April 1966 Vol. 27, No. 2

FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

COVER—This pile burst into flame shortly after ignition. It was treated with a 30-gallon dilution of one part asphalt emulsion and two parts water. See story on page 5.

(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.

USE OF TAMARIX TREES TO RESTRICT FIRES IN ISRAEL[1]

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Fire hazard in arid and semiarid regions is High during the dry and hot summer. Usually field and forest fires start along roads where cigarettes or exhaust sparks are thrown from motor vehicles and ignite the dry litter.

Fire hazard usually depends on three environmental characteristics:

1. Susceptibility of the plant material to ignition.
2. Temperature of the fire and type of burning produced.
3. Abundance, density, and ground position of fuel.

For example, fire races through dry remnants of grasses and herbaceous plants because straw is readily ignited, produces high, hot flames, is abundant in large, contiguous areas, and is dense enough for continuous fire propagation and yet spaced widely enough to secure sufficient oxygen.

The combustibility of wood and fabrics may be lowered considerably when they are impregnated with certain ions.[2] Broido and Nelson (1964)[3] noted that the susceptibility of corn straw to inflammation is inversely correlated to its ash content. They declared that the use of plants with a high ash content may reduce the fire hazard.

To reduce the fire hazard along roads in arid and semiarid regions, isolated strips free of combustible material are usually cleared. However, such clearing has to be repeated annually, sometimes has to be done by hand, is difficult to complete, and is expensive. Therefore, this article explains an alternative method for reducing this hazard.

In geographical regions where herbaceous plants supply most of the fuel for fires, planting of isolation strips with tree species that eliminate annual herbaceous undergrowth and produce highly fire-resistant litter may reduce the number and progress of wildfires.

USE OF TAMARIX *RESTRICTS FIRES*

A short survey of the trees in Israel revealed that trees with all of the above desirable characteristics do exist, and that some of these belong to the genus *Tamarix*.

The litter of *Tamarix* trees has a high mineral content (sometimes more than 19 percent of the dry weight). Furthermore, the plants are salt excreters, and salty drops drip from the trees almost every night[4 5].

Litter Accumulation Reduces Fire Hazard

Thus, in semiarid climates, the soil below these trees is rapidly covered with shedded salty twigs, accumulates much salt, and eliminates plant species that do not grow naturally on highly salty soil[6 7]. The depression of the plant undergrowth below *Tamarix* trees is not only remarkable below adult trees, but also below 3-year-old saplings, where the effect of shade is still insignificant (fig. 1). Such a depression of the undergrowth is advantageous in the reduction of fire hazards below and across *Tamarix* plantations.

[1]Adapted from "The Use of *Tamarix* Trees For The Restriction of Fires," which was published in La-Yaaran, Israel.

[2] Lewis, M. 1964. U.S. Pat. 3150919.

[3] Broido, A., and Nelson, M. A. 1964. Ash content; its effects on combustion of corn plants. Science 146:652–653.

[4] Waisel, Y. 1960. Ecological studies on *Tamarix aphylla* (L.) Karst. II. The water economy. Phyton 15:17-27.

[5] Waisel, Y. 1961. Ecological studies on *Tamarix aphylla* (L.) Karst. III. The salt economy. Plant and soil 13:356–364.

[6] Litwak, M. 1957. The influence of *Tamarix aphylla* on soil composition of the Northern Negev of Israel. Bul. Res. Council Israel 6D:38–45.

[7] Friedman, J., and Waisel, Y. 1964. Contribution to the arboreal flora of Israel: *Tamarix aphylla* (L.) Karst. La-Yaaran 13:156–161.

Figure 1.—The elimination of herbaceous plants below a 3-year-old sapling of *Tamarix aphylla*. (near Gevuloth, Israel, April 1965.)

Tamarix Litter Resists Ignition

The shedded twigs of *Tamarix* trees form a compact layer on the soil. Repeated field experiments revealed that the ignition of this type of litter is extremely difficult (figs. 2, 3). The litter of *Tamarix* resists fire not only because of its geometry. Even in the laboratory this twig litter is very difficult to ignite: usually a high-temperature gas torch is needed. Even when the litter is set on fire, the flames produced at the ignition point do not cause further burning, and when the igniting torch is removed the flames die.

Data on fire velocity in different plant litter are presented in table 1. Fire progressed rather fast through the grassstraw and pine needles, but in the litter of *Tamarix* it rapidly died. Thus, there is almost no fire hazard due to fire progress in such material.

The material used in the experiments reported in table 1 was ovendry. Thus, the results confirm the idea of Broido and Nelson (1964) that it is the ash content rather than the water content that results in the difference in burning between pine needles, hay, and *Tamarix*. This idea is further supported in experiments which compared the burning of natural litter of *Tamarix* with that of a litter which was thoroughly leached and ovendried at 85°C. 24 hours before the experiment. While the natural litter was hardly ignited, the leached material exhibited a slow but continuous flame.

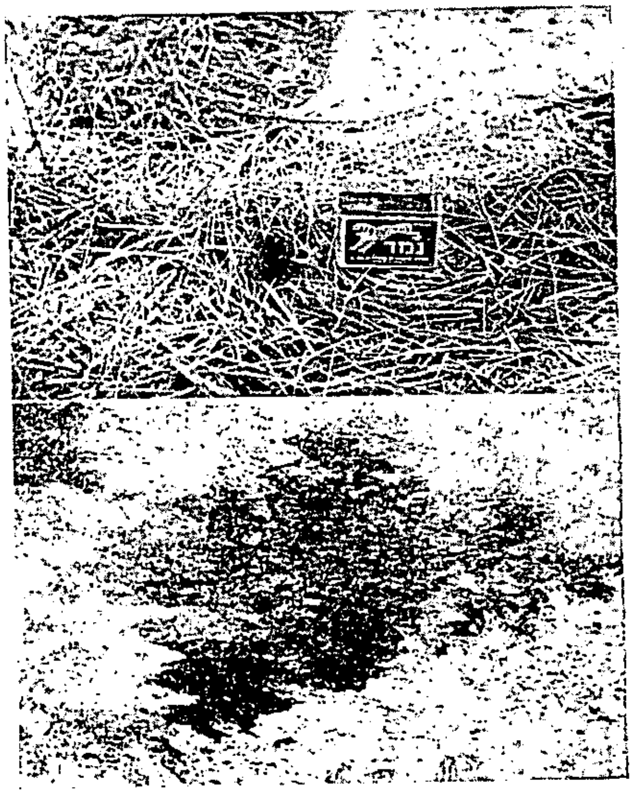

Figure 2.—The dimensions of a burned spot ignited with a single match: Top, litter of *Tamarix aphylla*; Bottom, straw of the herbaceous plants in the same area.

Figure 3.—The site of extinction of a fire which was advancing towards a stand of *Tamarix gallica*. The outlines of the unburned strip overlap the area where the shedded litter accumulates.

TABLE 1.—The progress of fire through a strip of uniformly prepared, ovendry plant material (2 cm. thick and 5 cm. wide). Gun powder (450 mg./4 $cm.^2$) was used as a prime.

Time since ignition (seconds)	*Distance from ignition point*		
	Pine	Hay	*Tamarix*
	Cm.	*Cm.*	*Cm.*
10	3	8	3
25	5	11	[1]
50	10	18	[1]
75	15	23	[1]
100	23	29	[1]

1 Fire extinguished.

Additional Advantages of Using Tamarix

Nevertheless, high moisture content of the litter still reduces the ability of plant debris to catch fire. The litter of *Tamarix* is superior even from this viewpoint. Due to the hygroscopic salt crystals covering the twigs, and due to its high mineral content, the litter is highly hygroscopic. The litter below *Tamarix* trees is often wet, not only during the night, but also a few hours after sunrise and an

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PROTECTIVE COATINGS OF ASPHALT AND WAX EMULSIONS FOR BETTER SLASH BURNING

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Disposal of logging slash is one of the biggest problems confronting the forest manager. He cannot burn during the summer because fires may escape. During the wet winter he can safely burn, but fuels often are too wet. He needs a method of keeping slash dry. Protective covers of tar paper, kraft paper, and plastic have been used. However, they are expensive, and wind can tear or displace them.

In 1961 Kirkmire[1] said that asphalt and wax emulsions sprayed on slash showed promise for speeding slash disposal.

Similarly, McNie[2] said that coating slash piles with asphalt and wax helped permit safe slash burning. Also, this operation cost less than previous methods. However, the fire control staff on the Klamath National Forest[3] in northern California found that treating slash on steep ground with an asphalt emulsion was expensive. Furthermore, workers had considerable difficulty handling, mixing, and applying the material. In a feasibility study in the winter of 1962-63, we found that slash piles sprayed with asphalt and wax emulsions could be burned during the winter when untreated piles could not. Also, the cost of applying asphalt to slash was about one-half that of covering slash with plastic.

THE STUDY

The study of the previous winter was enlarged in the winter of 1963-64, and this note reports the results of this later research. The 1963-64 study was conducted on the Duckwall Conflagration Control Experimental Area, Stanislaus National Forest, near Sonora, Calif. Station personnel met research employees of a company which develops and produces asphalt and wax products. They decided that three asphalt products and two wax emulsion products should be tested. These were asphalt emulsion Grade SS-1 ("Laykold Slash Cover"), asphalt emulsion Grade RS-1, priming solution (Asphalt cutback), a soil sealant wax emulsion, and a lumber sealant wax emulsion. Mixing ratios (asphalt or wax emulsion to diluent) of 1:1, 1:3, and 1:5 were used. Diesel fuel was used for diluting the priming solution, and water was used for the other four products.

Each of 45 piles (5 by 5 by 4 feet) of mixed conifer slash was treated with 6 to 10 gallons of solution. There were nine piles per product and three piles per mixing ratio. Fifteen more piles of the same type of slash were left untreated to represent controls. All piles were coated in the late fall when completely dry (fig. 1). The slash piles were burned on three dates:

November 15, 1963, when 2 to 3 inches of rain made slash burning safe.

January 29, 1964, when 6 inches of snow was on the ground and precipitation had totaled 17 inches.

April 23, 1964, when precipitation totaled 22 inches.

Each pile was ignited by a drip torch. The following were measured:

Figure 1.—Forest worker spraying asphalt emulsion on slash pile.

[1] Kirkmire, N. Report on preliminary tests of water proofing sprays for logging slash. 1961. (Unpublished report on file at Wash. Forest Protect. Assoc., Seattle, Wash.)

[2] McNie, John C. The role of water in burning right-of-way debris. 1963. (Report given at West. Forestry and Conserv. Assoc. Ann. Meeting, December 1963.)

[3] Report on the asphalt emulsion SS-1 treatment of logging slash in clear cut blocks. 1963. (Unpublished report on file at Klamath National Forest, U.S. Forest Serv., Yreka, Calif.)

Report on asphalt emulsion SS-1 treatment of right-of-way piled construction slash. 1963. (Unpublished report on file at Klamath National Forest, U.S. Forest Serv., Yreka, Calif.)

1. Time to ignite each slash pile, that is, the time required for fire to burn independently of the ignition device; and the number of times rekindling was necessary.

2. Time from ignition to the time the fire went out either because the fuels were consumed or would no longer burn—usually because of wetness. This time is called the burning time.

3. The degree of slash disposal. Three classifications were given:

Very satisfactory.—Pile ignites well, burns rapidly, hot, and clean, and little residue is left.

Satisfactory.—Pile ignites with some difficulty, burns moderately well, and leaves residue up to 3 feet long.

Unsatisfactory.—Pile does not ignite or ignites with difficulty, burns poorly or not at all, and leaves total pile or much residue in pile or perimeter (fig. 2). Perimeter residue exceeds 3-foot length.

4. Average fuel moisture percentages obtained from random samples of three size classes of slash material (0 to one-fourth inch, one-fourth to 1 inch, and more than 1 inch) in each test condition in February and April.

Observations were made and photos were taken of smoke output from coated and uncoated piles because smoke may be a smog threat in some areas.

Beads of recent precipitation that clung to the treated piles made ignition somewhat more difficult than in the untreated piles. This moisture dissipated rapidly, however, and the slash was much drier and burned quicker and cleaner.

RESULTS

Ninety-one percent of the slash piles sprayed with a protective coating and 40 percent of the uncoated piles burned satisfactorily. The coated piles also ignited somewhat quicker than the uncoated piles. The average moisture content of coated piles was 41 percent less than that of the untreated piles.

Figure 2.—This photo was taken after the initial attempt to ignite this pile. It was untreated and used as a control.

The slash was protected best by the SS-1 grade asphalt emulsion, priming solution, and the lumber sealant, in that order, and by the heavier mixes (no thinner than 1:2).

Because the slash was drier, the total output of smoke (slash plus coating) from coated piles was much less than that from uncoated piles.

RECOMMENDATIONS

From the experience gained in these field tests, we recommend the following:

Consider Alternative Methods

Preplanning may suggest that chipping, swamper burning, burying, spring burning, or other methods are cheaper and/or better.

Construct Slash Piles With Care

Piles should be compact, free of dirt, and large enough to build up heat to consume all the material.

Select Best Available Coating

Availability and cost of material and equipment will determine which coating is best.

The availability, cost, and performance of the SS-1 asphalt make it our first choice. However, it was a little more difficult to handle than the wax and primer. It cost about 30 cents per gallon in the supplier's 55-gallon drum and about 20 cents per gallon in bulk.

Our second choice is the priming solution, which protects slash well because it spreads and penetrates well. But it requires equipment that can tolerate petroleum. It cost about 50 cents per gallon (in supplier-furnished drums at plant). When the cost of the solvent is added, the total cost nearly equals that of the wax. Diesel fuel cost 15 cents, kerosene, 20 cents.

The lumber sealant wax was easy to work with, not messy, and sealed well. Its use will be limited, however, for it cost about 75 cents per gallon in drums furnished by the supplier at his plant. Costs of application will vary with type of material, equipment used, availability of coating material, type of slash, and the mixture used. The average cost of asphalts or waxes was $20 to $30 per acre. The cost for treating a cubic foot of slash averaged about one-half cent.

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SLASH DISPOSAL BY CHIPPERS

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Black Hills National Forest

ADVANTAGES OF CHIPPING

For disposal of logging or thinning slash, chipping has many advantages over piling and burning or broadcast burning.

Chipping may be done throughout the year. Best results are obtained when the material is green, but frozen or dry slash may be chipped.

Chipping slash can reduce the potential rate of spread and resistance to control of fire in recently logged over areas. Chipping also eliminates the need for costly piling and waiting for proper burning conditions.

Chipping does not reduce and can enhance aesthetic values; this is vital along highways and near recreation areas. It is the only practical method for concurrent slash disposal and cutting. Also, chips decompose quicker than normal slash.

CREW SELECTION

Crews must be well organized, trained, and supervised. Crew size depends on the distance the material must be hauled and on the capacity of the machine. A three- or four-man crew can usually keep the chipper working at capacity in ponderosa pine thinning slash. For safety, only one man at a time should feed the chipper.

WORK PLANNING

Best results are obtained when cutting methods are determined and chipper routes are laid out and mapped prior to commercial timber stand improvement. All trees are felled in one direction so that butts point one way and less handling is required. Windrowed material can be fed to the chipper continuously (fig. 1).

SELECTING CHIPPERS

In choosing a chipper, the size of material to be chipped must be considered. Most chippers can handle material with diameters up to 4½ inches, and some, 8 inches.

For economy, the chipper should have enough horsepower and torque to handle material continuously. Sufficient power on a weighted flywheel enables the cutting head to rotate uniformly. To reduce blade damage, a series of small blades staggered on the cutting head, rather than one large blade, should be used.

The unit should have an adjustable bonnet on the chip exhaust head. The bonnet adjustment should allow for 180-degree rotation and for some change in elevation. Thus, the distribution of chips can be controlled from the chipper to insure an even coverage over the ground or for side or end loading into trucks.

The Black Hills National Forest operates seven chippers. Five of these are mounted on trailers and towed behind conventional or four-wheel-drive pickups or small tractors, depending on terrain and ground condition. The other two units are self-propelled—the chipping heads have been incorporated into modified four-wheel-drive vehicles.

COST

The cost per acre, based on a commercial cut of 2,500 board feet per acre, averages $60 and ranges from $34 to $120.

Figure 1.—This self-propelled chipper is being used on windrowed brush piles.

THE "C" AND "D" ALERT SYSTEM, AN ATTACK PLANNING TOOL

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Lincoln National Forest

A difficulty in fire control planning is that the plans, once down on paper, are inflexible to some extent, whereas the fire itself is fluid. In obtaining flexibility of plan, however, there is the danger of being vague in one or more of the plan components. For development of flexible yet precise presuppression planning, the most promising area is between the ranger district or initial attack unit, and the zone or regional coordinated project fire organization.

The "C" and "D" Alert System strengthens the intermediate planning level between the ranger district direct attack unit and the full project fire organization. It is designed for fires in the "C" and "D" class, 10-300 acres, that occur during critical weather conditions, and often just beyond the resources of the average ranger district to control. Its objective is to contain hard-to-handle fires within the first burning period. It has the fluidity and quick mobilization of the ranger district organization, combined with the planning advantages of the project fire organization.

For the Southwest the three essential parts of the "C" and "D" Alert System are:

1. Prepackaged overhead teams for
   a. The Class C-Alert System, for 10-50 acre fires.
   b. The Class D-Alert System, for 50-300 acre fires.
2. Guides to provide for automatic dispatching of predetermined amounts of supplies, equipment, and crews.
3. A training plan, which will introduce the new system and teach the principles of sound fire organization and management. Not only professional people but GDA's, forestry technicians, and fire control aids should receive this training.

PREPARING THE SYSTEM

Overhead Team

In setting up a "C" and "D" Alert System, the first step is to decide on the particular configuration of overhead teams needed for the Forest or other combination of ranger districts. This is usually done by a panel of local fire experts. Figure

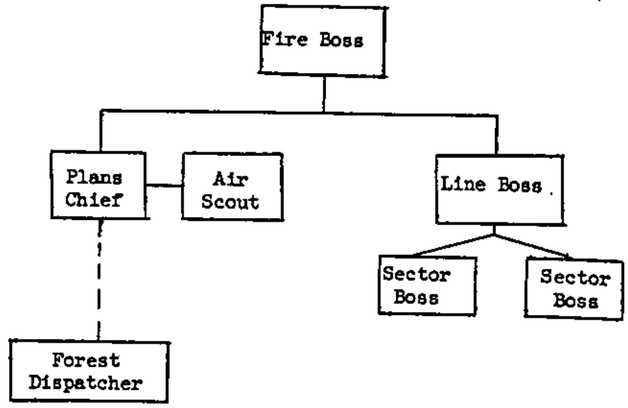

Figure 1.—Typical C-Alert overhead team.

1[1] is an example of a C-Alert team. In this example no service chief or campboss position was provided, and the service and plans functions were combined.

The D-Alert team is designed for the worst burning days, when it is recognized at first report that the fire will require more organization than the elementary C-Alert team can provide. The D-Alert team also functions as a backup organization, in case of imminent failure of the C-Alert team. Figure 2 is an example of a D-Alert team.

After deciding on the size and configuration of these teams, the panel should make a master list of forest personnel qualifying for as many team positions as possible. The list must be revised throughout the season by the Fire Staff Officer to account

[1] The dispatcher is recognized as part of the overhead team in this chart and in the forms that follow. Since our whole effort here is toward speed and efficiency early in the fire, it would be folly to ignore the pivotal role of the dispatcher.

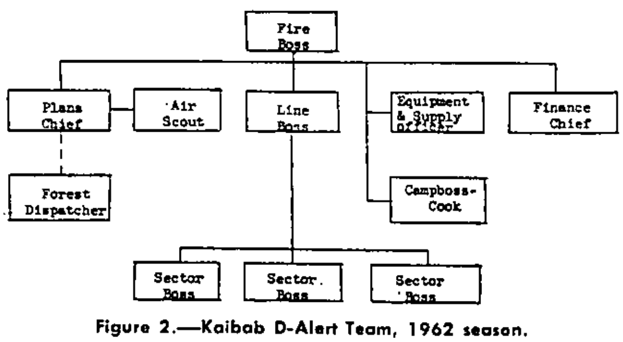

Figure 2.—Kaibab D-Alert Team, 1962 season.

for transfers and demonstrated performances, and annually by the panel.

During critical fire season the overhead teams are packaged weekly. On Wednesday morning the forest dispatcher fills out a Class-C Alert and Class-D Alert duty roster from the master list. The assigned duty is 1 week, until the following Wednesday morning. Figure 3 shows how the overhead team is planned from week to week. On some forests the fire boss position is filled by the district ranger, if at all possible, and his name is written in after the organization is alerted. Because of a general shortage of qualified plans chiefs, two people are usually assigned for plans chief duty. This double scheduling allows a district ranger who is a qualified plans chief to be preassigned for plans duty. The alternate plans chief is assigned to the fire if it is on his district.

The dispatcher then notifies the district rangers and the fire staff officer of the week's selection. After their approval, and with their help, he notifies the selected personnel. From the time of notification to the end of the duty period, these people remain in constant radio or telephone contact, keeping the dispatcher advised of their location.

Dispatcher's Guide

The dispatcher's guide should list the resources

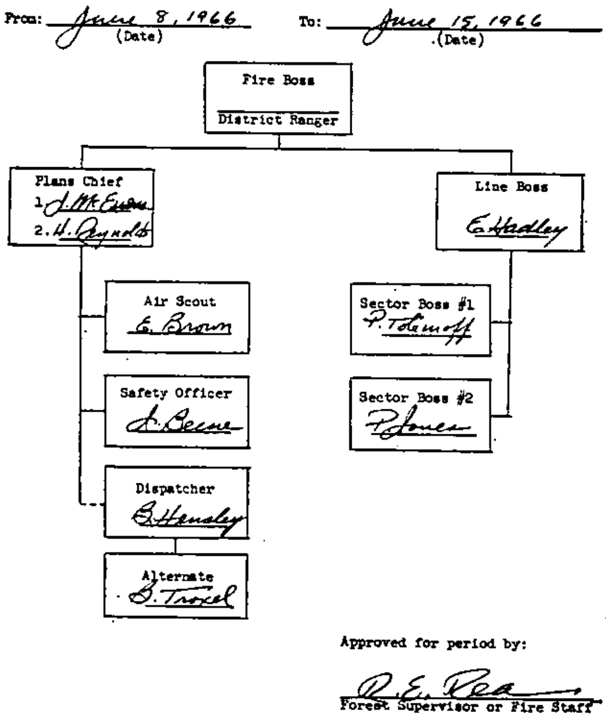

Figure 3—C-Alert duty roster.

DISPATCHER'S MATERIAL AND SUPPLY GUIDE

for Class C-Alert Fire

Dispatcher ____________________ Date __________

Assistant Dispatcher ____________ Time __________

Name of Fire __________

	Dispatched	ETA
Men and Overhead—2 Crew Bosses		
20 Crewmen		
2 Men for J. Deere 2010		
4 Men for Pumper Crews		
Vehicles and Equipment		
2 Pumper Units		
1 John Deere 2010		
1 Water Trailer, 250 gallon		
3 Powersaws with Equipment		
40 Man Tool Cache		
4 Sets Catapillar Lights		
Radios 4 Handy Talkies		

of men and materials that are needed and practical in most troublesome "C" and "D" fires in critical fire season.

As an alert is set in motion, the dispatcher immediately sends out men, equipment, and vehicles as the guide indicates, recording the dispatched time. The fire boss or plans chief has copies of the guide as kit components and need only order additions or deletions to what is contained therein. A second benefit of the guides is a substantial reduction in radio traffic during the fire emergency.

Training Plan

Because the Southwestern fire season may begin as early as March 15, the overhead school is held in early spring. At the school trainees are introduced

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RATE OF FOREST FIRE SPREAD AND RESISTANCE TO CONTROL IN THE FUEL TYPES OF THE EASTERN REGION

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Information about the rate of spread of forest fires helps fire control planners delineate hour-control zones and the required strength of initial attack and total forces, and it helps suppression forces make tactical decisions.

Rate-of-spread tables prepared by Jemison and Keetch (1942)[2] have been used in the Eastern Region for many years. However, since 1942, the danger-rating system has been changed, and instrumentation and methods of measurement have been improved.

In 1959, the Eastern Regional office of the U.S. Forest Service decided to study recent fire reports to correlate rate of spread with the current fire-danger rating system, and to compare the more recent rate-of-spread data with the 1942 data. The Northeastern Forest Experiment Station cooperated with the Eastern Regional office in reviewing their individual fire reports, Form 929,[3] for 1950–58 from all National Forests in the Eastern Region.

Burning index, wind, and slope were to be considered in computing rates of spread for each fuel type. Unfortunately, wind and slope data were missing from many reports, so only the burning index data could be used.

The definitions of fuel types used in this study have been used in the Eastern Region for many years. They were also used in the earlier studies of fire spread by Abell[4] and by Jemison and Keetch. A list of these fuel types by number and description follows. Tables 1–5 refer to fuel types by number only.

Fuel type (number)	*Description*
1.	Northern conifers, 4 inches d.b.h. and larger.
2.	Northern conifers, cutover, duff and no slash.
3.	Hardwood and hemlock-hardwood, cutover, no duff nor slash.
4.	Northern and Appalachian hardwood, 3 inches d.b.h. and larger.
5.	Hardwood reproduction.
6.	Southern pine, 6 inches d.b.h. and larger.
7.	Southern pine reproduction.
8.	Conifer slash (new).
9.	Conifer slash (old).
10.	Hardwood and southern pine slash.
11.	Grass, ferns, and weeds.
12.	Plantations.
13.	Laurel and rhododendron.
14.	Scrub oak.
15.	Unburnable.

RATE OF SPREAD

For all fires in each of the various fuel types, the average perimeter increase in chains per hour between discovery and attack varied from 4.9 for northern conifers 4 inches d.b.h. and larger (fuel type 1) to 27.1 for southern pine reproduction (fuel type 7). The average for all types was 21.9 (table 1).

Since the fastest-spreading 25 percent of fires normally account for much of the area burned, and for even more of the damage, the average perimeter increase in chains per hour for each type was computed for this group. These increases varied from 11.9 chains for fuel type 1 to 64.8 chains for fuel type 7, and averaged 51.7 chains (table 1).

The rates of spread for 1930–41 and 1950–58 were compared (table 2). For those fuel types with 50 or more fires in each period, the rates of spread were very similar. When fewer than 50 fires occurred in one or both periods, the differences in rates of spread were usually large.

[1] When this research was conducted, Banks was stationed at the Northeastern Forest Experiment Station, Upper Darby, Pa. Frayer is now retired.

[2] Jemison, George M., and Keetch, John J. Rate of spread of fire and its resistance to control in the fuel types of eastern mountain forests. 1942. U.S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 52, Asheville, N.C., 15. pp.

[3] Superseded by Form 5100-29.

[4] Abell, C. A. Rate of spread and resistance to control data for Region 7 fuel types and their application to determine strength and speed of attack needed. 1937. U.S. Forest Serv. Appalachian Forest Expt. Sta., Asheville, N.C., 7 pp., illus.

TABLE 1.—*Average rate of spread of all fires and of the fastest-spreading 25 percent of fires, by fuel types* (Eastern Region, 1950–58)

Fuel type No.	All fires				Fastest-spreading 25 percent of fires	
	Fires	Average perimeter increase	Standard error (S –) X	Standard deviation (S)	Fires	Average perimeter increase
	No.	*Chains per hour*	*Percent*	*Chains per hour*	*No.*	*Chains per hour*
1	9	4.9	42.0	6.3	2	11.9
2	13	12.8	26.0	12.1	3	28.7
3	7	6.4	47.0	8.0	2	16.1
4	742	21.2	4.4	25.4	186	52.2
5	348	20.8	5.5	21.3	87	46.7
6	58	22.6	16.8	28.7	14	56.5
7	60	27.1	13.8	29.2	15	64.8
8	5	7.6	43.8	7.4	1	15.5
9	9	23.4	25.4	17.9	2	43.6
10	101	24.8	9.1	22.6	25	53.3
11	182	26.6	7.2	25.8	46	59.7
12	7	20.1	43.1	22.9	2	50.3
13	24	18.8	33.5	31.0	6	52.5
14	17	17.8	21.0	15.4	4	36.6
15	7	17.3	40.4	18.5	2	44.6
All types	1,589	21.9	2.8	24.5	397	51.7

The combined data for the two periods probably represent the best information available on rate of spread in the Eastern Region (table 2). These combined data showed that 12 fuel types differed in their mean rate of fire spread by less than 15 percent. Types 1, 8, and 15 differed by more than 15 percent, but their rates of spread were the lowest.

For 1950–58, the average perimeter increase per hour for all fires, and also for the fastest-spreading 25 percent of fires, were computed for four burning-index (B.I.) ranges (table 3). The increase in rate of spread, for each of the three steps upward in burning-index ranges, averaged approximately 38 percent. This further indicates that successful fire control must be closely related to a burning index or some other measure of burning conditions.

The distribution of 1950–58 fires by rate-of-spread and burning-index range is shown in table 4. As expected, the percentage of fires that spread at the higher rates increased as the burning index increased. For example, only 3 percent of all fires that occurred when the burning index was in the range 1 to 11 spread at 50 chains or more per hour, whereas 27 percent of all fires that occurred when the burning index was 100 or more spread at this speed.

All spread data shown in this study are for the

TABLE 2.—*Comparison of rates of spread, by fuel types* (Eastern Region, 1930–41 and 1950–58)

Fuel type No.	Fires			Average perimeter increase of all fires			Average perimeter increase of the fastest-spreading 25 percent of fires		
	1930–41[1]	1950–58	Combined	1930–41[1]	1950–58	Combined	1930–41[1]	1950–58	Combined
	No.	*No.*	*No.*	*Chains per hour*	*Chains per hour*	*Chains per hour*	*Chains per hour*	*Chains per hour*	*Chains per hour*
1	14	9	23	12.1	4.9	9.3	21.7	11.9	17.9
2	24	13	37	30.2	12.8	24.1	86.7	28.6	66.3
3	55	7	62	22.3	6.4	20.5	55.7	16.1	51.2
4	914	742	1,656	20.7	21.2	20.9	47.4	52.2	49.6
5	634	348	982	21.5	20.8	21.3	51.3	46.7	49.7
6	161	58	219	22.7	22.6	22.7	53.0	56.5	53.9
7	97	60	157	25.1	27.1	25.9	55.2	64.8	58.9
8	15	5	20	15.8	7.6	13.7	35.8	15.5	30.7
9	12	9	21	26.2	23.4	25.0	67.5	43.6	57.3
10	141	101	242	25.4	24.8	25.1	60.9	55.3	58.6
11	516	182	698	26.8	26.6	26.7	58.8	59.7	59.0
12	....	7	7	....	20.1	20.1	....	50.4	50.3
13	7	24	31	33.1	18.8	22.0	83.2	52.5	59.4
14	13	17	30	35.6	17.8	25.5	85.2	36.6	57.7
15	....	7	7	....	17.3	17.3	....	44.6	44.6
All types	2,603	1,589	4,192	22.9	21.9	22.5	52.7	51.7	52.3

[1] Jemison and Keetch 1942.

early period of the fire between discovery and attack. This is usually limited to the first hour of the fire, frequently to the first half hour. Though these data are of value in helping determine initial-attack strength, they should not be misinterpreted as representing the rate of spread after the fire has gained momentum.

RESISTANCE TO CONTROL

Resistance to control, as considered here, is the relative difficulty within various fuel types of constructing and holding a fireline with hand crews. Although fire control has become more mechanized, such comparisons are still desirable.

Recording *man-hours to control* only, to the nearest 10 on the individual fire report, Form 929, has made calculations based on data from this source subject to large errors, particularly because many fires were small, requiring 30 or less man-hours to control. For example, in recording to the nearest 10, a fire that required 16 man-hours to control would be recorded as 20 man-hours—a difference of 25 percent between actual and recorded. To compensate for this discrepancy, the fire control staff of the Eastern Region Forests critically reviewed the resistance-to-control classifications, as computed from individual fire report data, and suggested adjustments. In applying these adjustments to the resistance-to-control classifications, they rated two fuel types as extreme, seven as high, four as medium, and two as low (table 5).

TABLE 3.—*Average rate of spread of all fires, and of the fastest-spreading 25 percent of fires, by burning-index ranges* (Eastern Region, 1950-58)

Burning-index range	All fires		Fastest-spreading 25 percent of fires	
	Fires	Average perimeter increase	Fires	Average perimeter increase
	No.	*Chains per hour*	*No.*	*Chains per hour*
1–11	274	13.7	69	34.3
12–35	691	19.6	173	48.6
40–95	548	26.7	137	61.6
100+	62	37.6	15	87.7
All ranges	[1] 1,575	21.7	394	52.1

[1] Fourteen fire reports showed no burning index; thus, they could not be used.

TABLE 4.—*Percent of fires spreading at various rates, by burning-index ranges* (Eastern Region, 1950-58)

Burning-index range	Fires	Perimeter increase per hour			
		Less than 30 chains	30 chains or more	50 chains or more	70 chains or more
	No.	*Percent of fires*	*Percent of fires*	*Percent of fires*	*Percent of fires*
1–11	274	88	12	3	1
12–35	691	80	20	8	4
40–95	548	66	34	15	7
100+	62	63	37	27	14
All ranges	[1] 1,575	76	24	10	5

[1] Fourteen fire reports showed no burning index; thus, they could not be used.

TABLE 5.—*Resistance to control by fuel types* (Eastern Region, 1950–58)[1]

Fuel type No.	Resistance-to-control class[2]
1	High
2	High
3	High
4	Medium
5	High
6	Medium
7	Medium
8	Extreme
9	Extreme
10	High
11	Low
12	Medium
13	High
14	High
15	Low

[1] Adjusted by fire control staff of the Eastern Region.

[2] Class standards for resistance to control: 2.5+ chains of held line per man-hour = Low; 1.8 to 2.4 chains = Medium; 1.1 to 1.7 chains = High; 1.0 or less chain = Extreme.

SUMMARY

Studies based on Eastern Region fire reports indicate that fuel type is not an extremely important factor in the rate of fire spread during the early period of the fire. Data for all fires for two periods, 1930–41 and 1950–58, show that for 12 of the 15 fuel types the rate of spread ranged within 15 percent of the mean of the 12 types. Data for the fastest-spreading 25 percent of fires show that for 11 of the 15 fuel types the rate of spread differed by no more than 10 percent from the mean of the 11 types.

The rate of spread increased substantially with increases in the burning index. As expected, the percentage of fires spreading at the higher rates increased substantially as the burning index increased.

Resistance to control, or the relative difficulty of constructing and holding a fireline with hand crews, differed appreciably by fuel types. Two fuel types were classed as Extreme, seven as High, four as Medium, and two as Low.

NEW MAP FOR SMOKECHASERS[1]

Missoula Equipment Development Center,
Missoula, Mont.

In a few years smokechasers will probably stop using the familiar folding map consisting of pocket-sized squares glued to cloth backing. A remarkable paper developed for industry is used for maps that have superior utility and cost one-tenth as much as the cloth-backed type.

The paper is "Tex-O-Print." Developed for shipping tags and labels, Tex-O-Print is impregnated with latex to resist abrasion and wetting, the two main injurers of smokechaser maps. Tex-O-Print maps are light, tough, and thin, and have excellent detail when printed by economical color lithography.

As many as 250 smokechaser maps have been prepared annually in Region 1 by the cut-and-paste method. The average annual cost was $2,550; about $2,300 was paid to workers who tediously cut maps into small squares and glued them to the cloth backing, leaving folding space between each square.

Some advantages of the Tex-O-Print maps follow:

1. They cost approximately $1, about $9 less than the old maps.
2. Tex-O-Print's toughness has eliminated the need for cloth backing.
3. The new maps when folded are one-fourth as bulky as the old ones.
4. On only the new maps, grease pencil delineations can be made and removed.
5. Only the old maps must be cut into small rectangles, thus disturbing the planimetric details.

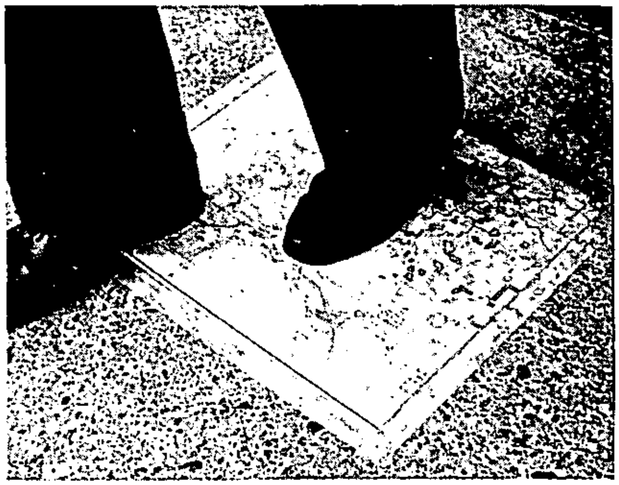

Figure 1.—People walked on a Tex-O-Print map as part of a durability test.

6. Only the old type of maps can be destroyed by damp weather and water. One Tex-O-Print map was taped to the sidewalk in front of a building. It was walked on by people entering and leaving (fig. 1). After 21 days of exposure to this treatment and to rain, snow, and sunshine, the map was wiped clean with a damp cloth. It was scuffed but serviceable.

Tex-O-Print maps used normally should last 5 years. During 1964, five R-1 Forests tested the new maps. Because reports were enthusiastic, the Region is supplying Tex-O-Prints as existing map stocks become exhausted. Tex-O-Print smokechaser maps are now approved for Service-wide use.

[1] J. W. Burgess, Division of Engineering, Region 1, Missoula, Mont., proposed use of Tex-O-Print for Forest Service maps.

BUTANE BOTTLE BLITZES BIVOUAC

HOWARD V. SHUPE, *Forester,*
Coronado National Forest

On July 7, 1965, the men at the Carrisito fire camp on the Coronado National Forest had been making progress in containing a 600-acre brush fire. The night crew had bedded down where a mesquite tree or a desert shrub provided shade from 106° F.

Then it happened. A spare butane bottle exposed to the sun reached its maximum pressure and blew the plug. The bottle was only 7 feet from operating gas burners, and the escaping gas drifted into the open flame. With the resultant explosion and liquid gas pouring forth, the bottle was converted into a giant undulating blowtorch. More nearby tanks soon exploded. The flames spread rapidly into the dry, parched fuels within and surrounding the camp, and tents and other equipment were consumed by flames. Men ran from the area, and vehicles were quickly moved.

(Continued on page 15)

(Butane Bottle—Continued from page 14)

Fortunately, fatalities or serious injuries, which were likely, did not occur. To prevent similar incidents from happening, the following safety precautions are recommended:

1. That open fires and fuel bottles not in use be at least 25 feet apart.

2. That extra fuel bottles be stored separately from fuel bottles in use.

3. That fuel bottles used where it is 100° F., or more, be filled to 80 percent of capacity to allow for expansion.

4. That shading be provided for fuel bottles whether they are in use or not.

(Tamarix Trees—Continued from page 4)

hour or two before sunset. The chances of a fire below a *Tamarix* plantation during these hours are negligible.

A long smouldering fire is hazardous because new fire outbreaks may occur with the onset of wind. *Tamarix* again seems superior due to the fast extinction of fire in its litter as well as in its burning wood. (table 2)

TABLE 2.—Data on flaming and smouldering of 10 grains of ovendry samples of pine needles, hay, and litter of *Tamarix*. Gunpowder (450 mg./4 cm.^{2}) was used as a prime.

Unit of measure	Pine	Hay	*Tamarix* Natural	*Tamarix* Leached
Time from ignition to extinction of flame (seconds).	60(55–65)	47(45–50)	14(5–20)	112(105–120)
Time between extinctions of flames and glare (seconds).	312(235–380)	301(210–435)	7(5–10)	170(160–180)
Loss of weight due to burning (percent)	84(80–89)	64(59–69)	4(2–6)	50(46–55)
Ash content (percent)	7.0(6.4–8.0)	8.0(7.6–8.3)	19.6(19.4–19.8)	15.6(15.2–16.2)

As shown in table 2, a fire of *Tamarix* litter extinguishes rapidly and burns only a minute fraction of the sample. However, the samples of hay and pine needles are burned thoroughly, and the resulting weight loss is 64–84 percent of the sample's dry weight. The duration of flaming and especially of smouldering in hay and pine is much longer than in *Tamarix*.

When the litter of *Tamarix* is thoroughly leached, and its mineral content is reduced from 19 to 15 percent, it burns more readily. However, even then the leached litter burns slowly, smoulders only briefly, and extinguishes before complete combustion.

Tamarix trees are easy and inexpensive to propagate; their growth rates are usually very high, and the large number of species spread over the world makes at least some of them available for planting in a large variety of regions. Thus, together with the above-mentioned characteristics found in Israel, it seems worthwhile to try and use *Tamarix*-planted isolation strips for the restriction of wildfires.

(Protective Coatings—Continued from page 6)

Mix Carefully

Mix one part emulsion to two or not more than three parts solvent (diesel fuel or kerosene for primer, water for others).

Coat Slash When It Is Dry

Average fuel moisture content should be less than 15 percent. Slash moisture is usually lowest in the fall.

Apply Liberally

Use very generous applications. Seal large holes and cracks. Priming solution and lumber sealant may be applied with any conventional power sprayer. The use of primer requires petroleum-tolerant gaskets, hoses, and other parts on pumps. Pumps to be used with SS-1 should have gears and impellers that are somewhat worn. Be sure positive displacement pumps have pressure-control devices. Exhaust heat may have to be directed on pump regions of close tolerance (packing gland) when pumping SS-1.

Burn as Soon as Possible

Coatings cracked by sun, wind, or insects will deteriorate. Consequently, it is best to burn as soon as you can do so safely. Burn before precipitation totals 8 to 10 inches. Use ignition aids and fuel boosters, such as petroleum gels, for faster ignition and fire establishment.

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(*Alert Systems*—Continued from page 9)

to the need for the system and its operational steps. They are thoroughly trained in the jobs to which they will be assigned in the system.

A 3-day school is ordinarily sufficient. The first half day is spent in orientation and system concept. The next day and a half are devoted to training in the individual overhead position, bearing down on sound principles of fire organization and management.

The third day comprises testing, group discussion, and simulated fire exercises. Another valuable training session is a postseason review in which forest personnel evaluate the system and suggest improvements.

MOBILIZING THE ALERT

The persons qualified to mobilize the alert, i.e., diagnose a fire as needing a "C" or "D" Alert effort, should be determined at the first planning conference. Usually rangers, assistant rangers, FCO's, and selected, experienced lookouts qualify. Once decided, the information should be publicized within the fire control force, and a check made to see that the persons concerned are made fully aware of their responsibility.

The steps in mobilization are:

1. Qualified officer (ranger, air patrol, lookout, etc.) advises the dispatcher of an Alert fire situation. His message should contain only essential information, e.g.: "Dispatcher, this is Ranger McVey. Scramble Class-C Alert, in Muleshoe Canyon, SW ¼ sec. 22, T. 6 S., R. 4 E.
2. The dispatcher then advises overhead duty roster of the Alert, giving the fire's location, and activates forces based on a material and supply guide form. (Often, many on overhead duty will acknowledge the Alert message and proceed without dispatching.)
3. Duty personnel advise the dispatcher of their ETA at the fire, pick up their kits (or arrange for the kits to be delivered at the fire), and proceed.
4. The air scout gets airborne and over the fire, prepares initial sketch map and polaroid photograph of the fire, and drops them to the fire boss or plans chief, whoever is first at the fire.
5. The fire boss or plans chief advises unarrived duty personnel of the headquarters meeting area, marking it for air observation.
6. The plans chief prepares duplicate sketches from the airdrop map of the fire for line and sector bosses.
7. The fire boss, with the plans chief's aid, evaluates the fire and his resources, orders more men and equipment as needed (or reclassifies the Alert), and rapidly develops an attack plan.
8. Using the plan and maps, a briefing is held with the overhead team, and the fire boss assigns sectors and implements the plan.

With the availability of two types of alert organizations, many combinations are possible. Ordinarily the C-Alert team is mobilized initially, followed by a D-Alert if needed. But on a worse burning day, the D-Alert may be initially mobilized. Furthermore, the acreage figures are only guides. Sometimes the larger D-Alert team might be mobilized for a 15-acre fire, and a C-Alert team for a 5-acre fire. The systems may and probably will be modified in practice. Basically the C-Alert team is one of two sectors, and the D-Alert team is one of three sectors. Since flexibility is important, it is possible to add sectors to either Alert team.

CONCLUSION

The "C" and "D" Alert System is designed for one burning period. If the fire is contained within 24 hours, the system has served its purpose. If not, the relieving team inherits more information and a better organization to build on than is generally the case. In any event, the system provides a preplanned framework, flexible and capable of expansion, to enable the quickest and most effective use of local personnel and material.