timber stand.

Osceola National Forest, Florida. Dense slash pine 15 years of age. Note dead needles draped over gallberry undergrowth and dead lower limbs. Wildfire in such a stand almost always results in a complete kill.

Prescribed burning to reduce fire hazard affects fire prevention, detection, suppression, and other fire control activities. Its justification depends on reducing the total costs of fire control in which incidental damage caused by the the burning is considered an item of cost.

This paper describes methods of prescribed burning developed and used on the Osceola National Forest in northeast Florida, a tract of 168,000 acres typical of managed forests in the southeastern flatwoods. On this area fuel accumulated in dangerous quantities for 15 years, during which time the presence of small slash pine throughout the forest made fire treatments impractical. As the slash pine began to reach a size where damage from slow-burning fire would be minor, trial burns were made. On the basis of these trials and other observations, plans were laid in 1943 to prescribe-burn approximately 100,000 acres of longleaf-slash pine in the following 3 years.

In the first year 39,130 acres were treated at a cost of 7.9 cents per acre, of which 0.7 cent was for planning, 3.2 cents for preparations (chiefly plowing fire lines), and 4.0 cents were direct costs of burning. Costs the second year for 33,100 acres were 6.6 cents per acre treated; planning 0.7 cent, plowing 3.7 cents, and direct cost 2.2 cents.

Damage from the first year's operations was estimated at 31.4 cents per acre treated, and in the second year at 8.7 cents. Because of general drouth and few periods of ideal burning weather, the damages sustained during the first year were greater than anticipated. Damages during the second year were reduced somewhat by the added skill and experience of the men conducting the work but primarily by the more favorable ground water and weather conditions prevailing. By treating a maximum area during good burning years and a minimum during unfavorable years, future damage should be held to 8 cents per acre or less.

Forest managers throughout the South, who after careful analysis determine that the use of fire for some specific purpose is desirable, will find the methods used on the Osceola National Forest helpful in planning and organizing their prescribed burning.

Methods Used

Prescribed burning, to give maximum benefits at the least cost and damage, involves the following steps: Analysis, planning, preparation, burning, and appraisal. Each step is important and necessary.

Analysis

To arrive at a satisfactory decision whether to use fire, an analysis of forest conditions must be made which will permit a sound comparison between the probable costs and damage and the expected benefits. Direct costs can be satisfactorily determined from data such as given here and from similar operations in the same forest type.

In the flatwoods, benefits are mainly in the reduction of hazard and the consequent reduction in the possibility of large and destructive fires. Damage will depend to some extent on the weather during the burning season, but most of all on the training, skill, and experience of the personnel. Although prescribed burning in this section will be most important to fire protection, its influence on grazing, silviculture, logging, game, turpentining, and other forms of land use must be carefully considered. The advantages and disadvantages of the practice vary widely from property to property and no simple and precise method of evaluation can be suggested. The practice should be undertaken, however, only after a careful analysis has convinced the owner of the need or desirability of the practice on all or part of his holdings.

Once he has analyzed his property and decided to burn, the owner must determine which areas to treat. Areas burned should ordinarily be distributed so as to serve as temporary firebreaks. Prescribed burning of areas of high fire incidence is a double gain, for the areas not only become safe themselves but also act as firebreaks. The detailed location of burning units should be decided only after field examination as described in the following section.

Planning

The prescription or plan is a most important phase of prescribed burning, distinguishing it from unorganized and often destructive use of fire. The prescription is prepared in the field at the time of examination. It specifies when and how to spread fire to achieve the greatest benefit.

The first step in planning is to make a field examination to secure the necessary data. On the Osceola National Forest experienced and responsible forest guards made the examinations under the direction of the District Ranger. In planning the use of fire on extensive areas, maps are prepared to show natural fire barriers, fire line locations, burning direction, areas to be excluded, usable roads and trails, and

Osceola National Forest, Florida. Slash pines gradually seeding in a former longleaf pine "ridge." Such stands cannot be treated successfully under prescribed burning because of excessive mortality in the crop trees below 6 feet in height.

other useful information. The examiners on the Osceola used aerial photographs for base maps on which to record such information. On small properties detailed examination and mapping may be unnecessary.

The size, abundance, and distribution of crop trees[3] determine where and how fire can be used. Small slash pine is easily fire-killed and extensive areas of slash pine crop trees under 6 feet high should not be burned. When the crop trees are slash pine 1 to 3 inches in

[3] In this work, the best trees at an average spacing of 10 feet were considered crop trees and smaller intermediate or suppressed trees were disregarded in planning the burning and in evaluating the results.

diameter at breast height, or longleaf from 1 year old to 3 inches in diameter at breast height, a backfire, that is, fire set to spread only against the wind, in the dormant season under proper weather conditions may be safely used. With crop trees 4 inches in diameter at breast height, or more, a flankfire is safe. A flankfire, set to burn at right angles to the wind, spreads faster and burns hotter than a backfire. Flankfires in such stands are cheaper to use and generally cause less damage than backfires. In the Florida-Georgia flatwoods, where young slash pine is common, a backfire is the usual prescription. On the Osceola, many stands otherwise suited for flankfire contain scattered groups of slash pine crop trees 1 to 3 inches in diameter at breast height, usually making it necessary to prescribe a backfire.

Small patches of slash pine crop trees under 6 feet high are often found in stands otherwise suited for burning. Whether to burn them with the rest of the stand or plow around them and exclude fire depends on the size of the patch, the number of small slash pine crop trees it contains, and its nearness to the fire lines needed to burn the rest of the stand. The tabulation below shows the smallest size patch found worth excluding on the Osceola National Forest. Smaller areas were often excluded when only a slight change was needed in the location of a plowed line.

Maximum area to exclude	Slash pine crop trees per acre under 6 feet tall
Acres	*Number*
6	50
5	70
4	95
3	135

The prescription first specifies type of fire, for all other steps depend on it. It then recommends preparatory work, mainly plowed lines to control the spread of the fire. Exterior barriers must be provided for all burning units; roads and streams should be used where possible to reduce plowing cost. Flankfire requires interior parallel lines about one-half mile apart to avoid too long a flank. Backfire requires a similar series of parallel lines close enough together that the area between them will burn out in the burning period. Backfire spreads about 1 foot per minute, and so 600 feet is the maximum distance between such lines unless more than 8 to 10 hours burning is planned. Since northerly winds are least variable, these interior lines are usually plowed in an east-west direction.

For most purposes the season for using fire is the late fall and winter after the first frost (about November 15) and before the beginning of needle growth in the spring. Prescribed burning should be completed before the start of the spring fire season, about March 1. It is desirable to burn as much as possible in wet years when the ponds are full of water. Day burning is easy to supervise and to do correctly, but night burning is necessary when minimum fire intensity is required. Plan to burn only when constant wind direction is forecast. As wind shifts and break-overs are the greatest source of damage, good burning

conditions are found when there is a 3- to 10-mile northerly wind in clear weather immediately after rain. Wind direction is commonly variable in the unsettled weather previous to rainfall. Wind shifts are also likely around noon and sunset. On the Osceola the northerly winds which prevailed 1 to 3 days after rains were the most reliable.

The prescription should also cover the size of crew and equipment needed. Motor equipment is used mainly to plow lines and to transport men and tools. Spreading and mop-up tools are needed for the burning job, and ample fire-suppression tools should be available in case of break-overs. Crew size is influenced principally by considerations of cost and safety. It is seldom safe to attempt prescribed burning with fewer than 3 men. Reasonable cost in relation to benefits requires that at least 10 acres be treated per man-hour; thus a crew of 5, including the leader, should treat at least 400 acres in an 8-hour day. Such a crew on the Osceola National Forest burned 500 to 1,000 acres per day (12½ to 25 acres per man-hour) setting as much as 10 miles of backfire and providing the needed mop-up and patrol. This crew was large enough to vary duties to meet particular fuel and weather conditions. At night, with no patrol, smaller crews may be superior, while if mop-up is needed it is better to have extra men than to take some away from the work of spreading fire. Continuous day and night burning can be used, if relief crews are available, to lower costs under exceptionally favorable conditions of weather, fuel, and stand. Good prescribed burning requires that crews be relieved after 8 hours of work.

All preliminaries and plans for burning should be completed by early fall to eliminate haste and consequent poor results.

Preparation

Preparation for burning consists mainly in plowing the lines provided for in the plan. Enough lines are plowed in advance to permit choosing one of several units on the burning day; yet, to prevent fallen needles and leaves from weakening the lines, plowing ordinarily should precede burning by not more than two weeks. Lines should be carefully located to minimize break-overs from hazardous fuels such as snags and thickets of gallberry. A two-disk plow such as the Mathis, drawn by a light tractor, will prepare a line about 6 feet wide at a cost of about $3.25 per mile. With several hundred miles of line to plow, such equipment is indispensable. Plowing and burning in one operation is inefficient since a line can be fired 3 times as fast as it can be plowed.

Burning crews should be selected and trained well before the start of operations. The plow operator needs to know how to read maps and aerial photographs and where lines should be located as well as how to operate and service his plow and tractor. Crewmen must be taught how to fire in relation to plowed line and hazardous fuels. Mop-up standards, changes to meet wind shifts, provisions in emergencies, etc., should be clearly understood by all. This training should be continued as long as necessary after burning starts. The continuity afforded by having the crew foreman examine, map, plan, and plow is desirable but seldom possible.

Reliable weather forecasts improve the quality of burning, and arrangements should be made to receive daily forecasts of wind direction and velocity, relative humidity, precipitation, and general state

of the weather. Forecasts twice daily at 12-hour periods are best; the first should be received by 8 a. m., before departure of the work crews, and the second before the usual quitting time.

Burning

Each day during the burning season the manager, guided by weather forecasts and experience, decides whether or not to burn and selects the best unit for conditions expected. With favorable weather low costs are achieved by spreading fire rapidly to increase area burned per man-hour.

To complete the burning job, the area should be mopped-up to prevent break-overs. The extent of mop-up will depend on the amount of dangerous fuels and on weather conditions.

Appraisal

Appraisal following burning may consist simply of field checks, or it may be a careful evaluation of both injury and benefits for the whole area. When crowns are not scorched above half their height, damage is minor: a few small trees are killed and growth on others is slightly reduced for a year or two. Scorching more than four-fifths of the crown results in excessive mortality and a sharp temporary reduction in growth rate of the survivors.

Recommendations

Prescribed burning methods used on the Osceola National Forest have been briefly described; the most important suggestions follow:

1. Use fire only when analysis reveals benefits should clearly exceed cost and damage.

2. Correlate prescribed burning with silviculture, grazing, game, crops, logging, turpentining, etc.

3. Prepare in advance (examine, map, plan, plow, etc.) so as to be ready when burning conditions are right.

4. Arrange for weather forecasts, especially of wind direction. A steady wind during the 8 to 10 hours required to burn a unit is of first importance in minimizing cost and damage; burn only when a constant direction is forecast for at least 12 hours.

5. Reduce costs when burning conditions are especially favorable by: (1) spreading backfire rapidly to have 10 or more miles burning at one time, and (2) using relief crews to take full advantage of favorable burning weather.

6. A competent crew is essential; it should be small and composed of reliable local men experienced in fire behavior and control.

7. The forester, to achieve efficient and successful prescribed burning, must use his intelligence, courage, patience, and determination.

OUTLINE FOR ANALYSIS OF FIRE PREVENTION ACTION AS APPLIED TO A PARTICULAR FIRE

All experienced fire control men agree that the most successful fire control job of all is the fire that was prevented from starting. We all give lip service and routine support to preventing fires, but too often we do not get down to cases and carry through on systematic plans and skillful application of lines of action to get real solutions. We need to cultivate the habit of regarding each preventable fire as a challenge to our resourcefulness and as a blot on our record. It is a game worthy of our best talent. The best solution often calls for more head work than figuring out the "who done it" in Sherlock Holmes style. "Who" is only one step. The even bigger job to every land manager is to arrive at "It won't happen here." That requires lots of team work!

In California, a great deal of thought and planning is now being given to the problem of arriving at this goal. In the process, Region 5 has devised an outline to guide the preliminary process of making a systematic analysis. If well carried through on a series of fires, one at a time, a sound plan of action geared to the local situation ought to evolve naturally. Here is their chart. Try it out, then see if you can devise a better one!

CAUSE

Get detailed facts of this. Seek basic cause that led to statistical cause.

- I. Preventable
  - A. What known fire prevention techniques were applied in this case?
    - 1. How identify hazard.
    - 2. Physical methods for abatement of hazard.
    - 3. How approach agency or person responsible.
    - 4. How inspire person or agency to undertake abatement.
      - a. Discussion.
      - b. Examples.
      - c. Sample demonstration.
      - d. Cooperative assistance.
    - 5. Enforcement methods possible to insure abatement.
      - a. Punitive measures (shut-down, etc.).
      - b. Cancellation of permit.
      - c. Legal action.
  - B. What is Forest philosophy concerning application techniques?

	a.	b.	c.	d.
1. How do	Supervisor and Staff.	Ranger.	FCAsst.	Guard.
2. What do	Supervisor and Staff.	Ranger.	FCAsst.	Guard.
3. When do	Supervisor and Staff.	Ranger.	FCAsst.	Guard.
4. Who do	Supervisor and Staff.	Ranger.	FCAsst.	Guard.

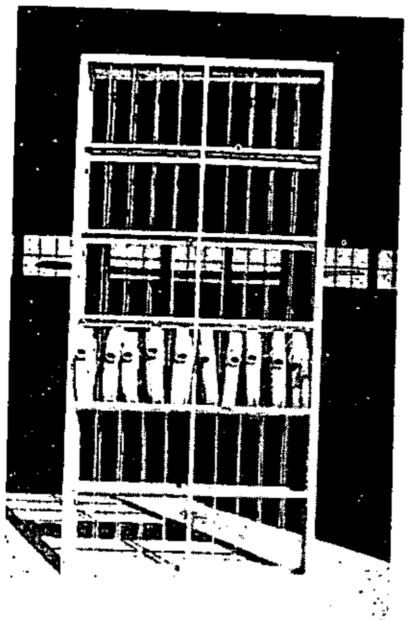
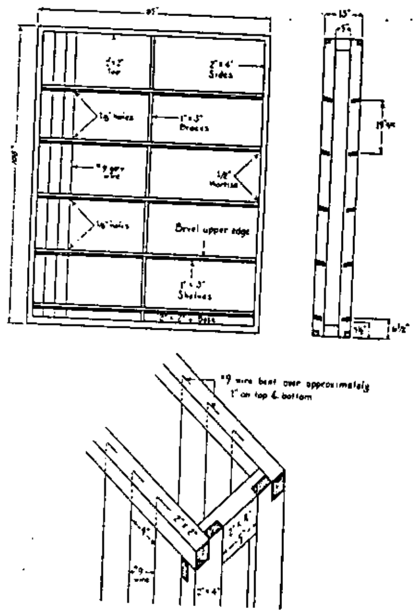
  - C. What actions taken in this case?
    - 1. Identify actions taken in accordance with A and B above.
  - D. Quality of actions taken?
    - 1. Positive
    - 2. Casual
    - 3. Negative

      Identify by facts.
  - E. Why did action fail?
    - 1. Follow constructive reasoning in arriving at conclusions.
  - F. How improve future action?
    - 1. Philosophy of responsibilities for action at all levels in B.
    - 2. Approach to agency or person responsible.
    - 3. Inspiration to agency or person responsible.
    - 4. Physical methods of abatement.
    - 5. Techniques, including identification of hazards.
    - 6. Application of enforcement measures.
- II. Nonpreventable Why?

HOSE STORAGE RACK

L. A. HORTON
District Ranger, San Bernardino National Forest, U. S. Forest Service

A hose storage rack developed on the Mill Creek ranger district has found favor throughout the San Bernardino National Forest. It permits the maximum amount of storage with the use of the minimum amount of floor space. It also allows the hose to be well ventilated and permits easy removal and replacement of hose.

Storage rack with capacity of 3,000 feet of 1½-inch hose; and diagram of storage rack with capacity of 5,000 feet of 1½-inch hose.

Dimensions may be changed so that a rack may be constructed to fit the available floor space. The photograph shows a rack that has a storage capacity of 3,000 feet of 1½-inch C. J. R. L. hose and occupies a floor space of about 4½ square feet. The rack in the diagram has a capacity of 5,000 feet and occupies 8 square feet of floor space.

The rack is constructed by building two identical units (front and back) and fastening them together with 2- by 4-inch blocking as shown.

Bill of material for a rack of 5,000 feet capacity:

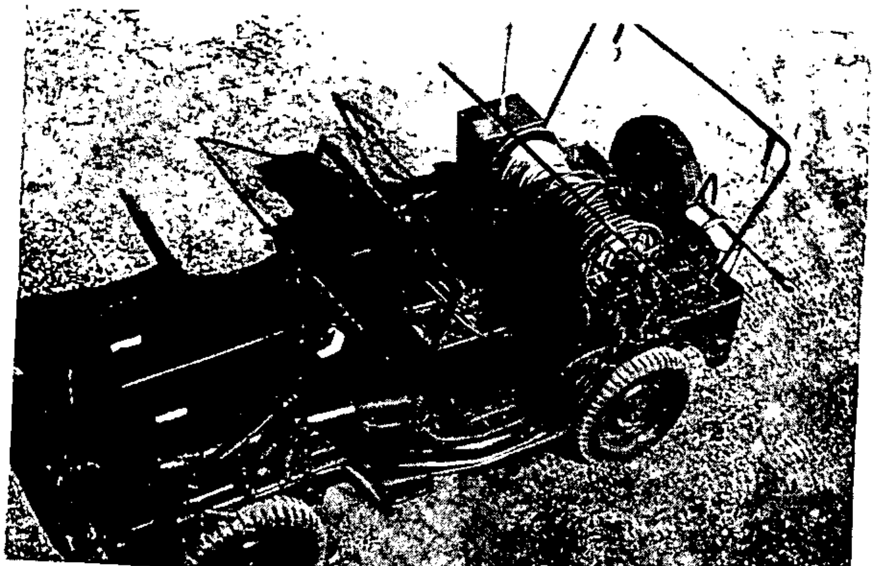
325 feet No. 9 galvanized wire.
4 pieces 2'' x 4'' x 9' (sides).
1 piece 2'' x 4'' x 5' (spreader blocking).
4 pieces 2'' x 2'' x 7½' (top and base).
2 pieces 1'' x 3'' x 9' (shelving brace).
10 pieces 1'' x 3'' x 7' (shelves).

JEEP TANKER

H. M. WHITE
Equipment Engineer, North Pacific Region, U. S. Forest Service

Region 6 has equipped five ¼-ton jeeps with water equipment and assigned them for the use of patrolmen in areas of special hazard. One is equipped with VHF radio and the others will be as soon as additional radios can be obtained.

The tank holds 60 gallons and was constructed to fill the space behind the seats. It is rectangular in shape, except that the front side is slanted to conform to the seat backs and the bottom is recessed at each side to fit over the snubber housing. A live reel, carrying 150 feet of ¾-inch garden hose, and a dead reel, with 150 feet of 1-inch rubber-lined hose, are mounted on top of the tank. The KUT-KUR radio is mounted at the end of the dead reel, with the antenna extending through a slit in the top. A canvas flap protects the radio controls when not in use. The microphone is mounted between the reels.

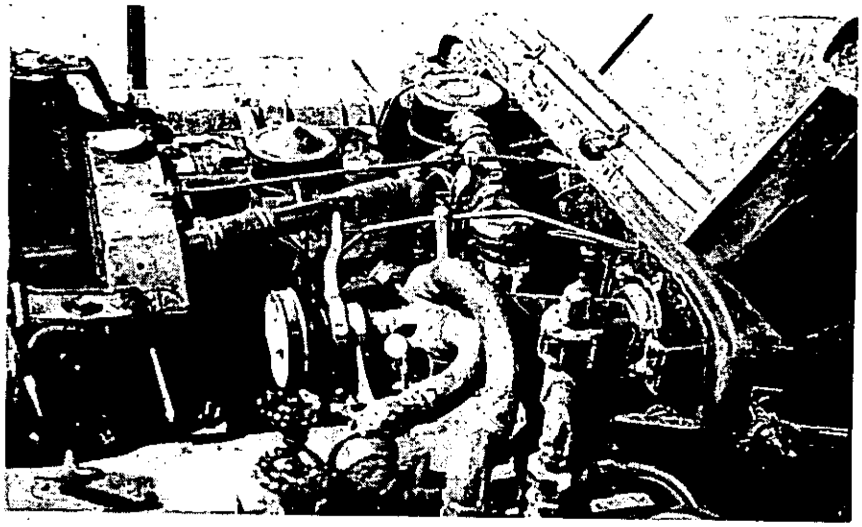


Tanker from above, showing part of tank, hose reels, pipe connections, suction hose, radio, back-pack can and pump, and spare tire.

It seemed better to mount the pump on the inside of the fender than to make the changes that would have been required to mount it on the engine block. The mounting chosen required a change in the

lower radiator connection to avoid interference with the fan belt. An intake outlet, with trap, and a 1-inch discharge outlet are provided at the front.

The intake line from the tank and the discharge line to the live reel are made of 1-inch copper pipe, obtained from Navy salvage. The valve arrangement permits filling the tank through its outlet to



Fan-belt pump, with intake and discharge connections, bypass valve, and pressure gage.

the pump. The only practicable place to carry the 1-inch suction hose is on the hood, as shown.

The fire equipment carried consists of Pulaski, No. 0 shovel, back-pack can and pump, canvas bucket, 1-gallon canteen, and headlight. The mounting for the back-pack pump was changed after the pictures were taken, because if mounted on the can, as shown, it would be subject to damage. To avoid this, clips were installed on the top of the tank immediately in front of the can and spare tire. The shovel and Pulaski are mounted on the right side of the truck body above the rear wheel. The other articles are carried in the glove compartment, between the seats, and under the right hand seat. A low box between the seats would, no doubt, be convenient for small articles.

Preventing gumming of back-pack pumps.—An excellent preventative for sore and aching arms and gummy back-pack plunger barrels was offered by Fire Control Assistant Davis of the Descanso District, Cleveland National Forest. By cleaning the plungers with solvent and then rubbing them with a bar of soap, they do not become gummy or dirty and, during use, furnish their own lubricant.—REGION 5.

PRELIMINARY REPORT ON AERIAL DETECTION STUDY

R. L. HAND and H. K. HARRIS
Foresters, Region 1, U. S. Forest Service

This paper reports a study to determine the most economical combination of ground and air detection, based on percent of coverage and frequency of observation. It does not attempt to prove that air detection is or is not superior to ground detection. Such proof would require the study of many additional factors.

Among the various uses of airplanes in fire control work in the western regions, aerial detection must be regarded as something of an anomaly. Although initiated nearly thirty years ago and used more widely than any other type of air service, it is generally regarded as merely an adjunct and in no sense a substitute for the old-fashioned ground or fixed detection system. Other uses of airplanes in fire control, such as the hauling of freight and passengers, cargo dropping, and aerial photographic mapping have been analyzed and compared with the older methods on cost and efficiency basis. So has smoke jumping in recent years. In every instance it has been found that each of these services has paid its way in better results or lower costs under given conditions.

It is our belief that the development of aerial detection has been hampered and delayed because of the traditional attitude toward so-called air patrols, though they have been, it is true, pretty much of a hit-or-miss proposition in the past. There are certain clearly recognizable, but not necessarily inherent difficulties and limitations in spotting fires from an airplane and these seem to have influenced the belief that no common ground could be found on which to base comparisons between air and ground detection. This study was to find a common ground and make comparisons.

Planning the Aerial Fire Control Experiment

In 1945, Region 1 embarked on an aerial fire control experiment involving some two million acres of inaccessible forest land. Ground detectors were reduced to a skeleton force and suppression was handled largely by smoke jumpers within this area, which, because it lies astride the Continental Divide, is usually referred to as the "Continental Area." This forest was selected not because it is especially adapted to the practical use of air detection, but merely to illustrate the principles involved.

In carrying on this experiment it was found that some system on which to base the comparisons was necessary. This resulted in a detailed study, the purpose of which was to determine at what point air detection should be substituted for ground detection on a sound economic basis. The preliminary findings are presented here with the full realization that they are tentative and incomplete. It will require at least several seasons of cautious and painstaking application of

the indicated principles on an experimental basis before we are ready for an all-out regional aerial fire control plan.

Standards for Comparison

As a basis for evaluating ground detection, Hornby's detection coverage curves were used. (See "Fire Control Planning in the Northern Rocky Mountain Region" by L. G. Hornby, page 73, fig. 20.) The average of these curves, when projected outward, indicates that in Region 1 approximately 500 lookout stations per million acres would be required to give 100 percent coverage. While absolute, complete coverage even with this number of lookouts is of course theoretical, it is reasonable to expect that a detection force of that intensity would give at least 95 or 96 percent, which for all practical purposes may be regarded as full coverage.

In addition to establishing a fixed point for the maximum degree of coverage, it was necessary to arrive at certain standards of frequency in observation that could be applied to both ground and air detection. Obviously, what we have thought of as constant detection is not constant at all, since no lookout can possibly see all of his visible area all of the time. A ground detector might be expected to spend 15 minutes of each daylight hour in actual observation, more constant observation being too severe a strain on the eyesight of the average individual. To put it in another way, all of the lookout's seen area comes under direct observation once each hour during the daylight period, which, for convenience, has been set at 16 hours per day as a maximum. This is closely in line with common practice in Region 1. The actual frequency is much greater than indicated because of the enormous overlap in visible area. This is equally true in air detection. Frequency of observation, combined with degree of coverage were thus set as the standards to be applied for comparison between air and ground detection.

To establish a curve for air detection that can be directly compared with the ground-detection curve, it was necessary to determine the total hours of flying required to maintain the hourly observation frequency rate over a 16-hour period. This was done in the following manner:

First, sample blocks representing different topographic types were selected from three widely separated areas, and these were profiled to determine flight courses and degrees of coverage obtainable (see A). Flights were projected across the sample areas, and by means of the profiles, seen area was computed for each trip until approximately 100 percent coverage had been obtained. By this means, fixed points could be established upon which to base an air detection curve. Flight time was computed for each trip, using an average ground speed for the slow planes used for present-day detection patrols, and the total applied to the million-acre unit by means of a conversion factor.

In working out the sample units representing different types of terrain, it was determined that from three to five trips, depending upon adaptability of the topography to air detection, would give from 95 to 99.4 percent coverage. Refinements made during later studies indicate that these percentages are conservative. Thus, the number of flying hours required to meet the frequency standard can easily be determined and a curve established that can be compared directly with

Hornby's curves based on the ground lookout system. The profiles were made at 1-mile intervals, approximately across the lines of flight, and from these profiles the final courses and flight altitudes were established to give the maximum coverage with the minimum amount of flying. Fuel types, special risk areas, contributed coverage (that seen from fixed lookouts), and the influence of topography on flying conditions often require adjustments, and these factors can all be given consideration when the profiles are made. Studies are under way at present to refine these "seen areas" by the addition of angle profiles, although it is of course realized that any appreciable degree of refinement must be followed up by adequate provision for the intensity of observation needed—probably requiring two observers on the more intricate courses. The profile method of determining flight courses and altitudes was used in the Continental Area during 1945 and 1946 with apparent success.

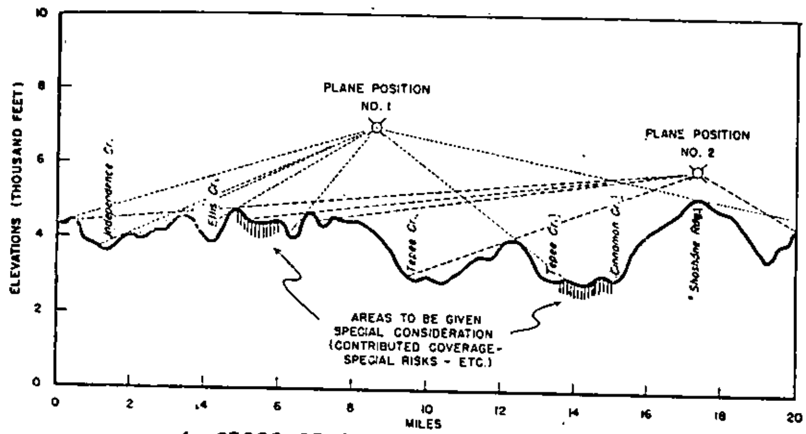
Cost Comparisons

As plotted on a cost basis, the air detection curve quite naturally starts at a higher level but increases at a lower ratio than the ground detection curve, and this is true up to a very high degree of coverage. With the ground organization, it has been determined that even under the most favorable conditions and where the justification is greatest, about 80 percent coverage is the limit that can be attained economically. Therefore, by plotting the two curves on a similar scale, it is possible to show graphically the theoretical point at which ground detection should be discontinued and air detection taken up to meet any particular situation.

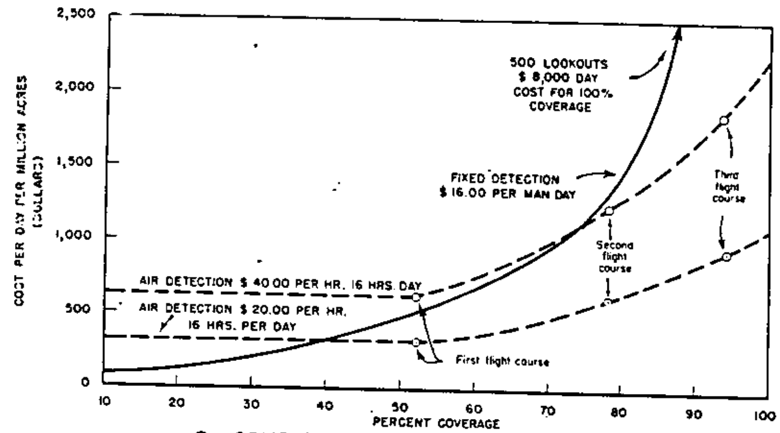
The detection data for ground coverage as worked out for the Coeur d'Alene Forest were used. For the past 7 years all forests in the region have had their fire control plans based upon an established rating for warranted degree of coverage, and that rating for the Coeur d'Alene is set at 79 percent. This means that the forest should have 79 percent of its area under direct visibility within an 8-mile radius when the danger class has reached 70, indicating the need for a full, normal-season organization. To obtain that degree of coverage in this instance requires the manning of 88 lookout stations per million acres, at a present-day cost of $16 per man-day for salaries and subsistence, and including prorated overhead.

We have no definitely fixed per-hour rate for air detection to correspond with the $16 per day ground detector rate. Forty dollars per hour is the present rate for our contract Travelairs, the planes we frequently use for patrol because they will also accommodate two fully equipped smoke jumpers. As nearly as we can determine, $20 per hour is a liberal rate at present prices for fully adequate types of ships for straight observation flights over mountainous terrain. Rates will vary greatly according to conditions and in an actual case it would be necessary to determine the rate specifically for the area under consideration.

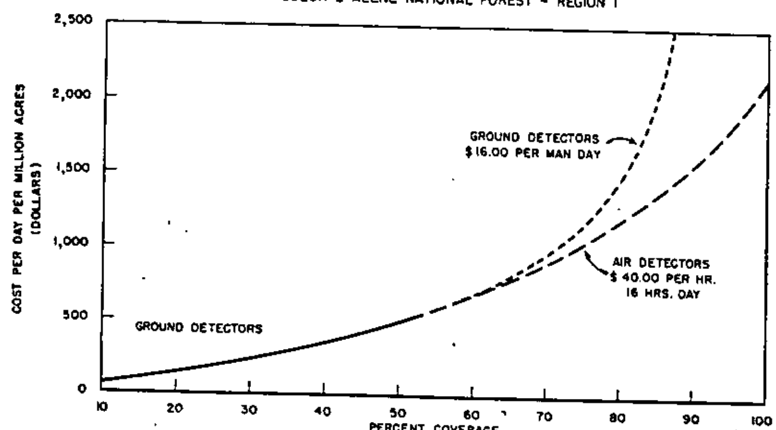
Now let us see what happens when we apply the corresponding air detection coverage on a cost basis (see B). It costs so much to put one plane in the air and to maintain the desired frequency standard that below 52 percent coverage there is no reduction in cost. One flight course, properly selected, will give 52 percent coverage. Subsequent courses add relatively less, as would be expected, although



A.- CROSS-SECTION PROFILE - AIR DETECTION



B.- COMPARISON OF AIR AND FIXED DETECTION
COEUR D'ALENE NATIONAL FOREST - REGION I



C.- COMBINATION-AIR AND FIXED DETECTION
COEUR D'ALENE NATIONAL FOREST - REGION I

the point of diminishing returns is met at a much higher percentage level than with ground detection, because of the flexibility of the air coverage. It was found that adding a second flight increased the coverage to approximately 78 percent, while a third flight brought it up to 93.5 percent.

Any interested person can determine a specific rate for his particular area and figure the comparative costs from the chart by interpolation. At $40 per hour for flying time (cost to include time and expense of observer as well as overhead elements) the air detection curve crosses the ground detection curve at 73 percent, which indicates that all coverage in excess of this figure can be obtained more cheaply by air patrol. At $20 per hour the corresponding figure is 39 percent.

These direct comparisons indicate what might be expected if air detection was substituted for the fixed lookout system. However, the most economical method would be a combination of the two, and the cost relationship can be determined by observing where the ground detection curve becomes steeper than the corresponding air detection curve (see C). Using the $40-per-hour figure, we find that fixed detectors should be placed in sufficient intensity to give about 55 percent coverage, which requires 37 positions per million acres. Further reference to the same chart indicates that the remaining coverage required to build up to 79 per cent can be obtained by air patrol at a saving of approximately $250 per day.

These comparisons are based upon a high frequency rate of observation (15 minutes per hour). Such rates would not always be necessary, particularly in areas of low occurrence and low hazard. Even in the more critical units, there is a chance for great savings over and above those shown by the direct comparisons. The cost of a ground lookout system in isolated areas goes on day after day, hour after hour, even during those times when the danger has been temporarily relieved and detectors are not needed. In the air detection plan only the few observers are a fixed charge. On safe days planes are grounded or used for other purposes, and on many other days of low danger the frequency of observation can be drastically reduced. Also, it is evident that greater flexibility will allow vulnerable spots and critical situations to be covered with far greater intensity with air patrol than with the conventional ground detector system.

Another and probably much greater source of savings should not be overlooked. Even a moderately intensive ground detection system involves a large investment in improvements, servicing facilities, and other elements not included in the foregoing analysis. In the Continental Area, for example, some 40-odd ground positions were eliminated, 32 of these being detectors. The cost of maintenance and replacement of living quarters, observatories, transportation and communication systems that were needed simply to service this organization amounts to considerable. To this should be added the operating and upkeep costs of pack stock, trucks, and warehouse space, together with the servicing personnel and the additional overhead required to recruit, train, and supervise a force of 40 men scattered over 2 million acres of roadless wilderness. Such considerations, while not included in the data, may be regarded as tending to balance some of the real or ostensible advantages of ground over air detection.

INSTRUCTION FOR PRESERVATION OF FIRE EQUIPMENT BY ARMY METHODS

NELS H. ORNE, *Engineer*
Forest Products Laboratory, Madison, Wis.

During the war years the Matériel Containers Division of the Forest Products Laboratory conducted corrosion experiments in conjunction with the Army Service Forces in which the use of various corrosion preventatives were studied. This article, or set of instructions, was prepared at the Laboratory at the request of the Division of Fire Control, after the author had completed a detailed report entitled "A Study of Army Service Forces Methods of Preservation for Use With Fire Control Equipment.". The use of these methods for various types of fire tools should greatly reduce the substantial losses resulting from deterioration. The Laboratory maintains lists of the suppliers of these preservatives and can furnish names upon request.

Army Service Forces methods of preservation were developed for many types of equipment and varied field and storage conditions. Preservation methods were based on the nature and function of the surfaces needing protection, as well as the types of exposure and degree of preservation desired.

Of the various preservatives available a number are considered suitable for fire control equipment. They may be readily applied with limited facilities.

The nature of the surface is one of the important considerations. Surfaces classified as noncritical, those which are not highly finished or operating surfaces, may be treated with a hard-drying, thin-film preservative. This category includes surfaces of hand tools such as shovels, axes, and brush hooks, as well as larger surfaces like those on fire line plows and other power equipment. For surfaces that are classified as critical, a soft, thick-film preservative is suitable. Critical surfaces include highly finished, operating, or machined surfaces, such as the external moving parts of pumps, plows, and power equipment, and cutting surfaces of saws, augers, and like equipment. Preservative lubricating oils are available for internal surfaces of engine assemblies and pumping equipment.

Cleaning Before Preservation

All equipment, in order to be effectively preserved, requires satisfactory precleaning. The degree of cleaning depends entirely on the character of the surface to be preserved. Noncritical surfaces can be cleaned for preservation with steel wool or a wire brush. Grinding is satisfactory, where adaptable. It is also advisable to soak or wipe the areas with a petroleum solvent or kerosene before applying the preservative. Critical or operating areas should always be wiped or soaked clean with a petroleum solvent before preservation. Crocus cloth is recommended for removal of corrosion in the cleaning process.

Preservation of Noncritical Surfaces

The hard, thin-film preservative recommended for preservation of noncritical surfaces dries to a coating the consistency of wax after application and the evaporation of the solvent in it. The preservative is available under Army Ordnance Tentative Specification AXS-673, Compound, Rust Preventive, Thin Film, and also under Army-Navy Aeronautical Specification AN-C-52, Compound, Exterior Surface, Corrosion Preventive, type 1. Although the preservatives available under the two specifications are basically the same, AXS-673 appears to offer the harder film. Equipment treated with the preservative can be used without its removal, although this should be governed by the use to which the equipment is put. The preservative is applied cold, either by dipping, brushing, or spraying. It is removed, where necessary, by soaking in kerosene. This removal can be accelerated if brushing or wiping is used in conjunction with the kerosene bath.

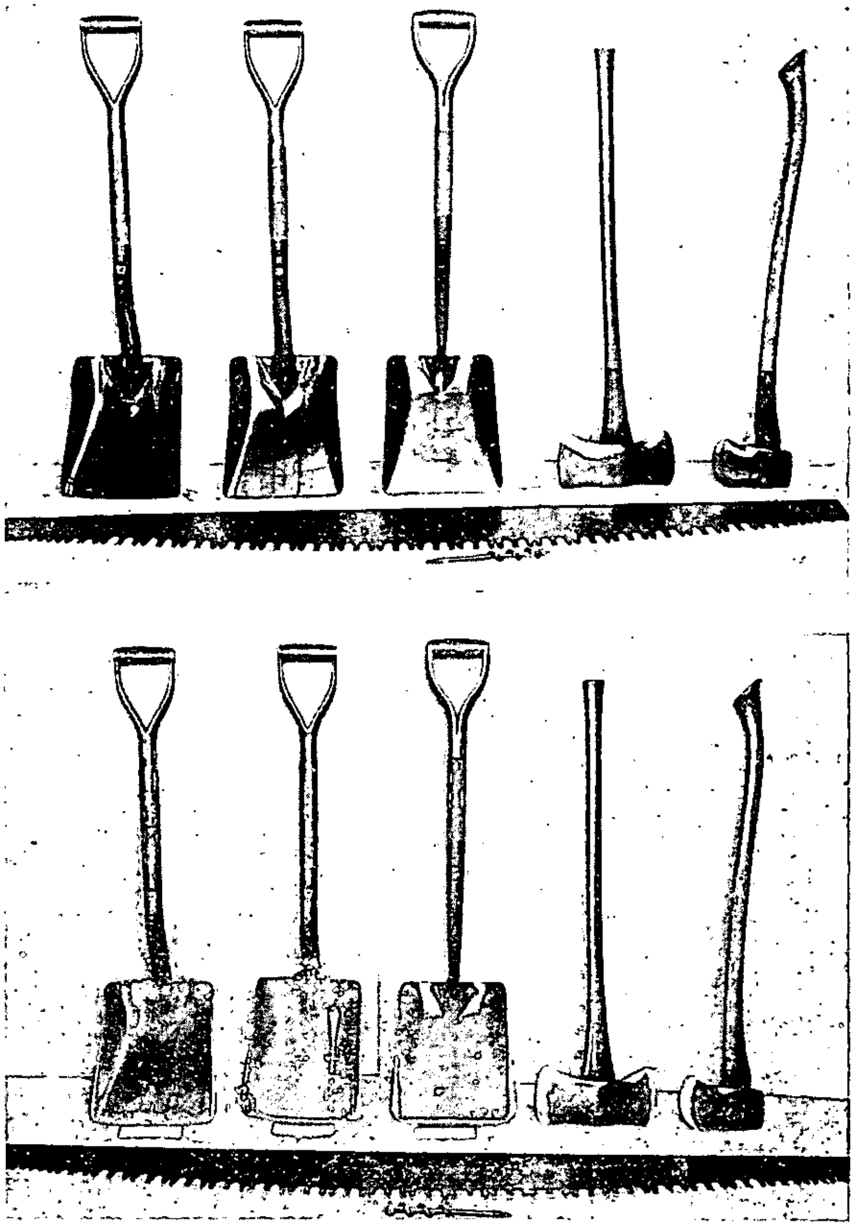
Preservation of Critical Surfaces

The soft, thick-film preservative recommended for use on critical surfaces is available under U. S. Army Specification 2-84, Compound, Rust Preventive, Light. It is a soft grease which may be applied cold by brushing at temperatures above 60° F. or by dipping in the preservative, where the size of the piece of equipment permits, with the preservative at 130° F. Surfaces coated with this preservative should be covered with a greaseproof wrap of any grade or type to facilitate handling. The soft consistency of the preservative permits the removal of a major portion of it by wiping without the use of a solvent, and complete removal by soaking in kerosene. Brushing and wiping while in the kerosene bath will accelerate the removal of this preservative, especially on parts hard to reach.

Preservation of Internal Surfaces

If an engine or motor is to be stored, the preservative most suitable for its internal surfaces is a lubricating oil containing a rust inhibitor. A preservative recommended for internal combustion engines is available under Army Ordnance Tentative Specification AXS-934, Oil, Engine, Preservative. The preservative is available in grade 1, equivalent in viscosity to SAE 10, and grade 2, equivalent to SAE 30.

Gasoline engines which have been operated on leaded gasoline must have their fuel tanks and crankcases drained and the engines then operated on unleaded, undyed gasoline for a 10-minute period, with the crankcase filled with grade 1 preservative. If the winter grade of oil, SAE 30, is specified because of special conditions, grade 2 preservative should be used in the crankcase. Where the engine has been operated on unleaded gasoline, the run period should be reduced to 5 minutes. Upon completion of the run period, seal the breather opening to the crankcase and drain the fuel and water-cooling systems. Seal openings after draining. Tape conforming to Joint Army-Navy Specification JAN-P-127, Tape, Adhesive, Pressure-Sensative, Water Resistant, type II, grade B, is recommended for sealing the openings.



Hand tools treated with preservative AXS-673: upper, before being put to a use-test; lower, after.

Attach a red tag to the oil filler cap; tag to read: "CAUTION—This engine has been treated for storage ———— (Date), and contains preservative engine oil. Drain and refill with seasonal engine oil before putting into service."

For protection of internal operating surfaces other than in engine assemblies, a preservative available under U. S. Army Specification 2–122, Oil, Lubricating, Preservative, Medium, is most suitable. This oil is an inhibited lubricating oil of vicosity SAE 30. It may be applied by dipping, brushing, spraying, or pouring into the interior surfaces. The preservative may also be used where an exterior surface coating is desired, although for satisfactory protection the piece of equipment should also be packaged in a waterproof package.

Army Range Finder Impractical for Fire Detection.—During the 1946 fire season Region 3 tested a standard U. S. Army Range Finder M–1916 for its usefulness in fire detection work at a tower in the Cibola National Forest, N. Mex. Because of its 1-meter square base and large mount the range finder could not be placed in the tower cabin. It was set up in the open at the base of the tower, thereby forcing the lookout to descend and ascend the tower for each observation. It was usually necessary to move the range finder to a different location for each smoke because of obstructions in the line of sight at the tower base.

The actual method of operation of the instrument is quite simple, and can be taught in a few hours to any individual of normal intelligence and normal vision. Unlike a transit or level, however, an abnormal amount of assiduous daily practice for several weeks or more is required before satisfactory competence can be attained. This is due to the manner in which the observation is taken. An accurate observation demands that an inverted image and an erect image of the target be brought just to, or only very slightly equidistant from, a horizontal line, and simultaneously in line vertically. Inexperienced observers may be surprised to find two successive observations on the same target give a difference in range of as much as 2,000 yards. Even experienced observers seldom obtain the same range on successive observations. In battle use, observers usually take five observations, select the two closest together, and use the mean range between these two.

The range scale on the finder reads from 400 to 20,000 yards, or roughly ¼ to 11 miles. The lower limit is no handicap. The upper limit, however, is somewhat less than the normal visibility in Region 3. Also, slight adjustments in alinement of images can change the range of a distant fire 1,000 yards.

The type of target usually encountered in fire detection adds to the possibilities of error. Battle observers try to pick sharp, well-defined objects such as buildings. The lookout, however, normally has a poorly defined target: a smoke column where it meets the ground or horizon. Such a target is almost impossible to bring into proper alinement.

From the experience in Region 3 with the Army Range Finder M–1916, these conclusions are drawn:

1. The amount of training and practice needed to insure a satisfactory standard of competence limits the use of this instrument to cases where observers will be more or less permanent.
2. Reasonably accurate observations of range were made on a maximum of 50 percent of fires within 5 miles of the lookout, and a maximum of 10 percent beyond 5 miles.
3. The size, shape, and character of the instrument itself makes its use very inconvenient at the average lookout.
4. The inspection, performance testing, maintenance, and repair needed to keep the instrument up to a satisfactory standard will add appreciably to someone's work load and will be expensive because it would require specially trained men.

W. Ellis Wiltbank, *Cibola National Forest, Region 3.*

WE PRODUCE FIRE TRAINING FILMS

J. Whitney Floyd

Chief Forester-Fire Warden, State of Utah and Professor of Forestry, Utah State Agricultural College

We needed fire training films. Together *We* are producing them.

During those man-shy fire years of 1942 and 1943 we, the fire control agencies in Utah, found ourselves faced with a huge fire control program but short-handed for men. The short-term men were too inexperienced and inadequately trained to cope properly with the fire training and suppression responsibilities at hand.

Something had to be done and a promising source of help was the Forest Fire Fighters Service being sponsored by the National Office of Civilian Defense. This we organized on a State-wide basis. We proceeded to recruit and train volunteer fire fighters to replace our former forces of Civilian Conservation Corps crews and regular personnel, who were largely in military service.

Our first State-wide training program was undertaken in the spring of 1943 with a three-man training crew made up of a representative from each of the following agencies: United States Grazing Service, United States Forest Service, and the Utah State Board of Forestry Fire Control. This team assisted every county Forest and Range Fire Fighters Coordinator in the State to train the volunteer fire fighters. One training deficiency was very noticeable. Aware of the most up-to-date Army training methods, trainees and trainers alike, repeatedly expressed their desire for visual aids to be used for training in brush-grass fire fighting techniques.

At the conclusion of the spring training program the training team expressed to the State Forest Fire Fighters Service Committee a general interest in producing a fire training film that could be locally adapted and applied. On August 20 of 1943, the State Coordinator called a meeting of his committee to consider the possibility of the fire control and land administering agencies cooperatively producing a fire training film. Subsequently, a questionnaire was sent out to the field personnel of the Forest Service, Grazing Service, Park Service, Extension Service, Soil Conservation Service, and Indian Service, and to State Forestry employees, asking for suggestions and opinions regarding what type of film they thought should be most suitable.

Ninety field men from the States of Idaho, Nevada, Wyoming, California, and Montana, expressed themselves in writing as to the needs and the quality of a brush-grass fire film. On December 10, the State Coordinator of Utah called a meeting of representatives from Idaho, Nevada, and Utah, to discuss plans for financing and organizing for the joint production of a brush-fire training film. The following points were discussed and agreed upon:

1. There is definite need for a fire training film covering fire suppression in cheatgrass and grass-brush types, and limited to the local area of Utah, Nevada, and Southern Idaho where cheatgrass is a big problem.

2. It should be 16 mm., in color, with sound, and be voiced by a narrator.

3. It should be simple, direct, and start right into action on suppression training with very little prevention or introductory material.

4. It should be directed to cooperators, per diem guards, and small volunteer crews—all with very little or no training.

5. It should not be over 30 minutes long—shorter if possible.

6. It should be limited to a small problem, a 5- to 7-man job, and should deal with the action expected to be taken on a small fire, using common hand tools—shovel and Pulaski tool.

7. In the development of the small problem the following points are desired:

a. A small fire, 3 to 5 acres.

b. As representative as possible of our intermountain foothill country.

c. Use of relief models or sand table terrain on which fuels and burning conditions can be pictured in total so that the entire problem can be seen and visualized by the trainees.

8. The presentation of the problem should develop the chronological steps of handling a suppression job, with emphasis on the various parts:

a. Preparatory arrangement and going to the fire.
b. Sizing up the situation.
c. Stopping spread.
d. Completing control line.
e. Mopping up.
f. Staying with fire or checking later.

9. Financial arrangements among the cooperating agencies should be informal to avoid complex and cumbersome agreements.

10. To appoint a production manager with full authority to arrange for the scenario, to select the areas for filming, and to requisition contributed help and facilities from the cooperating agencies.

A committee of three men—a chairman with authority to represent Idaho, Nevada, and Utah on both State interests and State Forest Fire Fighters Service; a representative of the United States Forest Service; and a representative of the United States Grazing Service—was appointed to act as an executive committee to determine policy and make major decisions. With this organization and informal financial agreements, we approached the problem in the winter of 1943. A scenario was prepared by the over-all committee, and field shots and indoor shots were taken. The committee as well as the field crews used in staging the scenes were employees of the various agencies. Each man became so absorbed in his job of producing a training film that the entire project progressed as a purposeful task without agency affiliation. The finished film, "Grass and Brush Fire Fighting," was released in March 1945. It has been credited by many of our control agencies as being one of the best of its kind produced to date. The cost of the film, including the contributed time of employees, travel expense, and cash outlay of all agencies, amounted to $7,307.42.

Our success in film No. 1 encouraged us to undertake a similar but more difficult project. On November 29, 1945, this same committee renewed its efforts to produce another film, "Fighting Large Brush and Grass Fires." The objective of this film, with emphasis on organi-

zation and communication in fire fighting, is to demonstrate the fire control techniques used in fighting large brush-grass fires with heavy equipment. Inside filming on an actual scale relief model was completed in the early spring of 1946 and the field shots were taken during the summer. Cutting and splicing the film, and adding the narration, are being done now. It is hoped that this film will be as useful for training fire fighters as was the first one.

Film No. 1, "Grass and Brush Fire Fighting," was finished by the Calvin Co., 1105 East Fifteenth Street, Kansas City, Mo., and may be purchased for $110. The State Foresters of Idaho, Nevada, and Utah; the U. S. Forest Service; and the U. S. Grazing Service have copies in their libraries for local use.

The New Ration E.—On September 18 about a dozen men sampled the new Army Emergency Ration, type E, at a luncheon arranged by the Equipment and Supply Section of the Division of Operation in the Washington Office of the Forest Service. Among those present were Messrs. Loveridge, McArdle, Campbell, Kramer, Godwin, Brown, Holden, and Kaylor. The group appeared to enjoy thoroughly the "ration luncheon," and the new ration was found generally acceptable to all.

The War Department advises that ration types K and C will be replaced by type E in the very near future. The Forest Service procured from them one case of the new type E for experimental purposes. Each case contains 48 cans, 8 accessory packets, and 8 cigarette packets. It is known as an 8-man ration case, and is designed to subsist 8 men for 1 day, or 1 man for 8 days. Each ration includes 1 accessory packet, 1 cigarette packet, and 6 cans (2 meat, 1 fruit, 2 B-units, 1 bread).

The 48 cans and 16 packets in the case procured were as follows:

8 B-1 units (a breakfast unit with cocoa and 1 unit of coffee, sugar, crackers, jam, and cereal).
8 B-2 units (a supper unit with 2 units of coffee and 1 of orangeade, candy, crackers, cookies, jam, and sugar).
8 bread (white).
8 fruit (cocktail).
4 hamburgers and gravy.
4 pork and beans.
4 pork and rice.
4 meat and beans.
8 accessory packets (gum, granulated salt, heat tablets, salt tablets, toilet paper, and can opener).
8 cigarette packets (9 cigarettes and 1 match book).

The meat and fruit units will vary according to the particular case received, since there are available 10 different kinds of meat items and 4 fruit items. Other meat units are chicken and vegetables, beef stew, frankfurters and beans, ham and lima beans, meat and noodles, and meat and spaghetti. Peaches, pineapples, and apricots are the remaining fruit units.

The E assembly permits considerable choice and more variety than the C or K rations. Also, it has more bulk and better palatability than the K. However, it is not so neatly separable into one- or two-man meal units as the K, which was popular because of its compact packaging.

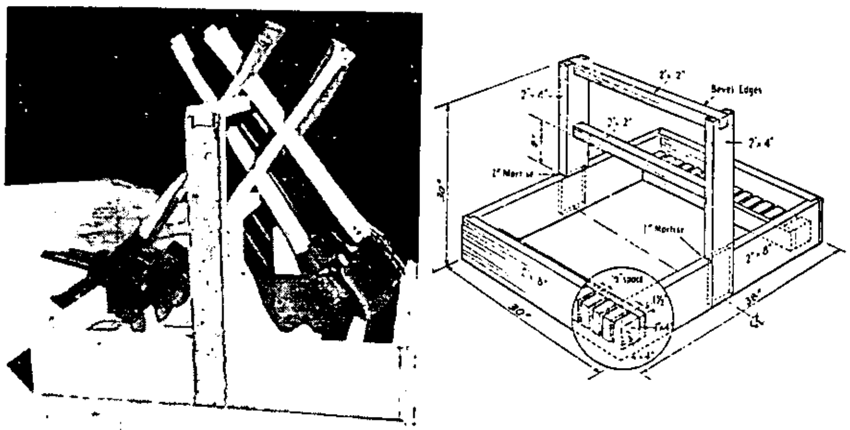
One case of E rations has been sent to each Forest Service Region for sampling and comments.—JOHN B. HOLDEN, *Equipment and Supply Section, Washington Office, Forest Service.*

BRUSH HOOK RACK

L. A. HORTON

District Ranger, San Bernardino National Forest, U. S. Forest Service

Convenience, safety, and a large storage capacity are the merits of a brush hook rack developed on the Mill Creek Ranger District. The rack is designed to hold 50 brush hooks placed in alternating positions, i. e., 13 blades down and 12 blades up on each side. This arrangement allows the backs of the 13 hooks to act as safety guards for the other 12. The blades of the hooks on each end of each row should always be placed down for safety. The tool handles are interlocked on the top and bottom cross bars. Two heavy chest handles on each side of the rack facilitate moving the rack or loading the unit on a truck without removing the hooks.



Rack with brush hooks in position, and diagram showing details of construction.

Tractor Transportation on Fires.—Forest officers have from time to time discussed the use of tractors in transporting supplies to isolated fire camps. Usually discussion centers around the use of stone boats or some arrangement of wheeled trailers. On the East Creek Fire on the Mineral District in 1945, a 55 tractor supplied the Eagle Creek Camp throughout the period it was occupied. The maximum number of men in the camp was 35, but the tractor could have supplied many more.

No stone boats or wheeled trailers were used. Division Boss Payne, faced with the necessity of moving a 35-man camp into isolated Eagle Creek, used alder poles, No. 9 telephone wire, spikes, two-by-fours, but mostly ingenuity to arrange a carrier on the principle of the Indian travois. Alder poles were inserted under the bulldozer hoist arms and wired to the frame work. These poles extended about 6 feet to the rear of the tractor on either side. Two-by-fours were spiked from pole to pole.

On this platform the camp equipment, mess gear, stoves, and bedrolls were piled. The load was covered with a canvas and securely lashed down. "She was big and cumbersome," said Payne, "but she got there. She was complete with tarp and all. We could have even thrown a diamond hitch, except I have forgotten how it's done."

On this particular job the country was so steep the tractor could not have made the return trip with either a stone boat or trailer. The travois arrangement performed satisfactorily on all the trips throughout the entire fire. The round trip distance was approximately 4 miles.—A. B. EVERTS, *Forester Snoqualmie National Forest, U. S. Forest Service.*

FEW FOREST FIRES IN GERMANY

Edward Ritter
Eastern Region, Forest Service

Go east, young man, if you are looking for a forest fire fighter's paradise. Incendiary bombs, phosphorous leaflets, tracer bullets, flame throwers, plane crashes—and yes, even cigarettes failed to start serious forest fires in western Germany during the war. From the small woodlots north of Cologne to the Black Forest of Baden, there was little evidence of forest fires. True enough, there were small burned areas in the Phalzerwald between Kaiserlautern and Ludwigshaven where a convoy of the Fuehrer's retreating supermen were strafed and their various vehicles and war machines went up in flames. In the Hurtgen Forest artillery air bursts damaged many trees. Considerable cutting by troops and forestry companies left much fuel on the ground. But the fall and winter of 1944–45 were cold and wet with much rainfall and snow. Even during the dry month of April 1945, however, there were no fires of consequence west of the Rhine.

After VE-day, in June 1945, about the time the British took over military occupation of the Rhine Province, a relatively large fire, nearly 600 acres, occurred in the eastern edge of the Hurtgen Forest. This was perhaps the largest single forest fire west of the Rhine during the last few years.

There was very little fire weather in northwestern Germany between July 1945 and June 1946. In Greater Hesse evidence of at least 100 fires was noted during the spring season of 1946. *Cause:* Probably hunter and warming fires, cigarettes, and incendiary. *Size:* From a few square feet to 10 acres. *Fuel type:* Spruce plantations 3 to 20 years of age with heavy crop of dry grass scattered throughout. *Damage:* Seedlings and young trees burned or badly scorched with mortality from 25 to 100 percent. *Percent forest area burned:* Estimated 0.025. *Risk:* Thousands of city people were in the forests continuously, chopping, carrying, and hauling fuelwood. Thousands of American soldiers were hunting, fishing, and wandering through the woods. Seventy-one thousand displaced persons from 20 different nations were in the process of repatriation during one 6-month period and the influx of another 57,000 added to the risk of the 4,000,000 German civilians who inhabited the area.

If forest fires were the most critical of the problems in Germany, we might be assured of a lasting peace as well as a forest fire fighter's paradise.

ARMY EXPLOSIVES FOR HAZARD REDUCTION

G. B. Johnson
Regional Fire Dispatcher, North Pacific Region, U. S. Forest Service

Many of the items developed by and for the Armed Forces during the recent war years are adaptable to forest fire control activities and the Forest Service has conducted tests to determine their practicability for this purpose. During the past year, in cooperation with the Army Corps of Engineers, tests were made with demolition explosives in felling snags.

Explosives furnished by the Corps of Engineers consisted of Tetrytol Demolition Chain M–1, Composition C–2, Composition C–3, Shaped Charge M2A2, and Shaped Charge M2A3. Three Army technicians, a commissioned officer and two noncommissioned officers, were assigned to the project.

Description of the Explosives

Tetrytol Demolition Chain M–1 consists of eight blocks of Tetrytol spaced 8 inches apart on a detonating cord (primacord) through the center of the blocks, with 2 feet of primacord on each end of the chain. Blocks measure 2 by 2 by 11 inches and weigh 2½ pounds each. Consistency of the explosive is hard and brittle. The velocity of detonation is 23,000 feet per second. Relative effectiveness as an external charge is 20 percent greater than TNT. Detonation may be obtained with a standard electric blasting cap attached to the primacord.

Composition C–2 is a plastic explosive of a consistency similar to putty and may be easily molded to obtain close contact for demolishing irregular shaped objects. Plasticity remains practically the same at temperatures ranging from 20° to 125° F. The explosive is packaged in blocks 2 by 2 by 11 inches, weighing 2¼ pounds, each block wrapped in glazed paper and enclosed in a cardboard carton. Eight blocks are packed in a cloth haversack with shoulder strap. A wooden powder box contains two haversacks. The velocity of detonation is 26,000 feet per second. Relative effectiveness as an external charge is 34 percent greater than TNT. Commercial explosives in the straight nitroglycerin and ammonia types of 60 percent strength have a relative effectiveness as external charges 83 percent and 53 percent, respectively, of TNT. A special Corps of Engineers' electric blasting cap or primacord is required for detonating C–2. This special cap is considerably stronger than a standard No. 8 cap.

Composition C–3 is similar in all respects to C–2 except that it is lighter in color and somewhat more plastic.

Shaped charges M2A2 and M2A3, designated as 10-pound and 15-pound charges, respectively, are identical except for the amount of

explosives they contain. They are also referred to as directional charges. The unit consists of a fiber container so shaped that a considerable part of the explosive energy is concentrated in one direction, resulting in an action known as the "Monroe effect." The explosive container is cylindrical with a cone-shaped top and a conical recess in the bottom. The explosive charge is loaded in the container at the factory. There is a detonator well in the top of the cone in which the detonator is inserted and secured by means of a plastic adapter. In the blasting operation the charge is placed on a fiber cylinder support, approximately 6 inches high, which keeps the charge at exactly the proper distance from the material to be penetrated. The action of these charges produces a penetrating effect rather than shattering. Several charges were tried on basalt rock with the following maximum results: One 10-pound charge penetrated 18 inches, and a second 10-pound charge placed over this hole deepened it to 32 inches; a 15-pound charge penetrated 28 inches, and another 15-pound charge placed over the hole deepened it to 44 inches. The diameter of both holes was 2½ inches. A special Corps of Engineers' electric blasting cap is required for detonation.

All of these explosives are highly inflammable. Tetrytol will burn at the same temperature as that required to ignite TNT. Fires are readily set when light fuels are dry and this is especially true when charges are not confined with stemming or mudcapping. They are exceptionally safe to handle because of their very low sensitivity as compared to commercial explosives and this accounts for the necessity of using a strong detonating agent.

Tests in Felling Snags

The tests were conducted in the old Yacolt burn on the Columbia National Forest. This area is the result of a disastrous fire which occurred in 1902, and while the fire-killed snags have been standing for 44 years, many of them are sound at the base. It was intended to make the tests on sound snags only but a few snags with varying degrees of decay were inadvertently shot. The latter are eliminated in determination of results obtained. All snags were Douglas-fir and ranged from 25 inches to 76 inches d. b. h.

Four methods of loading explosives were employed: (a) Sawed and chopped notches, unconfined and confined with mud, (b) auger bore holes, (c) external ring of Tetrytol Demolition Chain, and (d) Shaped Charge holes. Two notches, one each on opposite sides, and single notches were tried. Two cuts, with a saw, 4 inches apart and 5 to 8 inches deep are required for each notch. Wood was removed with a Pulaski tool. In boring holes for loading internal charges a portable electric power auger was used. This method is described in the Fire Control Equipment Handbook.

Results

Results obtained were as follows:

(a) After several trial shots it was determined that the amount of explosives in pounds required to fell a sound snag, using notches to contain the charge and without mudcapping, was the diameter squared and divided by 100. Thus, 25 pounds of C–2 or C–3 were

required for a 50-inch d. b. h. snag. Where mudcapping was used the charge could be reduced 20 percent. There was no advantage in using two notches with or without mudcapping. A clean shear was not obtained with this method. Frequently slivers up to 8 feet were left on the stump. Direction of fall could not be controlled.

(b) It was found that C–2 or C–3 was no more effective than a commercial 40 percent ammonia dynamite. A disadvantage was the time consumed in loading the 1⅛-inch bore holes. It was necessary to mold small pellets or rolls from the block of C–2 or C–3 to permit loading the hole.

(c) Tetrytol Demolition Chain wrapped around the exterior of a snag was successful up to 36 inches d. b. h. and a clean shear was obtained. This is a very fast method of felling a snag of this size and smaller. However, the amount of explosives used is considerably greater than required in the notching method, and it is exceptionally bad for setting fires.

(d) Shaped charges were tested to determine depth of penetration horizontally and for a means of quickly putting in a hole for loading and felling a snag with an internal charge. Several experimental shots were tried and finally a 15-pound charge was placed on the side of a 76-inch d. b. h. snag. The result was a hole entirely through the snag, 4 inches in diameter at the charge end and 1½ inches on the opposite side. The hole was loaded with a charge of C–3 computed to be sufficient to fell it. This failed, and it was subsequently felled with an overload of C–3.

Ten-pound and fifteen-pound charges were used to shoot holes through snags of varying diameters, which were left for a later test of final felling by the burning method. Results were not available at the time this article was written.

Paradoctor Appointed in Region 1.—Region 1 has completed arrangements for the service of Dr. Amos R. Little, former Army paradoctor, on emergency cases in inaccessible parts of the northern Rockies. The appointment of Dr. Little on a "when actually employed" basis marks an important forward step toward adequate protection against death from lack of immediate medical care in back-country accidents or other medical emergencies. The idea of parachuting civilian doctors originated with the late Dr. Leo P. Martin, of Missoula, Mont., who trained with the Forest Service smoke jumpers in 1941 and was killed in the crash of an Army plane a year later.

Dr. Little's preparation for this special work has been particularly applicable. He was sent to Missoula in the fall of 1943 as one of a party of 13 Army medical and training officers assigned for the purpose of training in Forest Service methods of parachute jumping. After training, Captain Little was assigned to search and rescue operations out of Casper, Wyo., and made several rescue jumps from that base. One highly successful rescue performed at 11,000 feet in the Colorado Rockies won him a medal as well as considerable repute as a skilled paradoctor.

During the summer of 1945 he was transferred to Great Falls, Mont., and his skill as a jumper was used successfully on several back-country accidents. Captain Little's services in these cases were in addition to his military search and rescue duties.

A graduate of Johns Hopkins Medical School, Dr. Little is now a practicing physician at Helena, Mont. The form of appointment and the nature of his duties in no way overlap or conflict with existing medical facilities available to the Forest Service, but add to its efforts to provide the maximum in medical service for its widely scattered field employees.

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 on a strip of paper attached to illustrations with rubber cement. 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 illustration. 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. Do not submit copyrighted pictures, or photographs from commercial photographers on which a credit line is required.

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

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