July 1966

Vol. 27, No. 3

file copy

FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

COVER—This prescribed burning crew is starting a backfire in South Carolina.

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D.C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (Sept. 16, 1963).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

PRESCRIBED BURNING TECHNIQUES ON THE NATIONAL FORESTS IN SOUTH CAROLINA[1]

ZEB PALMER and D. D. DEVET[2]

Many prescribed burning effects on National Forest lands are well known. However, little study has been done on burning techniques to achieve specific results under specific conditions of weather, fuel, and topography.

This note will primarily consider the prescribed burning techniques used on the National Forests in South Carolina. Prescribed burning has been used as a management tool for more than 20 years (fig. 1). Fortunately, the even-aged timber management plans for the Forests permitted extensive use of fire. More than 43,000 acres are now prescribe burned annually.

PURPOSE OF PRESCRIBED BURNING

The initial purpose was to reduce fuels to lessen the fire hazard. Later prescribed burning was used in undesirable species control, brown spot disease control, planting site preparation, seedbed preparation, range betterment, and wildlife habitat improvement.

Figure 1.—District Ranger on the Santee Ranger District, Francis Marion National Forest, briefs his crew prior to the start of burning operations.

Burning to improve wildlife habitat is used to obtain specific results such as:

1. Removing leaf and needle litter, which has a smothering effect on desirable forbs and legumes.
2. Stimulating quail indicator species such as Tick Trefoil (Desmodium spp.) and partridge pea (Chamaecrista spp.).
3. Increasing deer browse.
4. Encouraging fruiting of ground oak (Quercus pumila) and huckleberries (Vaccinium spp.).
5. Maintaining openings for deer and turkey.
6. Reducing basal area of noncommercial understory species.

IMPORTANCE OF WEATHER

Burn only if the weather is right. South Carolina weather conditions under which prescribed burning can be conducted follow. These conditions apply to most of the Southeastern United States.

	Winter	*Summer*
Relative humidity (percent)....	20-45	20-55
Wind velocity (m.p.h.)............	3-10	3-10
Wind direction..........................	(1)	(1)
Temperature range (°F.)........	34-75	85-100
Buildup index............................	3-30	6-40

1 Any reasonably constant direction is acceptable. The most unreliable wind directions are in the easterly quadrants.

A special fire danger weather station is not necessary. Local weather bureau offices can supply all of the above except the buildup index. Soil moisture conditions must be field checked. There must be a damp humus layer in the A_0 horizon.

FIRING TECHNIQUES

Five firing techniques are now used on the National Forests in South Carolina:

1. Backfire
2. Headstrip
3. Spot or Checkerboard
4. Flank
5. Head Fire

---

[1] This paper was presented by the authors at the Southeastern Wildlife Conference, Tulsa, Okla., on Oct. 11, 1965.

[2] Respectively, District Ranger, Ouachita National Forest, Ark., and Fire Control Staff, National Forests in South Carolina, Columbia, S.C.

These techniques are employed on specific occasions to accomplish specific purposes (fig. 2). Two or more techniques are used for most burns.

Backfire

A baseline is established, and perimeter and interior lines are placed approximately 10 chains apart. There may be plowed lines or natural barriers such as creeks, roads, or swamps. On slopes, the baseline should be the top of the ridge, and the perimeter lines should be on flanks. Interior lines should be as close to the contour as possible. The fire is started on the baseline (fig. 3). After the base is safeguarded, the interior lines are fired.

This method is employed in slope burning and burning in relatively young timber stands, and results in a minimum of scorch. It is recommended for prescribed burning beginners.

The method works well with heavy fuel, gives a minimum of scorch, provides heat at ground line for the longest periods, and is recommended for summer burning when there are high temperatures, heavy fuels, low relative humidities, strong winds, and high fire dangers. This method is the most popular, easiest to apply, and fastest.

However, this method needs steady wind from a constant direction, plenty of time, interior lines prepared in advance, and continuous and uniform fuels (at least 1 ton per acre of fuel).

Headstrip

Short head fires are run with the wind into a prepared baseline or burned area. The strips will vary in width, depending upon density and distribution of fuel. This technique is combined with a backing fire to initially secure the baseline. After the base is secured, strip burning is begun.

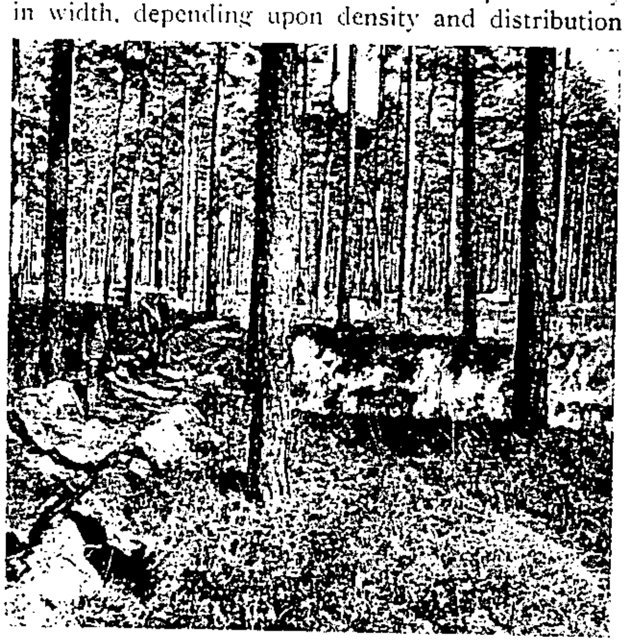

Figure 2.—Prescribed burning crew watches small test fire to see if it is burning according to the weather forecast.

Figure 3.—Backing fire is started along the plowed line used as a base of operations.

This technique can be conducted when relative humidity is 30 to 35 percent, has flexibility for wind direction changes, can be conducted in scattered, light fuels, needs minimum preparation, is relatively inexpensive, is cheaper because few plowed lines are required, and is rapid.

Spot or Checkerboard

This technique is also called "area ignition." A series of small spot fires are uniformly distributed so all spots converge before any one spot can gain momentum. Possible damage to residual stands is least for closest spots.

A skilled crew familiar with fire behavior and burning objectives is required.

This technique should be used primarily for winter burning at low air temperatures. It can also be used when conditions are too hot for headstrip burning.

Flank Fire

A fire that spreads perpendicularly to the prevailing wind is started. The line of fire is started directly into the wind (fig. 4). The fire then spreads laterally at right angles to the established line. This technique is frequently used to secure the edges of the prescribed burn when a backfire, strip head, or checkerboard fire progresses.

Flanking is the cheapest and fastest burning procedure.

This method requires a steady wind, uniform and preferably light fuels, and a trained crew.

(Continued on page 14)

PRESCRIBED BURNING TO REDUCE KUDZU FIRE HAZARD

MARLIN H. BRUNER, *Associate Professor,*
Forestry Department, Clemson University

Fire control men with experience in the South are aware of the problem caused by kudzu (*Pueraria thunbergiana* (S. & Z.) Benth.) in fire suppression.

This vine, introduced from Asia more than a century ago for ornamental purposes, and widely planted since the midthirties for erosion control, is now a common plant along many railroads and highways in the South. To the casual observer, the lush, green kudzu is only a vine adorning the roadside.

However, as fire control men who have worked in the South realize, this seemingly harmless plant changes drastically with the first killing frost. Its withered, dry leaves and vines are transformed into flashy fuels that provide a most effective bridge for carrying fires from rights-of-way to adjacent fields and woods. Fire suppression in kudzu is almost impossible without abundant water—the fires explode, and the entanglement of vines, stolons, and roots preclude the use of fire rakes and plows. Firefighting in kudzu is a difficult task, indeed!

On the Clemson Forest, managed by the Forestry Department of Clemson University, kudzu causes a fire hazard along 3 miles of railway right-of-way. Before control measures were initiated, fires started on this stretch during the dormant season and frequently entered the forest by means of the kudzu bridge.

Three years ago, with the approval of the railroad's district engineer, annual prescribed burning was begun. The following method is successfully employed:

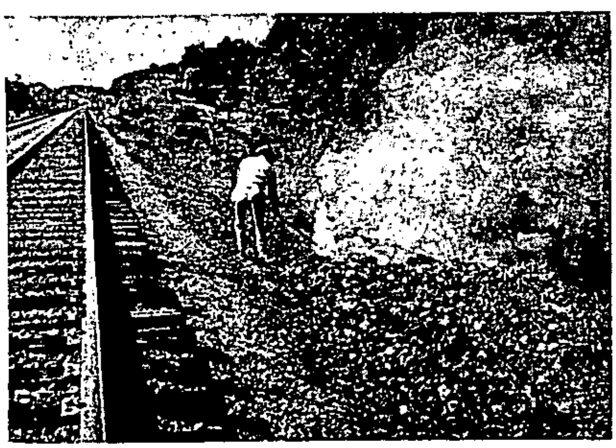

Figure 1.—Burning a kudzu strip previously killed by 2, 4, 5-T spray.

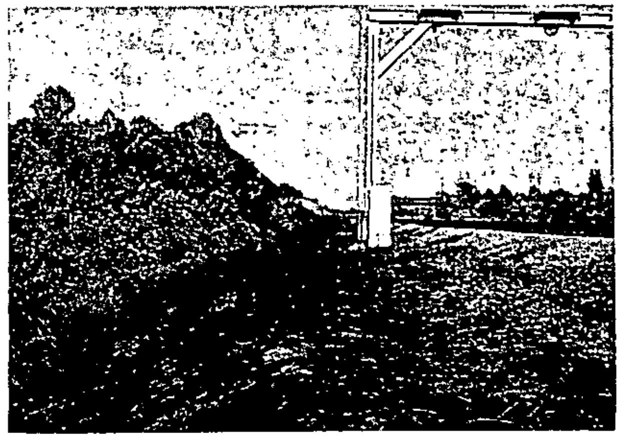

Figure 2.—Kudzu fire hazard has been reduced along railroad right-of-way by applying 2, 4, 5-T and then burning the vines.

1. During mid-August a strip of kudzu, about 20 feet wide, is sprayed along the right-of-way. A mist blower is used to apply a mixture of 5 gallons of 2, 4, 5-T (4 pounds acid equivalent per gallon), 5 gallons of fuel oil, and 20 gallons of water. Other formulations might yield equally good results.[1]

2. The kudzu is burned approximately 2 to 3 weeks later, after it has died and when good burning conditions prevail (fig. 1). The sprayed strip burns cleanly (fig. 2), and the fire dies or is easily controlled when it moves into the green, unsprayed vines, which serve as firebreaks before the first killing frost.

The total annual cost is about $30 a mile. Thus, a serious fire hazard of the Clemson Forest has been nearly eliminated, easily and inexpensively, by spraying and burning. Perhaps this procedure or a modified one will be useful for other persons confronted with a similar problem.

[1] All chemical compounds should be used only when needed and should be applied with caution.

A FIRE-BEHAVIOR TEAM FIELD UNIT

JOHN D. DELL, *Fire Research Technician, and* MELVIN K. HULL, *Meteorologist,*
Pacific Southwest Forest and Range Experiment Station

Fire-behavior officers from the Riverside Forest Fire Laboratory (in California) are finding that a team apporach to the fire-behavior job increases their effectiveness in serving the fire-control organization.[1 2] The fire-behavior team consists of two or three men. It makes frequent observations of weather, fuels, and topography in the fire area and reports findings to the fire-behavior officer.

Team members require much specialized equipment (see equipment checklist).

To increase team efficiency in field operations, a small fireclimate survey trailer has been converted for use as a field equipment trailer. The unit, designed and outfitted by the authors, is kept at the fire laboratory. Ready for immediate call, it contains all the supplies and equipment required by a fire-behavior team on a major wildfire (fig. 1).

It costs about $650 to equip the trailer. There are additional costs for backpack radios or a theodolite and tripod. The theodolite equipment, purchased commercially, costs about $1.500. This equipment occasionally is available from military surplus.

EQUIPMENT CHECKLIST FOR FIRE-BEHAVIOR TEAM UNITS

Items for Ground Observations and Upper Air Soundings

3 Kits, weather belt, w/sling psychrometer, wind meter, water container, compass, notebook, and RH and DP tables.

[1] Countryman, C. M., and Chandler, C. C. The fire behavior team approach in fire control. Fire Control Notes 24(3) : 50-60. 1963.

[2] Dell, J. D. The fire behavior team in action—the Coyote Fire, 1964. Fire Control Notes 27(1) : 8-10, 15. 1966.

Figure 1.—Components of the field unit include equipment for ground and winds aloft observations and upper air soundings.

2	Fuel moisture sticks
1	Scale, fuel moisture, portable
1	Altimeter
1	Fuel type guide, w/photos
1	Computer, forward rate of fire spread (R-5 Model 48)
25	Diagrams, pseudo-adiabatic
1	Hygrothermograph, w/shelter

Items for Winds Aloft Observations

1	Kit, pibal, including the following:
1	Theodolite, w/batteries
1	Tripod
3	Balloons, pibal (white, black, and red), box
50	Parachutes, pibal
60	Lights, pibal
1	Roll of string
1	Box of rubberbands
1	Container, water, plastic
2	Flashlights
2	Wrenches, crescent and Allen
2	Helium tanks, *full*
1	Regulator, helium tank, w/rubber hose
1	Balance, nozzle, w/base
1	Clipboard
200	Computation sheets, winds aloft[1]
1	Table, horizontal distance[1]
200	Charts, wind evaluation (11 by 17 inches)[1]
1	Scale, engineers, drafting, triangular (scales: 10 to 60)
1	Parallel rule

Items for Communication

2	Radios, backpack
1	Radio, portable, w/longwave band (for aviation weather broadcasts)

Miscellaneous Items

1	Table, folding, w/four seats
1	Clock, alarm
1	Lantern, electric, portable
1	Pair of binoculars
1	Knapsack
1	Case of emergency rations
1	Canteen
1	Set of keys, gate
1	Camera, Polaroid, w/film
1	Set of maps (forest, county, and topographic)
1	Set preattack block books (if available)
1	Fireline notebook
1	Kit, first aid and snakebite
6	Notebooks, field, pocket
1	Typewriter, portable
1	Package of paper, typing
1	Package of paper, carbon
25	Envelopes, filing, 9½ by 12 inches
2	Note paper pads
1	List, Region 5 fire weather stations
1	Instruction book

[1] These items are specially designed forms to evaluate winds aloft in the field, and will be further described by Melvin K. Hull in a separate report.

REGION 3 INSPECTION OF INTERNAL COMBUSTION ENGINES

Division of Fire Control

Region 3[1] has had some disastrous fires caused by faulty internal combustion engines. Greater use of National Forests by contractors, special-use permittees, and others has made a more rigid inspection system for internal combustion engines imperative. Equipment inspections have been mandatory for timber sales, contracts and permits, and Forest Service equipment. However, a method to identify inspected equipment had not been established, so control was inadequate.

A strong inspection program has several facets:

1. It covers tractors, loaders, trucks, pickups, powersaws, etc., and also all equipment used off surfaced roads in hazardous areas.

2. It enables each user of this equipment to understand the program, including its purpose and operation. It should also inform him of his responsibility to protect his equipment from fire.

3. It provides the Forest officer with proof of inspection. If equipment failed the inspection or had not been inspected, it could not be operated on the Forest.

The program was inaugurated in 1964. First, we developed an inspection form. The inspection covered spark arresters, mufflers, and exhaust systems. All previously inspected equipment had to be inspected in April, May, June, and July—the critical fire months for the Region. Uninspected equipment had to be inspected prior to use on the Forest. An inspection sticker was placed on approved equipment in a conspicuous place. The stickers for the four months had different colors. The July sticker, which was white, indicated approval until the next April.

In 1964, we significantly reduced fires resulting from internal combustion engines. We have reviewed the comments from designated Forests and have modified and planned our program as follows:

1. Our inspection form (fig. 1) has been revised.

2. All equipment without a previous formal inspection will be inspected before it enters the

[1] Region 3 (Southwestern Region) consists of Arizona and New Mexico.

FIRE PREVENTION INSPECTION
FOR INTERNAL COMBUSTION ENGINES

U. S. Department of Agriculture
FOREST SERVICE
Southwestern Region

Name and Address of Machine Owner/Permittee/Contractor

Page ____ of ____

Forest/Grassland | Ranger District | Inspection Period: April-May ☐ June-July ☐ August-March ☐

NOTICE: NO INTERNAL COMBUSTION ENGINE MAY BE OPERATED ON NATIONAL FOREST LAND UNTIL IT HAS BEEN INSPECTED AND APPROVED BY THE FOREST OFFICER IN CHARGE AND AN INSPECTION STICKER APPLIED TO INDICATE HIS APPROVAL. NO INTERNAL COMBUSTION ENGINES MAY BEGIN OPERATION UNTIL ALL REQUIREMENTS DESCRIBED IN THE CONTRACT, PERMIT, AGREEMENT OR POLICY ARE COMPLIED WITH.

Kind of Equipment Identify each unit by make and type	Equipment Serial Number	Each Unit is Equipped with an Approved and Serviceable							Action by Forest Officer in Charge				Sticker or Seal Number
		Shovel	Axe	Spark Arrester	Muffler	Exhaust System	Fire Extinguish	HP Pump	Disapproved By Signature	Disapproved Date	Approved By Signature	Approved Date	
1.													
2.													
3.													
4.													
5.													
6.													

STATEMENT BY OWNER:
I hereby agree to repair, replace or correct all deficiencies indicated on this inspection form before operating this/these engine(s) again on National Forest lands. All violations will be prosecuted.

Signature of Owner or Repres. authorized by Owner ____ Date ____

R-3 5100-4
(3/65)

Figure 1.—This is the inspection form for internal combustion engines.

woods. Inspected equipment is formally inspected twice a year, in March and May. The March sticker, which is green, is good until May 31; the May sticker, which is red, is accepted until July 31. A white sticker will be placed on equipment inspected from August through February.

3. The type of equipment and class of users are (minimum):

A. Internal combustion engines on timber sale areas.

B. Forest Service internal combustion engines, including GSA equipment and leased or rented private equipment.

C. Any permitted user where powersaws are used. This includes free use[2] because free-use permittees often obtain wood from old timber sale areas. (The powersaw sticker is of special material because of grease.)

D. Contractors of roads or those doing construction work in connection with special uses.

There will be no attempt to inspect grazing permittee pickups or trucks. However, their powersaws will be inspected. Hunters, fishermen, tourists, and those seeking recreation are not required to have inspection stickers.

[2] Usually permitted removal without charge of dead or dying timber by qualified individuals for personal use.

CAMERA GUNSTOCK MOUNT

ROLAND J. TREUBIG, *Forester,*
Louisiana Forestry Commission

A tripod is usually needed to steady the telephoto lenses of a camera; however, the standard tripod is generally quite cumbersome. The gunstock mount shown in figure 1 is a very convenient and portable substitute.

The gunstock mount is made of 5-8-inch exterior-grade plywood. A 1- by 1-inch hole is drilled from one corner of a 3- by

(Continued on page 16)

SCHEDULING AIRCRAFT FOR FOREST FIRE DETECTION

P. H. Kourtz, *Fire Research Officer, Canadian Department of Forestry*

The objective of all detection systems is to minimize the acreage burned prior to detection. Forest protection organizations, which continually try to improve their detection systems, are relying more and more on aircraft. In part of Canada, aircraft alone are used to detect fires; however, in most areas they supplement tower networks.

When only aircraft are used, no point in the forest is constantly watched. However, by determining the time required for planes to patrol given areas and the rate of fire spread from ignition to detection, the area burned prior to detection can be estimated. Under these conditions, to minimize burned areas, two questions must be answered. First, how many patrols should be made each day? Second, at what time should they be made? The number of patrols required each day varies with the number and rate of spread of expected fires. The time for patrols depends on the distribution of fires throughout the day; more fires are detected in the afternoon.

In Canada, the fire danger rating system developed by the Department of Forestry permits an estimate of the potential number of fires and their probable rate of spread. Rates of fire spread for various danger index classes were taken from Beall (1950).[1]

Danger index class	*Rate of perimeter spread (yd./hr.)*
Extreme	440
Moderate	365
Low	263

The rates, based on many 1938–46 New Brunswick fires, were averages for all fuels, times of day, and months of fire season.

To begin this analysis, it was first assumed that each air patrol covered 100 percent of the patrol area and that there was an equal chance of fire occurring in any place on the area. It was also assumed that there was an aircraft and pilot available at the specified patrol times and that he was able to detect all fires in the patrol area. For this analysis rates of spread for uncontrolled fires are required. Barrows (1951)[2] found that the average rate of spread from discovery to attack for uncontrolled fires burning in "High" fuels with a burning index of 70 was 293 yards of perimeter increase per hour. He stated that above-average rates of spread will occur in "High" fuels if the fires are spotting ahead. Eighty-five percent of the fires burning in "High" fuels with a burning index of 70 had a maximum rate of spread of 616 yards of perimeter increase per hour. Thus, the New Brunswick figure of 440 yards for the Extreme danger class was between the average and maximum values given by Barrows (1951). However, he found the maximum rate of spread was 143 yards of perimeter increase per hour for "High" fuels with a burning index of 20. The New Brunswick rate for the Low danger class was 263 yards per hour: this figure is above the average rate of fire spread for that danger class.

For this analysis, the rates of perimeter increase were converted to rates of acreage increase by the following formula (Hornby 1936):[3]

$$A = \frac{7.3\,P^2}{1{,}000}$$

where P = perimeter in yards and
A = area in acres

This formula assumes that the fire increases in an oval shape where P is $1\frac{1}{2}$ times the circumference of a circle of equal area.

The number of fires occurring each hour of the day was determined first for each danger index class from many 1938–51 New Brunswick fires, and second, for the combined danger index classes using a report by Beall and Lowe (1950).[4] While a large sample of fires was used, the division of the sample into four dangers classes did not provide enough fires to give a reliable occurrence and time-frequency curve. Therefore, the analysis was based on the occurrence times determined for the combined danger index classes.

Using data available on the occurrence and rate of spread of fires in New Brunswick, various air patrol times were simulated for each danger index class. By knowing the corresponding rate of fire spread, the distribution of fires throughout the day, and the time between the earliest detectable time and the time of the air patrol, the sizes of the fires at the time of the patrol were determined. It was

[1] Beall, H. W. 1950. Forest fires and the danger index in New Brunswick. Forest Chron. 26:2.

[2] Barrows, J. S. 1951. Forest fires in the Rocky Mountains, U. S. Forest Service. North. Rocky Mountain Forest and Range Exp. Sta. USDA Pap. 28.

[3] Hornby, L. G. 1936. Fire control planning in the North. Rocky Mountain Forest and Range Exp. Sta. USDA Progr. Rep. 1.

[4] Beall, H. W., and Lowe, C. J. 1950. Forest fires in New Brunswick 1938-1946. Canada Dep. Resources and Develop. Forest Fire Res. Note 15.

assumed that fires could be detected during daylight and that the fires did not spread during 8 night hours. The areas burned at the time of the air patrol were weighted by their corresponding occurrence frequencies. The total weighted areas burned for various patrol times and danger index classes are shown in table 1. A single patrol at 5:30 p.m. produces the lowest total weighted area burned for all three danger index class days. The weighted area burned during Extreme danger, as seen from a 5:30 p.m. patrol, is shown in table 2. The totals of the weighted areas burned were found for many patrol times, and the one that resulted in the lowest total was considered optimum. The effect of more than one patrol per day for the Extreme danger class was shown in table 3. Therefore, use of 1:30 p.m. and 6:30 p.m. patrols minimized the total weighted area burned. One to five patrols were simulated for the Extreme danger class (table 4). Each additional patrol reduced the total weighted area burned by approximately 50 percent.

TABLE 1.—*Total weighted areas burned for various patrol times and danger index classes*

Patrol time (one per day)	Low danger	Moderate danger	Extreme danger
	Acres	*Acres*	*Acres*
8:30 a.m.	5,404	10,398	15,106
10:30 a.m.	5,515	12,170	17,654
12:30 p.m.	5,701	10,792	15,689
1:30 p.m.	4,596	8,656	12,605
2:30 p.m.	3,338	6,273	9,154
3:30 p.m.	2,310	4,360	6,359
4:30 p.m.	1,857	3,516	4,790
5:30 p.m.	*1,665*	*3,176*	*4,639*
6:30 p.m.	1,787	3,429	4,679
7:30 p.m.	2,142	4,118	5,241

TABLE 2.—*Weighted area burned at time of a 5:30 p.m. patrol during Extreme danger (rate of perimeter increase—440 yards per hour)*

Time	Elapsed times to 5:30 p.m. patrol	Fire perimeter at patrol time	Fire area at patrol time	Number of fires starting	Weighted area
	Hours	*Yards*	*Acres*	*Percent*	*Acres*
7– 8 a.m.	10	4,400	144	0.6	86
8– 9 a.m.	9	3,960	115	1.8	207
9–10 a.m.	8	3,520	91	3.6	328
10–11 a.m.	7	3,080	70	5.5	385
11 a.m.–noon	6	2,640	51	8.5	434
noon–1 p.m.	5	2,200	36	13.3	478
1– 2 p.m.	4	1,760	23	15.8	363
2– 3 p.m.	3	1,320	13	15.7	204
3– 4 p.m.	2	880	6	12.7	72
4– 5 p.m.	1	440	1	7.5	11
5– 6 p.m.	0	0	0	5.3	0
6– 7 p.m.	23	6,600	311	3.0	933
7– 8 p.m.	22	6,160	273	1.6	437
8– 9 p.m.	21	5,720	239	1.7	406
9–10 p.m.	20	5,280	204	.6	123
10–11 p.m.	19	4,840	171	1.0	171
Total	----	----	----	----	4,639

TABLE 3.—*Effect of two patrols per day for Extreme danger class*

Time of two patrols (p.m.)	Weighted areas burned
	Acres
2:30, 6:30	1,494
1:30, 6:30	*1,445*
12:30, 6:30	1,831
1:30, 5:30	1,669
1:30, 7:30	1,628

The previous totals of weighted areas burned were found by assuming 100 fires occurred each day regardless of the level of the burning index. However, a New Brunswick study by Beall (1950) revealed the rates shown in table 5.

By knowing these occurrence rates, the danger index class, and an acceptable level of burned area, the optimum number of patrols during each danger class day could be approximated. The level of the total of the weighted areas burned which could be tolerated was chosen as the minimum that resulted from one daily patrol during a Moderate danger period (3,176 as shown in table 1). Therefore, the total of weighted areas burned on all days regardless of the danger index must be almost as low as or lower than this figure.

TABLE 4.—*Effect of additional patrols for Extreme danger class on weighted areas burned*

Number and optimum time of patrols	Weighted areas burned
	Acres
1— 5:30 p.m.	4,639
2— 1:30 p.m., 6:30 p.m.	1,445
3—10:30 a.m., 3:30 p.m., 7:30 p.m.	817
4—11:30 a.m., 2:30 p.m., 4:30 p.m., 7:30 p.m.	405
5— 6:30 a.m., 12:30 p.m., 2:30 p.m., 4:30 p.m., 7:30 p.m.	189

Because five fires were expected on each Extreme day and only one fire on a Moderate day, the totals of the weighted areas burned for each Extreme day must be one-fifth that of a Moderate day ($3,176 \div 5 = 635$). During the Extreme period

TABLE 5.—*Average rates of fire occurrence for various danger index classes*

Danger index class	Average rate of fire occurrence
Low	1 per 7 days
Moderate	1 per day
High	2 per day
Extreme	5 per day

three patrols will bring the total of the weighted areas burned to 817, and four patrols will reduce it to 405 (table 4). Therefore, there must be at least three patrols on Extreme days so there is approximately the same total of weighted areas burned as with one patrol on a Moderate day.

Many personnel believe that single daily air patrols should be flown at 2 p.m. because the largest number of fires are discovered then. The fires which have ignited that day would be detected when most are very small. However, many fires ignite after 2 p.m., especially between 2 p.m. and 8 p.m., and these fires will be very large by 2 p.m. the next day. Therefore, single air patrols should be flown so that the total weighted area burned will be minimized. As this analysis indicated, this time is well past the peak of the occurrence time-frequency curve.

There are several weaknesses in this analysis. First, while knowledge of the earliest times that an aircraft could discover the fires was required, the starting times of fires were used. However, fires cannot be detected as soon as they start. Second, more fire reports would be required in order to classify discovery times by danger index classes. If the sample had been large enough, the distribution of discovery times should have approached a smooth curve since conditions favorable for burning usually improve during the morning, peak in the midafternoon, and decline during the evening. Third, it was assumed that fires did not spread for 8 hours during the night. Such an assumption appears wrong because an average rate of spread was used. However, the rate of spread was determined for many fires, many of which were extinguished on the same day they were discovered. To determine the effect of the length of time of no fire spread on the patrol time, it was assumed that the fire spread at the same rate during the night and the day. For the Extreme danger class, the optimum patrol time was now 7 p.m. Therefore, the number of hours that the fire is assumed to not

(Continued on page 14)

NIGHT HELICOPTER USE IN FIRE CONTROL

Division of Fire Control, Washington Office

Small helicopters will probably soon be operational at night on forest fires. This assertion is based on the results of 3 years of tests and development work at the Missoula Equipment Development Center and the Pacific Southwest Forest and Range Experiment Station.

By using helicopters at night, advantage can be obtained from the following:

1. Reduced fire intensity and rate of spread.
2. Cooler temperatures, lower densities (at given altitudes), and greater air stability.
3. Less competition for airspace from air tankers, smokejumpers, and cargo airplanes.

With round-the-clock operations, more dependence can be placed on the helicopter. As experience is gained in night operations, duplicate systems for moving manpower and equipment and for scouting will become less necessary.

1963-65 TESTS

Before 1963, helicopters had been used for only a few night flights involving extreme firefighter emergencies. In 1963, the Missoula Equipment Development Center started preliminary studies to determine the feasibility of night helicopter operations for forest fire control. First, military use of helicopters at night was investigated. Nearly all military operations involve large helicopters capable of carrying expensive and sophisticated navigational instruments. It was not feasible or practical to install this type of equipment in the small helicopters commonly used in Forest Service operations. Next, the commercial market was surveyed for efficient lighting and navigational equipment. Several types of equipment were obtained and evaluated during a series of preliminary flights in 1964. Much was learned about pilot technique as well as about equipment. Techniques were refined as experience was gained. Equipment was replaced as improved types were obtained and evaluated. Based on 1965 tests in Montana and southern California, the following general tentative requirements and guidelines were developed.

REQUIREMENTS AND GUIDELINES

Pilot Qualifications and Training

A pilot must be willing and interested in night helicopter flying. Qualifications must be more stringent than for daylight helicopter operations. Pilots selected must receive necessary training in procedures and use of equipment for safe route finding and flight.

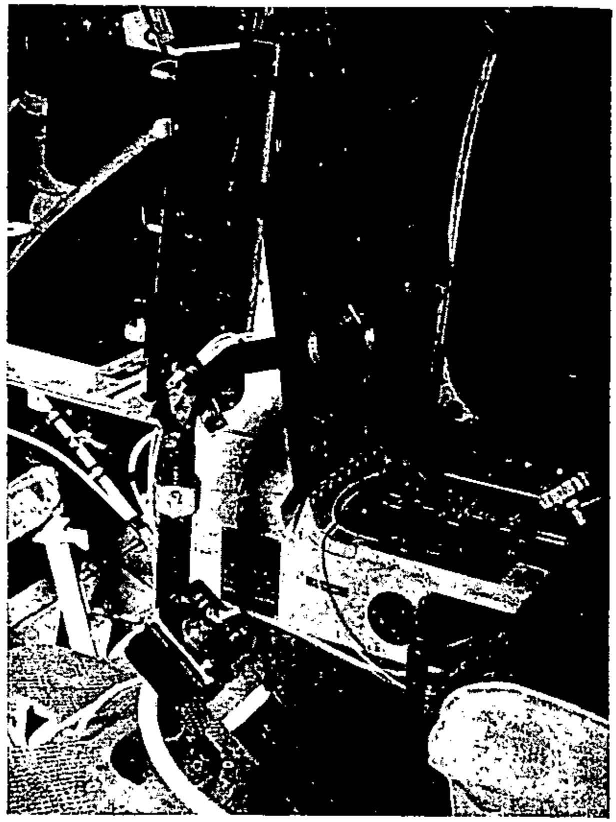

Figure 1.—Special instruments that were installed.

Helicopters

Newer helicopters with improved performance are essential because they provide a greater safety margin. The following special aircraft accessory equipment (fig. 1) also is necessary:

1. Controllable searchlight
2. Air-net radio
3. Altitude gyro (electric)
4. Directional gyro (electric)

A new lightweight, low-cost radar altimeter tested in 1965 probably has merit.

Helispots

The pad clearing should be a rectangle at least 100 feet wide and 100-200 feet long (fig. 2). Helispot boundaries should be marked with amber lights about a chain apart. When a big field or meadow is used, amber boundary lights are not needed around the entire spot. A green or blue light should indicate the center of the pad.

Helispots should be located so the best terrain can be used for flight routes. Special consideration must also be given to prevailing winds, smoke, and special obstacles or hazards. Specific guidelines for locating helispots in relation to flight routes cannot be given because many factors are involved.

A kit (fig. 3) for marking helispots and for communication with the pilot is essential. For a typical operation, it should include the following items:

1. 5 route marker strobe lights
2. 14 route marker (amber lens) lights
3. 16 emergency landing area marker lights
4. 30 6-volt dry cell batteries
5. 6 5-foot-diameter parachutes
6. 1 air-net radio

Equipment for each spot can be packaged into one or two fiberboard boxes for delivery by parachute, helicopter, or ground vehicle.

Obstacle lights should be used to illuminate hazardous snags, trees along the spot border, or other items that might interfere with flight. These lights should be pointed upward to illuminate the main rotor tips while the helicopter is on the pad. Green or blue lights should be used to mark approaches or turning points; recommendations of the pilot should be followed.

Wind direction is indicated with a lighted "U" or "T" Flashlights attached to white, translucent plastic golf club protector tubes are excellent. These are easily repositioned with changes in wind. Systems which are difficult to reposition should be avoided.

Flight Routes and Emergency Landing Areas

Flight routes must be selected by the pilot and flown during daylight. The routes, which are marked with beacons, should be over terrain with the best emergency landing areas. Each area is marked with one or more lights of a different color. Distances *between* helispots must be as short as possible.

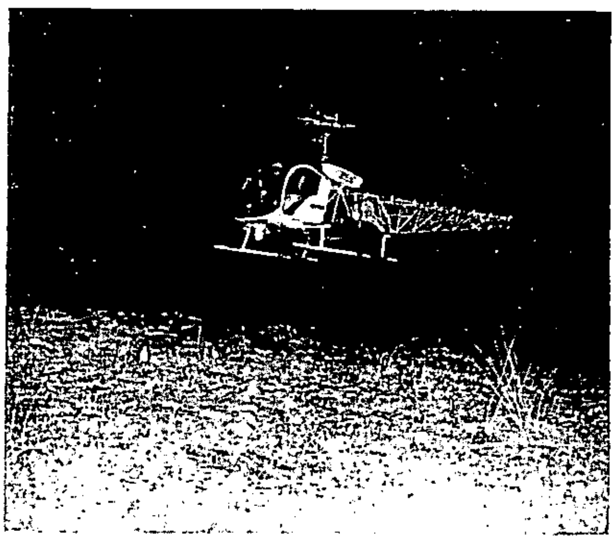

Figure 2.—A helicopter hovers above a helispot.

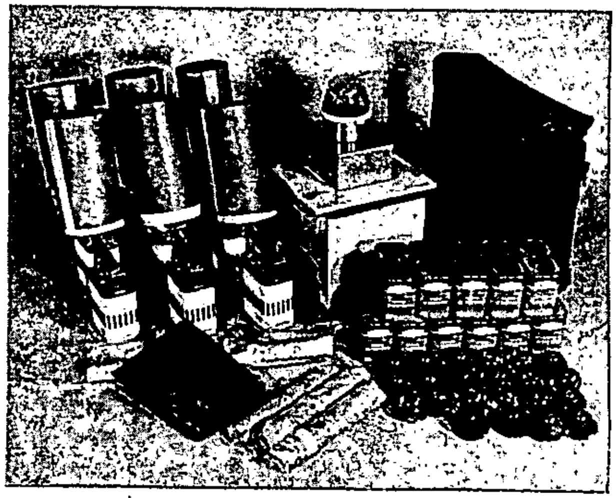

Figure 3.—Helispot marking kit used in these studies.

Visibility

Many interrelated factors affect visibility; these include weather, topography, vegetative cover, moonlight, and smoke. Visibility of ground references can be enhanced by locating helispots and flight routes so that smoke and dark canyons are avoided. Light-colored soil, rocks, vegetation, and cultural features such as roads provide ground references.

Clear skies usually provide optimum visibility and air stability. However, the amount of moonlight seemed to affect night visibility more than cloud cover.

Terrain

If visibility and weather are favorable, terrain usually will not restrict flying when flight routes and helispots are carefully planned.

Physiological Factors

The studies conducted in southern California in 1965 by the Pacific Southwest Forest and Range Experiment Station included physiological phenomenon affecting night flights. Night vision, illusions of vision, autokinesis (apparent but false movement of a light), flicker, and motion vertigo were studied in connection with night flying. These research and flight tests were closely coordinated with helicopter guidance studies conducted earlier by the Missoula Equipment Development Center.

SUMMARY

While flying is more hazardous at night, results of these studies indicate that night flying can be done safely under favorable environmental conditions by using well-trained and qualified personnel, special guidance equipment, and careful planning. However, more information on many phases of night operations must be obtained and analyzed before regular night helicopter flights will be approved for the U.S. Forest Service. Plans are being developed for limited field tests under fire conditions during the 1966 season. These and later tests may prove another valuable application of helicopters in firefighting.

Prescribed Burning—*Continued from page 4*

Head Fire

The head fire is employed on special occasions. The fire is permitted to run with the wind into a prepared firebreak that will stop the spread. This is a dangerous and specialized method employed primarily to kill all aerial vegetation. This technique is used to maintain a wildlife opening under certain conditions, and in brownspot disease control. It is also used when a hot, fast fire is needed.

If not carefully used, this technique could result in a wildfire with spotting, crowning, and other undesirable characteristics.

SUMMARY

Five basic firing techniques are employed for prescribed burning on the National Forests in South Carolina. One technique or a combination of techniques is best under certain conditions of fuel, weather, and topography.

Prescribed burning requires experience and knowledge of fire behavior. All personnel using prescribed burning should recognize the constructive and destructive power of fire.

Figure 4.—Flank fire is started with a backfiring torch by a crewman walking directly into the wind.

Scheduling Aircraft—*Continued from page 11*

spread is not critical in determining the time of the air patrol; however, it does greatly influence the total of the weighted areas burned and, thus, the number of patrols required each day.

The rates of spread of fires vary throughout the day. The average rates of spread used in this example were determined from fires burning under all conditions at all times during the day. The accuracy of the analysis may not have been reduced because it was assumed that fires started during all daylight hours. Therefore, the rate of spread has little effect on determining the best patrol time, but it has been shown that rate of spread greatly affects the number of patrols required each day. The main factor influencing the patrol time is the distribution of the discovery times throughout the day.

This method of analysis could be applied locally if there were sufficient data to draw smooth occurrence and time-frequency curves for each danger index class. An average rate of spread for each danger index could either be determined from many local fire reports or could be determined from a study such as that of Barrows (1951). This technique will become more useful in the future, when rates of spread for many types of conditions can be predicted more accurately.

LOS ANGELES COUNTY DEVELOPS NEW CONSTANT-SPEED ALTERNATOR

FRANK HAMP, *Battalion Chief and Equipment Development Officer, Los Angeles County Fire Department*

Editor's Note: Tests conducted by the San Dimas Equipment Development Center show that truck engine heat significantly reduces voltage output of an alternator. This reduction could be critical where voltage must be maintained for efficient operation. The Development Center has recommended field coil modifications to overcome the heat problem. Agencies considering installation of alternators should write directly to the Development Center to obtain further information.

After the Bel Air fire of 1961, the Los Angeles County Board of Supervisors ordered Fire Chief Keith E. Klinger to investigate the possibility of developing a small pump for drafting water from swimming pools. Klinger delegated this assignment to the author. Klinger had remarked that on several major watershed fires millions of gallons of water in swimming pools had not been used—mainly because of inaccessibility to heavy fire equipment. The department has a map of all swimming pools in the area it protects.

The author consulted personnel of Prosser Industries, Inc., Anaheim, Calif. A small, lightweight, portable pump was being marketed, but it required 115 volts of a.c. current at 60 cycles. After 2 years of intensive research, a suitable alternator has been developed for operation by mounting on fleet vehicles where remote operation of electrical equipment requiring domestic a.c. power is desired. It uses a series of automatically variable-speed pulleys that maintain a constant speed.

The first installation of the alternator and pump was made on patrol 82 (fig. 1), which is in the La Canada area.

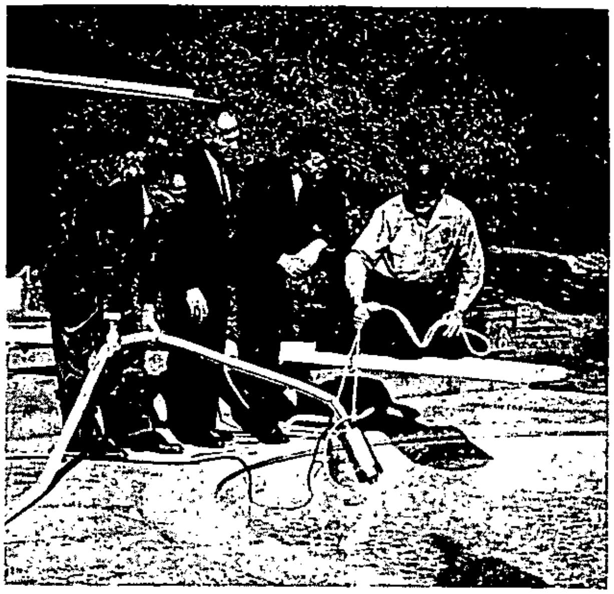

Figure 1.—Electric pump is being submerged in swimming pool.

Twenty-seven patrols are now equipped. These patrols are the first to be equipped because they are more mobile and can move closer to pools.

During the Verdugo Hills fire in March 1964, when the new equipment received its first operational test, it proved very effective. Many firefighting experts predict that all fire apparatus will soon be equipped with this type of alternator.

The development of the alternator has solved another fire department problem. Smoke ejectors and floodlights that require 115 volts previously had to be supplied by a gasoline-driven generator when a second source of electric power was not available. However, both operate very well on the power supplied by the new alternator.

AN INEXPENSIVE INCINERATOR

NEIL LEMAY, *Chief Forest Ranger, Forest Protection Division, Wisconsin Conservation Department*

Debris burning has long been a leading cause of uncontrolled fires in Wisconsin. The increasing number of people with summer homes and camps in forests and the growing use of oil or gas to heat rural homes have accentuated the problem.

Wisconsin law does not allow use of outdoor fire in the organized protection districts except for cooking food or warming individuals unless the ground is snow covered or a burning permit has been obtained. Therefore, a burning permit usually must be obtained for disposal of refuse.

A campaign against debris-burning fires indicated the need for a safe and inexpensive incinerator, which in turn would reduce requests for burning permits for debris disposal. Field men met these needs by developing the

LINTON A CARTER
535 HILLCREST AVE
EAST LANSING MICH
FCN OCT

U.S. DEPART
WASHIN... D. C. 20250

OFFICIAL BUSINESS

U.S. DEPARTMENT OF AGRICULTURE
POSTAGE AND FEES PAID

incinerator shown in figure 1. It was widely accepted and stimulated interest in the use of incinerators. Regular manufactured incinerators are readily available from dealers.

Widespread buying and maintenance of safe incinerators has reduced the number of fires resulting from debris burning. Also, the owner and maintainer of a safe incinerator is eligible for a seasonal permit. Thus, he does not need to obtain a permit every time he wants to burn debris, and he can still burn when burning permits are not issued because of High fire danger. Thus, the number of permits to be checked and accounted for has been reduced.

When an incinerator is obtained, the owner requests a seasonal burning permit. He then signs an application containing an agreement to abide by the rules for the use and maintenance of the incinerator. Finally, the incinerator is inspected; if it is approved, a seasonal permit is issued on the standard burning permit form.

An inexpensive sheet giving the construction details and a general statement of use for the incinerator developed by the field men was written and reproduced for free distribution. Its acceptance has been good, and the benefits have been rewarding.

The rules for the use of an incinerator, as agreed upon by the applicant for a seasonal permit, follow:

1. I will confine all of my burning, as it pertains to this permit, inside a metal or masonry incinerator unit which will be inspected and approved by a forest ranger.
2. I will burn within this incinerator only during the hours as listed in the burning permit.
3. I will have a responsible person present and suitable tools available during this burning period.
4. I will not set fire in this incinerator unit during dry, windy weather.
5. I will keep the area surrounding the incinerator unit clean and free of inflammable fuels.
6. I will keep my burning done currently with the need and not allow material to accumulate and overflow the incinerator unit.
7. I will maintain the incinerator unit as prescribed by a forest ranger.

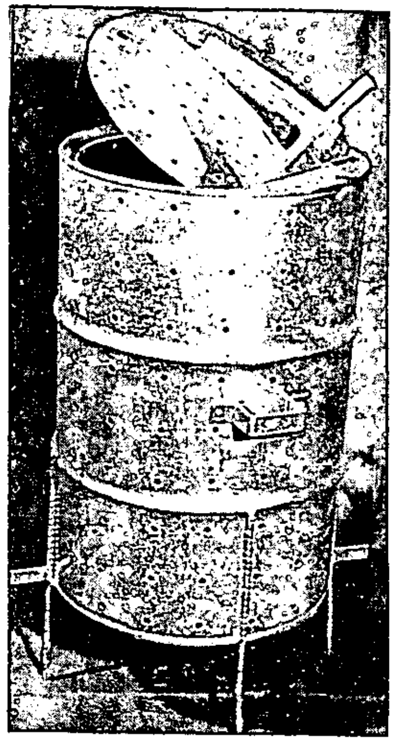

Figure 1.—This inexpensive incinerator was developed for debris burning.

Camera Gunstock—*Continued from page 8*

3- by ⅛-inch metal plate. A knurled-knob camera-thread screw is inserted through this hole. A thin slice of a rubber washer is cemented around the hole to prevent the screw from falling out and to secure the camera in a fixed position. Two holes, for wood screws, are positioned along the outer edge. The way the plate is mounted depends on the camera, lenses, and dexterity of the user. To insure a firm attachment, the metal plate should be cemented to the woodstock. An 18- to 20-inch cable release is inserted through a hole in the hand-grip and stapled to the stock, and it can be attached to the camera. This procedure enables the photographer to operate the shutter and point the camera with one hand while the other hand is free to focus, etc. An over-the-shoulder carrying strap can be added.

The gunstock mount was copied from a readymade item and has been used successfully with a Honeywell Pentax with a 300-mm. lens.

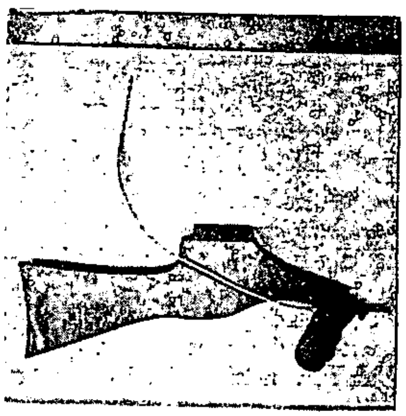

Figure 1.—This gunstock mount is used to steady the telephoto lens of a camera.