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FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

COVER — This Mars flying boat converted to an air tanker is dropping a 4,500 gallon load on a slash fire in British Columbia. (See story on page 3.)

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

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MARS — NOW GOD OF RAIN

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In these days of rocket ships and the superjet it is hard to get excited about an aircraft that has been obsolete for 9 years. But these planes are truly extraordinary. They are the five Martin Mars flying boats, the largest operational flying boats the world has ever seen or probably will ever see. From 1946 to 1956, when the last one was retired, they carried a quarter of a million passengers and countless tons of freight over the Pacific for the U.S. Navy.

Fortunately the Mars story does not end on a scrap heap. It is still being written in the skies over coastal British Columbia where two of the three remaining big transports have been converted to "water bombers" to control forest fires. (One ship was lost by the Navy in a fuel-leak fire in 1950, and one was destroyed in a 1961 crash.

While the four giant boats rested on the beach of the Alameda (Calif.) Naval Air Base awaiting possible destruction from 1957 through 1959, things were getting hotter and hotter for the forest industry of British Columbia. The two bad fire years of 1956 and 1958 convinced fire protection people that better forest fire control methods had to be found, and fast. The water bomber was one technique seriously considered.

Water bombing was not new — a variety of tests between 1930 and 1950 had stirred interest in this novel use of aircraft. Here was the potential for a first-order fireline tool if only a practical carrier could be found. Early experiments were mostly with a water-filled missile dropped from the plane. On very small fires the missile was at times effective, but it was expensive and also a hazard to ground crews.

By 1958 the air tanker was accepted as a part of the fireline team. In British Columbia, five Avengers were in water bomber service, and several Beaver and Otter float planes were equipped with small float tanks.

The small tankers did wonderful work on many small fires, but they didn't carry enough water to be effective on big fires. The ideal air tanker would have to carry a large water payload, preferably several thousand gallons.

Coastal British Columbia is tough flying country, with its steep, high mountains, narrow valleys, and rough air. Traditionally, it is float-plane territory. This rugged coast has few large airfields, but it does have countless sheltered inlets and numerous large lakes. So the choice of aircraft for the ideal tanker soon narrowed down to some type of flying boat. A search for such a flying boat throughout most of 1959 ended at Alameda, where the U.S. Navy was offering the four Mars aircraft for sale as surplus.

Late in 1959 five leading forest industry firms in British Columbia formed a new company, Forest Industries Flying Tankers Ltd.[1] Its purpose was to purchase, convert, and operate the Mars aircraft as water bombers for the member companies. The four aircraft, together with a treasury of spare parts, were purchased and ferried up to Victoria International Airport on Vancouver Island. Here Fairey Aviation of Canada Ltd., with a nucleus of the new tanker crew, started work on a new dimension of water bombers.

The Mars tankers were allocated their own VHF radio frequency, and member companies equipped their logging operations with portable sets for ground-to-air communication. In addition, the Mars tankers carry the radio frequency for the B.C. Forest Service and those of several local airlines. To round out the establishment, an operational base, complete with communications centre, fueling facilities, and crew living quarters, was built at Sproat Lake on central Vancouver Island.

1960

Early in 1960 the first of the converted new tankers was airbound on a series of stiff shakedown tests. By early summer, the tanker moved up to its operational base, ready for business.

The first fire call came on July 4th. Enroute, engine failure forced her to return to base. Four days later, she made four drops on a second fire. Again engine failure forced an early return to base. The trouble was traced to excessive vibration caused by faulty propeller blading.

During the rest of the summer, the Mars made 26 drops on 6 fires, delivering a total of 127,000 gallons of water. These first-year results were inconclusive. The Mars had not controlled any fires singlehandedly. The general opinion was, however, that the results justified continuing the operation with one aircraft.

[1] The companies were MacMillan & Bloedel Ltd., Powell River Company Ltd., British Columbia Forest Products Ltd., Western Forest Industries Ltd., and Tahsis Company Ltd. In 1961 the new company of MacMillan, Bloedel and Powell River Limited was formed. In 1961 Pacific Logging Limited joined the Flying Tanker Group when a reserve aircraft became operative.

1961

The 1961 fire season started with promise: the tanker did good work on two fires, but that was all — the third fire was its last. Disaster struck. On her first run, the Mars crashed in heavy timber close to the target area, carrying her four crewmen to their deaths.

Since the exhaustive inquiry into the crash by the Department of Transport found nothing to indicate malfunction or structural failure of the aircraft, the cooperating timber companies decided to put another ship into service. The second tanker, overhauled down to the last hull rivet, was ready for fireline duty early in 1962.

1962

When this second tanker moved up to Sproat Lake early in 1962, she was accompanied by a Cessna 195 float plane. This was to be the "bird-dog" plane. Experience had indicated the need for such an aircraft; subsequent fires have proven its worth. First over the fire, the bird dog establishes ground-to-air radio contact, identifies the fireline target, and then leads the Mars in on the best drop path. The bird dog has proven indispensable. In addition to its main job of making the tanker operation safer and more accurate, it acts as handy man around the fire — warning of spot fires or flying the Fire Boss over trouble areas.

In its first year of operation the new tanker saw relatively little action. The 1962 fire season was ideal from the loggers' point of view, with little real hazard. In all, 118,000 gallons of water were dumped on five fires. On the biggest of these fires the true potential of the tanker was recognized. Called in late in the evening, the tanker could only drop two loads before being grounded by dark. Early next morning four loads were dropped along the leading edge of the fire. Unfortunately, a jammed release door forced the aircraft to return to base before the whole front could be wet down. Ground crews were unanimous in their belief that a few more loads would have pinched off the fire and prevented the subsequent spread that required several days to control.

The end of another fire season arrived, and the tanker operation was still under critical scrutiny. The plane had done a creditable job on the few fires it had fought, but mechanical defects had put it out of action more than once. In defense of the Mars it was argued that any single tanker operation is vulnerable to breakdown. Lost time from even a minor breakage requiring base repair is vital on the fireline. The case for a reserve flying tanker was slowly developing.

1963

The year 1963 was by far the best the Mars tank organization had experienced. Fires were not numerou because the fire season was not particularly hazardou But, when the tanker was called out, its performanc won it full recognition as a member of the firelin team. For the first time the Mars completely exti guished a fire without ground crew support. On fast-moving lightning fire, it wet down bulldozed fir guards so that firefighters could work in close to th fire front. In two instances the Mars soaked down fir threatened timber edges to prevent crown fires fro starting.

September of that year started out dull and coo On southern Vancouver Island several operators starte to burn slash when rain was forecast. The rain did n fall; instead the weather turned dry. The slash fire fanned by brisk winds, were soon out of control. Th Mars saw more action in 3 days than in any of th preceding 3 years. In 32 runs the tanker droppe 177,000 gallons of water over a wide fire front. Unt the sea became too rough, salt water pickups wer made offshore from the fire; roundtrips were made i 10 minutes.

By yearend 1963 a record 495,000 gallons had bee dropped on nine operational fires. Forest Industri Flying Tankers now was confident the Mars coul make a major contribution to fire control. Plans wer made to bring a reserve ship into service the follow ing year.

1964

From the point of view of the crews, anxious fo action, the summer that followed in 1964 could n have been worse, although it was a blessing for th forests. The crew waited for four miserably wet sum mer months before they went into action. At year' end they had only bombed two fires! Base activitie however, were far from quiet. The new flying tanke LYL was nearing completion; at the same time majo improvements were being built into LYK.

The story of the Mars flying tankers could not b complete without some reference to the men who fl and maintain them, for they are a rather special bree of airmen. A crew of only four men fly the ship o operational tours. Hours of practice have honed th crews into fine precision teams.

A captain, or first pilot, is responsible for the suc cess of the mission and the safety of his aircraft. It i he who must decide whether it is safe to fly in over th fire area, considering terrain, smoke, and air turbu lence. Pilots as a basic minimum must have long e per ce in water operations and mountain flying. (and above an intimate knowledge of their terri- , they must be at ease in smoke-filled valleys ided by rocky hills. It is one thing to fly over this untry at a comfortable altitude, but it is quite an- ther to whistle down barely 250 feet over the treetops through bumpy air. Flying in to pick up a water load the captain takes complete control. He eases the air- craft down until it is planing through the water at precisely 70 knots. When the aircraft is planing smoothly he lowers the probes to start the water pickup (fig. 1).

The second pilot meanwhile is busy with the flaps and trim controls in preparation for takeoff. The moment loading starts the first engineer takes over control of power. In those critical 20 seconds needed o take on a full load he must maintain aircraft speed it 70 knots, then boost power for takeoff.

While flying to the fire, the second pilot listens to radio instructions from the bird dog pilot, who has already identified the first target and by now has lined up the best approach. The captain will make the water drop, but before he starts his bombing run he will probably fly over the fire to confirm the bird dog in- structions. Once committed to his run, the captain con- centrates entirely on the approach course and altitude. The second pilot takes over the throttles to maintain airspeed at 120 knots. Once past the target he applies climbing power to ensure a safe exit from the fire area.

Engineers double as flight and maintenance crews. Their long suit must be ingenuity in handling emer- gency repairs in a hurry.

The other member of the crew on the flight deck is the second engineer. When he is not busy watching the maze of instruments on the console to ensure that all systems are running green, he is making frequent inspections of the water tanks and various auxiliary power units.

Back at base the radioman takes over dispatcher duties. He must alert the base crew to any repairs or supplies the aircraft will need on return to base.

In slow years, when fire calls are few and far be- tween, the crew keeps a tight routine of maintenance, training, and base improvement. Within the organiza- tion the two operational ships are known by their radio call letters, LYK and LYL.

Water drop studies showed a thousand gallons of water would trail off away from the main target when- ever LYK released her load. To reduce this loss, slop- ing bottoms were fitted into the plywood tanks. The payload was reduced to 4,500 gallons, but the drop pattern was greatly improved. At 120 knots the tanker

Figure 1.—This Mars flying boat picks up 4,500 gallons of water in 20 seconds while planing at 70 knots.

now can uniformly drench a target area 800 feet long by 250 feet wide. With the reduced water load, extra fuel can be carried to extend operating time.

Perhaps the most interesting modification was the addition of blending equipment. This powdered water-gelling compound effectively concentrates the water load. Drops from an elevation of 500 feet cover the same target pattern as untreated water dropped from 250 feet. This extends the tankers' reach into many a rough corner previously unsafe to approach. The powder is injected into the probes by compressed air as the tanker loads water. Enough powder is carried on board to charge 10 to 12 full loads at a rate of 1 to 1½ pounds per 100 gallons of water.

Unfortunately, these operations are restricted to fresh water, since the compound is incompatible with salt water. Test drops from 250 feet above dense timber plastered the forest floor, windfalls, and vege- tation with a quarter of an inch coating of gel over an area 500 feet long and 200 feet wide.

Although now 18 years old, the two operational Mars ships are like new in their smart red and white paint, a vivid contrast to the olive drab of the last reserve ship still parked at the Victoria Airport. The hard-earned tradition of service established in their Pacific transport days is still going strong. In 5 years of flying tanker service, the Mars have dropped 903,- 000 gallons of water on forest fires. In addition, about 2 million gallons have been released in demonstration and training flights.

When the next bad fire season occurs, the Flying Tankers and their fine crews will be ready. For the harried Fire Boss there is nothing more welcome than his radio calling "This is Bird Dog — how do you read me?" He knows that the tankers will arrive in minutes and that his prayer for rain will be answered.

LOOKOUT TOWER SAFETY IMPROVED

A. B. Curtis, *Chief Fire Warden,*
Clearwater and Potlatch Timber Protective Associations,
Orofino, Idaho

Because more visitors climb lookout towers on the Clearwater and Potlatch Timber Protective Associations' areas each year, improved safety is needed.

Bertha Hill Lookout, on the Clearwater Timber Protective Association area, is one of the oldest (1902) lookout sites in the United States. Many thousands of acres of valuable forest land, publicly and privately owned, can be seen from the lookout. The fifth lookout tower at this location is shown in figure 1.

In 1965 the directors of the Clearwater Timber Protective Association decided that the increasing number of officials and visitors climbing the tower needed more protection. Therefore, a safety net (fig. 2) was installed.

A woven chain link fence material welded to 1-inch iron pipe framework was used. It is similar to the wire mesh behind home plate on a baseball field or the wire netting around a golf course.

The galvanized wire netting was cut in sections, 5 by 20 feet, and four sections, one for each side of the tower, were framed. The 5- by 20-foot wire nets ar anchored to the steel walk around sills with hinges a walk level so that the net can be raised or lowere during the winter to prevent snow buildup and th accompanying added weight. Built-in corner sectior were also made to protect the four corners. The fram work is strong enough to hold several hundred pound and the iron piping is adequately braced at about 7 foot intervals to provide a little more rigidity. The wir is number 11 gage, galvanized.

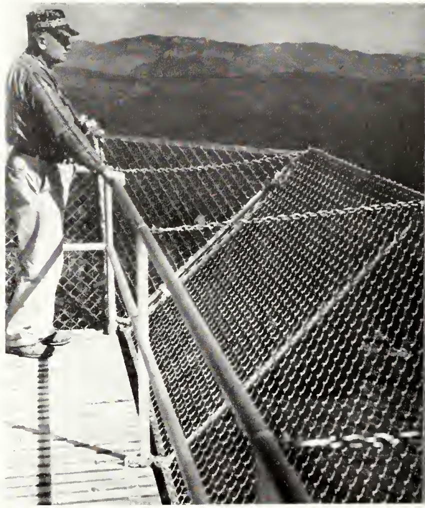

Figure 2.—Safety net on Bertha Hill tower.

Figure 1.—Bertha Hill lookout tower.

A 100-foot roll of wire fencing costs $40; pipin and chains cost 21 and 16 cents per foot, respectivel The total cost of the material was about $88. In add tion, laborers were paid $200 to fabricate the materia install it, paint, etc.

The safety net does not seriously impair the look out man's vision. When smoke is spotted, the mapboar can be moved for satisfactory azimuth readings.

THE HARROGATE FIRE — 15th MARCH, 1964

B. J. GRAHAM, *Bushfire Protection Adviser*

Note: This article is adapted from the South Australian Emergency Fire Services Manual, 1964.

General: The fire started at about 2.30 p.m. in Section 1938, Hundred Kanmantoo, on Mr. Brice's property (fig. 1). The fire travelled mostly east through valuable grazing land and burnt approximately 1,600 acres.

The exact cause of the fire is not known, but after investigations it is thought to have started from a spark from the exhaust of a chain saw.

Fuel type: Most of the area consisted largely of annual grassland; there was a scattering of Eucalypt trees.

Preceding seasonal conditions: The winter and spring preceding the current summer were very *wet*, and the current summer was mild. Therefore, pasture fuels in this area were abundant and completely cured.

Weather of the day: The temperature reached 92° in the afternoon of 15th March, 1964, with a light wind blowing west to northwest. The winds were consistent: the approximate mean velocity was 10 m.p.h.

Fire behaviour: Commencing at Sect. 1938, Hd. Kanmantoo, the fire swept generally east at 2½ m.p.h.

The rate of spread of the head fire was affected by such topographical features as creeks and ridges. These features and the country's rocky nature restricted access. Where possible, the flanks were worked by fire crews, and the head fire was confined largely to a front of 90 chains.

By 3:05 p.m. the fire had spread for approximately 70 chains east.

By 3:12 p.m. it had spread for another 60 chains, but the flanks were being controlled and the head fire continued east.

At 3:20 p.m. a pincer movement by units working on both flanks was becoming effective, and the head fire, still moving east, was narrowed to a 70-chain front. The fire had then travelled approximately 2 miles. At about this time the Brukunga Unit was destroyed, and one man (the driver) was badly burned. The farm buildings at White Hut, which were in the fire's path, were saved.

At 3:30 p.m. the head fire hit the Nairne-Harrogate road. It jumped over, but it was controlled after burning 50 acres. The rest of the front was controlled along

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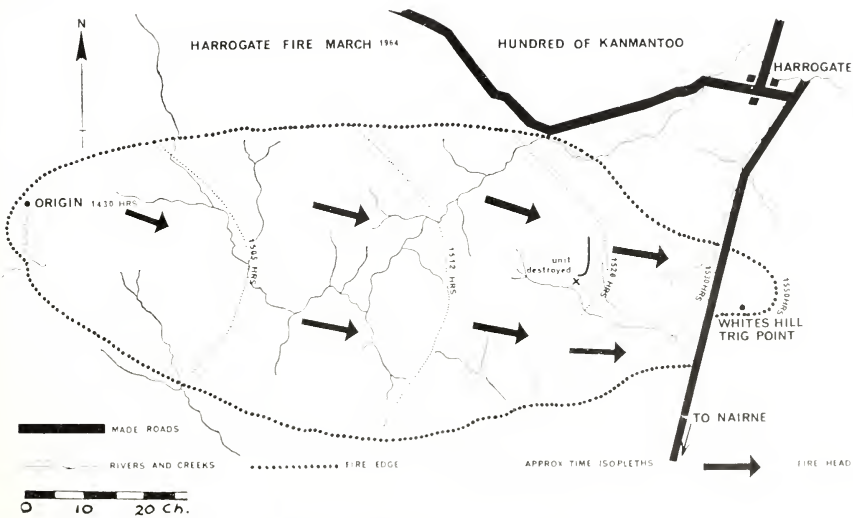

Figure 1.—Progress map of Harrogate Fire.

THE FIRE-BEHAVIOR TEAM IN ACTION—THE COYOTE FIRE, 1964

JOHN D. DELL, *Fire Research Technician*
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On a large wildfire, the fire boss bases much of his strategy on information provided by his staff and other assistants. In 1964, fire-behavior teams furnished advice at several forest fires in southern California. Each team, directed by a fire-behavior officer, gathered and analyzed vital information on weather, fuels, and topography. The team concept, originally described by Countryman and Chandler,[1] proved an effective method for evaluating the behavior of fast-moving fires. This note briefly describes how a fire-behavior team operated on the 67,000-acre Coyote Fire that burned on the Los Padres National Forest in September 1964.

ROLE OF THE FIRE-BEHAVIOR TEAM

Team observations and the fire-behavior officer's interpretation combined with reports of scouts and line overhead were extensively used in fire control planning.

An important function of the fire-behavior team is fire-weather observation. By working closely with the U.S. Weather Bureau's fire-weather forecaster, the team saves much time and avoids duplication of effort. Information provided by the fire-weather forecaster includes maps of the latest synoptic weather transmitted by radio by facsimile recorder (FAX) from the U.S. Weather Bureau.

Team members may also make upper air soundings of humidity and temperature or measure the winds aloft (fig. 1).

THE COYOTE FIRE

At 11 p.m., on September 22, 1964, a fire-behavior team was dispatched from the Riverside Forest Fire Laboratory to the Coyote Fire at the request of the Los Padres National Forest. Santa Ana winds, surfacing at night, had swept an almost-controlled brush fire across firelines into heavily populated residential areas. By early morning, the fire, then out of control, had burned more than 600 acres. One of the most devastating conflagrations in recent local history was imminent. However, during the day shift the fire ceased to threaten the residential areas as the Santa Ana winds returned aloft. The sea breeze and upslope wind caused the fire to spread into the mountains (fig. 2).

Figure 1.—Fire-behavior team takes a pibal (pilot balloon observation) with theodolite to determine patterns of local winds aloft.

At the Coyote Fire camp, the fire-behavior officer was briefed by the Weather Bureau's fire-weather forecaster on existing and anticipated weather. The fire-behavior officer made a behavior forecast ready for the Plans Chief before each shift so fireline overhead could be thoroughly briefed. Also, any sudden deviations were explained immediately to the Fire Boss, and a revised forecast was made.

Team members, meanwhile, began taking pilot balloon observations (pibals) of winds aloft, making ground observations, studying preattack maps, and talking with fireline overhead in order to better understand fire conditions. Equipped with its own transportation, radio net, and instruments, the team was able to disperse to various locations on the fire. A communications net linked the team with the fire-behavior officer, and pertinent information was sent regularly. Ground observations were made of temperature, humidity, windspeed, and wind direction; type, density, and condition of fuels in the path of the fire; topography and aspect; current fire behavior; and trouble areas. The fire-behavior team made a thorough surveillance of the area above and to the flanks of the

[1] Countryman, Clive M., and Chandler, Craig C. The fire behavior team approach in fire control. Fire Control Notes 24(3): 56-60. 1963.

Figure 2.—The huge Coyote Fire near Santa Barbara, Calif., (Sept. 22-Oct. 1, 1964) required the use of three fire-behavior teams. The fire burned more than 67,000 acres of brush-covered watershed.

main front. It noted that strong northeasterly winds were still aloft, although the layer had been rising since morning. The odds were against these winds surfacing as they had the night before, but the forecast indicated this might happen.

Early on the evening of the 23d, a team member was sent to the ridgetop above the fire to observe its behavior and to look for any signs of unusual changes. At 7 p.m., he noted that the humidity had dropped to 14 percent. Light and variable winds gradually developed into a strong northeasterly blast that gusted up to 35 m.p.h. The fire began to intensify on the upper slopes. These factors indicated the fire would probably resume the same pattern as on the previous night—but on a wider front. The fire-behavior team immediately reported these observations to the fire-behavior officer at fire camp. He, in turn, notified the Fire Boss so crews on the line could be warned. By 7:40 p.m., these winds were felt in Santa Barbara.

These winds continued most of the night. At 2 a.m. (September 24), temperatures as high as 92° F. and humidities as low as 10 percent were reported at the Weather Bureau's fire weather mobile unit at the fire camp. Fire again swept through residential areas in the foothills.

By morning the fire had burned along the entire Santa Barbara front, over the ridge, and down into the Santa Ynez River drainage. Personnel were added to the fire-behavior team to increase coverage of the growing conflagration. The fire-behavior officer and part of the team were requested to observe and advise on a critical backfiring operation on the west side of the fire. Another team member made an upper air sounding by helicopter, in order to determine moisture in the lower atmosphere and atmospheric stability over the fire.

In the fire-behavior forecast for the 24th, prepared early that morning, it was predicted that strong Santa Ana conditions would continue at high levels, but would weaken at low levels during the day. It was reported that fuels were very dry and hot runs could be expected where favored by wind or topography. Atmospheric instability would favor the development of large convection columns, spotting, and firewhirls. Santa Ana winds were again likely to surface.

During the next few shifts the Coyote Fire nearly doubled in size. More than 3,000 firefighters from all parts of the Western United States joined in the battle. Zone fire camps were set up at several points around the fire in order to place the manpower where it could be shifted most efficiently. This, of course, created a difficult communications problem for the fire-behavior team. Sending fire-behavior forecasts to all these zone camps over already overloaded communications systems was difficult, yet very essential. Every effort was made to bridge the communications gap and to relay forecasts to all camps, since many of the line personnel from distant forests were unfamiliar with some of the conditions that affect the behavior of southern California fires.

Another fire-behavior team flew from the Northern Forest Fire Laboratory at Missoula. Two more radio-equipped vehicles and extra backpack radios were brought in from Riverside. The fire-behavior officer reorganized and divided his enlarged team and located the shifts at four points around the fire (fig. 3).

Potrero Seco Camp. — The fire-behavior officer and fire-weather forecaster were headquartered here with the mobile weather unit. Team 1 was assigned to take pibals and upper air soundings, and to make ground observations and reconnaissance ahead of fire.

Los Prietos Camp. — Team 2 was assigned ground observations and reconnaissance on the west and northwest sides of fire.

Pendola Camp. — Team 3 was assigned ground observations, pibals, and reconnaissance in the upper drainage area of the Santa Ynez River.

Polo Camp. — One meteorologist was stationed here to take helicopter upper air soundings, ground observations, and reconnaissance on the south side.

Relay. — Here a pickup truck equipped with radio

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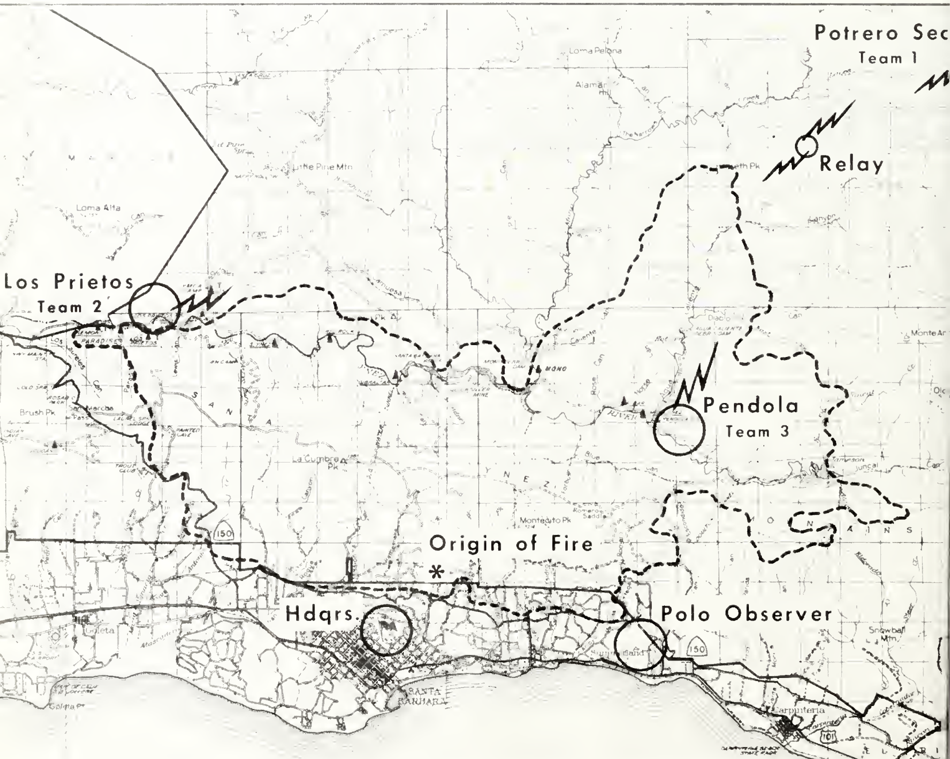

Figure 3.—As the fire spread north, the fire-behavior officer divided and relocated his team for better coverage.

IMPROVED SYSTEM FOR USING FIRE-WEATHER FORECASTS

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Introduction

Recently, a fire control agency determined that fire-weather forecasts to protect wild lands from lightning fires were not used often enough. This agency had used presuppression protection against possible lightning fires only when the fire-weather forecast called for thunderstorms.

The fire control personnel were insufficiently informed concerning the probability of fire occurrence. When a fire-weather meteorologist was consulted, he said that, to satisfy the public, forecasts had once contained predictions that an event would or would not occur. However, he indicated that much more weather information could now be furnished to fire control officials if forecasts could contain events that had only a certain probability of occurring. He indicated that, for three reasons, uncertainty always exists regardless of how weather forecasts are stated. First, only rather crude measurements can be made of the atmosphere; second, the prediction problem exceeds our ability for exact solution; third, there are unknown and changeable influences on the atmosphere from outer space. The meteorologist was convincing: the fire control agency decided that resources would be more efficiently conserved through systematic use of probability forecasts.

The fire control agency, the meteorologist, and the incident above are fictitious. However, they illustrate a point. The information that follows describes how probability forecasts can be used in fire control. We will specifically refer to thunderstorm forecasts and their use, but probability forecasts can also be used for other weather elements.

Definition of Probability

The most useful measure of the meteorological certainty of any weather event is a statement of mathematical expectancy or probability. We will define probability of thunderstorms, or of any other weather event, as being equivalent to the percentage of frequency of occurrence. For example, if 1,000 forecasts calling for 70-percent probability of thunderstorms have been issued, there should also have been about 700 days with thunderstorms.

Making the Best Decision

Protective measures against expected lightning fires should be taken when the predicted probability of thunderstorms exceeds the ratio of cost to loss. That is, the probability of occurrence of adverse weather should be compared with the ratio of the cost of protective measures to the loss resulting if no protective measures were taken and adverse weather occurred. No proof is given here, but a general derivation has been developed.[1]

The above may be expressed as follows: For the greatest economic benefit,

when $P > C/L$, agency should use extra protection.

$P = C/L$, agency may either protect or not protect.

$P < C/L$, agency should not add extra protection;

where P is the probability of occurrence,

C is the cost of extra presuppression protection, and

L is the loss that would occur if no extra protection were added and the adverse weather occurred.

Illustrating Use of Probability Forecasts

Use of probability forecasts is illustrated in the following example:

A Forest Supervisor decided to obtain the greatest economic utility from probability forecasts of thunderstorms, which were being routinely issued by the fire-weather forecaster.

His first problem was to determine the cost of extra presuppression manning and action for anticipated lightning fires. He found that costs of extra protection varied according to the general level of burning conditions. Average costs per day for extra presuppression manning for expected thunderstorms under given burning conditions were as follows:

Low	Moderate	High	Very High	Extreme
$25	$60	$100	$200	$400

Second, it was necessary to determine the average loss that would occur if no extra protection were provided. This required consideration of three factors:

1. Suppression costs that would have resulted either with or without extra presuppression.

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[1] Thompson, J. C., and Brier, G. W. The economic utility of weather forecasts. Monthly Weather Rev., v. 83, No. 11, November 1955.

AIR TANKER RETARDANT DROP WARNING DEVICE

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Shasta-Trinity National Forest

Firefighters have been injured severely and even killed by the impact of retardants dropped from low-flying air tankers. To warn ground firefighters of the approach of an air tanker on the final drop run, Joe Noble, safety officer of the Shasta-Trinity National Forest, suggested that an electronic siren be installed in the lead plane directing the air operation or in the air tanker. Because air tankers often operate on initial attack without lead planes. it was decided to install the siren in an air tanker.

The electronic unit provides three functions:

1. The traditional siren sound, a rising and falling wailing sound.
2. A sharp, short series of tones best described as "yelp."
3. A public address system.

After considerable research concerning available equipment, the Region 5 electronics engineer decided that a 24-volt model of a regular transistorized electronic siren/PA system as used for ground fire vehicles would be suitable for an experiment.

Aero Union, an air tanker contractor for both the California Division of Forestry and the U.S. Forest Service at the Redding, Calif., base, allowed installation of this warning system on one of their B-17 air tankers in September 1964. It was mounted on a flat metal plate in the nose of the B-17, aimed forward and down at about a 45° angle from the longitudinal axis of the fuselage (figs. 1, 2).

On aircraft other than B-17's, an adapter may have to be built to allow the forward and downward positioning of the speaker. The system control head is mounted in the cockpit to provide easy access for the pilot or copilot.

The warning system was first used on the Bear Gulch Fire (in rough country) on the Shasta-Trinity National Forest on October 15, 1964. Both the siren and yelp were clearly audible above both aircraft and fire noise. They were audible more than a mile from the fire, depending on elevation of the air tanker, position of the ground firefighters, etc. All on the fire agreed that the device gave ample warning to take cover before the retardant impacted.

The warning system was later tried on several fires on California Division of Forestry and other protection areas. Audibility of the signals was consistently good to excellent. The public address function was not tried while the aircraft was in flight, but it was successful in taxiing and in retardant-loading operations. The PA function, if proven successful in test flights, will be useful in warning firefighters of spot fires or other hazards.

Editor's Note: An air tanker warning device is being developed and tested by the Missoula Equipment Development Center. Permanent installation of such a device is not recommended for U. S. Forest Service use until development and tests are completed and a Forest Service standard is adopted.

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Figure 1.—Exterior view of speaker mounting plate in nose of B-17 air tanker. (Courtesy of Aero Union, Chico, Calif.)

Figure 2.—Interior view of speaker mounting in nose of B-17 air tanker. Interior bracing is shown. (Courtesy of Aero Union, Chico, Calif.)

SMOKEJUMPER AND ADVANCED FIRE CONTROL TRAINING IN THE CALIFORNIA REGION

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Northern California Service Center,
Redding, Calif.

Most smokejumper candidates selected from 1957 to 1961 in the California Region were college students. Few were foresters or interested in a forestry career. They jumped a few seasons, then took jobs in their chosen fields. By the end of the 1961 fire season it was obvious that much training and experience was being lost by the rapid turnover in jumpers.

A new approach to recruiting and training smokejumpers has been tried for three consecutive seasons since 1961 with outstanding results. The objective of the new program is to train career fire people in smokejumping and in other fire control skills, thereby increasing their adaptability and broadening their background.

At present men with at least two seasons of fire experience are selected from the Forests. The Forest recommends the man and must be willing to release him for one season for smokejumping and other intensive fire control training. Most of the men selected are already qualified as tank truck operators, crew bosses, or sector bosses.

The training program lasts for 8 weeks. A typical schedule starts with a 5-day field trip. The trainees carry an 80-lb. pack that includes rations, sleeping bags, tools, water, and personal items. They hike 20 miles cross country and have a different camp each night. During the week many subjects are taught that are of importance to the trainees. The week ends with a 6-hour small fire exercise. Two-man crews are required to find a simulated fire in an isolated location, fall a snag, complete a fireline, and then hike to waiting trucks. The exercise requires the use of map, compass, and pacing to find the fire and return to the truck.

Jump training starts the second week (fig. 1). The trainees learn how to exit from an aircraft, steer a parachute, and land. They also learn how to roll, let down in timber, and care for jumper equipment. Several hours are spent on the obstacle course to toughen muscles used in jumping, and also in the classroom on a variety of fire control subjects.

The men make their first practice jumps in the third week (fig. 2). Critiques of the jumps are held in the field, and classroom work continues on such subjects as radio use and procedure, parachute and cargo re-

Figure 1—Letdown practice.

Figure 2.—Practice jumps.

trieving, and fire behavior.

One week is devoted to helicopter and fixed wing aircraft operations. Subjects such as helicopter accessory use, retardant mixing, airport management, air attack procedures, traffic control, and record keeping are taught in the classroom. Field application follows.

The remainder of the course is devoted to leadership and instructor training. There are opportunities for additional self-training to fit individual needs and desires.

During the fire season the men are used either as jumpers or ground fire crews. Because of their fire experience, the top man on the jump list is Fire Boss for that fire. This gives each man a chance to exercise his leadership abilities and practice newly learned skills.

The program has been supported enthusiastically by the Forests. The men jump only one season, then return to their Forests better prepared to advance to more responsible positions. Old jumpers can return each June for refresher jumps. In this way, a reserve of trained men for emergency jumps is maintained.

Advantages of the Program:

1. Better fire control action: jumpers have more fire experience than under previous recruiting procedures.
2. Trained firefighters learn additional skills and receive training not available at the District or Forest level.
3. Additional training to potential supervisory fire personnel.
4. Saves screening over 1,000 applications and establishing register for recruitment of a small number of jobs.

Disadvantages of the Program:

1. Except for four or five cadres, a completely new crew must be trained each year since there are no returnees.
2. Forests may want their men to return before the end of the fire season to fill key fire positions left vacant by students returning to school.

ONE CELL FIRELINE LIGHT

John B. Richards, *District Warden, Douglas Forest Protective Association,*[1] *Roseburg, Oreg.*

Much of the Douglas Forest Protective Association's firefighting is done at night. Therefore, the Safety Committee developed the one cell fireline light (fig. 1). The light, which is primarily used during the laying out of firelines at night, eases the workload of scouts and bulldozer operators and reduces the accident hazard confronting scouts.

The light is made from 16-gage wire with enough tensile strength to retain shape and hold one flashlight battery. The coil on top is two complete wraps and is shaped to permit the insertion of a No. 14 bulb. The bottom is hooked to hold the knob on the positive end of the battery. The battery is inserted with the positive end down. One end is left long so the light can be hung from limbs, brush, and other objects. To aid the insertion and removal of the bulb, the thumb and index finger should be placed at points A and B and squeezing should be done gently.

The scout places the lights where the fireline should be constructed. He hangs them on tree branches, in the bark of old-growth trees, on top of stumps, and from brush. He works far in front of the bulldozer operator in order to reduce the possibility of logs, trees, rolling chunks, and rocks being loosened by the bulldozer and then striking him.

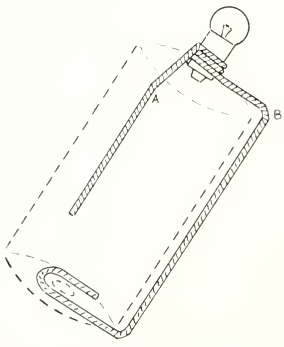

Figure 1.—The one cell fireline light is shown.

The lights are readily seen by the bulldozer operator. They enable him to know exactly where the line should be constructed, and they provide him with some visibility of the terrain.

Following fireline construction, the swamper, who is behind the bulldozer, can sometimes retrieve the lights. If he cannot, there is no great loss, for the lights are very inexpensive and easy to make.

[1] The Association is located in Douglas County, Oreg.

(*Harrogate Fire* Continued from page 7)

the road, and the fire was considered under control. The time was 3:50 p.m. The fire units then attacked the southern boundary and quickly obtained control.

Fencing losses: Several miles of fencing were damaged, and approximately 1 mile of it must be replaced. Some fences of sawn hardwood and iron droppers withstood the fire, but the wire components will last for a much shorter period because of the deterioration of the galvanising content.

Firefighting strategy: The organisation and method of attack employed by fire controllers was extremely efficient and resulted in the saving of large areas of heavily grassed land. Seventeen E.F.S. units, capably supported by private units, attacked the fire on the first day, and a lesser number conducted patrolling and mopping-up operations on Monday, 16th March.

The confining of this fire to approximately 1,600 acres is even more praiseworthy when one considers the rocky nature of this inaccessible country and the fact that except for the Nairne-Harrogate road no natural or artificial barrier was near the fire.

(*Coyote Fire* Continued from page 10)

relayed fire-behavior observations from the roving teams to the fire-behavior officer. The relay system, though makeshift, provided fairly good coverage of the fire, supplied more information on which to base forecasts, and made it easier for the teams to circulate forecasts to the various camps.

About 270 ground weather observations, 10 pilot balloon observations, and 7 upper air soundings were taken during the 6-day period the fire-behavior teams were assigned to the Coyote Fire. From helicopter, truck, jeep, and by walking the fireline, team members observed and reported conditions on the fire almost continually.

CONCLUSIONS

The Coyote Fire provided a good example of the effectiveness of the team approach in fire-behavior coverage of conflagrations. With information flowing in from various locations, the fire-behavior officer has more time to appraise the situation, consult with the weather forecaster, and furnish a more complete and accurate fire behavior forecast. With team members in constant communication, he can be alerted to areas requiring his special attention. The fire-weather forecaster, supplied with frequent weather observations taken by the team, benefits by having more detailed local information on which to base his forecasts.

The fire-behavior team, as employed in southern California during 1961, is certainly not the final answer to fire control problems. It is, however, the best approach yet developed for keeping abreast of the behavior of a forest fire. Equipped with the instruments, tools, and trained personnel to do the job, fire-behavior teams offer a service that — if properly used — can contribute to more effective fire control operations.

(*Fire-Weather Forecasts* Continued from page 11)

2. Resource loss from fire.

3. The various levels of burning conditions.

Loss estimates were difficult to obtain. However, the average loss per day from lightning fires when there was no extra presuppression protection under given burning conditions was as follows:

Low	Moderate	High	Very High	Extreme
$10	$80	$200	$670	$2,000

Third, each category of cost is divided by the same category of loss. Thus, the ratio of cost to loss for each category of burning conditions is as follows:

Low	Moderate	High	Very High	Extreme
1.00	.75	.50	.30	.20

Therefore, the Forest Supervisor should never use extra protection for predicted thunderstorms when the burning condition is Low. It is Moderate when a 75-percent or greater probability of thunderstorms was predicted. Extra protection would also be used when the burning condition is High with a forecast of 50 percent or greater probability; when Very High with a forecast of 30 percent or greater probability; and with an Extreme burning condition and a forecast of 20 percent or greater probability.

Conclusions

Use of judgment or use of the principles discussed above may result in the same decision. However, the complexity of the problem is usually too great to be handled efficiently through judgment. Utilization of forecasts based on probability of occurrence generally provides better results. However, more research is needed in order to more systematically apply the results of fire-weather forecasting to the problems of fire control.

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

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

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(*Warning Device*—Continued from page 12)

To reduce the tanker pilot's operations during a critical time (the drop run), the warning activation switch should be wired into the aircraft retardant tank door arming circuit. This would activate the warning signal when the doors are armed for dropping, normally only at takeoff and on the drop run. Also, the pilot would not have to remember to turn on the warning system.

Ground-level sound pressure and area coverage measurements of the electronic siren/PA system operated in aircraft at various altitudes are scheduled to be made during 1965 by the R-5 Electronics Branch.

To assure safety and reliable performance, complete standards covering the installation of electronic sirens in aircraft must be developed.

ELECTRONIC SIREN UNIT SPECIFICATIONS

1. Name: Fyr-Fyter Penetrator Electronic Siren and PA Unit (for 24/28-volt aircraft, Model 24 PT75; for 12/14-volt aircraft, Model 12 PT75.
2. Components:
   A9 SP75 Speaker. Noise-cancelling microphone. Audio input for the siren unit may be integrated into the plane's radio microphone selector system so that the existing microphone may serve the PA function.
3. Power:
   Output . . . 75 watts with single speaker
   Voice:
   - Idle 0.5 amperes
   - Talk 3.0 amperes

   Siren:
   - Maximum 3.5 amperes
   - Minimum 4.5 amperes
4. Weight:
   Cockpit control head 7 pounds
   Speaker 7 pounds
5. Dimensions:
   Cockpit control head 3½ x 7 x 6 inches
   Speaker
   - Diameter 8⅜ inches
   - Vertical 8¾ inches
6. Cost with non-noise-cancelling PA microphone: $309.00 list price.
7. Source: L. N. Curtis & Sons, 4133 Broadway Oakland, Calif.

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.)

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

YOAV WAISEL and JACOB FRIEDMAN,
Department of Botany, Tel-Aviv University, Israel

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

Fire hazard usually depends on three environmental characteristics:

1. Susceptibility of the plant material to ignion.
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 rasses and herbaceous plants because straw is eadily ignited, produces high, hot flames, is abunlant in large, contiguous areas, and is dense enough or continuous fire propagation and yet spaced videly enough to secure sufficient oxygen.

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

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

In geographical regions where herbaceous plants upply most of the fuel for fires, planting of isolaon strips with tree species that eliminate annual erbaceous undergrowth and produce highly fireesistant litter may reduce the number and progress f wildfires.

USE OF TAMARIX RESTRICTS FIRES

A short survey of the trees in Israel revealed hat 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 estriction of Fires," which was published in La Yaaran, rael.

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

[3] Broido, A., and Nelson, M. A. 1964. Ash content; its fects on combustion of corn plants. Science 146:652–65

[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 Gevulath, 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

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 advancin towards a stand of *Tamarix gallica.* The outlines of the un burned strip overlap the area where the shedded litter accu mulates.

needles, hay, and *Tamarix*. This idea is further sup ported in experiments which compared the burnin of natural litter of *Tamarix* with that of a litte which was thoroughly leached and ovendried a 85°C. 24 hours before the experiment. While th natural litter was hardly ignited, the leached mate rial exhibited a slow but continuous flame.

TABLE 1.—The progress of fire through a strip o uniformly prepared, ovendry plant material (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 litte still reduces the ability of plant debris to catch fir The litter of *Tamarix* is superior even from th viewpoint. Due to the hygroscopic salt crysta covering the twigs, and due to its high mineral co tent, the litter is highly hygroscopic. The litt below *Tamarix* trees is often wet, not only durir the night, but also a few hours after sunrise and a

(*Continued on page 1.*

PROTECTIVE COATINGS OF ASPHALT AND WAX EMULSIONS FOR BETTER SLASH BURNING

Harry E. Schimke and James L. Murphy,
Forest Fire Laboratory,
U.S. Forest Service, Riverside, Calif.

Disposal of logging slash is one of the biggest problems confronting the forest manager. He can not 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 waterproofing 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 coate piles also ignited somewhat quicker than the un coated piles. The average moisture content o coated piles was 41 percent less than that of th untreated piles.

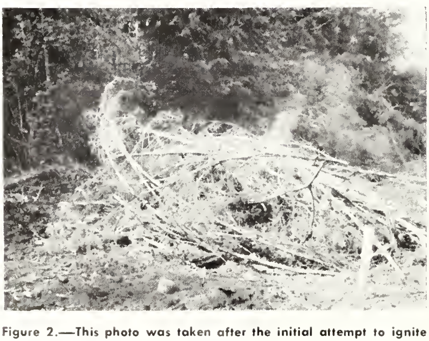

Figure 2.—This photo was taken after the initial attempt to ignite this pile. It was untreated and used as a control.

The slash was protected best by the SS-1 grad asphalt emulsion, priming solution, and the lumbe sealant, in that order, and by the heavier mixes (n thinner than 1:2).

Because the slash was drier, the total output o smoke (slash plus coating) from coated piles wa 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, swampe burning, burying, spring burning, or other method are cheaper and/or better.

Construct Slash Piles With Care

Piles should be compact, free of dirt, and larg enough to build up heat to consume all the materia

Select Best Available Coating

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

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

Our second choice is the priming solution, whic protects slash well because it spreads and penetrate well. But it requires equipment that can tolerat petroleum. It cost about 50 cents per gallon (i supplier-furnished drums at plant). When the cos of the solvent is added, the total cost nearly equal 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 i drums furnished by the supplier at his plant. Cost of application will vary with type of material, equip ment used, availability of coating material, typ of slash, and the mixture used. The average cos of asphalts or waxes was $20 to $30 per acre. Th cost for treating a cubic foot of slash average about one-half cent.

(Continued on page 15

SLASH DISPOSAL BY CHIPPERS

WAYNE R. COOK, *Forester,*
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

Daniel C. MacIntyre, *Forester,*
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

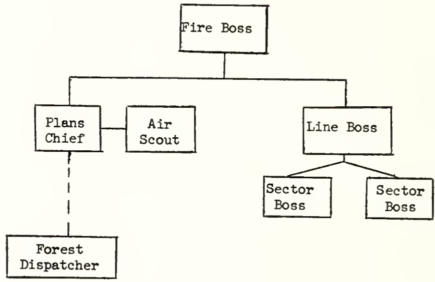

Figure 1.—Typical C-Alert overhead team.

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.

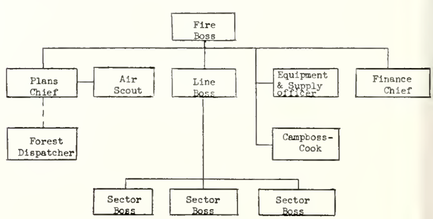

Figure 2.—Kaibab D-Alert Team, 1962 season.

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

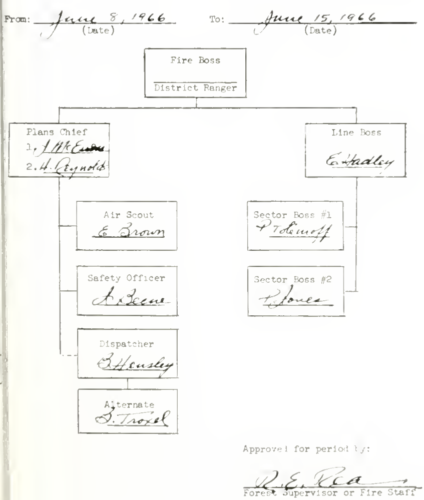

Figure 3—C-Alert duty roster.

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

(Continued on page 16)

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

W. G. Banks,[1] *Research Forester, North Central Forest Experiment Station,*
and H. C. Frayer,[1] *Former Staff Assistant, Branch of Fire Control, Eastern Region*

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.

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[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 ($S_{\bar{X}}$)	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	55.3
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

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

or 1950–58, the average perimeter increase per r for all fires, and also for the fastest-spreading percent of fires, were computed for four burning ex (B.I.) ranges (table 3). The increase in of spread, for each of the three steps upward urning-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.

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.

TABLE 5.—*Resistance to control by fuel types* (Eastern Region, 1950-58)

Fuel type No.	[1] 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 chains = Extreme.

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 vere likely, did not occur. To prevent similar in-idents from happening, the following safety pre-autions are recommended:

1. That open fires and fuel bottles not in use be t 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)

iour or two before sunset. The chances of a fire elow a *Tamarix* plantation during these hours are egligible.

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	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 xtinguishes rapidly and burns only a minute frac-ion of the sample. However, the samples of hay nd pine needles are burned thoroughly, and the re-ulting weight loss is 64–84 percent of the sample's lry weight. The duration of flaming and especially f smouldering in hay and pine is much longer than n *Tamarix*.

When the litter of *Tamarix* is thoroughly leached, nd its mineral content is reduced from 19 to 15 per-ent, 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 hree parts solvent (diesel fuel or kerosene for rimer, water for others).

Coat Slash When It Is Dry

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

Apply Liberally

Use very generous applications. Seal large holes nd cracks. Priming solution and lumber sealant nay 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.

July 1966 Vol. 27, No. 3

FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contro[l]

CONTENTS

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

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

Zeb Palmer and D. D. Devet[2]

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

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

PURPOSE OF PRESCRIBED BURNING

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

ure 1.—District Ranger on the Santee Ranger District, Francis Marion National Forest, briefs his crew prior to the start of urning 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 quadrant.

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. 31, [illegible]

[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

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 a base of operations.

of fuel. This technique is combined with a backir fire to initially secure the baseline. After the ba is secured, strip burning is begun.

This technique can be conducted when relati humidity is 50 to 55 percent, has flexibility for wi direction changes, can be conducted in scattere light fuels, needs minimum preparation, is relative inexpensive, is cheaper because few plowed lin are required, and is rapid.

Spot or Checkerboard

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

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

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

Flank Fire

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

Flanking is the cheapest and fastest burning p cedure.

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

(Continued on page 1

PRESCRIBED BURNING TO REDUCE KUDZU FIRE HAZARD

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

Fire control men with experience in the South re aware of the problem caused by kudzu (*Puer ria thunbergiana* (S. & Z.) Benth.) in fire sup ression.

This vine, introduced from Asia more than a entury ago for ornamental purposes, and widely lanted since the midthirties for erosion control, now a common plant along many railroads and ighways in the South. To the casual observer, the ush, green kudzu is only a vine adorning the road ide.

However, as fire control men who have worked n the South realize, this seemingly harmless plant hanges drastically with the first killing frost. ts withered, dry leaves and vines are transformed nto flashy fuels that provide a most effective bridge or carrying fires from rights-of-way to adjacent elds and woods. Fire suppression in kudzu is al ost impossible without abundant water—the fires xplode, and the entanglement of vines, stolons, nd roots preclude the use of fire rakes and plows. irefighting in kudzu is a difficult task, indeed!

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

Three years ago, with the approval of the rail oad's district engineer, annual prescribed burning as begun. The following method is successfully nployed:

gure 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 con fronted with a similar problem.

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

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.

[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.

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.

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

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

Items for Winds Aloft Observation

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

Items for Communications

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 for evaluating 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 faulty internal combustion engines. Greater use National Forests by contractors, special-use per-ttees, and others has made a more rigid inspec-n system for internal combustion engines perative. Equipment inspections have been man tory for timber sales, contracts and permits, and orest Service equipment. However, a method to entify inspected equipment had not been estab-hed, 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 d 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
									Disapproved		Approved		
		Shovel	Axe	Spark Arrester	Muffler	Exhaust System	Fire Extinguish	EP Pump	By Signature	Date	By Signature	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-u permittees often obtain wood from old timb sale areas. (The powersaw sticker is of spec material because of grease.)

D. Contractors of roads or those doing co struction work in connection with special us

There will be no attempt to inspect grazing pe mittee pickups or trucks. However, their powersa will be inspected. Hunters, fishermen, tourists, a those seeking recreation are not required to ha inspection stickers.

---

[2] Usually permitted removal without charge of dead 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 p wood. A 1- by 1-inch hole drilled from one corner of a 3-

(Continued on page 1

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 1½ 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 Prog. Rep. 1

[4] Beall, H. W., and Lowe, C. J. 1950. Forest fires in New Brunswick 1938-1946. Canada Dep. Resources and Development 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.	1,639
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 ÷ 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 performanc are essential because they provide a greater safet margin. The following special aircraft accessor 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 teste in 1965 probably has merit.

Helispots

The pad clearing should be a rectangle at leas 100 feet wide and 100-200 feet long (fig. 2). Heli spot boundaries should be marked with ambe lights about a chain apart. When a big field o meadow is used, amber boundary lights are no needed around the entire spot. A green or blue ligh should indicate the center of the pad.

Helispots should be located so the best terrai can be used for flight routes. Special consideratio 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 "L" 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

Figure 2.—A helicopter hovers above a helispot

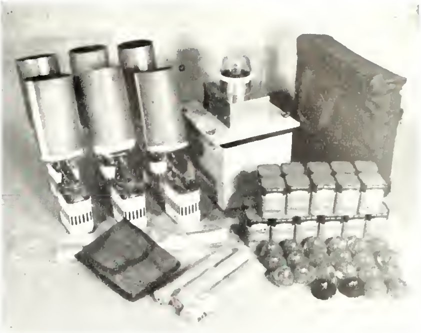

Figure 3.—Helispot marking kit used in these studies.

marked with one or more lights of a different color. Distances *between* helispots must be as short as possible.

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 1961, 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

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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.

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FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contro

CONTENTS

COVER—This U.S. Marine Corps HR2S helicopter is dropping 450 gallons of water. See story on page 4.

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

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DOUSING SNAGS WITH CHOPPERS

DOUG BAKER, *Forester,*
Rogue River National Forest

On May 5, 1966, lightning struck a ridge and arted the Scorpion fire on the Tiller District of e Umpqua National Forest (Oregon). When fire ntrol personnel arrived, the fire was burning in a ag patch on a north aspect in the center of the old eaver Creek burn. It covered about 35 acres, was chains long, and was 2,900 to 3,300 feet in elevan. The top of the fire was on a ridge, while the ttom was 300 to 400 feet above the creekbed. A uth aspect snag patch was just across the creek, hich was about 2 feet wide and 6 inches deep. he fire was spreading from snag to snag; as the ags burned and fell to the ground, ground fire gan below. There was little if any spread on the ound. There were 42.5 snags per acre, averaging 35 feet in diameter, and most of them were broken pped Douglas-fir with top rot exposed in the eaks. The fire was spreading erratically, driven gusty winds from local thunderstorms, and was otting downhill from the top of the ridge, where fire had started.

From our vantage point, a heliport 600 feet horintally and 300 feet vertically east of the east edge the fire, we could see 40 percent of the fire area l could observe firespread and wind currents rly well. A previously constructed helispot was) feet below the fire on the "stinger" of Scorpion lge. The heliport, which was on an adequate id, was about 1 hour's drive from the Tiller ger station.

Since the spread was entirely by snags and ground trol was not a serious problem, we concentrated putting a fireline around the area the first night. en at daybreak we planned to stop the spread the snag fires by using aerial retardants and by ing the snags within the fire area. We had to the snags while we still had cloudy weather h 40 to 60 percent humidity accompanying the tning and gusty winds. However, it was necesy to change our plans when we found that fixedg tankers and retardants would not be available.

Ve had one Hiller 12E helicopter on the fire, and pilot had saddle tanks available. He said he could water on a snag or a flareup without difficulty ur elevation. We requested a set of saddle tanks were sent a second helicopter equipped with such tanks. We also ordered the supply pumper for the helicopters, and the saddle tanks for the first helicopter were received with the pumper.

We began snag felling at 6:30 a.m. on May 6. We immediately faced the normal problem of felling Douglas-fir snags. The snags were on fire, and the falling embers had piled up around the base until the fellers couldn't get close. The lack of retardants required that additional snags be felled around the fire perimeter to stop the fire spread.

We then began our helitanker operation; we put 80 gallons of water on both helicopters and dropped the water on the snags. The felling crew then moved in and cut the snags. More water was available if it was needed to cool the area. The loading time for each chopper was 2 minutes, and the flight time averaged another 2 minutes. During the first hour of operation the two helicopters, with plenty of targets, dropped more than 2,000 gallons of water on the fire. We added detergent to the tanks as they were being filled, providing wet water for the operation. With 20 sets of snag fallers being supplied by two helicopters, most of the approximately 2,000 snags on the fire were felled the first day. In addition to time spent moving personnel and observing the fire, the choppers were used for almost 9 hours of flying time on water-dropping operations. They dropped 10,730 gallons of wet water on the fire. The cost per gallon of water, which was dropped very accurately on the fire, was a little less than 10 cents. The operation was very safe because flying speeds were low and visibility was good from the low altitudes used. The water dropped was not hazardous to ground crewmen because the small volumes dropped impacted at low speeds. The accuracy was excellent but could be improved with larger tank openings. The choppers couldn't hover with loaded tanks, so the drops were made at a forward speed of about 5 miles per hour.

In summary, using helicopters to drop wet water is a feasible, efficient, and fairly inexpensive method of putting water on selected portions of fires. It is especially effective on snag fires in rough country. Its efficiency would be less at higher elevations, but the severity of the problem would be less, so use of choppers with reduced loads could be considered up to 6,000 feet.

MASS HELITACK ON LARGE FIRES IN CALIFORNIA

Marvin Dodge,[1]
State Forest Ranger,
California Division of Forestry

Since helicopters were first positively used on a forest fire, on the Bryant fire, on the Angeles National Forest in southern California in 1947, more and more of these aircraft have been used in fire control. Until 1964, most helicopter attacks have been rather small. Generally, one or two helicopters have ferried crews to otherwise inaccessible firelines, transported supplies to spike camps, dropped water or retardants, and scouted firelines. More than a half-dozen helicopters have rarely been used on one fire or project.

However, in 1964 large-scale attacks by helicopters were used to support firefighting by ground crews on two major fires in southern California. Twenty-six helicopters were used at the peak of the Cozy Dell fire on the San Bernardino National Forest. Nineteen helicopters were used on the Coyote fire on the Los Padres National Forest. These aircraft performed well during both fires and were of great value in their control. An old concept in forest fire control—close air support of ground personnel—was proven applicable to large-scale operations. This paper describes the use of helicopters on these fires and the research planned to make mass helitack even more effective.

[1] The author is on assignment to the Forest Fire Laboratory, Pacific Southwest Forest and Range Experiment Station, Forest Service, USDA, Riverside, Calif.

THE COZY DELL FIRE

The Cozy Dell fire swept across 18,265 acres o watershed cover from July 21 to July 26.

Both military and civilian helicopters were usec

The U.S. Marine Corps Base at Santa An provided the military helicopters. They were use according to a joint program developed by th Marine Corps and the California Division of For estry. On July 24, the Marines dispatched fou HR2S (S-56) helicopters and nine HUS's (S-58's (fig. 1). One HUS led the other helicopters int the drop area. On July 25, the Marines sent fou more of the medium HUS's and one more of th larger HR2S models. During the 2 days thes aircraft dropped more than 55,000 gallons of wate during 231 drops.

The base heliport was in a large pasture abou 3 miles from the fireline. A well in the pastu contained an adequate water supply. Two Californ State Disaster Office pumper trucks boosted wat from the well through 2½-inch hose lines into tl helicopter tanks at four fill points. Marine Cor landing officers directed landings and takeoffs, flig patterns, and traffic control to fill points and servi areas. Liaison with fireline personnel was handl by California Division of Forestry personnel at tl base heliport and in the lead helicopter.

While the Marine helicopters dropped most the water, commercial helicopters transported pe

Table 1.—*Helicopters used on Cozy Dell and Coyote fires*

Helicopters	Designation	Passenger capacity	Weight when empty	Maximum takeoff weight[1]	Retardant carrying capacity
Commercial:		*Number*	*Pounds*	*Pounds*	*Gallons*
Bell	47G-3B1	2	1,772	2,950	100
Do	204B	9	4,600	8,500	320
Hiller	12E	2	1,755	2,800	100
Do	E4	3	1,813	2,800	100
Hughes	300	1	910	1,600	.....
Military:					
Sikorsky	HUS (S-58)	14-20	7,630	13,000	180
Do	HR2S (S-56)	30-36	20,960	31,000	450

[1] Actual figure depends on individual model and accessory equipment.

sonnel, hauled cargo, and scouted the firelines. Seven small private helicopters were used on the fire. A larger Bell 204B carried up to eight men per trip to critical spots on the fireline (table 1).

There were some problems in tactics and coordination. A few retardant drops were made far ahead of the ground crews. These drops were flanked or burnt through before the hand crews could take advantage of them. Also, some crews were too slow in following up the knockdown of hot fire when drops were made right in front of them.

THE COYOTE FIRE

The Coyote fire started on September 22 near Santa Barbara; it was contained on September 30. It burned 67,000 acres of watershed cover and destroyed 161 buildings and damaged 27 others. A high powerline near the origin of the fire limited the initial attack by aircraft. But as the fire spread uphill away from the powerline, "air attack became very effective."[2] If the air attack had not been stopped by darkness, the fire probably would have been held to 250 to 300 acres.

Privately owned helicopters under contract to the Forest Service, the National Park Service, and the California Division of Forestry were used on the Coyote fire.

Most of the helicopters operated were from four base heliports. The main base—a polo field east of Santa Barbara—provided ample space for helicopter operations as well as for the main fire camp. Adequate water was available. Turf designed for polo ponies eliminated the dust problem and seemed to hold up under helicopter traffic. Forest Service helitack crews handled traffic control, landing direction, and loading of cargo and retardants.

Every phase of helitack was used. Some of the operations follow:

1. Small portable pumps were used to pump water from tanks set up on ridges.
2. Water was flown to the ridges by helicopters (helipumpers).
3. Manpower was ferried to remote sections of the fireline.
4. Spike camps were ferried in and supplied with food and water.
5. Fire spread and control line construction was scouted and mapped.
6. Retardant was dropped in close support of ground personnel.
7. Wire was layed for emergency telephone communications.

Much of the retardant (Gelgard) was mixed and loaded at the polo grounds. A 1½-inch hose line, split into two lines with a "Siamese," supplied water to retardant mixing and loading stations. Aardvarks—lightweight eductor type mixers—mixed 2 pounds of fire retardant in each 100 gallons of water. The retardant was premeasured into coffee cans with snap-on plastic lids. When a helicopter landed, crewmen turned on the water and poured a can of retardant into the Aardvark. The helicopter was usually in the air within 2 minutes. However, the helicopter could not reach the fireline for 15 to 20 minutes.

Retardant mixing and loading were done near the fireline where feasible. Cisterns on ridgetops were used. Tank trucks provided water where roads permitted access to a ridge or other suitable helispot. From these locations, a loaded helicopter would be at the fireline within 2 or 3 minutes after takeoff. A two-man mixing crew with an Aardvark mixer, a lightweight portable pump, and an 80-pound bag of retardant could be flown by helicopter to meet a tank truck on a ridge. The helicopter could be loaded with fire retardant and take off within 10 minutes after landing the mixing crew beside a tank truck or cistern (fig. 1). Eighty pounds of retardant is usually sufficient for the daily mixing needs of two helicopters because retardant drops may be intermittent and the helicopters are often diverted to scouting or crew ferrying.

CONCLUSIONS

Although helicopters have been used in the control of some forest fires since 1947, only a few were generally used on each fire. In 1964 massive air attacks by helicopters were used on major forest fires for close support of ground crews.

(Continued on page 16)

Figure 1.—This Bell 47G helitanker is being loaded at a ridgetop heliport.

[2] Administrative Fire Analysis, Coyote Fire, September 22-October 1, 1964. Los Padres National Forest, Santa Barbara, Calif.

PHYSIOLOGICAL FACTORS AFFECTING NIGHT HELICOPTER FLIGHT

JAMES P. MORLEY, *Physical Science Technician,*
Pacific Southwest Forest and Range Experiment Station

Editor's Note: 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. See Fire Control Notes vol. 27, No. 3, July 1966, pp. 12-14.

Have you ever thought of flying over mountains in a helicopter after dark? Studies conducted recently in Montana and California show that night helicopter flying can be fairly safe if trained personnel use specific procedures.

Three of the reasons why firefighting agencies may want their personnel to fly after dark follow:

1. Fire control is likely to be more effective because of reduced fire intensity and rate of spread.
2. Density altitude and air stability are usually more favorable.
3. Helicopters do not have to compete with fixed-wing air tankers and cargo planes for airspace.

Even if you are not a helicopter pilot, the chances are good that in the next 2 or 3 years you will be a passenger in a night operation. What you do in the helicopter can make a big difference in the safety of the operation. Besides having a thorough knowledge of daytime safety rules, you should also be aware of some of the physiological factors that may affect both you and the pilot at night. This paper summarizes the latest aviation and medical information on these factors.

NIGHT VISION

Special ways of using the eyes at night are necessary because vision then is not as clear or as effective as during the day.

The part of the eye that senses light is the retina (in the back of the eye). It is composed of two types of sensory cells: the cones, which are only sensitive to fairly bright light but produce a distinct image; and the rods, which are sensitive to dim light but do not give a very clear image (fig. 1).

The cones are usually clustered in one small section of the retina; light from objects in the center of the field of vision is focused in this section. In fairly bright light, it is best to look directly at an object to take advantage of the sharp image that cones give.

The rods are usually spread out in the area around the section containing the cones; light from objects toward the edges of the field of vision is focused in this area. In dim light it is best to look just t the side of an object to take advantage of th greater sensitivity of the rods. If you lose sigl of the object, move your eyes in a circle, alway focusing them to the side of the spot where th object was.

In searching a broad area, scan a small are carefully and then shift the eyes to the next are Move the eyes often but slowly in dim light; th eyes can perceive little while in rapid motion, bu they are sensitive just after movement. If the imag becomes blurred, blinking may help.

Rods contain a chemical called visual purpl which breaks down in the presence of light. Whe this breakdown occurs, a message is sent to th brain as light hits each rod. In bright light, muc visual purple breaks down, and the rods lose mo

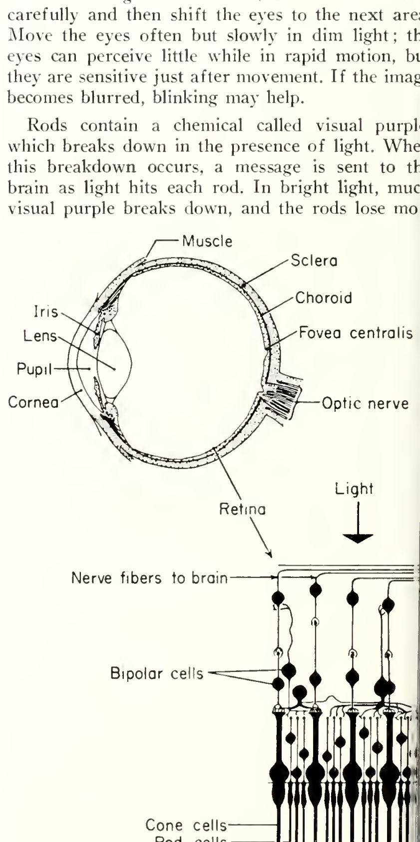

Figure 1.—The retina is the part of the eye that senses lig One group of its sensory cells, the rods, are sensitive to light; the other group, the cones, are only sensitive to fa bright light.

of their usefulness. When dim light returns, the visual purple begins to build up again, but there may not be a useful amount for 15 to 30 minutes. Thus, during night flying, it is important to avoid any exposure to bright light, such as the beam from a flashlight.

ILLUSIONS OF VISION

The pilot's vision is his most vital faculty. But even the best eyes can play unexpected tricks on the most experienced pilot. Some illusions may be quite unexpected.

If you keep your eyes fixed on a single light on a dark night when no other light is visible, that light may appear to move after 10 to 20 seconds even when you know it is stationary. If you stare at the light long enough, you may become almost hypnotized by it, and it will absorb all your attention. The apparent but false movement of a light is called autokinesis. The exact cause of this illusion is not known, but it may be prevented or removed by continually shifting fixation from point to point and by switching on other dim lights in the field of view, such as cabin instrument lights.

Another very confusing illusion is the sudden apparent splitting of light. A single light against a dark background may abruptly appear to split into two or more lights. The muscles that control the movements of the eyeballs have suddenly lost coordination. Closing the eyes briefly or looking at other objects may restore the proper muscle balance—unless the eyes are considerably fatigued.

A pilot sometimes believes that lights or objects in his field of vision have changed their motion or position, and he may not realize that his speed or direction has changed. When instruments are available, the pilot should use them to determine his motion. When they are not available, he will find known stationary ground objects (such as buildings, hills, etc.) to be useful references. Most pilots will try to avoid flying when no known sources of reference are visible, such as during fog, because direction and motion become almost impossible to determine. Do not ask the pilot to fly in visibility conditions he believes are or may become hazardous.

At high speeds, the pilot's normal sense of direction and motion may not be effective.

Illusions are aggravated by physical fatigue, alcoholic hangover, hunger, excessive flying, and monotony.

FLICKER VERTIGO

Flicker vertigo results from exposure to intense light flickering at frequencies of 10 to 30 per second. They can be produced by an idling propeller or rotor in the path of sunlight or by any other source of intense flickering light, such as an unauthorized night marker light.[1]

Flicker vertigo may come suddenly, but there is usually a brief warning, such as uneasiness or intense feeling of discomfort. The first impression is that a light source has suddenly increased in intensity, or that it has expanded so quickly that it fills your entire field of vision. If the condition becomes worse, you may develop a mental blank and then rapid progressive confusion and inability to speak. You may lose muscular control and your head and eyes may quickly and irregularly jerk to one side. Abrupt loss of consciousness and even convulsions may follow.

In trying to counteract flicker vertigo, you should keep your eyes open; closing them causes intense white light to filter through as red light, which is most effective in causing flicker vertigo. Instead, you should turn your head away from the path of light or block the light with your hand or forearm, being careful to avoid pressure on the eyes themselves.

Sensitivity to this condition is greatly increased by emotional excitement, fatigue, and stimulants or sedatives.

MOTION VERTIGO

Mechanisms in your inner ear detect tilt, movement, and rotation of your body and send this information to your brain. Under most circumstances, these organs give accurate reports when movements are not extremely slow or extremely abrupt, when turns are 90° or less, when accelerations and gravitational forces are normal, and when body support is stable. However, accurate reports are often not given. For example, if you are tilted or turned slowly, you may not be able to detect the motion accurately, if at all.

After receiving information on motion, your brain sends a message to your muscles. This signaling normally results in quick adjustment of your body to changes of its position in space. If this adjustment cannot be made, either because your detecting mechanisms are not working properly or because your body cannot make the proper adjustments, dizziness or motion vertigo will probably result. The symptoms of motion vertigo are sweating, nausea, vomiting, inability to stand, and a feeling of spinning or other motion. Ability to adapt to motion varies among individuals. Some people become sick and dizzy on planes and boats while others do not.

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[1] Various flash frequencies are being carefully studied by personnel of the Pacific Southwest Forest and Range Experiment Station, and any lights that may be approved for operational use by the Forest Service will not, in themselves, produce flicker vertigo.

THE CONCEPT OF FIRE ENVIRONMENT

C. M. Countryman, *Research Forester,*
Pacific Southwest Forest and Range Experiment Station

Webster[1] defines "environment" as "2: the surrounding conditions, influences, or forces that influence or modify"

This definition applies to "fire environment" very well. For fire environment is the complex of fuel, topographic, and airmass factors that influences or modifies the inception, growth, and behavior of fire.

Fire environment may be represented by a triangle (fig. 1). The two lower sides of the triangle represent the fuel and topographic components of fire environment. The top side represents the airmass component; this is the "weather" part of the fire environment.

INTERRELATIONSHIPS OF COMPONENTS

Fire environment is not static, but varies widely in horizontal and vertical space, and in time. The fire environment components and many of their factors are closely interrelated. Thus, the current state of one factor depends on the state of the other factors. Also, a change in one factor can start a chain of reactions that can affect the other factors.

For example, consider the simple topographic factor of slope aspect. The amount of heating of fuel by the sun on a slope depends partly on aspect. A slope facing east begins to warm first, and it maximum temperature occurs early in the day (fig 2A). A slope facing south reaches its maximum temperature about 2 hours later, and it is higher than the maximum of the east-facing slope (fig 2B). A slope facing west reaches its maximum temperature still later, and this maximum is higher than those of the east and south slopes (fig. 2C). The north slope also has its distinctive diurnal trend (fig 2D). The data illustrated in figure 2 were obtained from observations taken on a clear day on 45-degree slopes early in July at 42° N. For a different combination of cloud cover, slope, time of year, and latitude, a different pattern would be observed. This differential heating of different aspects affects the probability of fire starts, and also fire growth and behavior.

When the surface of a slope is heated, it transmits this heat to the air above it by conduction, convection, and radiation. The resulting increase in air temperature changes the relative humidity. In addition, local winds also are often strongly affected by the differences in air temperature resulting from the differential heating of slopes of different aspects. These winds are further modified by the configuration of the topography and by the surface fuels. Since the moisture content of fine dead woody fuel depends primarily on the relative humidity of the

[1] G. & C. Merriam Co. Webster's Third International Unabridged Dictionary, p. 760. 1961.

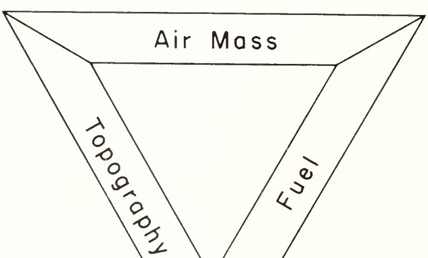

Figure 1.—Fire environment may be represented by a triangle. Each side represents a component of fire environment.

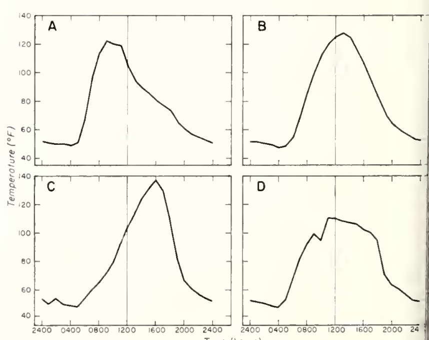

Figure 2.—Relationship of temperature to time of day on 45-degree slopes facing in four directions: *A*, East, *B*, south, *C*, west, and *D*, north. Data were taken on a clear day early in July at 42° N.

ir, the differences in heating of slopes can affect oth fuel moisture content and fuel temperature. The amount of heating of fuels, vegetative or urban, n the surface is affected by airmass conditions such s clouds, moisture content, and windspeed.

FIRE AND FIRE ENVIRONMENT

Where does fire fit into this picture? In an en-ironment without fire, radiant energy from the sun s almost the only source of heat. This energy heats he earth's surface and to a minor extent the air bove it. Most of the energy that directly and in-irectly modifies the airmass and fuel components f fire environment comes from the heated earth urface. Because of differences in slope, aspect, and round cover, heating by the sun is not uniform ome areas become much warmer than others. This ariation in the local heat sources creates the varia ility in local weather and fuel conditions.

Perhaps we can most simply consider fire as just nother local heat source. As a heat source it reacts ith its surroundings in the same way as other local eat sources: interacting with the airmass to create hanges in local weather, and with the fuel to odify fuel moisture and temperature. Because of e high temperatures in a fire, however, the reaction an be much more violent.

By adding fire to the center of the fire *environ ent* triangle (fig. 1), this symbol becomes the fire *havior* triangle. It is the current state of each of e environmental components—topography, fuel, d airmass—and their interactions with each other d with fire that determines the characteristics and havior of a fire at any given moment.

FIRE ENVIRONMENT PATTERNS

Because fire behavior and fire environment are terdependent, changes in one will cause changes in e other. To understand or predict fire behavior, e must look at the fire behavior and the fire envi-nment at all points of the fire. Thus, both fire be-vior and fire environment are pattern phenomena.

The scope of the fire environment depends pri-arily on the size and characteristics of the fire. or a very small fire, the environment is a few feet rizontally and vertically. For a large fire, it may ver many miles horizontally and extend thousands feet vertically. An intensely burning fire will volve a larger environmental envelope than one rning at a lower combustion rate.

OPEN AND CLOSED FIRE ENVIRONMENTS

From a fire behavior standpoint, fire environment can be separated into two general classes: (1) closed environment and (2) open environment. Inside a building, for example, the fire environment is nearly independent of outside conditions. Fuel characteristics are determined by the construction of the building and by its contents. The climate, and hence, the moisture content of the hygroscopic fuels, is controlled by the heating and cooling systems. Air movement and topographic effects are nearly nonexistent. This is confined or "closed" environment. However, the environment outside buildings is not confined. Current airmass characteristics vary with the synoptic weather patterns and local conditions. Wind movement and topographic effects prevail. This is "open" environment.

Fire burning inside a building is controlled by the fire environment within the building. The outside environment has little effect. As long as the fire remains within the building (fig. 3*A*), there can be no spread to adjacent fuel elements. The fire is confined.

If the fire breaks out of the building, it is no longer burning in a closed environment. Outside conditions can influence its behavior, and the fire can spread to other fuel and grow in size and intensity (fig. 3*B*).

Closed and open environments also exist in wildland fuels; however, the boundaries between the two environments are not as clear as they are in urban areas.

For example, a fire burning under a dense timber stand (fig. 3*C*) is burning in an environment that may be much different than that above or outside the stand. Fuel moisture is often higher, daytime temperature is lower, and windspeed is much slower. In this situation the fire is burning in a closed environment.

If the fire builds in intensity and breaks out through the crowns of the trees (fig. 3*D*), it is burning in an open environment and can come under an entirely different set of controls. Fire behavior and characteristics can change radically.

Open and closed environments exist in other fuels as well as timber, such as grass and brush. Because of the short vertical extent of these fuels, the probability of fire burning entirely in a closed environment is much less. But the closed fire environment in a fuel bed influences fire behavior, even if only part of the fire is burning in a closed environment.

The most obvious use of the concept of fire environment and fire behavior patterns is probably in understanding and predicting wildfire behavior.

but the concept can also be used in prescribed burning. In fires of low or moderate intensity, which are usually desired in prescribed burning, the fire environment pattern largely controls the behavior pattern. Thus, by knowing the fire environment pattern for the area, the fire behavior pattern can be predicted. And by selecting the proper environment pattern, the desired type of behavior can be obtained and dangerous points can be alleviated.

SUMMARY

Fire environment is the complex of fuel, topographic, and airmass factors that influences or modifies the inception, growth, and behavior of fire. It is the current state of these factors and their inter-relationship with one another and with fire tha determines the behavior and characteristics of a fir at any given moment. Fire environment is not stati but varies widely in space and time. Both fire env ronment and fire behavior are pattern phenomena and both patterns for the area of the fire must b considered in order to understand and predict fire's behavior. Because of the difference in th fire environment patterns, the behavior of fire burr ing in a closed environment may be vastly differer from one burning in an open environment. Th concept of fire environment and fire behavic patterns is useful for the understanding and pre diction of fire behavior for both wildfires an prescribed fires.

Figure 3.—These fires are burning in the following fire environments: A, Closed urban, B, open urban, C, closed wildlan D, open wildland.

QUALITY CONTROL IN FIRE DANGER RATING

JOHN J. KEETCH, *Forester,*
Southeastern Forest Experiment Station

Fire control officers need accurate data to develop, execute, and evaluate their procedures in fire control management. One of the most valuable sources of data for the fire control officer is the fire danger rating. But to use the ratings with confidence, it is imperative to establish and maintain uniform standards of measurement and effective methods of data verification. These are the functions of quality control.

Quality control is much more han a rigorous check of the observer's record sheets. It must start with the fire danger station network and continue through a eries of checkpoints to the final omputations on the daily record. To clearly define quality control, and what must be done to implement it, this tool is discussed in he following six sections: Site, nstallation, maintenance, operaion, recording, and computation.

SITE

Professional judgment is needed n site selection and equipment nstallation. Both checkpoints must be standardized so there is a uniorm fire danger rating system nstead of a series of systems.

The general location and specific site of a station must assume rst priority. Readings from inruments that are incorrectly loated are wrong and cannot be ounterbalanced by the work of he most meticulous observer. If irport-type exposures could always be found, proper site selecion would not be difficult. But here are few ideal sites in areas here fire danger stations are eeded. Obstructions or unwanted eflecting surfaces are usually resent on sites that are convennt for observers. Topography, surrounding woodland, and nearby manmade structures must be carefully considered for their probable effect on each fire danger element to be measured. Also, a thorough understanding of the instrument exposure standards and the basis for them is necessary.

The instructions in chapter 600 of the Forest Service National Fire-Danger Rating System Handbook are the best guides for proper placement of fire danger stations. Specialized training in site selection is also necessary. Experience in site evaluation is vital; therefore, site selection should be a Regional responsibility, and should be made by one qualified staff man.

INSTALLATION

When a good site has been selected, adequate equipment must be properly exposed and correctly installed. The exposure part of the problem is the most difficult, particularly the anemometer installation. At substandard stations where instruments are improperly exposed, the measured elements will, in effect, be weighted differently than was intended in the design of the system.

Only qualified staffmen should give final approval to the placement of instruments, both for the existing network and for new stations. This responsibility includes their recommendations for upgrading or relocating stations that were already approved, but where the immediate environment has changed because of tree growth or the addition of structures, roads, parking areas, or irrigation systems. The standards for installation in chapter 600 are somewhat easier to follow than the rules for site selection, even though acceptable equipment varies somewhat.

MAINTENANCE

Inspection sampling of stations in several Regions has clearly shown that prompt and effective maintenance is one of the most important factors in quality control. Maintenance includes the routine cleaning, minor adjustment, and repair of instruments and their supporting devices according to the guidelines in chapter 800 of the National Fire Danger Rating Handbook. Alertness, mechanical proficiency, and knowledge of the instruments and their mechanisms are required. High maintenance standards are easily achieved; mistakes are almost always due to carelessness rather than to lack of knowledge. Unadjusted anemometer contacts, a reduction in cup rotation because of dirt or lack of oil, unmatched thermometers, dirty wicking, or leaky rain gages inject inescapable errors into the basic fire-danger record.

The professional judgment needed in site selection and installation is not necessary. The primary responsibility is local rather than Regional because effective maintenance requires frequent checking. The network of stations on a National Forest should be checked at least twice each year (see section 890). The results of the semiannual visits will determine which stations require more frequent visits from the local staff officer or designated technician.

OPERATION

When an adequate training program is in effect, the observer must continue correct daily operational procedures. The measurement routine is simple and easily understood. The source of error is

(Continued on page 16)

GET THE MOST FROM YOUR WINDSPEED OBSERVATION

John S. Crosby and Craig C. Chandler[1]

Surface windspeed is often the most critical weather element affecting fire behavior and fire danger. It is also the most variable and, consequently, the hardest to evaluate.

Air moving across the surface of land is constantly changing speed and direction. Standing still, one observes a series of gusts and lulls. Because of gusts, trying to measure windspeed is much like trying to measure the speed of a car on a winding mountain road. It slows on the turns, speeds up on the straightaways, and slows to a crawl on bumpy stretches. To obtain a reliable average speed, one must determine the time required to travel at least 2 miles. And the rougher and more crooked the road, the longer is the distance required to obtain a reliable average. This same principle applies to wind measurements. The greater the gustiness (the ratio between the range in momentary windspeeds and the average speed), the longer it takes to determine a reliable windspeed.

Peak windspeeds that persist for 1 minute can affect gross fire behavior, including rate of spread and fire intensity. For example, a surface fire in pine litter spreading at 10 chains per hour with the wind averaging 5 miles per hour would spread 11 feet farther than expected during a minute when the wind was blowing at 9 miles per hour. During that minute it would burn with twice its average intensity and would be nearly three times as likely to jump a prepared fireline.

Momentary gusts have little effect on the overall rate of fire spread and intensity, but they do produce large fluctuations in flame height and can easily trigger crowning or throw showers of sparks across the fireline when other weather factors are in critical balance. Gusts will usually be close to the average value and will rarely exceed the maximum value.

Gustiness is caused by mechanical and thermal turbulence.

Mechanical turbulence is produced by friction as the air flows over the ground surface. Its magnitude depends on the heigh above the ground where measurements are made, the roughness o the ground surface, and the wind speed. The maximum mechanica turbulence is found close to th surface in rough topography o windy days.

Thermal turbulence occurs whe horizontal wind meets convectiv currents produced by unequa heating or cooling at the grounc Its magnitude depends mostly o topography, ground cover, sola radiation, and atmospheric stabil ity. The maximum thermal turbu

Table 1.—*Wind gust estimating table*[1]
(Miles per hour)

Standard 10-minute average	Probable maximum 1-minute speed	Probable momentary gust speed	
		Average	Maximum
1	3	6	9
2	5	8	12
3	6	11	15
4	8	13	17
5	9	15	18
6	10	16	20
7	11	17	21
8	12	19	23
9	13	20	24
10	14	22	26
11	15	23	27
12	17	25	29
13	18	26	30
14	19	28	32
15	20	29	33
16	21	30	35
17	22	32	36
18	23	33	38
19	24	34	39
20	25	35	40
21	26	37	42
22	27	38	43
23	28	39	44
24	29	40	46
25	30	41	47
26	31	43	49
27	32	44	50
28	33	45	51
29	34	46	53
30	35	47	54

[1] All readings were taken in the afternoon 20 feet above the ground.

[1] Respectively, Research Forester, North Central Forest Experiment Station, Forest Service, USDA, Columbia, Mo., and Assistant Chief, Forest Fire Research Branch, Division of Forest Protection Research, Forest Service, USDA, Washington, D.C.

ence occurs above rough topog-raphy with patchy ground cover luring sunny afternoons in un-table air.

Gustiness is a serious problem 'or both fire researchers and fire-control planners. Because of gusti-less, wind measurements at two ocations cannot be compared un-ess they are taken at the same leight above the ground and for he same length of time. For maxi-num comparability, measurements should be taken as high above the ground as possible and for as long is possible. But high towers and ong observations are expensive. Therefore, for fire-danger rating ve have established a standard nemometer height of 20 feet and standard observation time of 10 ninutes.

While these standards are fine or fire-danger rating, they often onfuse the firefighter on the round. Rapid changes in fire be-avior are determined by rapid hanges in the wind blowing on he burning fuel, and not by hanges in the long-term average vindspeed 20 feet above ground. Often the firefighter loses confi-ence in his meteorologist or his veather station, or both, because e is told to expect a 16-mile-per-our wind and found the fire anned by 35-mile-per-hour gusts. He often must estimate the varia-ons in windspeed that may be xpected for the average speed hat is reported.

To help firefighters estimate ustiness, we determined the 10-ninute average speed, the probable astest 1-minute average speeds, nd the probable average and ighest momentary speed or gust uring the fastest 1-minute speed table 1). The table values were etermined from several hundred oon and afternoon observations ade at Salem, Mo., during fire easons. They were taken when ustiness was likely to be greatest, s it often is on difficult fires. hus, the estimates are most accu-rate when they are needed the most.

TABLE 2.—*Standard windspeed estimates based on maximum gusts*[1] *(Miles per hour)*

Fastest gust observed on hand-held anemometer[2]	Standard windspeed when atmospheric condition is:		
	Stable[3]	Neutral[4]	Unstable[5]
0-3	0	0	0
4-6	1	1	1
7	2	1	1
8	2	2	1
9	3	2	2
10	4	3	3
12	6	4	4
14	8	6	5
16	10	8	7
18	12	9	8
20	15	11	10
22	17	13	12
24	19	15	14
26	22	17	16
28	24	19	18
30	27	21	20
32	29	23	22
34	32	25	23
36	34	27	25
38	37	29	27
40	39	31	29

[1] Standard windspeed is 10-minute average speed 20 feet above the ground

[2] Readings were taken 5 feet above ground. For best results observations should be made for several minutes.

[3] This column usually should be used for observations between 8 p.m. and 8 a.m.

[4] This column usually should be used for observations between 8 a.m. and noon, and between noon and 8 p.m. on overcast days.

[5] This column usually should be used between noon and 8 p.m. on clear or partly cloudy days.

It is difficult to convert wind-speeds taken by firefighters to the standard windspeed. In preparing spot forecasts for project fires, wind measurements are often made with a hand-held anemometer. This instrument indicates gust speed accurately, but it is almost impossible to accurately determine average speed with it. Consequently, the windspeed reported from the fireline almost invariably is the average gust speed rather than the accepted 20-foot, 10-minute standard. Therefore, another table was developed to convert gust speed 5 feet above the ground to the standard 20-foot, 10-minute speed for stable, neutral, and unstable conditions (table 2). This conversion should be used when fire-danger indexes are determined from fireline observations or when wind information consists of a mixture of hand-held and tower observations.

ONTARIO TESTS A NEW TYPE OF FOREST FIRE HOSE

G. P. Elliot,
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Ontario Department of Lands and Forests

Ontario is one of the largest users of forest fire hose in Canada. The Ontario Department of Lands and Forests maintains approximately 31,000 lengths of hose at its various headquarters strategically located in the Province.

The capital investment for this hose is approximately $1 million. Also, much of this hose must be replaced each year because of various causes of failure. Replacement costs are almost half of the annual expenditure for fire suppression equipment.

This high rate of replacement has stimulated an endeavor to find hose with a longer useable life. Requirements include resistance to burning, ability to transmit water with low friction loss, and durability and mobility.

Two types of forest fire hose are used in Ontario:

1. Lined hose is used to deliver water to the fireline. It has low friction loss and withstands high pressures, which is desirable for this part of the hoselay. Lined hose is not resistant to burning if exposed to direct heat and flame.
2. Unlined linen hose is used at the fire perimeter. This hose with its weeping characteristic does not burn under pressure.

An ideal hose should incorporate these features:

1. Low friction loss
2. High resistance to burning under pressure
3. Ability to withstand high pressures
4. Resistance to abrasion in handling and storage
5. Flexibility when dry or wet

Figure 1.—This self-wetting or percolating type of lined hose can withstand fire.

A percolating lined hose (fig. 1) that meets most of these requirements has been manufactured. It is a composite of natural fibres and synthetics.

In 1964 this new type of forestry hose was supplied to the Ontario Department of Lands and Forests for evaluation tests. Test results indicated that the friction loss ratio of the new hose was approximately 50 to 70 percent of the difference between standard types of unlined and lined hose. Its weeping capacity provides resistance to damage by heat or flame. Its weight and flexibility correspond with standard types. Its flexibility is satisfactory for handling and packing procedures now used.

This initial investigation resulted in a recommendation to purchase a certain quantity of self-percolating hose for field testing. Some hose was tested during the 1965 fire season, and initial reports appear favourable. All field establishments will have this hose during the 1966 fire season. Therefore, data on its performance and durability will soon be available.

This new type of percolating lined hose is a major improvement. However, the search for a better type of forest fire hose is being continued in Ontario.

Mass Helitack—Continued from page 5

Close ground support by helicopters speeded control. Effective retardant drops knocked down hot spots just ahead of the crews. They greatly reduced the hazard to the firefighters, particularly when flareups on slopes below the crews could have forced a retreat. Often the crews did not have to battle hot fire to put in control lines. Also, hot spotting ahead of the crews by the helicopters slowed the fire spread and shortened the control line that did have to be built. However, the crews still had hard work in heavy brush and on steep, rough topography.

The mass use of helicopters in the control of both fires emphasized problems that need further stu Foremost among these are:

1. The use of helicopters at night. Air co ditions then are more favorable, and because fi usually are not as intense at night, control wou generally be easier.
2. The close coordination of helicopters wi other aircraft, ground equipment, and grou crews. Research in systems analysis is need to help develop the optimum balance among types of firefighting forces.

Studies on both problems are now being conduct by the Forest Service.

Quality Control—Continued from page 11

usually carelessness and intermittent lack of attention to detail in the day-after-day routine.

The selection and training of observers and followup is primarily a local responsibility. Almost daily contact may be needed for some time, especially with new observers. Thus, the district in which the station is located should have direct responsibility for correct operation.

RECORDING

The accurate and legible recording of observed data may be considered a part of operation, and the level of responsibility is the same. It is discussed separately, however, because an excellent record taker may be a poor record keeper. Even when a station is perfectly installed, maintained, and operated, a record with indistinct or uncertain entries is useless as a source of future information. Observers must understand that their work is of permanent value.

However, observers, in their zeal to make clear and legible records, have sometimes hand copied or typed the original data from a scratch sheet. This, most emphatically, should not be done. Mistakes in copying are easily made, and many such errors have been noted. Exactness in preparing the original record, with use of carbon for copies that are needed, is all that is required.

COMPUTATION

When the data are in order, the buildup index, spread index, or other operational indexes must be correctly computed. Errors in computation are not as serious as mistakes in previous sections because corrections can be made. For example, poor exposure or a faulty anemometer may result in the recording of windspeed as 10 m.p.h. instead of the correct 15 m.p.h. Moreover, such an error would probably not be detected in a review of the record. But the same error in computation, resu ing in an incorrect spread ind could easily be found by reco puting. Thus, the final step quality control should be to co pletely recheck all computatio

This computation should done at the district level beca any sizable error will advers affect preparedness action. Mo over, any questionable items be discussed directly with the server, and it is a good train measure.

The records from a Natio Forest network should be cur lated in the Supervisor's office spot checked. Comparative che ing at the Forest level may rev inconsistencies that were not parent at the source.

Fire danger data forwar from the Supervisor's office, eit to the Region, Fire Research C ter, U.S. Weather Bureau, other cooperators, should be free from error as is possible i six steps in quality control h been successful.

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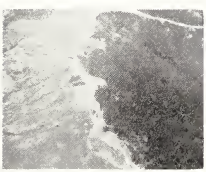

COVER—The fuel-break shown stopped the Horse Fire on the Mendocino National Forest (Calif.). **See related story on page 4.**

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

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THE CAROLINA BLOWUP[1]

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April 1, 1966, was not a day for April Fool kes in the coastal pinelands of North and South arolina. It was an explosive fire day unrivaled recent times. In those hot 24 hours, 72,000 res in the two States were burned, 3,000 acres er hour. It was a Black Friday for more than) families whose homes were destroyed.

A news release from the South Carolina State orester's office in Columbia summed up the tuation: "The driest March in ten years cre- ed the forest fire danger that exploded on Fri- y, April 1st, into an almost uncontrollable tuation. In three days, Friday, Saturday, and inday, 480 wildfires burned 70,000 acres bring- g the total fire loss since July 1965 to 4,800 ldfires burning 120,000 acres of woodland."

This was the greatest loss in 11 years. Before e rains came on April 4, the forest area burned the two Carolinas during this explosive period ached 144,000 acres. The largest fires were in e coastal pinelands, but damage was not lim- d to that area as numerous fires sprang up ross the Piedmont.

The conflagration came as no real surprise to rest protection personnel. A very dry March d followed a dry winter.

On March 30, a meteorologist from the U. S. rest Service's Southeastern Forest Fire Lab- tory in Macon, Ga., telephoned the State for- ry headquarters in Raleigh, N.C., and Colum- , outlining the full danger of the unstable ather conditions. Wind and pressure patterns h as these had come to the South before. They ally meant trouble on going fires.

The North Carolina State Forester immedi- ly cancelled all burning permits and pro- ited use of fire near woods. Yet even with s preventive measure, fire crews in the Tarheel te fought 273 wildfires covering 18,000 acres the last 2 days of March.

n South Carolina on the same day, the For- y Commission closed all State parks to public s. On the evening of March 31, the governor ied a proclamation prohibiting the use of fire acent to woodlands—the first time this had r been done. (The authority was provided in aw passed after the disastrous 1954-55 fire son, when 7,000 fires burned 159,000 acres.)

[1] Adapted from American Forests. July 1966.

APRIL 1

April 1 dawned clear and windy. The 10 a.m. report from Jones Lake tower on North Carolina's Bladen Lakes State Forest showed a high spread index, fuel moisture of 6 percent, and a steady wind of 18 miles per hour from the southwest.

By early afternoon rural residents and travelers in the Carolinas knew there was a serious fire situation. They didn't have to be told over the radio or see it in the news. They could smell the smoke and feel it burn their eyes.

The steady southwest winds were flowing between two areas of high pressure. One of the systems had recently passed out into the Atlantic. The second, a fast-moving cold front, was coming in from the Mississippi Valley. At 7 a.m. the leading edge was over the Great Smoky Mountains. By 1 p.m. it was in the Piedmont crossing over Charlotte and Winston-Salem. That evening it reached the Atlantic coast, bringing thunderstorms to Wilmington, N.C.

As the front hit, prevailing winds were pushed eastward by the strong winds within the system. This meant a 90-degree wind change as it passed. Fires that had made a narrow run to the northeast quickly turned southeast, their long flanks becoming new wide heads.

THE AMMON FIRE

One of the blazes that got the most publicity threatened the little town of Ammon, N.C., for 2 days and blackened 17,000 acres around it. The smoke was first reported at 1:30 p.m. on April 1. Rumor was that someone had been burning off an area to improve duck hunting, but no one was quite sure who it was.

Forty minutes later a forestry truck on patrol radioed that a second fire was coming out to the highway from nearby Black Lake. Crews just completing control lines on the White Oak fire only 15 miles away rushed to both new blazes.

Reconnaissance aircraft swung over from the large Newton Crossroads fire a scant 20 miles eastward and advised ground crews on the course of the flames and the best control action.

The fire towers, now nearly all socked in by smoke, relayed urgent radio messages between headquarters and the men on the firelines. "Fire

(Continued on page 15)

FUEL-BREAKS—EFFECTIVE AIDS, NOT CURE-ALLS

JAMES L. MURPHY, LISLE R. GREEN, and JAY R. BENTLEY,[1]
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"This fire hit the ridge and kept right on going—it didn't even know the fuel-break was there." Or: "That fuel-break sure didn't do what it was built for—we wasted a lot of money and time building it." Or: "Fire will spread faster in tall grass on a fuel-break than in the brush." Or: "We don't need to worry about that side of the fire—there's a fuel-break up there." Such remarks have long been made and will continue to be made. Obviously, all firefighters do not understand the purposes and limitations of fuel-breaks, but strategically placed fuel-breaks help reduce the conflagration or fire disaster problem.

Figure 1.—Fuel-break in southern California brush.

Figure 2.—Fuel-break in Sierra-Nevada mixed conifer typ
central California.

DEFINITION OF A FUEL-BREAK

A fuel-break is a strip of land on which the primary fuel, usually brush (fig. 1) or timber (fig. 2), has been permanently converted to a lighter, less dense fuel type to facilitate fire control. As prescribed by an interagency committee (Anonymous 1963)[2], fuel-breaks on ridgetops, in valleys, and along roads and wide benches are at least 200 feet wide. A firebreak—a road or other strip with exposed mineral soil—is often within the fuel-break.

A fuel-break may be built to help protect a single campground or community, or a connected network may be constructed to safeguard large wildland areas.

PURPOSE OF FUEL-BREAKS

1. Fuel-breaks break up the continuity of heavy fuels, and if the fuel-break system is dense enough, they help firefighters prevent fires from reaching and maintaining high-energy output levels. Resistance to control is less on fuel-breaks, and retardants dropped from aerial tankers may be more effective.

2. Fuel-breaks are permanent preattack installations, and when they are well located and constructed, they are effective in firefighting. They provide access for crews, ground tankers, and other vehicles. Thus, a fireman can backfire while *he* is the "boss"—not when the fire is.

3. Fuel-break systems provide defense depth. The first objective of an attack is to s the fire in place. Subsequent strategy is direc by current fuel and fire behavior, but the fu break becomes important in fire-suppress strategy. If the fire jumps, fire control for can be regrouped and redeployed until the can be held. Meanwhile, under most burn conditions, the flanks and rear of fires can be h at fuel-breaks. Because fuel-break systems i prove the chances of fire control forces contr ling fires during the first burning period, "c trol by 10 a.m." becomes a realistic objecti even for conflagration fires.

4. Fuel-breaks used as line locations tend reduce mopup and patrol costs after a fire controlled. They provide safer access for fi fighters. And the lighter fuels on the breaks not hold fire tenaciously or as long. Conseque ly, the problem of high costs due to slow, tedi mopup and long, intensive patrols can be a viated.

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[1] Research Forester and Range Conservationists, respectively.

[2] Anonymous. Guidelines for fuel-breaks in southern California. U.S. Forest Serv. Pacific SW. Forest and Range Exp. Sta. Fuel-Break Rep. 9. 1963.

USE OF FUEL-BREAKS

Fuel-breaks alone are not expected to stop a ot, fast-moving fire. They are designed for ofensive tactics, such as backfiring, and must be ianned—usually the sooner the better. They ust be further cleared to serve as control lines, it with their reduced resistance to line conruction, a wide defense line can be established irly quickly.

Fuel-breaks provide some security to the firean. He can better estimate his safety and his pportunity for attacking successfully when he is an opened ridge or canyon bottom from hich to reconnoiter and work. However, fueleaks, while furnishing *relatively safe* access d attack points, can lure a crew into false serity. The ground cover may be flashy fuel th a rate of spread greater than that of adcent fuels in which the fire is burning. Men ould not be placed far out on a fuel-break uns larger, standard safety zones are at about arter-mile intervals, as recommended in guidees.

Experienced crews must quickly fire out the shy ground fuel at the right time. Enough ne is needed to plan and safely execute the ing. It is preferable not to fire when a highensity fire is "making a run" at the break. ind and heat generated by a big fire close to grass-covered break can cause many spot fires annual grass and dry perennial grass that read rapidly and imperil men on the line. Also, ing-out can be risky in dry grass during adrse winds because of the rapid spread of the e and the high proportion of spots that "take". e situation may not be so critical on timred fuel-breaks, where low-growing perennials, h as bearclover, which are not as flashy as ss, provide fuel-break ground cover.

BENEFITS OF VEGETATION ON FUEL-BREAKS

Vegetation on fuel-breaks limits their effeceness as barriers to fire spread. Firefighters ow that dry, herbaceous ground cover—cifically tall grass—is a flashy fuel which ns with much heat. However, to reduce soil sion, such vegetation must be left on fuelaks or new ground cover must be established. A dense cover of grass or forest litter is fairly ble and can be maintained free of brush quite xpensively. However, it is first necessary to all brush sprouts and seedlings, preferably chemical spraying. Killing may require 3 to ears, and fuel-breaks should not be started ess funds will be available to complete the job. entually grass or litter will usually choke out new brush seedlings and make maintenance fairly easy.

Although a grass cover may be needed on a fuel-break, all grass need not be left as hazardous dry fuel. The excess can be removed by grazing, mowing, or burning. Grass species that remain green for long periods are desirable. Techniques for management of the current vegetation growth can be developed after the heavy fuels have been modified during fuel-break construction.

A mixture of grass or litter and brush is unstable, and attempts to maintain it usually fail, or only a small acreage can be maintained because of high costs. Also, a mixture of grass or litter and low-growing brush may burn hotter than grass alone. Brush clumps, when left on fuel-breaks, may flare up from sparks and burning embers during firing operations.

Vegetation on fuel-breaks may do more than reduce erosion and stabilize ground cover. Forage grass or timber can be grown on areas formerly covered by dense brush. However, a thinned timber stand left after fuel-break construction may produce less than a natural stand, and thus add to the costs rather than benefits of fuel-break construction.

MULTIPLE-USE AND FUEL-BREAKS

Fuel-breaks must be planned and constructed as part of the total management program. Specific guidelines for fuel-break planning, engineering, and construction are usually formulated and approved by fire control specialists and timber or other resource management specialists working together under the concept of multiple-use management. The guidelines help assure that fuel-breaks are compatible with good land management. Thus, the very factors that make fuelbreaks valuable in fire control also make them valuable from a total management standpoint. Brush areas may be converted to forage grass or to timber production. Slash and other debris are cleaned off the forest floor in timber areas. Trees are thinned and pruned. The wildlife habitat is improved. Live ground cover maintained on fuel-breaks reduces erosion. The net effect of fuel modification should be higher production in both timberlands and brushlands.

CONCLUSIONS

Fuel-breaks are not cure-alls—they are prebuilt firelines that provide safer access to otherwise dangerous areas; they give the firemen a better chance of controlling fires. And, like other fire tools, they must be used for a specific purpose, in a specific place, and at a specific time.

A NEW APPROACH TO FIRELINE CONSTRUCTION[1]

R. W. JOHANSEN, *Research Forester,*
Southeastern Forest Experiment Station[1]

Backfiring from single- or multiple-plowed lines often does not control fast-spreading fires where spotting occurs. Because backfires spread slowly into the wind, they frequently do not burn out an adequate isolation strip quickly enough to stop fire spread. A new approach is needed to quickly increase the effective fireline width.

In a study in which a ground tanker with a high-output pump was used, it was shown that a chemical solution fireline can stop a head fire in the highly flammable palmetto-gallberry fuel type of southern Georgia. Fifteen percent diammonium phosphate solution was used to make chemical lines 30 feet wide and 300 feet long. A head fire was then started and allowed to run 170 feet to the treated line. Fire spread averaged 1 chain per minute. Fire did not penetrate more than 10 feet into the chemical line before the flames were extinguished, even though application rates were as low as 1 gallon per 100 square feet. The burning experiments were conducted with a Spread Index of 16-18 (High) and a Buildup Index of 30-55. Plowed lines would easily have been crossed by the spreading fire.

This test suggested a method for the quick construction of a wide control line in front of an approaching wildfire. Instead of depending on the slow spread of a backfire to reinforce a plowed line or road, firefighters could quickly make a line by strip head firing into the prepared chemical line. Width

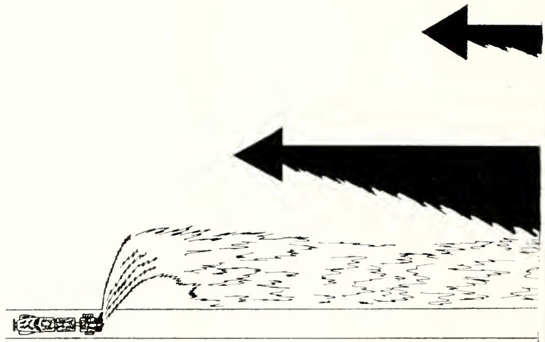

Figure 1.—Construction of a fireline with chemicals and strip head fires is shown.

would depend upon burning conditions. Subsequent strip head fires would quickly extend the line width to 500 feet or more if desired (fig. 1). A chemical line could also be established on the downwind side of a road; this line would be used primarily to catch spot fires. The road would serve as the fire break into which the fire would run.

The cost of diammonium phosphate would be about 2½ cents per foot of line for a 30-foot-wide line at an application rate of 1 gallon per 100 square feet. Thus, 1,000 feet of line would cost $25 and $50 for 1 and 2-gallon chemical applications.

Table 1 shows the rate at which chemical firebreaks can be completed along woods roads with mobile-pumping equipment. The rate of line construction depends on the speed of the vehicle, the pump output, and the desired application rate. For example, the table shows that a 300-gallon-per-minute pumper can supply 2 gallons of retardant per 100 square feet of land to a 30-foot-wide line while traveling at 5.7 miles per hour

TABLE 1.—*Rate of chemical fireline construction by application rate*[1]

Rate of vehicle movement (m.p.h.)	Application	Rate
	Gal./100 sq. ft	Gal./1,000 ft. line
11.33	1	300
5.67	2	600
2.84	4	1,200
1.42	8	2,400

[1] A 300-gallon-per-minute pumper was used; the line width was 30 feet.

[1] The author is stationed at the Southern Forest Fire Laboratory, Macon, Ga.

Because of costs, chemicals ould not be used when plowed ıes and backfiring will stop e spread. However, on high e-danger days, when spotting ay be a problem, and lines 30 et and wider are needed quickly, the chemical lines plus variable-width strip head fires could be advantageous.

SUMMARY

Results of this study indicate that a 30-foot-wide fireline of diammonium phosphate can stop a strip head fire moving into the prepared chemical line. To provide more safety against spotting during high danger days, successive strip head fires can be used to widen the burned-out strip in the path of a wildfire.

HELICOPTERS AND FIREMEN—THE RUBY FIRE TEAM

FRED W. TYLER, *Fire Control Officer*
Saugus District, Angeles National Forest

"The helicopter will prove to be most versatile firefighting tool er developed." Frank C. Jeffern, Fire Chief of the Forest rvice's California Region, said it about 20 years ago. . . . How e his prediction proved to be! licopters, when used in support ground crews on fires, have peatedly shown their effectiveess.

For example, helicopters and men united to control the potially dangerous Ruby Fire on Angeles National Forest. On y 23, 1965, at about 3:40 p.m., Warm Spring lookout on the ıgus District of the Angeles tional Forest detected smoke in rby Ruby Canyon. When the ial-attack pumper unit hit the ı, it was burning on about a f acre of medium to heavy sh in the bottom of a deep yon. The fire spotted to both es of the canyon. The initialtck crews, aided by air tanker port, were able to hold the fire the south slope of the canyon. vever, due to the steep slopes dry brush, it burned over the of the ridge on the north side he canyon. Quick followup by d crews and tractors held the n fire to about 500 acres.

ut . . . a potentially dangerous ation had developed. As the n fire burned up the slope and proached the ridge, many firerds carried over the fireline on flanks and at the ridge. Many spot fires developed. However, since it was late in the day, these fires didn't flare up; they only smoldered. Crews could not have found them during the night. But many were sure to flare up the next morning when burning conditions intensified.

TEAMWORK—HELICOPTERS AND MEN

Fire control plans were needed to keep the spots from developing into a major fire in Ruby Canyon and the adjacent canyon. Three helicopters were ordered to the fire that evening; all crew and sector bosses assigned to the next day's shift were alerted to the spot fire danger. The helispot was established. Helicopter and ground crew radios were checked. Fire retardant (Gelgard) was ordered, and equipment was checked and readied for use.

By dawn of July 24th, fire crews were lined out along the fireline and the helicopters were loaded with retardant. The helicopter-firemen team was ready for action.

When it was light enough to fly safely, one helicopter flew almost constant reconnaissance. Ground crews kept alert for spot fires. At about 10 a.m. the first spot fire occurred. The reconnaissance helicopter radioed a location and condition report to the heliport and to the nearest ground crew. A helicopter dropped retardant on the fire. The retardant held the fire until the nearest crew could break through the brush and control it. This combined helicopter-ground attack continued throughout the day. Twenty-five spot fires were controlled by this team, and more than 7,000 gallons of retardant was dropped by the helicopters. It took 32 to 38 seconds, an average of 34 seconds, to fill the helicopter tank with retardant. Average flight time to the spot fires was 8 minutes. The total effort was efficient because of trained and experienced heliport crews, good air to ground communications, and the versatility of the helicopter.

SUMMARY

A team of helicopters and ground crews prevented a major fire on the Saugus District of the Angeles National Forest. The helicopters dropped retardant which kept spot fires small until ground crews could control them. The versatility of the helicopter was again proved. The helicopter can fly reconnaissance, ferry men and equipment to and from the fireline, and give ground crews the confidence they need to control the fire.

Experienced firemen believe that the combined helicopter and ground crew control of the spots prevented a major fire which could very possibly have exceeded 5,000 acres. A conservative estimate of savings in suppression costs and watershed damage is $400,000.

DEVELOPING FOAM WITH AN AERIAL TANKER

J. W. COLQUITT[1] and R. W. JOHANSEN, *Research Forester, Southeastern Forest Experiment Station*

All forms of foam have been used to control fires. Several types of foam dispersal equipment are used with different foam systems; however, aerial tankers had not been used for dispersing foam.

After an appraisal of the different methods of producing foam—chemical, aerosal, and mechanical—the mechanical system was selected for economic reasons. A mechanical foam is generally produced by trapping air within a stabilizing liquid to form bubbles. The liquid is passed through a special nozzle, or it is introduced into a high-speed airstream such as that available in the air tanker slipstream.

OBJECTIVES

The study was initiated to establish whether air tankers could be used to dispense foams successfully. Answers to the following questions were also desired:

1. What types of foam solutions are compatable with diammonium phosphate salts?
2. What kind of volume expansion can be expected?
3. What effect do viscosity builders have on foam solutions and their foaming capabilities and stability?

PROCEDURE

Two types of foam materials were tested for air tanker use—protein-base and synthetic-base concentrates. Prior to the tests with an aerial tanker, these materials were tested in a laboratory to observe foam stability, compatibility with ammonium phosphate salts, effect of thickeners on foam formation and stability, and expansion rates.

Eight drops were made by a TBM air tanker. Except for one 400-gallon load, all solution volumes released from the aerial tanker were 200 gallons. The drop altitude was about 75 feet above the highest obstruction, unless otherwise noted.

RESULTS

Drops 1 and 2 were made with a protein-based foam concentrate in water. The first drop, a 200-gallon load, was made at 110 m.p.h. on a pulpwood-size pine stand. Complete aeration did occur, but the foam just floated into the trees with little if any force (fig. 1). The second drop, a 400-gallon load dropped at 100 feet and 140 m.p.h., was made on a flat, grassy area to assess foam expansion. The resulting pattern was 330 feet long and 220 feet wide, and the foam expansion ratio was 32:1. Foam stability was not good; the entire amount dissipated within 1 hour.

The ground pattern width r[esulting] from a TBM retarda[nt] drop is normally 50 to 60 fe[et] and is not significantly affect[ed] by crosswinds of less than [...] m.p.h. However, the 220-fo[ot] width in the test resulted fro[m] an 8 m.p.h. crosswind. Ther[e]fore, the density of normal foa[m] is low enough so that even lig[ht] winds cause considerable dri[ft].

To increase foam density, a[nd] thus overcome the drift pro[b]lem, for several drops industr[ial] gums were added to increa[se] the viscosity of the solution. [At] 125 m.p.h., there was apparen[t]ly not enough energy in t[he] slipstream to aerate the so[lu]tion, and no foaming occurre[d]. At 170 m.p.h. some foam w[as] formed, but not enough for [a] successful drop. The foam th[at] did form was very stable.

The greatest foam producti[on] in the tests reported he[re] was from a high-expansi[on] synthetic-base concentrate [in] water dropped at 140 m.p.h. [at] 100 feet (fig. 2). Stability [of] this foam, however, was [...]

(Continued on page 1

Figure 1.—Foam formed above tree crowns reached the ground mainly through canopy openings.

Figure 2.—A synthetic-based solution [pro]duced the most foam, but dissipa[tion] was most rapid.

[1] Colquitt was a Field Assistant at the Station when the work reported in this article was performed.

KEYS TO A SUCCESSFUL AIR-ATTACK PROGRAM

E. F. McNamara, *Assistant Chief, Division of Forest Protection, Pennsylvania Department of Forests and Waters*

Pennsylvania has had a very satisfactory water-bombing program since 1960. Costs and personnel requirements are probably the two main reasons why many State forest fire control agencies hesitate to initiate a water-bombing program. Water-bombing costs must be included in the total State budget for forest fire control. To obtain maximum utilization of the few available personnel, efficient organization and operation of water-bombing programs are necessary. In order to achieve this optimum use, the Division of Protection staff has given careful attention to three critical factors: Training, preseason preparations, and operational performance.

TRAINING

Training is probably the most important of the three factors. If training is conducted properly, operational performance should be good. Our slogan has been "Every man must be trained to do as much as possible beyond his regular job." Training is conducted annually: Policies change, experienced employees require refresher courses, and there are always new employees. The training of the three men who operate our airplanes and helicopters—the pilot, air operations officer, and pump operator—is basic. In addition, the fire control organization that may work where water bombing is conducted must also be trained.

Pilot training is done in two stages, prior to and during field operations. Key points covered are:

A. Department fire control organization

B. Radio communications

C. Forest fire terminology

D. Fire behavior and fire control tactics of ground control forces.

E. Drop techniques

Pilots with water-bombing experience in Pennsylvania are used as instructors to train new men with little or no retardant-dropping experience or to train pilots whose experience has been in other States.

Air operations officers are staff foresters in the Forest District offices or qualified forest foremen working on nearby State Forest areas. These men are trained before operations, and a review and critique session is held after operations are concluded. Training includes:

A. Aircraft performance and capabilities

B. Weather and its effects on operations

C. Air-attack program policies and procedures

D. Reports and forms

Pump operators who are new employees are trained at the airbase for several days before operations begin. Experienced men usually are also given a brief refresher course just prior to the start of operations. Areas covered are:

A. Pump operation and maintenance

B. Tank capacities, control system, and retardant mixing procedures

C. Use of radio, aircraft servicing, and similar routine operational tasks.

Training for the ground fire control organization varies. The district foresters are annually briefed on old and new procedures. Circular letters are used when needed to outline new policies and policy changes. Smokechaser units (two- or three-men hotshot crews who operate from a light firetruck in areas below aircraft operations) are given 1-day training sessions on aircraft drop techniques, safety factors, and followup ground attack. The volunteer fire wardens are similarly informed at annual fire warden meetings and in periodic District newsletters.

PRESEASON PREPARATIONS

The logistics of an effective air-attack program must be decided well before operations. This is one year-round duty of the Division of Forest Protection staff, especially the air operations advisor. Some of the more important items that must be arranged, at varying intervals, before operations are listed below. Most of these are handled by the Forest District staff in whose area the airbase is located.

A. Headquarters building or van (clean, neat, and with proper heating units)

B. Telephone (connected)

C. Radio (serviced and operational)

D. Maps (up-to-date and usable)

E. Aerial photos (properly filed and available)

F. Equipment including pump, standby pump, repair parts, and tools (available and functioning)

G. Storage tanks for water and retardant (repaired, in place)

H. Water and retardant (stocked to tank capacity)

I. Telephone lists of all Department personnel and cooperating individuals, fire companies, and other agencies (up-to-date and available)

J. Forms, reports, and Instruction Manual (available)

Through great effort and use of checklists based on experience, these details and many minor ones must be checked before the arrival of the aircraft and fire weather.

OPERATIONAL PERFORMANCE

Small Airplanes

For the small airplanes (Stearmans), which have a 150-175-gallon capacity, and helicopters, the following procedures are used (fig. 1).

The aircraft are based where our studies have shown that many fires occur. They operate within a certain radius of the airbase. This radius is based on their speed and drop load.

Initial attack is the basic use for these units. Therefore, the initial fire report goes to Air Attack Headquarters, and the aircraft is dispatched immediately. To permit rapid initial attack on fires, a few false alarms can be tolerated.

If the area within the operational radius is free of fires, a plane may work on fires outside this area. Good communications permit a recall of the plane if a fire begins in the original operational area.

The small plane provides support action on fires that escape initial suppression only if it can be useful and no new fires have occurred.

In a multiple-fire situation, the air-attack officer considers the distance from the base, type of fuel, fire danger, and available manpower to determine priority of operation.

Helicopters

The procedure for use of helicopters is the same as that for small airplanes. Heliports are located on the basis of fire incidence, accessibility, and topography.

Figure 1.—This Sikorsky S-55 helicopter can carry 250 gallons of water and retardant, 125 gallons in each of two tanks. When not carrying a drop load, it can transport eight fully equipped firefighters. Its cruise speed is slightly over 100 m.p.h.

The helicopter's versatility is an important reason for its use in the air-attack program. While its use as a water bomber has priority over its other uses, helicopters have been used to transport men, equipment, and food and water to the fireline. They also permit a boss to see an entire fire.

Large Airplanes

Our experience with large air tankers has been limited to the 600-gallon TBM and the 1,600-gallon Chase (fig. 2).

Logistical problems governing the use of the TBM do not differ much from those for the Stearman. However, the operation must be from an adequately surfaced airstrip with facilities for faster loading.

The additional problems to be solved when the Chase air tanker is used are at least in proportion to the size of the Chase over the Stearman.

Only certain previously inspected airports are adequate to handle the weight of this plane when it is fully loaded. Fortunately, there are enough suitable airports in Pennsylvania to provide good statewide distribution. Two of our main operating bases, one each in the eastern and western parts of the State, handle this plane very well.

The storage facilities for this aircraft, which has a 1,600-gallon capacity, are much greater than for the 150-gallon Stearman. Also, a 50-gallon-per-minute-capacity pump is not adequate to refill the Chase. To solve many logistical problems, this aircraft carries a pump, hose, and fittings when it leaves the base to operate in another part of the State.

This large airplane is used for two types of operation. The basic guidelines for effective use of this expensive unit cover initial-attack and support action.

Figure 2.—The Chase, a twin-engine aircraft, can carry up to 1,600 gallons of water and retardant. It can make four drops of 400 gallons each, or two drops of 800 gallons each. Its cruising speed is 160 m.p.h.

Initial Attack

Within a 50-mile-radius attack circle of the Hazelton and Mid-state Airports, the Chase air tanker will operate on an initial-attack basis. District dispatchers needing the Chase air tanker within its initial attack circle can call the air control officer at the Air Control Center.

Within this circle, for fires reported within the operational circles of the Stearman, the latter will be dispatched on a first-call basis. However, if these aircraft are already attacking a fire, the Chase air tanker will be dispatched to new fires within the operational circles of the Stearman.

Support Action

If a large attack tanker is needed outside the 50-mile initial-attack zone, the District Office needing the aircraft must fill in a form containing basic data that will permit the Division Office to evaluate the necessity and desirability of sending the plane. These data include location and size of fire, potential area loss, and other technical data.

If the plane is not engaged in bombing operations within its basic circle and the fire potential is justifiably great, the aircraft is dipatched by the Division Office to the fire. Four auxiliary bases are cleared and processed for servicing the large bombers, and they must, after the initial drop, work from the one closest to the fire.

The tanker returns to its primary base as soon as it completes action on the fire and is released by the District, or it may be recalled by the Division Office if conditions within the primary operational circle dictate.

All the above operations are handled by the standard base crew of air operations officer, pump operator, and pilot. The Chase and one small bomber have headquarters at one base and are handled by a single crew. Two small bombers sometimes work together from a single base, and they are also handled by the standard base crew.

COST

The basic annual cost of the program, based on guarantees to contractors for the minimum operations period, is $56,000. The total cost depends on fire weather and fire frequency, particularly within the operational areas. During the severe 1963 fire year, the total cost for both water-bombing airplanes and helicopters was $71,761.19. This figure is for fire control; it did not include administrative costs for Department personnel and equipment.

CONCLUSIONS

The Division of Forest Protection believes that its air-attack program has greatly strengthened the initial attack on forest fires. More than 40 percent of all fires in the State have been suppressed when the aircraft are on contract. The cost of the program is justified because of the steady decline in average fire size. Also, by assisting small units of trained firefighters to hold fires to very small acreages, it has alleviated the problem caused by a shortage of firefighters. This acreage reduction has been achieved despite rising fire incidence and partly reflects the tremendous initial-attack capability of water-bombing aircraft.

Foam—Continued from page 8

forest. Within 15 minutes all of the foam had disappeared. Dissipation was even quicker in diammonium phosphate salt solutions.

DISCUSSION

The rate of foam production from solutions containing liquid foam concentrates depends on variables such as: (1) Nature of the concentrate, (2) amount of concentrate in solution, (3) solution viscosity, and (4) energy applied to the solution. The first three variables can be controlled easily, but it is difficult to regulate the energy supply in an aerial drop except within narrow ranges. The TBM tanker cannot safely carry a load at speeds under 115 m.p.h., and heavy loads should not be released at speeds exceeding 160 m.p.h. due to extreme negative G-force stresses that develop on the wings.

Water solutions of some foam concentrates tested did foam readily when released from the air tanker at normal drop speeds. However, the foams produced were light and very susceptible to drift, and were not very stable. The water quickly flowed down the film surfaces to the ground, leaving a "dry" foam residue.

In the laboratory foam stability and density are both improved by the addition of industrial gum thickeners, but more energy is required to make foam from thickened solutions. Enough energy to adequately aerate such a solution is not available in the airstream of a tanker travelling at 150 m.p.h. However, tankers capable of dropping at higher speeds may be able to lay a stable foam line.

The use of foaming agents in firefighting chemicals dropped from aerial tankers does not seem promising. But foaming can occur in a free-falling liquid drop from a tanker, and when further improvements in foam concentrates are made, new evaluations may be useful.

FIGHTING FIRE WITH HIGH-PRESSURE AIR JETS . . . SOME PRELIMINARY RESULTS

DEAN L. DIBBLE[1] and JAMES B. DAVIS, *Research Forester, Pacific Southwest Forest and Range Experiment Station*

Water is the traditional medium for fighting fire. But in some areas, water may be scarce, hard to obtain, or costly. The possibility of using a substitute for water, such as air, has interested many foresters. The idea is not new. Nearly 30 years ago, Lorenzen[2] reported on the use of compressed air in fire suppression. Other articles have since appeared. Also, another medium, high-expansion foam—produced by flowing air through a detergent system—has been tried.

Most investigators have considered air as a propulsion force for water, for blasting litter from the fireline, or for modifying wind patterns. However, the direction of an airblast at the fire has been tried only a few times, and most of these attempts have involved a large-volume, low-pressure airstream generated from some distance.[3] What would happen if a high-pressure jetstream was applied directly to the base of the flames?

LABORATORY STUDY

To determine the feasibility of this technique of fire suppression, a small-scale laboratory study was conducted at the University of California's Richmond field station in the spring of 1965. An attempt was made to extinguish fires burning in 7- by 12- by 36-inch chicken wire cages filled with excelsior in amounts equivalent to dry grass weighing 800 to 16,000 lbs./a. Similar tests were made with assemblies of 1/2-inch-diameter pine dowels. The fuel loading of these dowel assemblies was equivalent to 320,000 lbs/a. One end of the fuel was ignited, and after the fire became established, an attempt was made to put it out with a compressed airblast. Various airflow rates, pressures, and techniques were tried.

Success depended almost entirely on a combination of fuel arrangement and air pressure that permitted the airblast to penetrate through the unburned fuel to the base of the fire. If the air could penetrate, the extinguishment was quick—probably quicker than could have been accomplished with water. But if the fuel arrangement prevented penetration, the airblast formed eddies that actually spread the fire. Fires could be blown out consistently with air at 100 p.s.i. when fuel loading did not exceed the equivalent of 8,000 lbs./a.

PRELIMINARY FIELD TESTS

Next, preliminary field trials were conducted early in the summer of 1965. A trailer-mounted compressor was used as our "fire engine". This piston-type compressor had a capacity of 131 c.f.m., 100 p.s.i. It was equipped with 100 feet of standard airhose and a "forester"-type nozzle. Grass volume at the test site was relatively high (6,000 lbs./a.) (fig. 1). Burning conditions were moderate.

After blowing out eight fires, we concluded that the air-pressure technique was slower than water. Also, this technique was not always dependable. As in the laboratory, difficulty was experienced where the fuel was matted and air could not penetrate to the base of the fire. However, the technique did offer some promise; we never ran out of air or had to go for a new load. Consequently, we decided to combine techniques.

Figure 1.—This crew is fighting a grass fire with air from a trailer-mounted compressor.

[1] Dibble was a Meteorology Technician at the Station when the work reported in this article was performed.

[2] Lorenzen, C. Tests on the use of compressed air in fire suppression. U.S. Forest Serv. Fire Control Notes, 22 pp., illus. 1939.

[3] Forest Service, USDA. A wind machine and fire control. U.S. Forest Serv. Firestop Progr. Rep. 8, 8 pp., illus. 1955.

We retained the airblast equipment and designed and built a small tank truck consisting of a pressurized 125-gallon water tank and 25-gallon tank for powdered fire retardant (flow-conditioned diammonium phosphate). The system was piped so that the crew could use either air, water, or retardant powder. The same hose and nozzle system was used for all three media. (fig. 2).

Since tanks pressurized with compressed air are potentially dangerous, they were designed with required safety tolerances and equipped with gages, regulators, and safety valves. Both the air and water systems worked very well. The unit could handle an airflow of 131 c.f.m., with a nozzle pressure of 90 p.s.i. The water system delivered about 20 g.p.m., with a nozzle pressure of about 80 p.s.i. The compressor did not have to be operated continuously when water alone was used. Once the tank was pressurized it would expel itself just like a rural-type pressure system. However, the powder system developed difficulties—the powder often became wet or caked.

FIELD TRIAL

The tank truck unit was used in 14 test fires in 1965. Each test plot was 100 feet square. Fuel was annual dry grasses that averaged about 1,000 lbs./a. The fire danger rating was usually "high". Other pertinent data were as follows:

Temperature .... 89-96° F.
Relative humidity .... 15-22 percent
Fuel moisture stick .... 2.2 percent
Wind velocity .... 3-8 m.p.h.
Burning index (grass)[1] 16-20

[1] California Fire Danger Rating System.

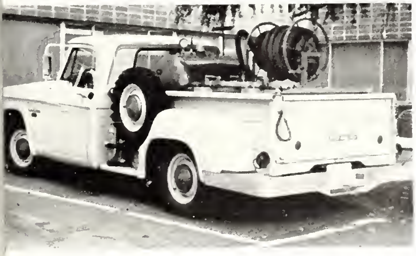

Figure 2.—This test truck is equipped with airblast, water, and retardant powder systems.

We started the fires at the upwind edge of the plots and began putting them out as soon as they had reached a uniform front. Although compressed air alone put the fires out in 10 of 12 trials, it took four times longer than water (table 1). In two trials the fire became so intense that it was necessary to rapidly switch to water to protect the nozzleman.

We also had 10 times more rekindles when the airblast was used. This number probably occurred because the nozzleman was too busy trying to stop the fire to be careful.

TABLE 1.—*Comparative fire suppression time using water and air*[1]

Fire number	Extinguisher	Time required for extinguishment	Rekindles
No.		*Seconds*[2]	*No.*
1	Air	68	4
2	....do....	69	4
3	....do....	64	3
4	....do....	77	8
5	....do....	65	5
6	....do....	68	4
7	....do....	64	3
8	Water	14	1
9	....do....	16	0
10	Air	[3] 60	....
11	....do....	67	2
12	....do....	68	5
13	....do....	[3] 58	....
14	....do....	66	2

[1] Wind NW, at 3 to 8 m.p.h. with gusts of 12 m.p.h.
[2] Time needed to put out a line of fire 100 feet long.
[3] Water needed for final control for protection of equipment.

The most effective firefighting technique with the airblast was to start from an anchor point and progress along the fire edge, blowing the fire back into the burn. Much eddying and erratic fire spread resulted when the nozzleman started in the middle of a burning line. Air blasting is a special safety problem. Because air does not have a trajectory and will not carry like water, the nozzleman had to work closely ahead of the fire in the unburned fuel.

Two trials were conducted using air in an indirect attack; the results were disappointing. Al

(Continued on page 15)

FIRE WEATHER TELEMETRY

FRANK E. LEWIS, *Forester,*
Forest Service Electronics Center, Beltsville, Md.

Telemetering is a system employing electronic instruments to measure quantities, transmitting the result to a distant station, and there indicating or recording the quantities measured. It sounds simple all right! Is it applicable to protection of forest and range lands from wildfire?

Fire control managers have long noted the lack of information on weather conditions in remote areas and on many midslope locations.[1] [2] In mountainous country, manned stations are few and are usually in the valleys or on ridgetops. Also, with the increasing use of aerial detection, in many areas lookouts are no longer available to make weather observations. Samples have been inadequate and dependable data has been expensive to obtain.

Telemetering weather conditions has been perfected using several systems. Various degrees of success have been obtained for many years, both by the military and others. Several systems are commercially available. However, generally the systems are too expensive or/and require too much attention by technicians for widespread use in fire protection.

Since the late 1950's, considerable work in developing a dependable, economical fire weather telemetering system specifically for fire danger data has been done at the Forest Service Electronics Center, Beltsville, Md. Extensive field tests continue, but contract costs, exclusive of weather sensors and communications equipment, remain high. Two operational systems based upon earlier basic designs were delivered to the Forest Service during 1966. They have been installed on National Forests in Montana and Wyoming and by the Bureau of Land Management in Nevada. These systems and their functions are described as follows:

The control station (fig. 1) consists of a control console with a modified electric typewriter and radio equipment. Data is transmitted by the various observation stations upon radio command and is automatically recorded on the typewriter. The central station can be programed to operate unattended and obtain reports at preset observation times.

The console is 20 by 18½ inches and weighs 80 lbs. It operates from a 60-cycle, 105-125-volt power source and draws 20 watts. The unit, exclusive of radio equipment, costs about $3,200.

Figure 1.—Control station console and radio equipment.

A set of weather sensors [is] used to measure weather con[-]ditions at the observation sta[-]tion (fig. 2). The sensors con[-]vert the data into electrica[l] quantities. The set costs ap[-]proximately $700.

The circuit components an[d] relays which process the infor[-]mation for radio transmissio[n] are mounted on panels in [a] standard 40- by 19-inch relay rack.

The total weight is 85 lb[s]. The equipment operates from [a] 24-volt battery pack compose[d] of 16 No. 6 industrial dry cell[s]. One pack will operate the un[it] for a full fire season. The cos[t] of this equipment is approxi[-]mately $4,000. This does no[t] include radio equipment, whic[h] is housed in a separate enclo[-]sure.

The station monitors the fol[-]lowing five parameters o[f] weather over the indicated ranges:

1. Wind direction, 8 cardina[l] points of the compass
2. Wind velocity, 2 to 6[?] miles per hour

(Continued on page 16)

Figure 2.—Telemetry station No. 4 on Poi[nt] Six near Missoula, Mont.

[1] Tucker, James B. Planning the locations of fire danger stations. Fire Control Notes 21 (2) : 46–47. 1960.

[2] Keetch, John J. Developing a network of fire danger stations. Fire Control Notes 25 (4) : 3, 4, 6. 1964.

ir Jets—Continued from page 13

hough the technique has been successful else-
here in leaf litter fires[4,5], enough dry grass
ould not be removed to stop the fire.

CONCLUSIONS

The airblast method alone is not as effective s water for controlling a running fire in me-ium to heavy grass. Furthermore, it is more azardous to men and equipment. An adequate ompressor is expensive and heavy. A com-pressed air system without proper engineering and required safety features can be dangerous.

However, if fuel is light, water scarce, and the compressor can be used on other jobs, airblasting may be practical—particularly if it can be combined with a water system. The airblast looks promising for mopup in light fuels. Large compressors used for construction of forest roads could be sent to the fire for this purpose.

An airstream to propel water and fire retardant liquids and powders also has promise. Our water system worked well, and we expect our powder system to do a good job when it is re-engineered. Related studies, here and elsewhere, have shown the effectiveness of portable back-pack-type mistblowers for delivering both liquids and powders. The study of firefighting with air jets will be continued.

[4] Nicloles, J. Mand, and Paulsell, L. K. A new idea in refighting: Airblast line building. Univ. Md. Agr. Exp. ta. Bull. 725, 7 pp. illus. 1959.

[5] Welsh, J. L. Backpack mistblower as a fireline builder. .S. Forest Serv. Fire Control Notes 26(7): 2 pp., illus. 964.

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arolina Blowup—Continued from page 3

ported across from Melvin's store." "Fire has mped the South River into Sampson County." Fire burning two homes and a half-dozen farm uildings on Beaver Dam Church Road." Fire as everywhere!

By 3 p.m. the Ammon fire had jumped Cedar reek Road and was headed toward the settle-ents. The district dispatcher reluctantly pulled unit off the Black Lake fire, now only 10 miles way, and committed his last reserve tractor ow.

Still the flames continued their advance. Air nkers of the North Carolina Forest Service oled hot spots and were credited with helping lunteer fire companies save several homes and tbuildings.

Evening came with a smoky orange light. own in the swamp the fire rumbled. The cane ent up with a crackle that sounded like a rifle atoon in action.

The cold front hit the Ammon fire at 7 p.m. expected, the flames changed direction. Al-dy the Whiteville District Forester was head-toward N.C. Highway 242 which now lay in nt of the fire. Control was impossible now, t he wanted to be sure everyone was out of the y.

FLAME—150 FEET HIGH

Smoke was intense. The fire could be heard in distance, and the glow of the flames appeared ough the forest. Then the pines across the hway exploded into what he described as a et of flame 150 feet high.

Simultaneously, three lightning bolts from the thunderheads overhead accompanying the cold front struck the main fire. As rapidly as it came, the fire moved on, throwing burning limbs and brands 1,000 feet ahead of it. Finally, the skies opened up with a brief downpour that knocked the flames out of the trees until there was nothing but flickering snags in the night.

Tractor units spent the night plowing lines, but without the flames to guide them it was hard to locate the leading edge in the dark. The situation was made more difficult by the many small spot fires that were scattered out ahead as far as a quarter of a mile.

The thundershower was only temporary relief. Severe burning conditions were forecast for the next day. Again and again crews sought to strengthen their plowlines, but the backfires would not burn. Without fire, they were unable to construct a fire-break wide enough to hold a new onslaught.

As expected, a drying wind came up with the sun on April 2. By mid-morning the scattered embers were fanned to life. Crews worked in vain. Flames were rolling again and took little notice of the lines that had been plowed across their path. The Ammon fire had places to go and another 10,000 acres to burn before a general rain and a massive control effort would contain it 2 days later.

Yes, April 1, 1966, will be long remembered in the Carolina pinelands. But the severe test was well met by courageous firecrews and modern equipment.

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POSTAGE AND FEES PAID

MARKING FIRE HANDTOOL HANDLES[1]

REGION 10, *U.S. Forest Service,*
Juneau, Alaska

A quick, efficient method of painting fire handtool handles for identification is described.

1. Select a piece of cloth 6 to 8 inches wide and 20 to 30 inches long.
2. Fold the cloth to the desired width of the identification band to be painted.
3. Fasten each end of the cloth to a solid, secure item. The ends should be approximately 25 inches apart (fig. 1).
4. Apply a coat of paint to the upper surface of the cloth. By folding the cloth several times, it will be able to hold plenty of paint.
5. Place one hand above the section to be painted and the other hand below the section. Thus, the handle will be at a 90° angle to the cloth.
6. Lower the handle to the cloth.

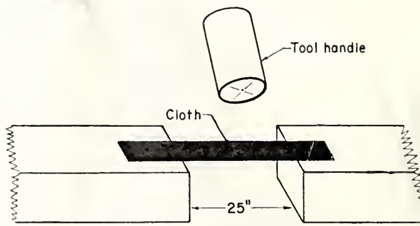

Figure 1.—Diagram of components used in painting fire handt handles.

7. Rotate or roll the handle 360° to provi a smooth, even, continuous band of paint.

Approximately 10 handles can be painted befo more paint must be added to the cloth.

[1] Adopted from R-10 Forest Service Handbook, FSH 5125.3, Fireman's Guide.

Telemetry—

Continued from page 14

3. Humidity, 0 to 99 percent relative humidity
4. Temperature, 0° to 129° F.
5. Precipitation, 0 to 99.99 inches

Equipment used for radio communication between a central station and its satellites are a standard VHF transmitter and receiver units. Central station equipment is typically a 25-watt tabletop console. Observation stations generally use an FM 3-watt battery-powered portable packset. Surplus older radios can often be used to perform the required function, thus saving an investment in equipment exclusively for telemetering.

Central stations, of course, must be at some suitable headquarters. Observation stations for a system should normally be at sites 2 to 25 miles from the central station, depending upon the needs of the rating area. Some of the more remote installations might require intervening repeater stations for reliable system performance. Up to 10 observation stations can be tied into one central station.

The fire weather telemetry system described above was designed to be compatible with the needs of the National Fire Danger Rating System. The equipment is capable of accommodating inputs from additional sensing equipment should it later prove necessary, but efforts are now directed mair toward simplifying the syste to reduce initial investme costs. Once reasonably deper able and economical equipme is available, use of telemetry provide coverage for protecti areas as large as an entire N tional Forest would be feasit The data gathered by teleme could be integrated with tl gathered and transmitted by dinary methods already in u

Ultimately, improved sam ing techniques and bet knowledge of fire weather a fire behavior may permit use totally automatic systems, t into fire danger computers cated at central points.

FIRE CONTROL NOTES

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE APRIL 1967 VOL. 28, NO. 2

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire cont

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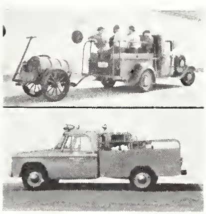

COVER—Small forest fire fighting tankers—early 1930's and 1967.
See related article on page 3.

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

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DEVELOPMENT OF SLIP-ON FOREST FIRE TANKERS

CARL E. BURGTORF[1]

Firemen have been working for more than 25 ars to increase the versatility of tanker trucks for est fire suppression. Development of these units the 1930's was restricted because few types of mps and vehicles were available. Many early kers were single-purpose units permanently in lled on $1\frac{1}{2}$- or 2-ton trucks; they held 250 or re gallons of water. Pumps were usually power eoff models driven by the truck's engine.

Because of their expense, these single-purpose icles could not be provided in sufficient numbers meet all the needs for tankers during emergencies. is fact, and the availability of improved equip nt, soon prompted the development of the in ensive slip-on unit—a tank, pump, and related essories—which could rapidly be mounted on any e bed or pickup truck.

As the effectiveness of smaller tankers, with their ter mobility, was recognized, the larger tank cks were more and more supplemented by small -on patrol tankers. The availability of the mili four-wheel-drive jeep resulted in more use of slip-on tankers. In many areas water could be vered closer to the fireline.

The small slip-on-tanker became an efficient est fire fighting tool as emphasis was switched n attempting to provide large quantities of water he fireline to skill in applying small amounts ectively. Firemen were trained to use water from e small tankers to knock down the flames and cool the line to allow handcrews and line-building equipment to work more efficiently and safely. As the use of slip-on units grew, they were constructed in greatly differing designs and sizes for a variety of applications. This led to Service-wide surveys to provide direction in further development of slip-on equipment.

In October 1946, a list of all types of fire equipment in use included two styles of gear pumps and one centrifugal pump. Tanker types, by rated vehicle capacity, included an R-7 ½-ton, R-6 ¾-ton, R-9 ¾-ton, R-5 $1\frac{1}{2}$-ton, R-6 $1\frac{1}{2}$-ton, and an R-5 and a State of Michigan slip-on unit.

A second survey was conducted in 1955. The list of tankers in use showed the increasing popularity of smaller units, for it included the 50-gallon slip-on patrol tanker, 70 of which had been purchased in the 1950-54 period. In the 60- to 200-gallon sizes, 200 slip-on and fixed-mount tankers had been purchased during this same period. There were 153 larger (250- to 360-gallon) tankers purchased.

To provide uniformity in design, a Service-wide specification was issued in August 1955 for the 50 gallon patrol slip-on unit. In 1965, the specification was revised to incorporate improvements, but the unit is still a small patrol tanker (fig. 1).

In 1964, a Service-wide project for slip-on tanker updating and standardization was assigned to the San Dimas Equipment Development Center. All regions were canvassed to determine what types of equipment were in use and to obtain suggestions for improvements. Nearly 1,500 slip-on tankers were inventoried (table 1).

[1] Former Forester, Division of Fire Control, Washing D.C. (retired).

TABLE 1.—*Slip-on Tankers by Regions and Tank Sizes*

Gallons	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10	Total
50	10	57	58	10	111	103	7	29	51	.	436
60-80	4	15	0	4	155	34	4	5	7	0	228
100-125	18	42	0	8	34	43	8	6	8	0	167
140	18	9	0	14	0	0	0	40	7	0	88
160-175	22	7	0	16	9	85	8	0	28	0	175
200	36	8	40	33	4	45	2	5	10	0	183
250	0	3	0	18	21	0	1	5	2	1	51
300	6	3	0	2	61	14	0	1	3	0	90
400-1,400	7	7	0	9	0	14	0	0	0	0	37
Totals..	121	151	98	114	395	338	30	91	116	1	1,455

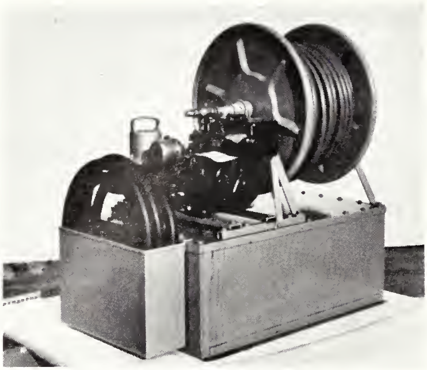

Figure 1.—The compact 50-gallon slip-on unit requires little space and is simple to operate.

The trend within Regions has been toward standardization of sizes, types of pumpers, and plumbing used on the forests. This trend has been adversely affected by the diversity of commercial pumping equipment and by various adaptations of this equipment in the field. In 1964, more than 12 tank si (40-200 gallon units) were reported. The grea deviations in ground tanker usage were in nom clature and in plumbing styles. The latter var by forests, and some installations were haphazar reducing the efficiency of the pumping unit.

The status of the Service-wide Slip-On Tan Updating and Standardization Project represent consolidation of many good tanker design featu in use or commercially available. Several manuf turers have produced pumping equipment for m than 30 years. They have made many improveme in design. Most of their products have been veloped in close coordination with experienced f fighters. For example, it has been decided to mount the pump and motor at a level with the t base on some tankers developed at the Center (2). Such mounting improves the driver's vision, lowers the center of gravity of the unit, with centrifugal pumps, prevents draft proble This mounting will be new to some areas. But a M sissippi pump company has manufactured e mounted pumps for many years for use in East States.

(*Continued on page*

Figure 2.—This 75-gallon metal tank slip-on unit is mounted on a pickup with Low Silhouette body equipped with guardrails hose reel guide. The inset shows end mounting of the pump. This series is also available in 125- and 200-gallon tank siz

LOMA RICA AIR-ATTACK BASE

Ed Corpe, *Deputy Forest Supervisor*
Lolo National Forest[1]

The Loma Rica Airport, adjacent to the Tahoe ıtional Forest in Nevada County, Calif., was first ed for airtanker operations in 1957. However, e to its short runway, it was suitable only for gle-engine aircraft such as the TBM.

A decision in 1964 by the Federal Aviation ency and Nevada County to extend the runway to arly 1 mile, permitting multiengine airtanker operons, and to construct taxiways, which would e crowded existing airtanker facilities, provided opportunity for planning a new and expanded tanker base.

FEDERAL-STATE COOPERATION

Both the Forest Service and the California Divi n of Forestry recognized the need for improved -attack facilities in the area, and the planning l construction of the new base was a joint effort. · key factor in the final successful development this modern installation was the full cooperation ween the two agencies. The Forest Service pursed the site, provided limited financing, furned the engineering design, and gave high ority to the acquisition of surplus equipment and erial. Heavy equipment and conservation camp w labor were furnished by the California Divin of Forestry.

mprovements include three concrete slab fillports ced for simultaneous loading of three B-17 air kers; increased retardant mixing and storage ca ilities, including electric pumps and a retardant overy system; better facilities for the office, t's readyroom, shop, and warehouse (all in one ding); and an improved taxi-traffic pattern g. 1).

ɡe 1.—Aerial view of Loma Rica air-attack base is shown.

CONSTRUCTION

Construction was carried out in two stages to permit the existing facilities to remain operational during the 1965 fire season. In the early spring of 1965, work started on the first phase. More than 14,000 yards of fill was placed and compacted on the sites for the aircraft area; the retardant mixing and storage delivery lines, water lines, communica tions lines, and electrical conduits were placed in the same ditch.

At the end of the fire season, the second stage of construction began. After final filling and grad ing, base rock was spread on the site, and mixers, tanks, and pumps were moved in from the old base. Pierced steelplate was installed as temporary paving until an asphaltic concrete mat could be laid.

THE NEW BASE

The base, which was operational during the 1966 season, has double batch mixers for use with a long-term retardant such as Firetrol; they have a ca pacity of 12,000 gallons per hour. A 200-gallon-per minute gravity-feed mixer is used for a short term retardant (such as Gelgard). Four storage tanks hold 62,000 gallons of slurry. The retardant is de livered to the fillports by three electric pumps (with 500-, 600-, and 800-gallon-per-minute capacities. (fig. 2) When the largest pump is used, an F7F airtanker can be loaded in less than 90 seconds. A

(Continued on page 15)

[1] Former Fire Control Officer, Tahoe National Forest.

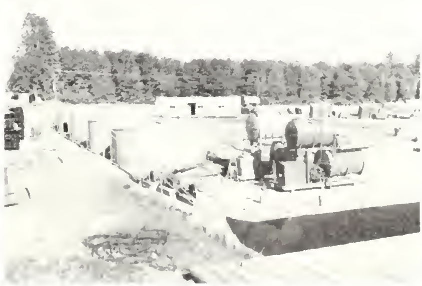

Figure 2.—View of batch mixers, storage tanks, and loading pumps during installation.

IMPORTANCE OF COORDINATED AIR-GROUND ATTACKS: A COMPARISON OF TWO FIRES

Paul G. Scowcroft, James L. Murphy, and Lynn R. Biddison [1, 2]

"Send in air tankers!" In recent years this order has become increasingly familiar when a forest fire started. But experienced firefighters know that the use of air tankers is expensive and that other fire control methods may cost less. Therefore, "Don't send in air tankers" has become an equally familiar order. When air tankers are sent, the most effective fire control action is a well-coordinated air-ground attack.

There are only a few well-documented cases of significant air-ground attacks. This article describes two fires that started 7 years apart on nearly the same location on the San Bernardino National Forest in southern California. The Monkey Fire of 1965 was potentially more dangerous than the Monkey Face Fire of 1958. But the 1965 fire was controlled at 35 acres in 3 hours, and the 1958 fire was controlled at 600 acres in 53½ hours.

This difference was due to several factors; these included greater use of air tankers, improved fire retardants and mixing-loading techniques, and better management of men and machines—especially in coordinating the air-ground attack. All other factors were important only because of this last factor. A study of the two fires suggests that a coordinated air-ground attack supported by properly trained hot shot crews can reduce the cost of putting out a forest fire.

Figure 1.—Head of the fire in 1965 was stopped by air attack at point X. Slopes were steep and heavy cover was ahead of the fire. Broken line indicates area of 1958 Monkey Face Fire; continuous line indicates area of 1965 Monkey Fire.

THE TWO FIRES

The Monkey Face Fire began at 12:30 p.m. July 8, 1958, and the Monkey Fire started at 2: p.m. on August 6, 1965. The two fires started o half mile apart on the same steep mountain slo dominated by heavy chamise and chaparral (fig. They occurred at about the same elevation, and t average slope of the fire areas was about the sa

A comparison of the two fires shows their si larity:

Item	Monkey Face Fire, 1958	Monkey Fire, 1965
Location	T. 1 S., R. 1 W., sec. 11	T. 1 S., R. 1 W., sec. 11
Elevation	4,600 feet	4,415 feet
Slope at origin	+45 percent	+4 percent
Average slope	+130 percent	+140 percent
Fuel type	Heavy chamise and chaparral.	Heavy chamise and chaparral.
Date and time of origin.	July 8, 1958 (12:30 p.m.)	Aug. 6, 1965 (2:05 p.m.)
Date and time of attack.	July 8, 1958 (12:43 p.m.)	Aug. 6, 1965 (2:17 p.m.)
Control time	53 hours, 31 minutes	2 hours, 55 minu
Area at discovery	<1 acre	<1 acre
Fire load index	13 (high)	53 (extreme)
Rate of spread at discovery.	100 chains per hour	60 chains per ho
Character of fire	Spotting	Spotting

The 1965 Monkey Fire had at least four times t damage potential as the 1958 fire; this fact w indicated by the large difference in the fire lo index.[3] One item—rate of fire spread at discove

[1] Snowcroft and Murphy are Research Foresters, Pac Southwest Forest and Range Experiment Station, Berke Calif. Biddison, formerly a Research Forester at the Stati is a Fire Staff Officer, San Bernardino National Forest.

[2] The assistance of Everett Waterbury, Air Att Specialist, San Bernardino National Forest, in gather and preparing certain data and information for this arti is gratefully acknowledged.

[3] A combination of the ignition and burning indexes the California Wildland Fire Danger Rating System. T adjective rating for a fire load index of 53 is "extrem

seemed to contradict the existence of greater mage potential in 1965. The difference in rates as attributed to the slopes on which the fires were rning when discovered. As the 1965 fire approached the canyon walls, the slope more nearly ualed that encountered in 1958; thus, the differ ce due to effect of slope was diminished. Once e Monkey Fire reached the steep slopes, under the treme burning conditions, the rate of fire spread obably exceeded that of the 1958 fire.

AIR ATTACK AND HOT-SHOT CREWS—THE ONE-TWO PUNCH

During both fires the ground crews had to scale eep (135 percent) slopes, and the fire head easily oved faster than the crews. Air tankers operated om Ryan Field, 26½ air miles away, were dis tched to both fires.

In 1958, air tankers dropped 5,000 gallons of bo e on the fireline. Helicopters were not used to iver retardant.

In 1965, air tankers made 16 runs, dropping more n 10,500 gallons of Firetrol and Phos-chek[4] on flanks and head of the fire. Fire spread slowed stopped on about 55 chains of the fire's perime . Two helicopters also made small drops on hot ts. The checkline held for 2 hours, allowing the -shot crews to construct a final fireline around fire's head. If the fire had not been checked, it obably would have moved into the San Gorgonio lderness area and burned about 1,500 acres of vy fuels on steep terrain where there are no ds and few trails.

A comparison of the suppression forces used on two fires follows:

n	Monkey Face Fire, 1958	Monkey Fire, 1965
ial-attack rces.	One man with handtools.	One man with handtools.
owup forces....	Hand crews, ground and air tankers.	Hand crews, ground and air tankers, and ground machines.
imum number line workers.	516	215
und tanker e.	11 chains	105 chains[1]
tanker line......	0 chains	55 chains
und machine e.	0 chains	5 chains

The tanker line was increased almost tenfold in 1965 use the fire originated on the valley floor and more meter could easily be reached by hoselays. The 1958 began on the slopes of the mountain.

[4] Firetrol and Pros-chek are trade names for two long r retardants based on di-ammonium phosphate and am oum sulphate, respectively.

COSTS AND DAMAGES

Costs and damages were higher in 1958 than in 1965. Suppression costs were $160,000 in 1958 but only $19,160 in 1965. Estimated damages to resources amounted to $33,210 in 1958 and $300 in 1965. In addition, an indirect cost was incurred in 1958 when rain from a thunderstorm swept more than 40,000 cubic yards of debris from the burned area (fig. 2). About $100,000 was spent to remove the debris and clean up the area.

The erosion potential was far greater in 1965 because in November and December of that year, southern California had the heaviest rains of the past 25 years. Yet, no measurable erosion or production of debris resulted. And there was no damage which would have required expenditures for repair.

The savings in suppression costs and damages as a result of effective combined air-ground attack on the 1965 Monkey Fire totaled $274,520 even after adjustment for the declining value of the dollar.

Figure 2.—Flood damage that originated from the 1958 Monkey Face Fire included more than 40,000 cubic yards of debris and buried portions of a State highway. The debris was washed from the burn (see below).

RAILROAD FIRES IN OREGON

JAMES B. CORLETT
Manager, Oregon Forest Protection Association

During much of American history, the great, puffing mainline steam locomotives pulled long lines of cars across the mountains, plateaus, and valleys of the West. In the woods, the old saddlebacks, Shay and Climax engines, pulled seemingly endless loads of logs to the tidewater mills, where lumber schooners paused in their voyages to the ports of the world.

However, these steam locomotives caused many fires along forest rights-of-way; therefore, many years ago the Oregon Legislature enacted laws regulating ashpans, screens, the water supply, and fire-fighting equipment. Some of these laws are still in force.

With the advent of diesel-burning locomotives, many protection people hoped that railroad fires would end. However, the new equipment became worn, lower grades of fuel were used, and equipment maintenance was not always optimum; therefore, railroad fires again became a major protection problem.

Railroad right-of-way fires on the forest protection districts of Oregon are increasing. For example, from 1954 through 1958, 3.2 percent of the yearly average of 828 man-caused fires on Oregon forests were railroad fires. However, for the 1,058 fires from 1959 through 1963, the percentage rose to 4.8. Incomplete statistics for 1964 and 1965 indicate that an even greater increase in the percentage of railroad fires can be expected for the 1964-68 period.

A recent report from 51 of the 402 rural and city fire departments of Oregon shows there have been 230 railroad right-of-way fires during 1965 in Oregon in nonforest protected areas. Of course, trains may not have caused all these fires. For example, some fires are caused by people throwing burning material from trains or smoking while walking along the tracks, or by youngsters playing with matches. However, most of these fires were caused by carbon sparks, brake shoes, hot boxes, fusees, dirty or faulty spark arresters, section gangs at work, etc.

Chip nets, right-of-way clearing, hotbox detectors, and lubricant and fuel oil research are being used by many railroads to reduce right-of-way fires. However, even greater emphasis on railroad fire prevention is needed. Protection organizations, legislators, and citizens unaware of these efforts have difficulty understanding why more has not been done.

Cooperation between the railroads and forest protection organizations in Oregon has been quite goc Reasonably good channels of communication ha been established, and forest organizations have lo had standard procedures for recovering costs i curred extinguishing railroad fires. The State fore laws contain provisions about the spread of fi to forests, and these laws have probably help create the good working relationship between t railroads and forest protection agencies.

Railroad fires are especially difficult for sm rural fire protection districts, many of which depe almost entirely on volunteer firemen. Because of i adequate finances, these men must often opera without adequate training, equipment, or protecti devices. The recovery of railroad fire suppressi costs by rural fire protection districts is complicat and confusing. In some of the newer rural fire d tricts, the volunteer firemen may not be fully i formed about the Oregon fire laws. For examp railroad rights-of-way, rolling stock moving the over, or improvements thereon are by law not i cluded in rural fire protection districts unless t railroads consent to be included. However, the Sta Fire Marshal has authority to order the accumu tion of any combustible material on any premis including railroad rights-of-way, removed or t condition remedied. He also has authority to e force such orders if necessary.

Some Oregon residents advocate the legislati approach to the problem of railroad fires. Howev many have learned that legislation does not nec sarily yield the most desirable or workable solutio to problems. It should be undertaken only after possibilities for cooperative solutions have be exhausted.

In 1963, all fire organizations in Oregon—ru and city, private associations, State, and Federal formed the informal Oregon Fire Action Coun to solve fire problems through cooperative actic One major accomplishment of the Council has be to open channels of communication among all c ganizations concerned with fire prevention and co trol. All participants have learned that their pro lems are not unique and, through cooperative effo solutions can frequently be developed. The Coun believes that the railroads have a strong interest a stake in the prevention of railroad fires. Some ma annual contributions to fire prevention progran Others also contribute money, time, or training

(Continued on page 1

A WEATHER BRIEFING BOARD FOR FIRE CONTROL

D. John Coparanis, *Fire Weather Meteorologist*
U.S. Weather Bureau
Portland, Oreg.

Regional Dispatcher: "There's a lightning fire out of control in southern Oregon on the Fremont. I'll need to draw on some men and equipment from up north. What does the weather look like for the next 2 or 3 days in Washington?" This type of question is often heard in the Portland Fire-Weather Office during an active fire season. The Portland Fire-Weather Office is unique because it is a Weather Bureau facility in the Division of Fire Control of a Forest Service Regional Office (R-6). Therefore, Fire Control personnel can easily "tap the weatherman" for information.

Besides issuing daily fire-weather forecasts, the fire-weather meteorologist at Portland provides twice-daily briefings on Regionwide (Washington and Oregon) weather. The Regional Dispatcher attends these briefings and uses information received for both planning and operations. Additional briefings are sometimes provided for other Forest Service officials.

Some of these briefings are very detailed because the weather patterns cause a variety of weather effects over the forecast area. The details are difficult to remember 5 minutes after the briefings, especially when it becomes necessary to apply these details to each of the 19 National Forests in the Pacific Northwest Region.

Therefore, a visual display board for the weather elements important to Fire Control was installed (fig. 1). The board consists of five parts:

1. Surface and upper air weather maps
2. Fire-weather forecasts from the six Fire Weather offices: Portland, Salem, Medford, and Pendleton (all in Oregon) and Olympia and Wenatchee (both in Washington)
3. Regional map showing rainfall
4. Teletype copy of satellite bulletin
5. Regional map depicting forecast weather elements for each National Forest

The surface and upper air weather maps are received over the facsimile machine ready for display.

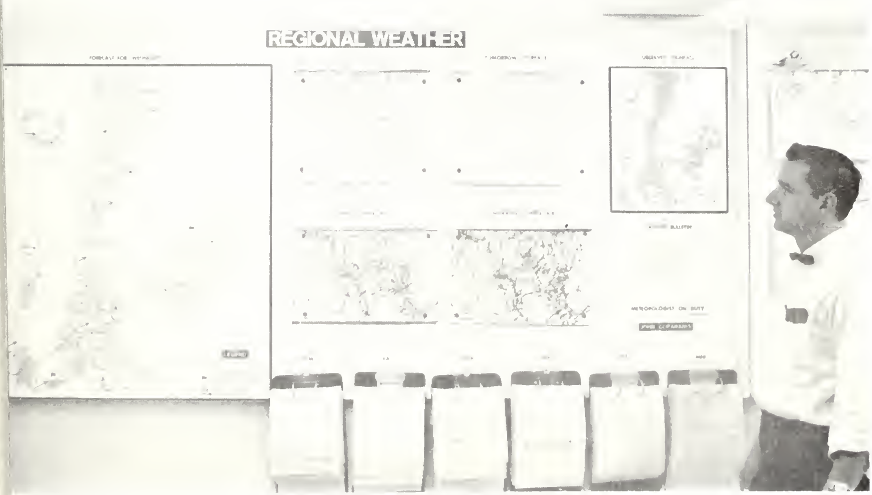

Figure 1.—This weather briefing board is at the Portland Fire-Weather Office.

These depict the weather patterns over much of the Northern Hemisphere both as they are observed "today" and predicted for "tomorrow." Use of these maps permits the three-dimensional characteristics of the atmosphere to be described.

Detailed fire-weather forecasts received at the Regional Office from the six Fire-Weather offices in the Pacific Northwest are posted on clipboards.

A small Forest Service Regional map is used to record rainfall. This information is important because it indicates the areas relieved from drought.

Environmental Science Services Administration satellite pictures of cloud cover over and adjacent to Oregon and Washington are received daily at the Weather Bureau Office in Seattle, Wash. These pictures are interpreted by meteorologists at Seattle and transmitted in plain language messages over weather teletype. This information is often included in the fire-weather forecasts to place emphasis on certain weather predictions.

A large Forest Service Regional map depicts forecast elements for each National Forest; color coded numbers are used (fig. 2). The forecast lightning probability is shown as a red number and the forecast minimum humidity as a green number. In addition, the forecast speed and direction of winds over ridges is shown for larger areas. All this information is extracted from the detailed fire-weather forecast. If a "Red Flag" forecast—one which calls attention to a weather condition of unusual importance—is issued by a Fire-Weather Office, a red flag tag is placed at the Fire-Weather Office's location. The metal rim tags with numbers are hung on permanent small pins (two per Forest). These tags are easily changed so the board can be kept current. The wind tags can be hung on pins or temporarily taped anywhere on the base map to show the general windflow over a large area.

Figure 2 graphically shows a special fire-weather condition. As can be seen by the wind direction arrows posted, southerly winds aloft are entering southern Oregon. In the summer in the Pacific Northwest, these winds have a high correlation with widespread thunderstorm activity. Consequently, a high probability of lightning (60-80 percent) is forecast for most Oregon Forests. Minimum humidities predicted for this same area are 10-20 percent. These conditions have prompted two Fire-Weather Offices, Medford and Pendleton, to issue "Red Flag"

(Continued on page 16)

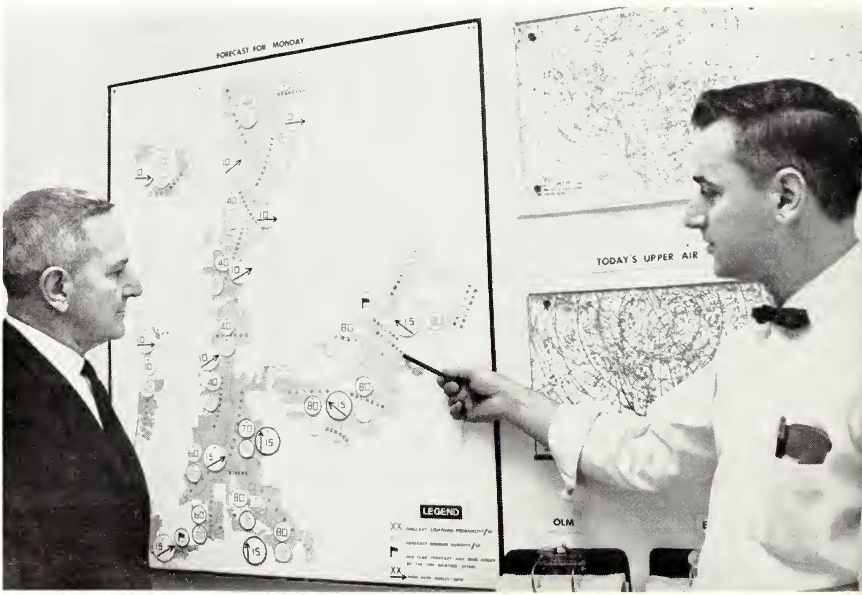

Figure 2.—This Regional map visually depicts important forecast fire-weather elements.

A MODERN DISTRICT WAREHOUSE

Donald H. Marriott
Fire Control Officer, Trabuco District
Cleveland National Forest[1]

The fire warehouse on the Orleans District, Six Rivers National Forest was recently remodeled to provide a modern facility for the efficient handling and storage of equipment and supplies.

Major changes in the structure included removal of all windows to permit better utilization of wall space and to reduce maintenance and cleaning costs. Also, all partitions, closets, and panels not needed for building support were removed. These changes have facilitated movement of supplies in and out of the building, and permit a quick inventory of all fire equipment. The original two 32-inch doors and one heavy sliding door were replaced by three 10-foot aluminum overhead doors. Incandescent light fixtures were replaced by daylight-type fluorescent lighting. Porch lighting was similarly improved, and night loading is now very safe.

Shelf storage 8 feet high and 1½ to 3 feet deep has been constructed along the entire 46-foot rear wall. Metal lettering strips like those used in supermarkets are fixed onto each shelf, and the name and inventory count of items on each section are shown. A rolling ladder provides quick access to the upper shelves (fig. 1). Handtools are stored in two racks similar to those shown in an earlier Fire Control Notes article.[2]

Open bins on both sides of the stairway hold smokechaser equipment where it is readily accessible and easily inspected. The space under the stairs was closed off and is used for storing brooms, mops, and other maintenance supplies. A screened, rodent proof room was built to provide storage space for radios, batteries, blankets, and fusees. A separate lock is used on this room.

Figure 1.—This ladder provides safe access to items stored on upper shelves. The attached table holds material while a man climbs down.

A hardboard flooring surface permits easy movement of the individual castered pallets on which all floor cache boxes are stored, and the entire fire equipment inventory can be moved onto trucks by one person. Also, all equipment on the ground floor can be quickly wheeled back behind the stairway to make a 30- by 26-foot area available for meetings and training sessions.

The second floor is used primarily to store project tools and equipment. Bulky or heavy items are moved to and from this area by a stair lift. This consists of a small 110-volt electric winch which pulls a wheeled platform on rails up the stairway (fig. 2). This type of lift was selected instead of a cage elevator to save floor space on both levels. The winch housing is built against the rafters, where lack of headroom prohibited storage.

The docking facilities are able to accommodate five vehicles at one time. Either side or rear loading is possible at two of the three bays. A removable chain railing guards all dock edges.

Savings in man-hours spent handling equipment and supplies during the next 5 years are expected to pay for the remodeling of the warehouse. Also, since inspection of tools and supplies can be more easily carried out because they are readily visible, maintenance of the fire cache will be improved. A third and important benefit of the facilities is safety equipment is handled by units, and lifting and carrying is not needed.

Figure 2.—View of stair lift and control panel is shown. When not in use, the lift platform is pulled up out of the way under winch at head of stairs, and rails fold up along far edge of stairway.

[1] Former Fire Control Officer, Orleans District, Six Rivers National Forest.

[2] Region 4, Forest Service, USDA. Care and storage of handtools. Fire Control Notes, vol. 24, No. 4, October 1963, pp. 99-100, illus.

MARKING PERMANENT HELISPOTS WITH FIBERGLAS PANELS

P. A. Theisen, *Forester*
Siskiyou National Forest

An inexpensive, prefabricated marking system which requires little maintenance was developed on the Siskiyou National Forest in southwest Oregon. The markers identify permanent helispots developed for multiple use management (fig. 1.).

The helispot marker is made from yellow corrugated Fiberglas panels, which are readily available from local building suppliers. Other high-visibility colors are also available.

Panels are cut to specifications (fig. 2) and drilled for 3/8- by 10-inch spikes driven into the ground to anchor the panels. Rubber or plastic washers can be used between the spike head and the Fiberglas to prevent the panel from being pushed past the spike head if frost heaving is likely to occur. Identification letters and numbers are painted on the base panel with black polyurethane paint. The sides of four triangles can be cut from a 10-foot-long panel of Fiberglas 26 inches wide. Three bases can be cut from a 12-foot by 26-inch panel.

The Fiberglas and 14 spikes needed for one helispot marker cost approximately $3.27.

Figure 1.—A completed marker for a permanent helispot is shown.

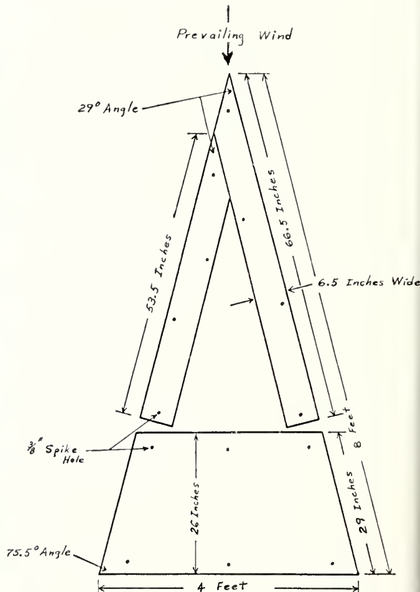

Figure 2.—Diagram of Fiberglas panel used to mark permanent helispots.

THE RELATION OF SPREAD INDEX TO FIRE BUSINESS IN CONNECTICUT

John J. Keetch, *Forester*
Southeastern Forest Experiment Station

The State of Connecticut has used fire danger measurements to plan their fire prevention and other fire control activities for more than 25 years. In 1964, the spread tables of the National Fire Danger Rating System were adopted; they replaced the type 8 Burning Index meter used since 1954. This article examines the relation between spread index and two easily measured aspects of fire business—number of fires and number of acres burned by size class. Connecticut was selected for this study because it has a heavy fire load and an active fire control organization. Also, the State started using the spread index a few months earlier than other States.

The Connecticut State Park and Forest Commission is responsible for protecting about 2 million acres of forest and woodland from fire. This task is particularly difficult because the State is fourth in population density (517 people per square mile according to the 1960 census). The cause of fire is related to this high population density. During the 1954-63 period, 98.2 percent of the State's fires were man-caused.

In 1964, 943 fires burned 3,566.6 acres. The percentage of man-caused fires was the average 98.2, but the total number and acres burned were 50 percent greater than the average for the previous 10 years. This relatively high rate of fire activity provides a good basis for evaluation of the effectiveness of spread index and its relation to fire business.

By definition, the spread index is a number (on a 100-point scale) indicating the relative, not actual, rate of forward movement of surface fires. The spread index value is an abstract number until it is related to the local conditions of a fire protection unit. But reliable data on free spread of wildfire are seldom recorded. Therefore, fire business items related to spread that *are* recorded must be considered; these include the distribution of fires and acres burned by size class. This information is immediately useful in interpreting and applying the spread index in local fire control preparedness planning.

Fire data for this study were obtained from code sheets prepared by the State for the annual Forest Fire and Forest Fire Danger report. Daily spread index values were read from fire danger records prepared at four fire danger stations operated by the State and at one station operated by the U.S. Weather Bureau.

Fires may occur on almost any day in the year, but they usually are not distributed evenly. Fires are concentrated in the spring and fall because burning conditions are more severe and because fire starting agents are more active.

In 1964, more than 90 percent of the fires and 94 percent of the burned acreage occurred during the spring (March-May) and fall (September-November). This distribution of fires and acres suggested that a two-part grouping of the data might be most useful to identify the general relation of spread index to fire business. Accordingly, in tables 1 and 2, spring and fall fires are combined to represent the fire season; summer and winter totals indicate off-season trends. The ranges of spread index in units of five provide a finer breakdown than is normally used, but the added detail improves clarity.

Since the two seasons were equal in number of days, factors other than time must account for the unequal fire experience between them. The factors contributing to the difference are numerous, but they may be broadly grouped into those bringing changes in: (1) Relative risk, (2) ignition potential, (3) rate of spread, and (4) effectiveness of control effort. The spread index obviously provides only a portion of the information needed to equate fire danger and fire business in the State. Nevertheless, until more refined tools are available, such as an index related to ignition, the spread index may be used as a general guide.

It is clear that fires did not have an equal opportunity to start and spread in the fire season and in the off season (table 1). In the off season there were only 11 days of spread index 15 or more; there were 94 such days in the fire season. Also, in the lowest four spread index ranges, where both seasons were represented, average fire incidence per day in the fire season was two or three times the rate in the off season. This comparison indicates that the activity of fire starting agents is greater in the fire season by a ratio of 2 or 3 to 1. In turn, this ratio suggests that a given level of preparedness is needed at a lower predicted spread condition in the fire season than out of season.

TABLE 1.—*Number of days, fires by size class, and average fires per day, by spread index range, Connecticut, 1964*

FIRE SEASON

Spread index	Total days	Total fires by size class			Average per day (all fires)
		0-9.9 acres	10.0-99.9 acres	100+ acres	
0-4	28	6	0	0	0.2
5-9	18	24	1	0	1.4
10-14	43	111	9	0	2.8
15-19	36	190	8	0	5.5
20-24	34	211	22	1	6.9
25-29	15	145	13	1	10.6
30+	9	95	11	3	12.1
All	183	782	64	5	4.7

OFF SEASON

Spread index	Total days	0-9.9 acres	10.0-99.9 acres	100+ acres	Average per day (all fires)
0-4	98	13	0	0	.1
5-9	48	26	0	0	.5
10-14	26	22	4	0	1.0
15+	11	27	0	0	2.5
All...............	183	88	4	0	.5

The distribution of fires by size class in table 1 reflects the potential for fires to spread faster as the spread index increased. The bulk of the fires were held below 10 acres regardless of spread index, but holding down the size apparently became more difficult as the index increased. During the fire season, about one fire of more than 10 acres occurred every 4 or 5 days in index range 10-14, about 1 per day in index range 25-29, and more than 1 per day at index 30+. Fires of 100 acres or more appear at index 20-24, but most (3 of 5) occurred during the 9 days when the spread was 30+.

Presumably, fire preparedness was increased as the potential for fires to spread increased because most fires were contained at a small acreage. The largest fire reported was 250 acres. But evidence that the task became more difficult as spread index rose is indicated in table 2. Below index 20, only 43 percent of the acres burned were by fires of more than 10 acres in final size. Above index 20, this percentage rose to 68. In the top spread range, the larger fires accounted for 78 percent of the total burn. Certainly factors other than those indicated by spread index were involved; such factors included topography, elapsed time, and local fuel concentrations. But the record does indicate a strong trend for fires to become harder to handle as the index climbs.

The consistent increase in average fire activity with each rise in the level of spread index reflects the greater opportunity for fires both to start and to spread as the index rises. Average occurrence in the fire season climbed gradually from about 1 fire every 5 days in the lowest spread range to about 12 fires per day in the top spread range (table 1). A similar increasing trend in the area burned on an average day is indicated in table 2.

In summary, while the figures in the tables are averages, the continuous uptrend in the average daily fire business indicates a potential change in average fire load that should be extremely useful to fire officials in interpreting and applying predicted spread index in preparedness planning. The values reported here apply only in Connecticut, but similar trends may be expected in other areas where man-caused fires are of major concern.

TABLE 2.—*Number of days, acres burned by size class, and average acres burned per day, by spread index range, Connecticut, 1961*

Spread index	Total days	Burned area by size class			Average acres burned per day (all fires)
		0-9.9 acres	10.0-99.9 acres	100 acres+	
FIRE SEASON					
0-4	28	4.2	.0	0	0.2
5-9	18	31.7	18.0	0	2.8
10-14	43	180.6	183.0	0	8.5
15-19	36	273.6	170.0	0	12.3
20-24	34	374.1	550.0	120.0	30.9
25-29	15	227.1	227.0	100.0	36.9
30+	9	194.7	227.0	466.0	98.6
All..........	183	1,286.0	1,380.0	686.0	18.3
OFF SEASON					
0-4	98	16.4	0	0	0.2
5-9	48	33.5	0	0	.7
10-14	26	30.2	80.0	0	4.2
15+	11	54.5	0	0	5.0
All..................	183	134.6	80.0	0	1.2

CHILDREN WITH MATCHES

NATIONAL WILDLIFE FEDERATION CONSERVATION NEWS

Berkeley, Calif. Would you believe 92 percent [o]f the forest fires started by children playing with [m]atches are set by boys (not girls)? It's true, at [le]ast in the Angeles National Forest where the Uni[v]ersity of Southern California made a study of that [p]roblem for the U.S. Forest Service. Would you be[li]eve that 5-7-year-olds set most of the fires studied? That's true, too. Dr. William S. Folkman, a sociologist doing research on forest fire prevention, said the Angeles National Forest was chosen for the study because it is representative of a problem now developing all over the United States—increased residential development and higher human populations at the fringe of wildlands.

[A]ir-Attack Base—Continued from page 5

[A] [.]000-square-foot quonset building is at the corner [o]f the aircraft area; it provides space for the office, [re]adyroom, shop, and warehouse. Two F7F air[ta]nkers under Forest Service contract are stationed [a]t the base. At least one B-17 is expected to be [av]ailable in the future.

The Loma Rica base is operated jointly by the California Division of Forestry and the Tahoe National Forest. Work schedules and safety and operating plans are developed and approved by both agencies, and operational costs are shared.

U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C. 20250

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Slip-On Forest Fire Tanker—Continued from page 4

However, Service-wide demonstrations are needed to inform fire control personnel of end mounting and other new or changed equipment designs. The San Dimas Equipment Development Center has selected titles for slip-on tankers for Service-wide use. The Center has distributed much needed information about new equipment and become recognized as a source of technical assistance.

Region 5 has sponsored and financed the development of prototype tankers incorporating many design features which have Service-wide application. The R-5 ground tanker committee has kept experienced firemen informed of slip-on tanker development at the Center. Regions 6 and 9 have also been leaders in the use of water equipment in forest fire control. The design of slip-on tankers has been influenced by every Forest Service Region.

Two primary advantages will result from the Slip-On Tanker Updating Standardization Project. One will be completion of Service-wide specifications for popular-size tanker outfits, and another will be development of standard Forest Service plumbing drawings for qualified pumpers. Purchasers will be able to select and match tanks, pumpers, and reel or tray and have them assembled by qualified contractors.

Slip-on tanker purchases planned during th 1964-69 period include 260 small (50-80 gallon) 165 medium (100-250 gallon), and 40 large (ove 250-gallon) units (fig. 3). The 50-, 75-, 125-, an 200-gallon tankers are expected to be the mos popular in the future.

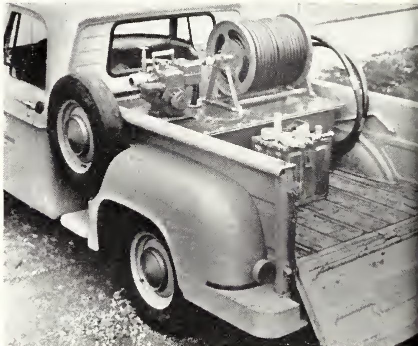

Figure 3.—An 80-gallon slip-on unit with a Fiberglas tank i shown. These tanks are lighter than metal, and allow mor water to be carried.

Weather-Briefing—Continued from page 10

forecasts. Lower probabilities of lightning, and generally higher humidities, are predicted for the other Forests in the region.

The Division of Fire Control is very enthusiastic about the weather briefing board. During the fir season, it is posted twice a day to coincide with th twice-daily fire-weather forecasts. The day of th week for which the forecast is valid is posted abov the large Forest Service base map.

Railroad Fires—Continued from page 8

other prevention programs, both in and out of the railroad organization.

However, the problem of railroad fires needs additional serious study, and the Council has invited representatives of the Oregon railroads to join in its deliberations and efforts. The protection organiza tions are confident that, by working together, th many problems connected with railroad fires can b better clarified. Cooperative solutions can be de veloped which will benefit all parties concerned.

FIRE CONTROL NOTES

S. DEPARTMENT OF AGRICULTURE FOREST SERVICE JULY 1967 VOL. 28, NO. 3

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contr

CONTENTS

COVER—The Clark National Forest (Missouri) prevention helicopter is shown scouting a small fire. Such early arrivals deter incendiarists and permit early warnings to be given to legal burners. On wildfires, the two-man crew can usually handle the initial attack. See story on page 6.

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

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PROBLEMS IN ESTABLISHING FIRE-WEATHER STATIONS IN ALASKA

F. D. Paxton, R. M. Bowman, and C. D. Johnson[1]

The role of the Fire-Weather Forecaster in laska in the early detection and control of lightng-caused fires is fairly new. However, the value the forecasting assistance provided by the eather Bureau to the Bureau of Land Management is clearly recognized.[2] But more stations in mote areas are needed to intensify the observaon network and thereby strengthen implementation the National Fire Danger Rating System.

Many interesting problems may be encountered establishing a new fire-weather observation staon in Alaska. The State's vast area and sparse pulation provide a serious obstacle to adequate eather sampling. There are two primary requireents in the selection of new sites. They must fill void on the meteorologist's map to assist in the rly detection of critical lightning storms, and, ore important, someone must be available to take servations.

In 1965, one suitable site was selected at Stevens llage, a settlement of about 80 Athabascan Inans 100 miles north of Fairbanks, on the Yukon ver. Official reports had not been recorded at the lage, but analysis indicated that the general area d a high incidence of thunderstorm activity. erefore, it was necessary to establish an observan station in the locality. However, it could not be talled until early June because of the Yukon ver breakup and subsequent flooding. Meanwhile, nning and logistics, while not extensive when mpared to some Arctic area supply situations, nsumed considerable time. Aircraft schedules re coordinated with other suppression and preppression activities; equipment was purchased, d instruments were packed for the rugged trip amphibious plane.

On the date of the trip (June 7), the waters of e Yukon, while not in flood stage, were still high. e current is particularly swift near the village it weaves through a maze of islets and across s. The banks at the village are steep and covered h black sand and clay. The pilot landed after he was certain that there were no visible snags or obstructions which would endanger the aircraft. Soon he was able to pull the craft far enough upon the bank to unload. Interested villagers lined the bank to watch. The Chief of the village was immediately contacted, and a potential native observer was soon interviewed.

Shortly thereafter, selection of a proper instrument exposure site was begun. A narrow grassy area in the center of the village was not usable because of the nearness of the buildings and traffic. Since the buildings were located upon the highest ground close to the river, and a shallow slough surrounded the backyards of the log houses, the rear area of the log house cluster was also unacceptable. A path went across the slough and through a heavy brushy stand of willow, white birch, and alder to a small dirt airstrip, still unusable due to mud, about 800 yards from the village. Because the trees were tall, a site too near the runway could not be used, for the anemometer tower would be a hazard to incoming aircraft. A site along this path, about 300 yards from the village, was finally chosen.

Four men from the village were hired to clear an area approximately 130 feet square. Disposal of the brush was not difficult—it was piled in rows along the outside edges of the clearing. After these windrows are cut about every 5 feet with chain saws and left in the summer sun to season, this wood becomes a readily available source of winter fuel for the villagers and will soon be used in their stoves.

Before the instrument shelter, the rain gage, and the anemometer were erected, it was necessary to remove roots and debris, and to level a 16- by 16-foot area near the center of the clearing for the instrument enclosure. The first blow of the pulaski firefighting tool hit permafrost. All digging and leveling had to be accomplished in the frozen subsoil. The dislodging of roots and stumps in permafrost is, at best, difficult, but here the problem was greater because the shade of the brush and the duff covering the ground had prevented even a superficial permafrost retreat. To provide for the leveling of the shelter, pulaskis were used to chop into the dirt and ice. To measure the true wind at the site, the anemometer had to be placed 20 feet above the average height of the surrounding brush. This required a 50-foot tower, which

Continued on page

[1] Paxton is a Fire Weather Forecaster, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce. Bowman is Unit Manager, Ft. Yukon Administrative Unit, and Johnson is Fire District Supervisor, Fairbanks District and Land Office. Both are employed by the Bureau of Land Management, U.S. Department of Interior.

[2] Paxton, F. D., and King, L. D., Sky fire in Alaska—Summer 1964. Fire Control Notes, v. 26, No. 2, April 1965, pp. 5-7.

A LOOKOUT CARGO WINCH

Missoula Equipment Development Center

A hand-operated winch for raising and lowering cargo between the ground and the catwalk of a fire lookout tower has been designed at the Missoula Equipment Development Center. The design meets the following requirements:

1. Capacity of 200 pounds.
2. Ability to handle loads of at least 3′ by 3′ by 3′.
3. Capacity for 75 feet of cable.
4. Locking device to keep boom from swinging while a load is raised.
5. Breaks.
6. Rapid unwind system for returning empty hook to ground.
7. Safe and simple operation.

A prototype model was extensively tested during construction of a new lookout on Blue Mountain on the Lolo National Forest, Mont. The model was used to raise materials for the cupola (fig. 1).

While the winch was designed primarily for use on Region 6 style lookout towers, it is adaptable with minor modifications to other tower designs. However, some older lookouts lack standards, and custom modifications would be needed.

Figure 1.—View of winch installed on a lookout tower catwa

Cost of the winch when produced singly or small quantities is about $150. Fabrication drawin are available from the MEDC.

BALLOON DROP

James C. Larkin, Western Zone Air Officer, Region 4

During early September 1966, the Payette National Forest in Idaho was being plagued by a seemingly unending rash of lightning fires. The largest, the Flossie Lake fire, was burning on more than 5,000 acres of lodgepole pine in the remote Chamberlain Basin area.

Manning and supply had to be carried out by air, with the planes landing at a back-country airstrip located just south of the fire. Extensive use of the Forest Service C-46, three C-47's, and many smaller aircraft soon had 300 firefighters and their equipment on the fire. However, the dense smoke which blanketed the area made the job of supplying these men touch and go. Many trips by the planes were cancelled, or the aircraft turned back to McCall, because of almost zero visibility at the Chamberlain strip.

A light rain fell during the night of September 12. This proved a godsend to the firefighters, but compounded the supply problem. The next morning the airstrip was blanketed by a dense, 500-foot-thick layer of fog. Rations at the fire camp were short. Breakfast had been prepared in McCall, but there was little chance that the plane could land Chamberlain before noon.

Fire Boss Reed Christensen radioed McCa "Load up the Doug with chow, rigged for par drop. We'll have something worked out by the tir you get here."

We arrived over Chamberlain in the C-47 short after dawn. Floating above the fog was a stri of fluorescent weather balloons. Airport Manag Gary White came on the airnet. "Make your dr on the balloons."

I made a pass and two bundles were kicked o White reported, "Good! Next time correct a hu dred feet to the right, and drop a little sooner

By the third pass we zeroed in on the targ our chutes landing "right on." Fifteen minut later chow was on the table.

A gimmick fostered by 300 empty stomach yes, but also a demonstration of real initiative a one more note to add to the fire control story.

Editor's note:

Such low-level flights over fog or cloud cover should be carri out only in multiengine aircraft. Also, particular care must exercised on the ground to designate the drop zone so that p sonnel and equipment are not endangered by the drop.

FIRE DANGER COMPUTERS

Frank E. Lewis, *Forester*
Forest Service Electronics Center

'an electronic computers be used by fire control nagers to efficiently and economically calculate danger ratings? To provide an answer, in Sepiber 1965 an equipment development project was igned to the Forest Service's Electronics Center, ltsville, Md. Use of analog methods seemed sible. A pilot model of a computer was designed l constructed by Fred Biggerstaff, an electronics gineer, and this development led to the fabriion of a test unit (fig. 1) now being demonated and evaluated.

The device is designed to perform most of the cessary calculations for determining spread index sed upon the National Fire Danger Rating Sysn. Four weather elements—RELATIVE HU-DITY, DRY-BULB TEMPERATURE, ND SPEED, and PRECIPITATION—are inted by setting dials calibrated for each element. e BUILDUP from the previous day is also set the proper value by use of a dial. An estimate the appropriate HERBACEOUS STAGE is roduced by setting a switch at one of three itions. A three-position meter switch permits following items to be read directly from the ters: FINE FUEL MOISTURE, FINE FUEL READ INDEX, and DRYING FACTOR and, er the buildup dial has been repositioned to reet the latter, ADJUSTED FUEL MOISTURE TIMBER SPREAD INDEX.

One feature in the design of the first test model lighted display which uses appropriate colors indicate FIRE DANGER CLASS. As conucted, it is linked directly to the SPREAD DEX meter. Those rating systems that combine ain other factors with SPREAD INDEX to rve at a FIRE DANGER CLASS would require lightly different circuitry to provide a similar play capability. The estimated cost of producing n computers in volume is about $1,000 per unit, ending on the design refinements. Other apaches toward fire danger computers have been gested as a result of developments to date.

simpler, much less expensive, and essentially automated electronic fire danger computer has been proposed. Such a computer could be patred after the "do-it-yourself" type constructed h high school science kits. Such computers ally operate on flashlight batteries and use inensive potentiometers and a simple electrical ter. As with slide rules, graphs, and tables, eral successive steps would be required to obtain

Figure 1.—Fire Danger Computer (Test Unit No. 1).

final answers. To perform one step in a series of calculations, two of the three potentiometers must be rotated and set to appropriately calibrated scales. Then the third potentiometer must be rotated until the null meter reads zero; at that position the answer for the particular step can be read from a suitably calibrated scale.

Computers are employed as research tools in the development and or modification of various systems; one with a suitable design could serve a similar purpose for the National Fire Danger Rating System. A fire danger computer could be linked with suitable weather sensors via telemetry equipment and recorder equipment to provide fire danger data continuously or at preprogramed intervals. Such systems would, of course, require a computer design somewhat more sophisticated than that provided in the test unit. Suitable telemetry systems and sensors already exist.

Continued on page

Fire Danger Computers—*Continued from page 5*

Perhaps the greatest present potential for units such as the one being evaluated is for training. Such a device can clearly illustrate the relative effects of the various individual input elements, as well as some of the concepts represented by the various calculations. The same purposes cannot be accomplished as conveniently or effectively with pencil and paper, tables, graphs, and slide rules and meters.

Additional phases of the National Fire Danger Rating System are still being developed. While these aspects will be of great importance to fire control managers, they will further complicate the rating process. Use of electronic computers may be the best solution for performing all of the various operations which may ultimately be required. If rating systems become too cumbersome or too subject to errors in calculations, it would l best to use a computer at a central location handle the rating process for individual ratii areas. A suitable communication system would, course, be vital to any such centralization of tl rating job.

Meanwhile, the slide rule meter or a simple cor puter such as that described above may be the on items both sufficient and justifiable. Use of the mo elaborate and automated systems, except for trai ing or research, may not be practical now. It increasingly valid for managers to obtain assis ance in choosing the best alternatives for makii decisions. Increasing importance attached to tl values at stake and suppression costs will requi application of all phases of modern technology the protection job, including fire danger measur ment and rating.

THE HELICOPTER—AN EFFECTIVE FIRE-PREVENTION "TOOL"

Division of Fire Control

Region 9

A different approach to fire prevention problems is being evaluated on the Clark National Forest in Missouri. Since the spring of 1966, a helicopter fire-prevention and initial-attack project (with emphasis on prevention) has been conducted on three ranger districts. The other districts are serving as control areas. The Clark has a history of a high rate of man-caused fires.

PLANNED OPERATIONS

A Bell 47 Super-G helicopter, which carries a pilot and two-man crew, is used. The aircraft has a radio and a 40-watt public address system.

Planned use of the helicopter during the fall and spring fire seasons totals 110 hours. This time is budgeted as follows: Fall, 30 hours for hunter prevention contacts and surveillance and 10 hours for smoke investigation; spring, 50 hours for smoke investigation and 20 hours for prevention contacts and surveillance. In their prevention work, the helicopter crew patrols areas of hunter concentration and works with ground patrolmen in making prevention contacts. During general surveillance or smoke investigation missions, the crew contacts landowners doing burning (fig. 1). They also conduct "hot" investigations on fires started by incendiarists, debris burners, hunters, and others, and they observe and pursue suspects.

The helicopter crew is used on initial attack only on fires where it has a definite advanta over ground forces. When the crew is used in initi attack or for scouting a going fire, it is reliev of fire duty as soon as possible so that the m may return to prevention work.

Figure 1.—"Controlled" fires of local ranchers that escape responsible for one-third of the fires on the Clark Natio Forest. The helicopter crew can land nearby and advise farmer on safe burning.

Continued on page

DISPOSING OF SLASH, BRUSH, AND DEBRIS IN A MACHINE-LOADED BURNER

Harry E. Schimke and Ronald H. Dougherty

Forest Fire Laboratory, Forest Service, USDA

Riverside, Calif.

Land managers continually seek better methods f disposing of slash, brush, and debris resulting rom logging, thinning and other clearing operaons. The problems of disposal are many. When ash is dry enough to burn, burning in many cases unsafe or difficult because of the control lines, onstant watch, and mopup which are required. owever, if weather conditions permit slash burng to be done safely, the material may not burn ell; constant kindling, stoking, and chunking may necessary. And sometimes slash will not burn all. Of course, slash can be chipped, buried, or auled away, but these methods are relatively pensive.

At times it is undesirable to "live" with the slash until conditions are right for burning by the usual methods. This is particularly true of slash left after road construction, or after the development of fuel-breaks or recreation areas. A method is needed to permit the burning of slash when it is created, regardless of its moisture content or weather conditions; this method must also cost less than other disposal methods.

Personnel of the Pacific Southwest Forest and Range Experiment Station developed and tested a portable slash burner. This unit is mechanically loaded and consumes slash as fast as it can be fed into the burner—regardless of how green or wet the material is. Burning can be done safely under all but the most hazardous burning conditions (fig. 1).

Figure 1.—Slash is hoisted into the burner box by this loader equipped with a specially constructed fork unit.

TEST CONDITIONS

The slash burning equipment was tested on six types of materials under various weather conditions. All trials were held early in 1966 at an elevation of 5,000 feet. The types of material burned during this test were:

1. Partly cured mixed-conifer slash resulting from fuel-break thinnings (hand-piled).
2. Small, green mixed-conifer sawlogs (cut and piled after fuel-break rethinning).
3. Cured mixed-conifer logging slash (as lopped).
4. Cured mixed-conifer slash and brush (piled by bulldozer during fuel-break construction).
5. Green mixed-conifer thinning-area slash (broadcast over the thinning area).
6. Green manzanita brush (bulldozed during land clearing).

Burning was done when it was raining, snowing, windy, calm, dry, and fair.

The burning was done in a confined unit; therefore, there was little danger of escape, and the operation was continued when open burning would not have been permitted owing to the danger of escape. More than 957 tons of material, an average of 9.2 tons per hour, were burned.

EQUIPMENT

The burner was an open-top, skid-mounted, transportable metal "box." It was 14 feet long, 6 feet wide at the base, and tapered outward to 8 feet at a height of 6 feet. The box was supported by 1-foot uprights on plow steel runners curved up on both ends. Fourteen-gage steel sheets were mounted to an angle iron frame on the sides and ends, with 1-foot holes at the base for a draft. The grates of the burner consisted of a channel iron frame supporting perforated airplane landing mats.

The loader was a small, 42-hp., crawler-type tractor with hydraulically operated, specially made front unit forks. None of the commercial forks were satisfactory for picking up slash. Therefore, Station personnel constructed a four-tined fork mounted to the backplate of the loading unit and a three-tined holddown fork which could be actuated by the hydraulic cylinder used to operate the loader bucket. The total unit weighed about 9,000 pounds and could lift and transport loads up to 2,000 pounds—a weight equal to that of a slash pile with a 7-foot diameter.

OPERATION OF BURNER/LOADER

One man could perform the entire operation. However, a swamper was kept with the unit—primarily for safety.

The loader pulled the burner into the slash are unhooked it, and fed a couple of loads into th burner. After the load was ignited and began burn ing, the loader fed slash almost continuously, movin the burner as needed so the loader would not hav to travel more than about 25 yards. Farther trav slowed the operation. The burner also had to b moved regularly to prevent a buildup of coals an ashes beneath the grates because such a buildu would reduce the desired air draft. And grat continuously embedded in coals would warp o burn out.

Slash which was not too wet was easily ignite with any conventional ignitor. For wet or gree fuels, one or two discarded tires were used to g the fire going.

Sufficient coals usually remained in the burn overnight, and reignition was not necessary eac morning.

More air was often forced through the burn with a wind machine to see if the addition of blower system to the unit would be desirable. Aft numerous trials under various conditions, it wa concluded that the added air, while accelerating th burning rate, was not needed. The fuels usual were consumed as rapidly as the loader cou feed the burner.

The loader unit proved highly maneuverable an could work within close confines.

One phase of the test involved picking up un prepared material within a pine thinning area. Th thinned trees had been sawed off and allowed to fa in place. Some thinnings were up to 25 feet lon Although considerable maneuvering was require the material could be gathered and removed by th loader. But it was difficult to get the slash into th burner. If the trees had been bucked into 12-14-fo lengths and arranged in one direction, they cou have been gathered, removed, and burned muc more easily.

It was easy to pick up scattered logging slas where it lay. The forks were lowered to the groun and the unit was moved through the slash deposit When the forks were full, the load was delivere into the burner. The same procedure was followe in clearing slash and debris on roadsides.

Another phase of the test involved loading an burning green manzanita brush as it was cleare by a bulldozer. This material burned very hot an rapidly. A larger burner would be required if muc brush of this size were to be burned. Because of it size and shape, manzanita brush usually would hoo onto the sides of the burner and not fall complete into the fire.

COSTS

Average hourly costs for slash disposal follow:

End loader, crawler type	[1]$2.00
Operator	[2] 3.26
Swamper	[3] 2.71
Burner	[4] .31
Total	$8.28

[1] Based on Forest Service WCF equipment rental rates r FY 1966.

[2] Based on 1966 GS-7 salary.

[3] Based on 1966 GS-5 salary.

[4] Initial cost of $800 amortized for 4-year period (based annual use of 8 hours per day, for 20 days per month, d for 4 months).

The cost per hour per ton ($0.90) compares vorably with other methods of slash disposal, and is cheaper than most methods. Disposal by piling d burning cost $1 per ton, where there were tons of slash per acre.[1] In studies of slash dissal in the central Sierra mixed-conifer type,[2] rying slash cost $1.76 per ton and chipping $2.77 r ton.

DISCUSSION

The method of slash disposal described in this icle can be adapted to most situations. Howr, use of the loader is limited in steep, rocky, or ise-growth areas.

For most burning jobs, the largest burner that n be transported legally on a 1½-ton truck should used. Such a unit could be 18 feet long, 8 feet wide, 7 feet high, and have a minimum clearance of 18 inches between the grates and the ground. A larger unit could be designed for logs, stumps, or other large material, but this would require special transportation equipment (tilt bed, low boy, etc.). The sides of the unit should be vertical so the slash load will bear directly onto the fire bed and grates and not onto the sides. To prevent the grates and frame from sagging, the runners should be placed well in from the sides so they will support the slash load directly. The unit should be equipped with a stiff hitch to prevent the burner from overrunning the loader when traveling downhill. The steel used in building the unit should be of heat-tolerant firebox plate. Its cost is slightly higher than that of mild steel.

The 40-hp. crawler loader proved a satisfactory companion for a burner of this size. The loading unit should have six forks, each 5 feet long, spread over an 8-foot width. It should be made of spring steel heavy enough to withstand all stresses encountered. Three holddown forks, made of the same material, are sufficient. A plastic shield should be provided to protect the driver from the intense heat of the fire.

With this loader-burner combination, slash volumes of about 200 cubic feet can be cleanly picked up with one pass. Once a loading technique is developed, production rates of 10 tons per hour can be expected.

Owing to the high burning temperatures and combustion efficiency maintained, little smoke was emitted. Little spotting occurred because the material that normally develops firebrands was rapidly and completely consumed. Because the fire was always contained, the need to care for many fires, as in pile burning, was eliminated. Therefore, there was no need to place lines around numerous pile fires, chunk and patrol, or extinguish them. If conditions require the burning to be shut down, it is easy to extinguish the burner fire.

[1] Unpublished fuel-break construction costs on file at the nislaus National Forest, U.S. Forest Serv., Sonora, if.

[2] Schimke, H. E., and Dougherty, R. H. 1966. Disposal logging slash, thinnings, and brush by burying. U.S. est Serv. Res. Note PSW-111, Pacific SW. Forest & nge Exp. Sta., Berkeley, Calif., 4 pp.

INFORMATION FOR CONTRIBUTORS

Please submit contributions ough appropriate channels to Director, Division of Fire Contr, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be ed in duplicate, double spaced. The author's name, position, and organization should appear directly below the title.

Articles covering any phase of forest, brush, or range fire control work are desired. Authors are encouraged to include illustrations with their copy. These should have clear detail and tell a story. Only glossy prints or India ink line drawings can be used. Diagrams should be drawn with the page proportions in mind, and lettered so as to permit any necessary reduction. Typed captions should be attached to the illustrations, or included in the text following the paragraph in which they are first mentioned.

ARSON IN THE FOREST

EDWIN R. OUTLAW, *Criminal Investigator*
Ozark-St. Francis and Ouachita National Forests

Arsonists are hard to apprehend, so it is a great day in the life of a criminal investigator when he is able to obtain a confession made freely and openly. This happened recently to the author, when a young man, who we'll call John Thomas, admitted setting several fires.

The story began on a Monday in early March when Thomas reported a fire to Forest Service personnel and then helped suppress it. The fire was on private land, immediately adjoining National Forest land, and burned 28 acres. The same night another fire burned itself out, destroying an old house. Two days later, nearby fires were extinguished, again after being reported by Thomas, who had smelled leaves burning. District personnel noted that Thomas had reported each of the fires. On Friday the situation really became difficult. Thomas reported that he had been wounded in a gun battle with arsonists.

I immediately contacted the county sheriff, who had made a preliminary investigation of the shooting. He stated that while he could not obtain evidence, he thought Thomas set the woods on fire and shot himself to make it look good.

Thomas was called in for an interview. He told me how he had helped put out the fires. He also said that on Friday night, he went over the ridge and saw two men setting fire to the woods. He fired at one of them, and they began to run, shooting at him as they fled. He returned their fire, and believed he hit one man, as he heard him grunt. Part of our conversation follows:

"The other man turned around and started shooting at me, and the stock of my rifle probably saved my life. As it was I got hit in the leg with a bullet."

"Could you describe either man?"

"No, they were running away from me, and I didn't get a good look at them."

"Do I have your permission to make laboratory tests of the revolver and rifle?"

"Sure, and if you want me to, I'll take a lie detector test."

The State Police obtained a .22 revolver, the rifle, and Thomas' trousers, minus a swatch mysteriously cut from one leg, and sent these items to the FBI laboratory for tests. The examination disclosed that the right side of the front portion of the stock of the rifle had been damaged by a projectile about 0.23 inch in diameter. The damage was the same as that produced by a small caliber bullet fired at close range and traveling at a relatively low velocity.

When this report was obtained from the FBI, I went to reinterview Thomas, but he had vanished. I then visited his girlfriend, and she said he was working in a nearby city. When I told her I wanted him to take a lie detector test, she was surprised for she thought he had taken one. She said she would help me locate him. On Saturday night, March 26, the girl called me and said Thomas was ready for a telephone interview. He promised to meet me on Monday the 28th. However, he didn't appear for this interview or for a second one arranged for April 11th.

He had left the area, according to the county sheriff, who told me that he had a warrant for Thomas' arrest on a charge of issuing a bad check. He said that he would notify me if Thomas were apprehended. When I again interviewed his girlfriend, she told me he was living in a mo in the city and had a job the Accompanied by the investigat on the Kisatchie National Fore John E. Boren III, I located t motel, and started watching During the evening a man—r the suspect—came to the room pick up Thomas' clothes. 11:30 p.m., we received a pho call from Thomas, who said would be in the Ranger's off the next morning. Again he c not appear.

On April 27, Thomas was fin ly interviewed. He had been a prehended in Minnesota on t bad check charge, and return to the county jail.

He told the story substantia as it had been deduced, and add details about the shooting. He sa he was carrying his pistol in cocked position and accidenta shot himself in the left leg. Af being hit, he became frighten and returned to his truck and g his rifle. He then fired three sh from his pistol at the stock of t rifle, and the remaining shots in the air. He then got back into truck, returned to his girl's hou and told her about running in the man.

In confessing, he said that did not know why he had set t fires, that he did not kn whether they were on private la or on National Forest land, a that he really didn't care. He t me he was sorry he had set t fires, and that after serving time on the check charge, would reimburse the Forest Ser ice in any way possible.

This investigation is an exc lent example of what can be a complished when Forest Serv personnel carefully investigate fire, and receive all possible c operation from county, State, a Federal law enforcement agenci

A NEW TOOL FOR SLASH DISPOSAL

Robert L. Asher, *Fire Control Technician*
Winema National Forest

The disposal of logging slash ı the pine and transition types ıs long presented a problem. atch clearcutting, where the ash can be treated by broadcast ırning, is seldom practiced. Sective cutting or various degrees f shelterwood harvesting are uch more common. The cost of isposing of the logging debris in ıese areas is high, and the posbility of the residual stand being xtensively damaged is great.

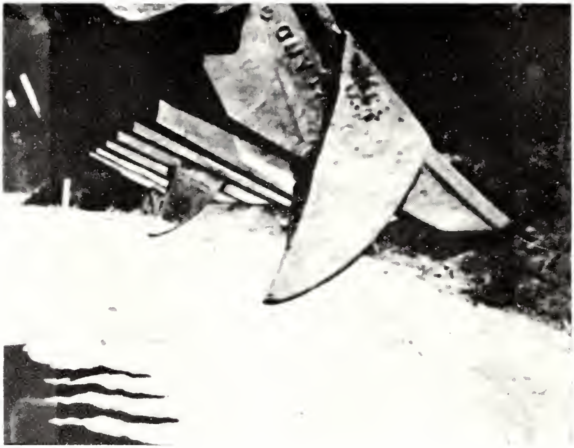

Figure 1.—View of reverse teeth mounted on standard brush blade.

EQUIPMENT TESTS

To reduce costs and to miniize damage to valuable reproıction, personnel of the Wimena ational Forest, Oreg., experiented with machine piling. Varis tractor sizes, from a John eere 440 to a D-8, were used. raight blades and standard ush blades were tested. Sucss varied according to the com nations of equipment used.

The larger tractors effectively ed the slash, but they were pensive to operate and often maged the residual stand ex nsively.

Smaller tractors did not dame the residual stand as much, but ey could not move some of the aterial efficiently.

Use of straight blades resulted excessive stand damage and il disturbance. Even the best erator could not see well ough to avoid damage. Also, thout the rake effect, either exsive material is left on the ound or much soil is carried o the piles. Therefore, burning s difficult.

Much better results were obıed with the standard brush de. Because of the rake adatage and better visibility, ich cleaner piles were built. mage to residual stands also was reduced. However, the tractor had to be positioned behind the slash to be piled, or the slash had to be sideswiped away from residual trees so it could be moved into the piles. This operation often created as much slash from destroyed reproduction as the amount treated.

USE OF REVERSE TEETH

To reduce damage to the residual stand, the old principle of reverse teeth on a brush blade was employed. There are several blades which will do the job, but they are quite expensive. They work on the principle of a set of teeth which can be reversed when the blade is to be used to pull material. After the conversion is completed, they make an effective tool. These blades were developed for rock work on road construction, but they are adaptable for slash disposal. Their main disadvantages are their excessive cost and the difficulty and expense of changing the position of the teeth. Also, with the teeth reversed, the blade is not as effective in pushing material.

To overcome these drawbacks, the standard brush blade was modified by welding three solid reverse teeth on the outside and middle teeth (figs. 1, 2). The teeth are small and utilize the back of the brush blade as part of the whole device. The cost of modifying the blade, including buying the stock, cutting the teeth and braces, and welding them in place, was about $75.

ADVANTAGES OF NEW BLADE

This device has several advantages over other brush blades and reverse tooth systems. In addition to lowering the cost of the initial investment, residual stand damage can be substantially reduced because the slash can be pulled away from standing trees instead of being pushed. Second

Continued on page

Slash Disposal—***Continued from page 11***

one piece of equipment can be adapted to several jobs. Finally, the size of the brush crew working with the tractor can be reduced considerably. With the conventional brush blade, six men and four chain saws were needed. They had to hand treat almost 25 percent more slash. With tl new blade, the slash could l treated by two men with cha saws and the tractor operato

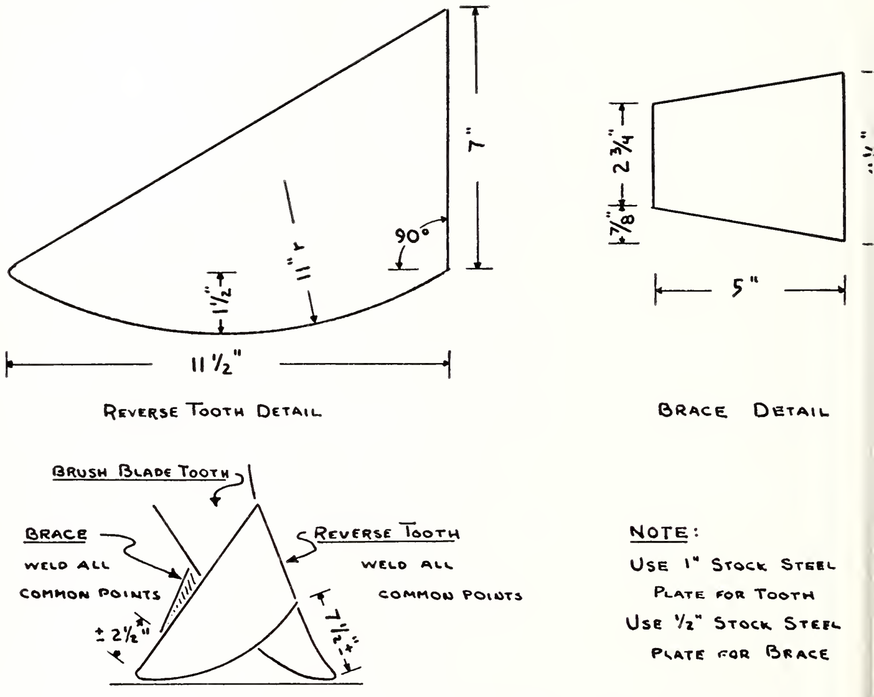

Figure 2.—Fabrication details of reverse tooth and brace are shown. The brace is welded to the reverse tooth and the opp site side of the brush blade tooth.

SPARK ARRESTING MUFFLERS FOR POWERSAWS

Washington Office Division of Fire Control

Forest Service timber sale contracts and other permits usually contain provisions which require spark arresters on internal combustion engines during the fire season. Effective mufflers and arresters for heavy equipment have been available for many years, and in 1959 a standard[1] was established for them to qualify under the contract provisions.

However, this standard does not apply to arrester mounted on engines used in multiposition applica tions (for example, chain saws). Without definit guidelines to rate such arresters, requirements fo chain saws have varied by regions. Usually th standard factory mesh- or baffle-type mufflers i good condition have been accepted for situation other than extreme fire danger.

In 1964, the San Dimas Equipment Developmer Center conducted special tests to establish suitabl

[1] Forest Service Interim Standard No. 1 for Spark Arresters for Internal Combustion Engines, Apr. 7, 1959. (Superseded in Jan. 1965 by Forest Service Standard for Spark Arresters for Internal Combustion Engines, Standard 5100-1)

quirements for powersaw spark arresters. These sts measured the temperatures of the arrester shell id the exhaust gas, the carbon arresting effective-ss, and the back pressure that developed. Results ive been shared with the manufacturers and with e Power Saw Manufacturers' Association Com-ittee on spark arresters.

The Center determined that a screen-type arrester-uffler will meet the requirements for powersaw gines if screen openings do not exceed 0.023 inch. t least 80 percent carbon arresting effectiveness is otainable. Screen clogging is usually due to lead recipitates from the gasoline, rather than carbon. s with all arresters, careful inspection and mainte-ance are necessary for satisfactory performance.

While an official standard has not yet been estab-shed, the San Dimas Center has developed the fol wing guidelines for powersaw muffler-arresters:

1. The arrester should have a woven screen with maximum opening of 0.023 inch.

2. The screen should be constructed of heat and corrosion resistant wire at least 0.025 inch in diam eter. Stainless steel or a chromium alphatized screen is recommended.

3. The total screen opening area (effective ex haust area) should be at least 125 percent of the engine exhaust port area.

4. Construction of the unit should permit easy removal and replacement of the screen for field in spection and cleaning.

5. The arrester should be capable of operating for a minimum of 8 hours before cleaning is needed.

6. The screen should be usable for 50 hours.

7. The screen should be inspected at least after every 25 hours of use, and should be replaced as soon as corrosion and a resultant increase or de crease (clogging) in opening size are noted.

8. Replacement screens should be carried by saw crews.

A FIRE TOOL SUPPLY TRAILER

Milo R. Drilling, *Forestry Technician*
Huron-Manistee National Forest

A fire tool supply trailer developed on the White oud District provides a fire cache that can be oved quickly and easily to a going fire (fig. 1). iring high fire danger the trailer is dispatched to ch fire with the initial attack force, making tools d equipment readily available for use by reinforce-ents or volunteers reporting at the fire scene.

The trailer can hold tools and equipment for as any as 60 men. It also has a small portable pump, se, and a 100-gallon water supply (fig. 2). The compartments are of varying size, permitting the transportation of equipment needed for any local conditions.

The unit has a gross weight of 2,100 pounds and can be pulled by a half-ton pickup. It has a "Prior Level Ride" axle, which permits good stability even on rough roads.

The unit, which has proven useful on 20 fires, also serves as a fire headquarters, a communications center, a timekeeper's station, and a first aid station.

Figure 1.—The fire tool supply trailer is shown.

Figure 2.—These tools and equipment are transported by the trailer.

Fire-Weather Stations—*Continued from page 3*

was constructed from 3- to 5-foot segments of hollow aluminum tubing. The stakes for guy wire supports for the tower were driven into the frost with sledge hammers.

The observer, Winthrop Silver, closely watched the unpacking of the instruments and their installation in the shelter. Each instrument and its operation was explained, and indoctrination in taking observations was given (fig. 1). He was shown cloud charts and how to identify various cloud types, particularly the cumulus varieties. He was also shown how to encode the sky condition, dry and wet bulb temperatures, wind direction and speed, rainfall amounts, maximum and minimum temperatures, and thunderstorm activity. Silver was shown how to operate the radio, which we installed in one corner of his log cabin, and how to transmit this information. All fire-weather observers in Alaska report weather data twice daily. These observations are sent by radio to collection centers at McGrath, Fairbanks, and Anchorage at 8 a.m. and at 2 p.m. Alaska Standard Time.

Our airplane finally left the shore at Stevens Village and pulled out onto the wide, roily Yukon River at 6 p.m., and we then flew to the airport at Fort Yukon further to the northeast.

Figure 1.—Winthrop Silver receives instructions on the operati of the newly installed Stevens Village fire weather statio just south of the Arctic Circle in Alaska.

The recorded cost of the initial establishment of the Stevens Village Fire Weather Station was $1,947. This figure does not include time spent in planning or successive costs for operation an maintenance.

THE FOREST LOG

Oregon Department of Forestry

Forest fires last year destroyed more value in Oregon than at any time since the first Tillamook fire of 1933.

Forest property damage approached $4,050,000 during the 1966 fire season on lands under protection of the State Forestry Department and cooperating Forest Protective Associations. Some 1,301 forest fires burned over 52,671 acres. Although the number was only 20 more than the previous year, the burned area was up 38,625 acres.

The Oxbow fire which exploded on August 2 accounted for 42,875 acres of the burned area th past year and caused in excess of $3,000,000 damag Control costs on this fire ran to over $900,000. Th second most disastrous conflagration was the Iver Peak fire which occurred on August 9 and covere 1,636 acres before it was controlled at a cost o $443,204. Damage was estimated at $298,225.

re Prevention "Tool"—Continued from page 6

Wide publicity has been given to the helicopter oject. News media personnel throughout Mis uri were invited to see the operation. Demonstra- ons of the aircraft and its capabilities were made at hools and at smaller communities within the study ea. Selling fire prevention was the main goal.

RESULTS

The helicopter prevention project is proving ective, not only in the many prevention contacts thin the study area but in the investigation of cendiary fires. It has discouraged persons who ight set fires because they realize how easily d quickly the crew can arrive (fig. 2).

orest officers directly connected with this project el that the response of the school children and izens who have been contacted is good.

One apparent result has been that the incendiary es are now generally set at night. To counter this ect, the Forest personnel have increased their ed-wing, multiengine night aerial detection ghts, and ground patrols have set up stakeouts ring high fire danger. Incendiarists are finding more difficult to set fires within the study area.

During the 1966 spring fire season, it was difficult determine the success of the program due to ny variables in weather, risk, etc. However, the t of the project was definitely offset by the re- ction in ground forces needed for smoke chasing, i suppression, investigation, and prevention ntacts.

In the fall season, when den tree fires are the in cause of wildfire in the study area, an effort s made to contact all hunters, either at their s or in their camps. If no one was present, a evention message was left. Sometimes a hunter camp would be contacted through the public dress system on the helicopter or by dropping message. During the latter half of the deer sea- , only one "accidental" fire occurred. During squirrel season, only one den tree fire occurred the area: formerly there was a high concentra- n of den tree fires.

During the 1967 spring fire season, the helicopter tinued to prove its value as a prevention tool. rough April 15 the Potosi Ranger District cked 101 landowner-controlled fires which did develop into statistical fires. The helicopter cked 80 of these. However, eight additional s escaped control by the owners and required suppression. The average size of these fires was 1.75 acres; prior to the helicopter project, debris fires averaged 6.5 acres.

Figure 2.—Fast initial attack by the helicopter crew held this incendiary fire to less than one-fourth of an acre. Their early arrival probably prevented other sets.

CONCLUSIONS

The following improvements in the Forest fire control program have been noted in the study area:

1. No severe incendiary fires.
2. A drastic reduction of hunter and den tree fires.
3. A reduction in debris fires which escaped owners' control.
4. Stimulation of all phases of fire control.
5. A reduction in fire costs, and strengthening of the suppression organization.
6. Good public reaction supporting the stepped up program and this new "tool."

In summary, the helicopter is proving an effective tool in both fire prevention and suppression in Missouri. But the helicopter alone cannot substitute for all prevention and investigation activities. However, in combination with supporting ground crews, night aerial detection, periodic round-the-clock surveillance, and good public relations, it offers an opportunity to reduce indiscriminate burning in the Ozarks.

U. S. DEPARTMENT OF AGRI
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OFFICIAL BUSINESS

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OSTAGE AND FEES PAID

ELECTRONIC DISPLAY FOR FIRE NEWS

MERLE F. PUGH, *Writer-Editor*

Pacific Northwest Region

Because major forest fires are of interest to almost everyone, Forest Service fire dispatchers are very frequently asked for information during a "going fire" situation. Coworkers and the public want to know what's going on.

Last summer an electric "bulletin board" was installed (fig. 1) in the lobby of Portland's Multnomah Building, where Region 6's headquarters are located. The board proved popular and valuable.

The visual display system was used throughout the fire season to show fire danger by areas and the location and size of going fires. A two-circuit panel in back of a cork facing illuminates the lights (Glo-pins) and tubes (Glo-tubes) stuck into it. A flashing unit permits certain pins to flash on and off (when fires are out of control). Lighted tubes i dicate the names of fires burning and their acreag When a fire is controlled, a "controlled" tag placed on the tube.

The Region also uses the electronic display provide information on other National Forest acti ties. For example, during the winter ski areas a shown. Areas open daily have one color of light those which operate only on weekends have anoth color.

Several electronic display boards are sold; th cost $200 to $2,000. The two-circuit unit purchas by Region 6 costs $360; in addition, a power-pa costs $146; a flashing unit, $82.10; and Glo-pi $1.75 each. The total cost was approximately $6

Figure 1.—Region 6 Fire Dispatcher Clarence Edgington and Assistant Dispatcher Yvonne McNeil examine electric display bo showing fire danger and going fires.

FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contr

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COVER.—A general view of a mobile fire laboratory is shown. See story on page 7.

(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).

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PREPARING A TOTAL PREVENTION PROGRAM

MERLE S. LOWDEN

Director, Division of Fire Control[1]

Fire prevention is an essential part of any com- ehensive fire control program. Its need and lue are generally accepted by firemen. How- er, prevention work is becoming more varied d complicated. Many approaches must be con- ered in planning and executing a total preven- n program. To obtain optimum effectiveness, known and applicable approaches must be used. me approaches that do not always receive enough ention are discussed in this article.

When the public thinks of fire prevention, it ually visualizes posters, TV appeals, and other ormation items of the Smokey Bear type. Use these media is an important part of any com- hensive fire prevention effort, and it is the t method of informing the general public and tain groups such as school children. However, ny other approaches to fire prevention are eded in a well-designed program.

n this article other prevention work has been ssified into several general fields: Risk en- eering, hazard engineering, exposure controls, ustrial user controls, and law enforcement. ch of these fields is applicable in various de- es—depending on the location and the preven- n problem. It is important to first obtain an imum analysis of fire causes and then to care- ly plan actions to meet needs. It is desirable to r to improve definitions, increase our investiga- ns, and obtain better information on who is re- nsible and what is involved in man-caused s. Fire prevention research can be particularly ful in providing administrators with guides for aining better records of fire-starting causes. s effort is now receiving particular attention a cooperative study project in the South. A statistical center is planned. Fire records n all fire control agencies in the Southern tes are to be gathered and analyzed.

RISK ENGINEERING

Risk engineering includes all ways of eliminating sparks that start forest fires. Basic research is needed on the sizes and types of carbon that cause fires, how they are emitted, what can be done to eliminate them, and similar problems.

The change to diesel engines did not stop engine fires or fires from diesel tractors. An "offensive" diesel tractor under a heavy load emits sparks from an unprotected or poorly protected exhaust stack. Also, all diesel oils, as well as other fuels, are not equally hazardous. Additives can be placed in fuels to decrease the likelihood of carbon particles starting fires. However, economic considerations further complicate the situation. Cheaper fuels generally cause more fires, and engine designs which reduce the problem often cost more.

Much can be done to prevent "engine" fires. Effective spark arresters will prevent emission of fuel sparks that cause fires. The Forest Service has established a method of testing and certifying arresters that meet a certain standard. A new Identification Guide lists tested arresters. New and better arresters have recently been developed for powersaws and similar small engines. While much more must be known about the sparks from engines, aids and methods for working on the problem are available. Equipment should be inspected regularly by competent specialists to be certain required devices are functioning.

New devices for reducing offensive gases that increase air pollution may be a source of future fire problems. These are being studied at the San Dimas Equipment Development Center (Calif.). New cars with these devices may prove a source of serious trouble. These devices, now required in some areas, are fairly certain to receive wider use. When smog control equipment is attached to engine exhaust systems, the temperature usually rises. Some afterburner type units still undergoing research may produce exhaust gas temperatures high enough to ignite forest fuels. Development of special protective devices such as guard-

[1] This article is adapted from a speech presented at the Society of American Foresters Annual Meeting, Seattle, Wash., Sept. 14, 1966.

or exhaust deflectors may be needed. Fortunately, automotive engineers are also trying to solve the smog problem by "cleaning up" motor designs. The trend is to design out smog-producing characteristics and thereby obtain better combustion for the car of the future. This approach is much more practical than adding apparatus to the present exhaust systems; such additions may create corrosion which destroys metal parts in about 10,000 miles, or causes high temperature. Also, it seems there will always be the motorist who drives through dry grass. Such grass may have an ignition temperature dangerously close to the heat of his dragging exhaust system. His tail pipe may be turned down, his muffler defective, and his engine missing.

There are also fires from railroad brake shoes and sparks from pulleys and cables. New electric brakes prevent brake shoe fires, but sparks from cables are particularly troublesome. New types of materials must be sought. Alert vigilance can help at points where cables contact wooden fuels. Increases in cable logging and even the new balloon systems that use cables may be a problem. The need to be alert to new risks is constant.

Community dumps have been a fire risk source for many years. In some localities legislation concerning their location and other safeguards has been helpful. Many fire control units have made special efforts to clean up or "fireproof" dumps. Such efforts have usually eliminated or greatly reduced dump fires. A new, mobile incinerator has had favorable use for campground refuse, but dumps for local refuse are sure to be used for many years. These dumps must not continue to be a cause of wildfires. There is much that can be done to improve the "fire proofability" of most dumps.

HAZARD ENGINEERING

Obviously the objective of prevention is to prevent sources of ignition from contacting burnable material. Hazard engineering can eliminate natural vegetation and other materials that burn. Vegetation can be removed where sparks are most likely to fall—along railroads, on roadsides, in recreation areas, near powerlines, and in similar places. Some phenomenal results have been obtained from close cleanups along certain sections of railroad tracks and highways (fig. 1). Fire crews of the San Bernardino National Forest, Calif., have done much such work along forest roads and highways. They cleared road edges for 10 feet on many miles of highways and roads and reduced roadside fires from 52 to 11 percent of all fires on the Forest.

One stretch of railroad had a history of high, but fluctuating, fire incidence. The number of fir was almost directly correlated with good or poo right-of-way cleanup. On a short section of righ of-way, railroad fires averaged 7 to 9 per yea After a cleanup, there was none.

Firemen have long searched for a retardant spray over high-risk fuels to keep them from ig niting. Tests in California and elsewhere have r vealed some retardants that are effective but n durable—the first rain washed them away. A effective and economical retardant will be foun but more effort is needed.

The chip problem along certain railroads h been particularly vexing in recent years. Chi blowing off heaped railroad gondolas pile up rights-of-way, particularly where wind curren are strong. These chips provide an ideal fuelbed f sparks to ignite. They also are a safety haza when they block railroad switches and tunn drains. Concern about this safety hazard, or t persistence of protection agencies, or possibly combination of both, has resulted in some improv ment. Intensive cleanup of chips has been done a few places. An embargo on high-piled uncover cars in the Pacific Northwest has produced de inite results, and chips are no longer "flying" at wi Cutting the height of chips on cars or putting either permanent or temporary covers can pret well cure this problem.

At the national level, the American Associati of Railroads and the Railroad Section of the N tional Fire Protection Association have promis to help with the railroad fire problems. Sever States, including Michigan, Missouri, and Califo

Figure 1.—Cleanup of hazardous material along roadsi greatly reduces the chances of fires starting. Those that occur spread slowly and can be quickly controlled.

a, have been working hard with railroads on haz-
rd and risk problems. It is particularly important
at local fire managers work with railroad
ople both to make them aware of problems and
seek joint solutions (fig. 2).

Highway fire prevention cleanup can and does
hance roadside beauty. Foresters are rightly con-
rned with soil erosion. But to prevent disastrous
res, some small soil losses may have to be accepted
mporarily. For example, vegetation may have to
removed along roads until a cover is found
hich does not ignite. We need to be working with
ghway commissions and road engineers to design
adsides that are less hazardous as sources of
res. Snags or trees frequently fall across power-
nes and produce fires. Removal of dead and risk
ees can prevent most of these fires. Research is
eeded on roadside fire hazards and their allevia-
on.

The elimination of fuels where fire starts are
ely is being done around forest homes and other
ildings surrounded by flammable fuels. Califor-
a's "Fire Safe", a formal program, has this aim.
ate officials hope to extend law enforcement so
e program will be successful. They are convinced
will eliminate many fires, particularly those that
art in the most hazardous places and often cause
rge property losses. We now accept as standard
actice cleanup in recreation areas (especially
ound fireplaces, stoves, and tables). Dust likeli-
od may prevent a complete cleanup in such places.
t we can at least lessen the problem. The search
r new fireproof ground covers needs to be con-

ure 2.—Concentrations of light fuels along railroad rights-of-way present a severe hazard and substantially increase the chances for railroad fires to occur.

tinued. We need "fireproof" overlooks, vistas, way-
sides, and similar places where people congregate.

Some people broadly define prevention and include the action needed to hold fires to small size. This may seem like suppression rather than prevention. It is valuable to build firebreaks and wider fuelbreaks to stop fires or help hold them at critical locations. This is the chief purpose for the cleared lanes on the ridgetops over much of southern California, and such areas are being cleared in other parts of the country. For years "light" burning has been advocated to remove hazards, and it can be effective in prevention. Such burning should be carefully prescribed and competently done. There is no question that fire, if properly used, can prevent many fires and hold others to small acreages. While, this in reality may not be fully pertinent to this general subject, it is in effect, hazard engineering.

Regulation of burning, on government or private land, is a particularly important prevention job. Debris burning is one of the large causes of fires, and these fires often occur at critical times and in especially hazardous places. Both hazard and risk engineering are involved. When a better way is found to dispose of limbs and other slash debris or to make them less hazardous, more fires will be prevented. On some National Forests operators bury debris on road construction projects. This eliminates the hazard and also the risks of escape fires when burning is done. Experiments have been conducted with various chemicals and decomposition agents including fungi to dispose of fuel debris, but I know of no noteworthy results. Current concern for clean air has raised many questions as to the effect of hazard reduction by burning on air pollution. We have some facts, and research is being conducted to find more. It's a big job to explain our work to "Clean Air" administrators so excessive restrictions are not placed on burning. Formulation of mutually satisfactory regulations and methods will continue to require orientation and understanding by all concerned.

EXPOSURE CONTROLS

There are a wide variety of actions under exposure regulation. Limiting the exposure of the forest to fire risks may restrict the activities of individuals and often is unpopular. In the Forest Service, our general objective is to permit maximum use of the National Forests. In some locations it is necessary to restrict the use of fire under extreme conditions of fuel, weather, or exposure. Sometimes an area may be closed to all use. However, at other times people may quired to smoke only in certain areas, obtain a campfire permit, or carry fire tools.

Even changing the hunting seasons to keep people out of the woods at certain times is a form of exposure regulation. Like other regulations, it is only used when other means are not adequate. Regulations are usually resisted, but people informed of the reasons for limitations are remarkably willing to comply with them. Mass media can be particularly helpful by advising people of severe fire danger and the reasons for restricting their actions. All regulations should be lifted as soon as possible.

Signs and posters are used as part of exposure regulations. These are used to motivate people to action or inaction when they are exposed to forest fuels. We are just beginning to learn, through research and tests, about effectiveness of various signs. It is certain that people must see, read, and understand a sign before they will act upon it. It should provide a reason, a stimulation, or a reward for doing the right thing. All of these things need consideration in sign planning as a part of your total prevention program.

INDUSTRIAL USER CONTROLS

Industrial users working in forests are in a somewhat different class, and controls on their actions are usually applied differently. The work they do may be under some type of permit, contract, or special regulation. This permits an advance determination of restrictions to action, and sometimes these can be put in writing. With recent improvements in fire danger rating, these exposure requirements can be more closely related to action fire needs. For instance, we can specify by humidity readings or danger ratings when a logging operator will be permitted to log. Fires start much more readily when relative humidities are below 25 percent. Thus, some special regulation of the exposure is needed. Other restrictions such as demanding watchmen during certain seasons, requiring mufflers or spark arresters, and designating when and where fires may be built all contribute to prevention.

LAW ENFORCEMENT

Another general prevention category is law enforcement and the accompanying trespass or collection action. This should not be slighted in a prevention program. All law enforcement should have as its chief goal the prevention of fires. This is true whether it is applied to enforcement of prefire efforts such as rules and restrictions or in the investigation and apprehension of fire starters. It is important to apply the law equally to all people, l it is also important to keep the prevention object foremost in mind. We often do not have choic but where we do, we should stop and appraise. A we doing this or taking this action in a mann that will obtain maximum prevention, or are being vindicative, arbitrary, or too authoritativ

It is established Forest Service policy and pra tice to try to collect both costs of suppression a resource losses from those responsible for starti fires. Many ramifications of responsibility, neg gence, and similar items are involved. An aggr sive program of trying to collect from fire start or those responsible has had a marked effect preventing fires in many places. Since this is specialized activity, we have found trained, fu time law enforcement officers particularly help in areas where there is much of this business; th also provide assistance in areas where person don't have much such business.

Closely related to law enforcement are deterre activities that keep people from violating laws regulations. These have much the same effect the policeman on the beat. They range from "red" fire pickup going up a road to a helicop overhead with a prevention banner. Certain people are more careful if they are being watch Helicopters and airplane patrols have been effe tive in reducing incendiary fires. Night patrols w aircraft have worked well in reducing incendia fires in Missouri. Frequent patrols and "fire-cha ing" helicopters in incendiary areas have been hel ful.

There is another prevention activity I shou mention which cannot be placed within any of t categories I have listed. But it is directly relat to all of these categories. This is the human e gineering or a person-to-person relationship b tween a fire officer and a possible fire start There are many approaches and methods in huma engineering. They range from contact with a know incendiarist to a casual conversation with a fore visitor. Men who spend all or most of their tin on this work are especially desired, but we do have the funds to hire nearly enough of the people. Yet we recognize their great value a hope to hire more.

When I ask field men what they need most improve their prevention work, they often tell n they need more prevention patrolmen or specialist This is an age of specialization, and these men ca develop many new and improved approaches an techniques. Through training these techniques ca be transmitted or improved. In a total preventio

Continued on Page 1

A NEW MOBILE FIRE LABORATORY

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Southern Forest Fire Laboratory
Southeastern Forest Experiment Station
Macon, Ga.

A new mobile fire laboratory being used at the Southern rest Fire Laboratory to scien- cally document both high-in- sity (blowup) wildfires and scribed fires. The unit also be used for investigating ls, collecting meteorological a, and other special purposes. e laboratory has already prov- valuable in the documentation a series of prescribed fires in the monitoring of a wild- during the disastrous spring 6 fire season in South Caro- .

he mobile laboratory is used base station and is the con- and communications center all documentation activities. mary weather observations are en at the mobile unit. Record- meteorological instruments are d for making a continuous rec- of onsite weather conditions oughout the burning period. l moisture is also determined he fire site.

ESCRIPTION OF BASIC UNIT

he basic unit is a 20-foot, dem-axle house trailer drawn a ¾-ton truck. The truck a V-8 engine with an all- el drive. An observation deck been installed on the top of trailer; the deck also provides se for radio antennas and an ometer staff. A compact ratory in the trailer contains nsiderable scientific and elec- ic equipment; much of this ipment is specifically designed fire research. There are also ral facilities such as gas, air, vacuum outlets, an electric ance, and other laboratory ware. A constant operating perature for electronic equip- et is maintained during the summer by a 7,000-B.t.u. air conditioner and in the winter by an electric heater. Electric power is supplied by a 5,000-watt, gasoline-powered generator. An auxiliary 2,500-watt unit is transported with the trailer for use in case of primary equipment failure. Both generators produce 120-volt, 60-cycle current.

FIRE WEATHER STUDIES

A basic requirement for documenting wildfires or prescribed fires is observation of onsite meteorological conditions that affect fire behavior. Relative humidity, temperature, windspeed, wind direction, and barometric pressure are recorded continuously during the entire documentation period.

Relative humidity and temperature are recorded by hygrothermographs in portable weather shelters. A microbarograph is used to continuously record station pressures.

A system utilizing a Gill microvane and three-cup anemometer as sensors is used for wind observations. The anemometer has a threshold value of 1.25 m.p.h. A dual-channel galvo recorder permanently records wind direction and windspeed on a 0- to 50-m.p.h. or 0- to 100-m.p.h. scale. The sensors can be placed at any height desired. However, they are generally used at the 20-foot height (or its equivalent) in the open and at the 4-foot height within the stand. An aerovane coupled to a dual-channel recorder provides a reserve wind-recording system. The aerovane, which is not as versatile or sensitive as the basic system, is mounted on a mast above the observation platform.

Portable equipment—sling psychrometers, Dwyer wind meters, aspirated psychrometers, Biram anemometers, and compasses—is carried with the trailer for onsite readings.

Current observations on atmospheric conditions aloft are restricted to single pilot-balloon soundings (pibals) for determining windspeeds and wind directions. Two theodolites, a helium tank, balloons, a plotting board, and pibal accessories are stored in the trailer. Future observations on winds aloft may include double theodolite soundings.

Now under investigation is a cold-rocket system designed to carry a radiosonde aloft for monitoring relative humidity and temperature from ground level to 5,000 feet. Data will be radioed back to a recorder in the trailer. Relative humidity and temperature profiles can then be plotted and used to calculate atmospheric stability. This setup should provide much needed information on the relationship of stability and extreme fire behavior.

FUEL MEASUREMENTS

An electric oven is used to dry fuel samples for weight and moisture content determinations. Because at least 24 hours are required to ovendry pine-litter samples at 85° C., this arrangement is used only during a long stay in the field. A Karl Fischer titrimeter to permit immediate moisture content determinations is being installed. These measurements will be especially beneficial for use in prescribed burning. An Ohaus moisture determination balance is also used in the fuel moisture measuring system.

FIRE TEMPERATURE MEASUREMENTS

In documenting prescribed fires, fire temperatures are related to time. The principal value of the data obtained is its relation to research being done on lethal time-temperature ratios for control of undesirable species. The measuring system is composed of four temperature sensing staffs, four strip-chart recorders, a multipoint, automatic reference-junction compensator, a control jack-panel, a 1,400-foot extension cable, and four 150-foot fireproof extension cables. Each temperature sensing staff has four chromelalumel thermocouples. These thermocouples are permanently mounted at four heights—ground level, 1 foot, 4 feet, and 8 feet.

Fireproof lead assemblies are used within the fire area to connect the temperature sensing staffs to an extension cable that runs back to the trailer.

The reference junction compensator has a constant reference temperature of 150° F. The recorders have an adjustable span between 0 and 50 millivolts. Each recorder measures temperatures at one specific height (fig 1).

At present, only one temperature sensing staff can be connected at one time. The staffs are placed in the fire area so that, as the fire progresses, the main extension cable can be manually shifted to each firep lead assembly for each res tive staff. However, the sy has been designed so that v more extension cables are ad the switching may be done a control jack-panel rather manually in the field.

PHOTOGRAPHY

Photography is important i documentation of fire beha and fuel conditions. For fire havior, emphasis is placed on or photography because b contrast is achieved between smoke column and backgroun

Different models of 35- cameras are used, but the effective and versatile type

Figure 1.—Data on fire temperature over time will help in determination of lethal ratios for control of undesirable species

re photography is one in which ne lens f-stop and distance set- ngs can be set while the ob- erver is looking through the iewfinder. Black and white pho- ography is done with a 4 by 5 raphic camera.

A 16-mm. movie camera with n electronic time-lapse mecha- ism is used to record the shape, ngle of tilt, motion, and circula- on in the smoke or convection olumn associated with high-in- ensity wildfires.

COMMUNICATIONS

When high-intensity wild- res are being documented, ra- io communications must be aintained with the fire control rganization. Mobile transceivers at operate on State fire-control equencies in the Southeast have een installed in the tow truck nd in a sedan. To supplement ese mobile radios, crystal re- ivers, which can also monitor e State fire control frequencies, ave been installed in the trailer.

To keep current on the weather uation, a surplus Government C-348-R receiver is used for onitoring the continuous trans- ibed weather broadcasts from e Federal Aviation Agency's light Service Station. These broadcasts, covering a 250-mile radius from the station, give a brief weather synopsis, a forecast of significant area weather, a winds aloft forecast, local radar reports (RATEP), and selected pilot reports (PIREPS).

Intracommunication between team members and the mobile laboratory is also essential in documenting prescribed fires. Communications are maintained by a network of portable transceivers. One transceiver is permanently mounted in the trailer and serves as a base station.

ACCESSORIES

Incidental, yet desirable, items for the operation of the mobile laboratory include the following:

1. Tote-Gote trail scooter (valuable for moving documentation equipment into the field and fuel samples back to the trailer)
2. Collapsible anemometer mast (20 feet)
3. Exterior-mounted machinist's vice.
4. Mechanic's and carpenter's handtools
5. Hand-operated winch (1,000-lb. capacity)
6. Screw-type trailer stabilizer jacks
7. Pioneer tools
8. Electrical repair kit with soldering gun
9. Trouble lights and exterior floodlights
10. Assorted hand-held battery-operated lights
11. Office and drafting accessories
12. Small library of pertinent literature
13. Field first-aid kit with oxygen equipment and stretcher
14. Complete set of fire handtools with gasoline-powered trench flailer

SUMMARY

Prescribed fires and wildfires are complex, and collecting accurate scientific data, especially on high-intensity wildfires, is very difficult. The mobile fire laboratory provides a method for thoroughly documenting such fires.

There have been few documentations; therefore, the data have not been used much. However, as more prescribed fires are recorded, detailed analyses will be necessary to interpret the data and provide meaningful guidelines for conducting more efficient and effective prescribed fires. Also, as more wildfires are documented, fire behavior and the variables affecting it will be better understood.

COOPERATORS OBTAIN EXTENSIVE USE OF REGION 6 FIRE SIMULATOR

HOWARD E. GRAHAM, *Forest Service, Portland, Oreg.*

The Region 6 fire simulator as constantly used from late ptember 1966 through mid- ly 1967. It was in Region 6 f r 29 weeks and in Regions 1 a d 5 for a total of 11 weeks.

In Region 6, 530 men received luable training. More than two- t rds of these men were from c operating agencies. Use in Re- g n 6 was as follows:

Agency	Time used (Weeks)	Men trained (No.)
Oregon State Forestry Department	19	275
Bureau of Land Management	2	36
Washington Department of Natural Resources	1	24
Washington Forest Protection Assn.	1	20
Forest Service, Region 6	6	175
Total	29	530

It is planned to make the simulator even more accessible to cooperators. The simulator has been used only at the Forest Service Redmond Air Center, Redmond, Oreg.; cooperators will soon be able to assemble and use the simulator at their own facilities. In preparation, Region 6 personnel have trained cooperator personnel as simulator [illegible]

INCENDIARY PROJECTILE LAUNCHER TESTED FOR REMOTE SLASH IGNITION

John D. Dell and Franklin R. Ward[1]

Burning logging slash on steep, clearcut units in the Pacific Northwest is hazardous work. Dislodged rocks or rolling logs often endanger firing crews working downslope. There is a need for a method of slash ignition that can be done remotely from accessible spots outside the logging unit.

In the fall of 1966, a pneumatic incendiary projectile launcher was tested for slash ignition in the Douglas-fir region (fig. 1). The test site was an 85-acre clearcut unit on the Umpqua National Forest, Oreg.

An earlier demonstration of the launcher had indicated that it might prove effective for backfiring or for prescribed burning.[2] Originally designed as an airborne launcher for smoke markers in antisubmarine warfare, the device can fire projectiles filled with any gel-like fuel.

In the Oregon tests, a commercial diesel-gel product was used. The launcher was pallet-mounted. Bottled nitrogen provided pneumatic pressure. The purpose of the test was to determine if the launcher's accuracy, range, fire-starting capabilities, maneuverability, safety, and ease of handling were suitable for effective remote slash ignition.

TESTS AND RESULTS

The projectiles used were military surplus ite
They were made of wood; they weighed about
ounces, and were 3 inches in diameter and 18 inc
long (fig 2). A delayed fuse ignited the projecti
fuel store about 10 seconds after impact.

To test the launcher's effectiveness and accura
we designated and marked 10 preselected tar
areas. The launcher was first set up on a r
across a canyon 500 yards from the unit to
burned. The launcher, however, could not proj
the missiles further than 350 yards, although
manufacturer claimed to have fired projectiles
far as 500 yards in some previous tests. Only th
rounds were fired from this spot.

We then moved the equipment across the cany
to a position on a landing above the slash unit.
remaining rounds were fired from that positi
down and laterally along the slope. Nearly all
ing was done with the launcher in a mortar p
tion, lobbing the projectile toward its target.
the 18 rounds fired, 10 ignited in the general vicin
desired. The remaining eight projectiles eit
broke upon impact, failed to ignite, or complet
missed the designated target areas. Accuracy—e
at the closer ranges—was only fair. Of the
rounds which ignited slash, eight were withi

Continued on Page

[1] Respectively, Forestry Research Technician and Research Forester, Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.

[2] Nailen, R. L. New technologies field-tested at California brush fire. Fire Eng. 119(2): 49–50. 1966.

Figure 1.—In the Oregon tests, the incendiary projectile launcher was fired up to 350 yards.

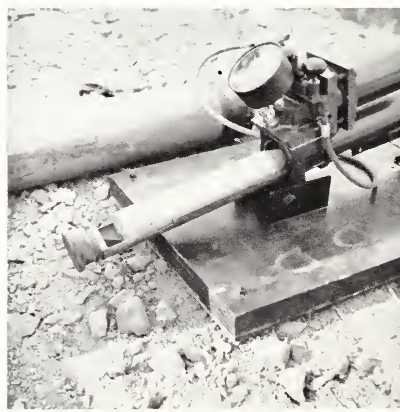


Figure 2.—Exit velocity of projectile is determined by the p sure stored in the pressure chamber, which completely e ties after each firing.

SPRINKLER SYSTEM PROTECTS FIRELINE PERIMETER IN SLASH BURNING

William J. Orr and John D. Dell[1]

Broadcast burning of logging slash on Douglas-r clearcut units nearly always presents some risk. sually, careful planning reduces most of the risk. relines are constructed on unit perimeters, snags e felled, and fire pumps, hoses, tankers, and man wer are positioned for optimum fire control.

A difficult slash burning job may require special ntrol measures. Where water is available, an oscil ing sprinkler system shows promise for pro-tting the fireline perimeter. Such a system can be ed to saturate live vegetation and dead fuels at tical points next to firelines. And the water, if operly applied, can reduce or eliminate both spot-g and fuel ignition by fire radiation.

A simple, effective, and inexpensive sprinkler stem for extra fire protection on slash burns has en developed by fire control personnel of the eet Home District, Willamette National Forest, eg.[2] District personnel have used the sprinkler stem effectively on several difficult prescribed rns. If topography and accessibility are not too verse, a two- or three-man team can usually up the system in half a day. Vegetation outside fireline usually can be adequately saturated in or 5 hours. Sometimes the system is set up the before a burn and operates overnight.

The use of sprinkler systems for slash burning not a new concept. Although use has been lim- in the Pacific Northwest, several similar inkler innovations have been used in recent years the Gifford Pinchot (Wash.) and Mt. Hood reg.) National Forests.[3] In the Kamloops District, tish Columbia, Canada, 30-inch lengths of hard stic pipe for spray nozzles have been used with ne success.[4] Several small holes are drilled into pipe; each section is bowed into an arc with wire. gular 1½-inch hose couplings were fastened pipe ends to permit the attachment of hose line. system uses a pump or gravity-supplied pres- e of 90 to 150 p.s.i.; each sprinkler covers a foot area.

[1] Respectively, Fire Control Officer, Sweet Home Dis-t, Willamette National Forest, Oreg., and Forestry Re-ch Technician, Pacific Southwest Forest and Range eriment Station, Berkeley, Calif.

[2] The sprinkler system was developed by William Orr, Dewey, and George Schram, Sweet Home District, amette National Forest, Oreg.

[3] Anonymous. Slash burning job eased by sprinklers. For-t Industries 93(13): 75, illus. December 1966.

[4] Anonymous. Slash-burn sprinklers. British Columbia uberman, p. 42, August 1965.

THE SWEET HOME SYSTEM

The Sweet Home sprinkler system consists of regular 50-foot sections of 1½-inch CJRL fire hose that distribute water to a maximum of 20 oscillating Rain Bird sprinklers. The sprinklers can be adjusted to any degree of rotation required. Usually 180° is used so that only the area outside the fireline is wet down. The system can cover up to 1,000 lineal feet of fireline. The number of sprinklers that can be operated effectively depends on the capacity of the pump being used and the elevation that the water must be lifted.

Each sprinkler (fig. 1) is mounted on a 4-foot section of rigid galvanized steel conduit connected to a ½-inch tee. A 12-inch length of conduit, with a short piece of ⅝-inch iron rod driven into one end, is connected to the other end of the tee. The rod serves as a spike for driving the sprinkler mount into the ground.

Water is distributed from the main line to the sprinkler mount through a 5-foot length of ¾-inch plastic garden hose. One end of the garden hose is connected to the ½-inch tee on the sprinkler mount. The other end is connected to a faucet and hose line tee. These outlets are spaced at each couplings along the 1½-inch hose line. The faucets allow adjustment of volume and pressure at each sprinkler head so that the maximum number (20)

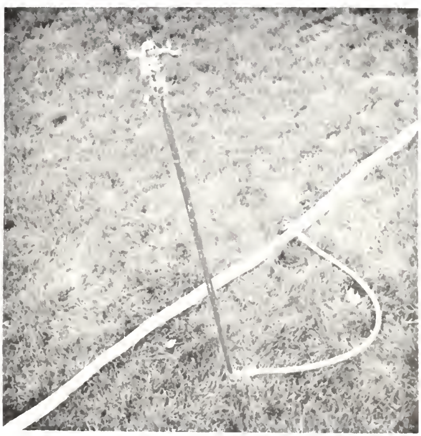


Figure 1.—The main line, sprinkler connection, and sprinkler are shown. The sprinkler is mounted on a 4-foot section of rigid galvanized steel conduit.

can be operated if desired. The adjustments must be made progressively from the lowest to the highest elevation to provide an even distribution over the line.

An Edwards 120 fire pump, capable of 45 g.p.m. at 150 p.s.i., is used with the system. Any pump with an equivalent capacity would be adequate.

Hoses are laid directly on the fireline, with each sprinkler 5 feet outside the line. Mounts are driven into the ground at right angles to the slopes to provide maximum sprinkler coverage. When operating at 180° rotation, the sprinklers provide a 25-foot-wide wet line. At full rotation, the width is doubled. At corners, the sprinklers are set at 270°.

The sprinklers are also useful in mopup operations to wet down smoldering embers in the burn area. The sprinkling begins from the fireline perimeter, and the system gradually is moved inward.

Sprinkler systems often provide the extra margin of safety necessary in difficult areas where steep topography, aspect, fuel concentrations, or poor boundary locations increase the risk of fire escapes. They also increase the feasibility of burning out of the normal season under more severe conditions. Sprinklers are not applicable to all prescribed burning, but they often are useful tools.

EQUIPMENT

In addition to a fire pump and sufficient fire hose, the system requires the following parts and equipment (source of supply shown after description of item): [5]

[5] Many commercial sprinklers are available. The Sweet Home system uses a Rain Bird model No. 25 PJ, which has an output of about 5 g.p.m. at 50 p.s.i.

100 ft. Conduit, rigid galvanized steel, ½ in. (10-ft. sections)—General Services Administration
100 ft. Hose, garden, plastic, ¾ in.—GSA
10 ft. Rod, iron, ⅝-in. diameter (cut in 6-in. lengths) local machine shop
20 Pipe tees, ½ by ½ by ½ in.—GSA
20 Pipe couplings, ½ in.—GSA
20 Pipe nipples, ½ by 3 in.—GSA
20 Hose line tees, aluminum or brass, 1½ in. female 1½ in. male by ½ in. female—Western Fire Equipm Company
20 Faucets, with hose bib, ½ in.—GSA
20 Sprinklers, Rain Bird, full circle—local distributor
19 Hose couplings, ¾ in. (reusable)—GSA
20 Hose clamps, ¾ in.—GSA

ASSEMBLING THE SYSTEM

1. Cut the 10-ft. lengths of ½-in. conduit half, and cut 12 in. off each unthreaded end.
2. Drive half the 6-in. pieces of ⅝-in. rod i one end of the 12-in. section of conduit (use a pr if available).
3. Cut pipe threads on the opposite end and a on the unthreaded end of the 4-ft. piece of cond
4. Remove the male fitting from the 100- length of plastic garden hose and cut into equal lengths. Attach female hose coupling one end of each piece.
5. Slip the other end of the garden hose on ½-by 3-in. pipe nipples and apply hose clamps
6. Sharpen the end of the protruding ⅝- iron rod to a blunt point and assemble at bott end of conduit mount.

COSTS

The cost of the 20-unit (1,000-ft.) sprinkler s tem is about $350, not including the main line h and pump. When costs for assembling are add (about 2 man-days), expenditure would proba total about $400.

POLAROID LITTER MAY BE USEFUL EVIDENCE

CLEO J. ANDERSON, *Forester*
Prescott National Forest

A search for evidence after suppression of a man-caused fire on the Carson National Forest uncovered much common picnic litter and a half-dozen throw-away negative tear sheets from a Polaroid camera. The tear sheets gave us some hope of identifying the offenders.

However, our hopes were diminished when we contacted a photographer to see if an image could be produced from the discarded tear sheets. He called the Polaroid factory and was told it could not be done.

The local FBI agent was then contacted. While he could not assure us, he was very coope tive and said he would see w was possible. The FBI was a to produce a picture from blank-looking piece of black per. This knowledge will be u ful to other investigators w find discarded Polaroid t sheets at the scene of a tresp

FIRE RETARDANT VISCOSITY MEASURED BY MODIFIED MARSH FUNNEL

Charles W. George and Charles E. Hardy, *Reseach Foresters*

Northern Forest Fire Laboratory
Missoula, Mont.[1]

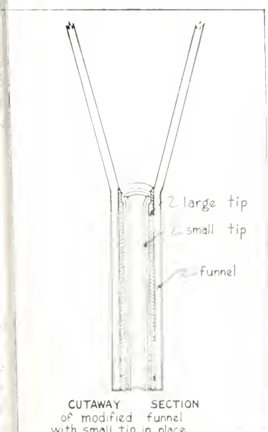
Use of chemical retardants in rest fire suppression is now a mly established procedure. To tain the most effective applica-n, the optimum viscosity for ch retardant is needed. In turn, timum viscosity of each fire ardant depends on the project r which it will be used.

Retardants applied from ground uipment must be viscous enough build up a thick layer on the el, but must remain easy to mp. Those applied from air kers must be more viscous in der to cling together during the op and to reach and adhere to fuel properly.

The viscosity of fire retardants extremely difficult to estimate ually, and most viscometers pable of rendering reliable asurements are expensive and cannot be used in rough field situations.

To provide the measurements of viscosity needed in the field, a Marsh funnel can be modified (fig. 1) for use with all commonly used fire retardants. This funnel has a 6 inch-diameter top, and is 12 inches long. The 10 mesh screen that covers half of the top should not be used as it may change the structure of the retardant. If lumps or impurities are present, pour through screen, but delay viscosity determinations for at least 5 minutes.

Viscosity is measured by agitating the fluid, pouring it into the funnel as high as the screen, and recording the seconds necessary for 1 quart to pass through the funnel (fig. 2). Several fire-retardant materials have a much higher viscosity than that of the drilling muds for which the funnel was designed; thus, the orifice, or tip, is not large enough to accommodate these retardants. However, if the original tip is removed and replaced by a larger one, satisfactory determinations of viscosity can be made. Use of the large tip can be limited to the thicker materials, and the original one can be reinserted for measuring the thinner, less viscous materials.



igre 1.—Cutaway section of the modi-fid Marsh funnel with small tip in place

Figure 2.—Measuring viscosity with modified Marsh funnel

METHOD OF DETERMINING VISCOSITY

There is no single correlation between calibration of the Marsh funnel and that of rotational viscometers (e.g., Brookfield) for all retardants. The two types of instruments respond differently to such characteristics as rate of gelation, gel strength, thixotropy, and density. Consequently, the Marsh funnel must be calibrated for each fire-retardant material. The following method established the relation between viscosity measured in centipoises and in "March funnel seconds":

1. Samples of each retardant were mixed at several viscosity levels. The retardant was not touched for 15 to 18 hours after mixing.

2. A Brookfield model LVF viscometer, at 60 r.p.m. and using spindle 4 (spindle 2 for Phos Chek 259), rendered viscosity measurements in centipoise units. The readings were taken after the spindle had turned for 1 minute in the sample.[2]

3. From the same samples we filled the Marsh funnel to the screen and measured the seconds required for 1 quart to run out the bottom into a graduated beaker. Measurements were made using both the large and small tips. Table 1 shows the relation

[1] The Laboratory is administered by Intermountain Forest and Range periment Station, Ogden, Utah.

[2] Gel and [illegible] retardants [illegible] to the [illegible]. Therefore, stirring was needed for 15 seconds before reading.

Table 1.—*Relation of Marsh funnel time to viscosity as measured by the Brookfield model LVF viscometer at 60 r.p.m.*

[CENTIPOISES]

Time for 1 quart to flow through funnel[1]		Fire retardant								
		Gelgard M		Gelgard F		Phos-Chek		Bentonite, large tip	Fire-Trol 100	
		Large tip	Small tip	Large tip	Small tip	202, large tip	259, small tip		Large tip	Small tip
Min.	*Sec.*									
0	15	....	....	....	...	....	...	500	930	....
0	30	....	20	....	20	....	5	1,875	2,140	....
1	00	550	170	625	153	1,000	136	2,450	2,800	1,460
1	30	700	280	780	275	1,380	274	2,675	2,940	1,810
2	00	820	370	883	378	1,640	413	2,815	....	1,960
2	30	908	442	962	471	1,855	...	2,925	....	....
3	00	980	508	1,038	550	2,010	...	3,005	....	....
4	00	1,098	616	1,180	672	2,315	...	....	....	....
5	00	1,188	...	1,316	...	2,560	...	....	....	....
6	00	1,264	...	1,444	...	2,760	...	....	....	....
7	00	1,327	...	....	...	2,950	...	....	....	....
8	00	1,387	...	....	...	....	...	....	....	....

[1] Funnel must be *full* to screen before testing begins.

between viscosities measured by the Brookfield viscometer and the Marsh funnel seconds equivalents.

INSTRUCTIONS FOR MODIFICATION AND USE

A packet to help field personnel modify and use a Marsh funnel to measure viscosity is available from the Northern Forest Fire Laboratory, Forest Service, USDA, Missoula, Mont. 59801. The packet contains instructions for modification, a drawing of the modification, information on places where a ready modified Marsh funn can be purchased, instructions f using table 1, and an expansion table 1 that covers each 5 secon through 3 minutes and each seconds beyond 3 minutes.

INFORMATION FOR CONTRIBUTORS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be typed in duplicate, double spaced. The author's name, position, and organization should appear directly below the title.

Articles covering any phase of forest, brush, or range fire control work are desired. Authors are encouraged to include illustrations with their copy. These should have clear detail and tell a story. Only glossy prints or India ink line drawings can be used. Di grams should be drawn with t page proportions in mind, and le tered so as to permit any nece sary reduction. Typed captio should be attached to the illustr tions, or included in the te following the paragraph in whi they are first mentioned.

revention Program—*Continued from Page 6*

rogram it is particularly important to provide such raining. Where men cannot devote full time to this vork, other men should put as much time as possible n it. Our prevention men do a lot of complementary obs closely related to their primary contact job. They inventory hazards and try to get them eliminated, inspect permits and uses, put up signs and osters, make group contacts, enforce rules and iws, etc. Some States are doing an outstanding job ith personal contacts. Mississippi has developed a contactors" handbook and is doing an intensive aining job in such work. Results have been parcularly good.

To provide better prevention some special prevention test areas deserve attention. These are mangement units that have had many man-caused fires. n these relatively small areas we try to do a lly adequate prevention job. We improve the fiancing to do what is considered needed. This is n attempt to see if fire prevention work really ys. New innovations or ideas are tried on these eas.

Results of fire prevention research are immeately applied and tested. Several such results are perational throughout the country, and we want ore as quickly as we can finance them. Results to date have been good. Hopefully, ideas developed or proven successful can be extended to other areas.

Fire prevention research is really just getting well underway. However, there are many ways to improve current techniques or approaches to the phases of prevention I have listed. Much research concerning people's attitudes and reasons for starting fires is necessary. We need to go behind apparent causes and perhaps find deeper and real causes. I have long advocated each fire be thoroughly analyzed as to cause and possible prevention, just as automobile accidents and personal injuries are. This idea is still good. Also, equipment can be designed so it is less likely to start fires. There are many opportunities for building fire prevention into forest management without great cost or problems if proper consideration is given.

I could list other jobs and items that are closely connected to prevention and need to be included in a total program. By making friends and influencing people to act wisely in the forest, we are helping fire prevention. If we remove a risk or alleviate a hazard, it should help. All these efforts mean fewer fires, less firefighting, and the saving of more resources. Prevention is sure to pay if well planned and properly directed.

---

ojectile Launcher—*Continued from page 10*

-yard target area; the other two ignited slash but re farther away from the desired ignition spot.

These firings were made only to determine the uncher's practicability as a technique for slash rning. No attempt was made to determine sts of the launcher or its accessories.

CONCLUSIONS

The launcher, in its present form, does not seem erational for slash burning. It seems fairly equate for maneuverability and safe and easy ndling. Its range, 300 to 400 yards, is suitable most slash ignition use. The greatest limitation the launcher is its lack of accuracy—a necessary equirement for effective slash ignition where ls are concentrated but not always continuous.

Primarily, the launcher needs a rangefinder to nprove accuracy. A slightly smaller bore should nprove accuracy and help the projectile achieve eater velocity. A modified projectile with builtin fins would probably prevent "tumbling" in midair and further improve accuracy. Also, weight could be reduced and maneuverability improved by replacing the present pallet mounting with an adjustable tripod. And some weight might be reduced at the breach. Petroleum gels are usually quite effective as fire starters when carefully placed in a good fuel bed, but they sometimes failed to produce satisfactory ignition with the projectiles used in this test. A fuel store consisting of a napalm-type material, when detonated, might produce better fire dispersal. Although the launcher failed to meet all the objectives set forth, this test helped indicate the engineering modifications needed to make the device operational.

EDITOR'S NOTE: *A formal project to develop a projectile launcher system for igniting slash fires was started at the Missoula Equipment Development Center in 1966. A prototype system has been developed under a subsequent contract, and is being tested during the current season. Results of this project will be available at a later date.*

HELITANKER PREVENTION SIGN PROVES VALUABLE

E. F. McNamara, *Chief, Division of Forest Protection*
Pennsylvania Department of Forests and Waters

Since Pennsylvania first used helitankers (in 1960), they have proven to be effective fire prevention tools. The State's entire airtanker program is based on placement of aircraft in areas of high fire occurrence. When helicopters are under contract, there is a marked reduction of fires in areas with a high rate of incendiary fires.

We have long wanted to install a high-visibility sign on the helitanker to identify it as a forest fire control unit. Such a sign would increase the fire prevention effectiveness of aircraft. However, we had to decide what type of sign was needed and how it should be secured to the helitanker.

During the 1966 fall fire season we experimented with two signs of 70 by 22 inches painted on 1/8" tempered hardboard. These signs were first painted with fluorescent international orange paint and then lettered with 7-inch black letters. The signs were secured by brackets to the skid cross members on both sides of the helicopter. The installation was approved by the FAA inspector. Both the reaction from the public and the reduction in fires in the test area convinced us that the signs were very effective in reminding people to be careful with fire in or near a forest.

Figure 1.—This helicopter is used in Pennsylvania's fire prevention campaign.

During the 1967 spring season each of five Bell helitankers under contract to the Division of Forest Protection were equipped with two signs (fig. 1). Again all installations were approved by the FAA.

Constant vibration damaged t structure of the hardboard the original pair of signs. The fore, the 1967 signs were made three different materials: 1/4" p wood, corrugated vinyl plast and aluminum. The three mate als will be thoroughly inspect after the 1967 contract period determine which is the m suitable.

FIRE CONTROL NOTES

PARTMENT OF AGRICULTURE / FOREST SERVICE / JANUARY 1968 / VOL. 29, NO. 1

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contr

CONTENTS

COVER—Typical chaparral-covered watershed, Angeles National Forest, Calif. See story on page 3.

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

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WHAT ARE WE GOING TO DO ABOUT THE BRUSH IN SOUTHERN CALIFORNIA?

Keith E. Klinger[1] and Carl C. Wilson[2]

The Spanish vaqueros had a name for it—"chap-o"—from which we get the name "chaparral." t more often we call it brush. Like today's fire-hters, the vaqueros probably cursed the dense nd of shrubs covering the mountains of southern lifornia. It was an obstacle to foot and horse trav- Though the Indians were using the nuts, berries, l seeds of several of the plants for food and dicine, the early settlers found the brush of lit- economic value. It was expensive to convert to hards or pastures. And it burned like tinder. A early naturalists, however, recognized the que beauty and watershed value of this plant mation.

Ve will examine both the assets and liabilities brush: its value as a vegetation type, and its ard as a fuel and what we can do about it.

California redwoods are known throughout the rld, but few people have heard of what south- Californians call their "elfin forest."[3] This for- consists of some 5 million acres of chapar-—a mixed formation of low, hard-leaved, stunted s and shrubs. This growth is the result of short, , cool winters, and long, arid, hot summers. aparral grows slowly—shrubs 25 years old may rage only 2 or 3 inches in diameter and 5 or 6 in height. It includes more than 150 species of ody plants. Chamise, manzanita, ceanothus, su-, sagebrush, scrub oak, and buckthorn repre- 90 percent of the growth.

n the United States, this type of forest growth urs chiefly in southern California. Similar nt formations are found along the coast of le, in Europe and Asia, along the Mediter-ean, in Africa near the Cape of Good Hope, and the southern and southwestern coasts of Aus-a and Tasmania.

he chief economic value of chaparral is its ty to control erosion and promote rapid infil-on and thus help conserve ground water. Chap-l also provides food and cover for game ani s and birds.

THREE BEST-KNOWN BRUSH SPECIES

he most abundant of the chaparral species in afornia is chamise (*Adenostema fasciculatum*). It grows almost everywhere throughout the range of the chaparral. Some botanists have estimated that it makes up about one-third of the cover. Chamise grows from sea level to 5,000 feet. It resprouts readily after a fire, and its longlived seeds germinate abundantly under the ashes in the mineral soil. This plant is easy to recognize because of its small, needlelike, olive-green leaves. It blooms late in the spring after most other brush species have flowered. Then, about mid-June the mountains become white with its bloom. Later, the chamise fields turn a rusty color as the blossoms fade.

The second most common shrub is scrub oak (*Quercus dumosa*). This plant is often dwarfed in stature—sometimes not more than 5 to 6 feet tall. The crooked trunks and branches are stiff and tough, and the thickets are almost impenetrable. In good seasons some pure scrub oak stands bear a crop of acorns estimated at several tons per acre. Scrub oak can resprout from its root crown after fire. This characteristic helps make it one of the more persistent brush species. Hormone brush killers like 2, 4,-D will kill chamise, but scrub oak seems to thrive on brush-killing chemicals and is known as a "hard-to-kill" species.

A third species—California sagebrush (*Artemesia californica*), a sister of the Great Basin sagebrush (*Artemesia tridentata*)—is common in many parts of the chaparral belt. Its ashy, gray green foliage is similar to its desert relative, making it easy to distinguish from the other shrubs. It is not as aromatic as the Great Basin sagebrush, but it still has a penetratingly pungent odor when one wades through it on a hot day.

THE CHAPARRAL HAZARD

Fire behavior experts say that chaparral is the most flammable brush in the United States. Its litter and dead portions usually are easily ignited, and almost every fire is a crown fire because of the horizontal and vertical continuity of the fuel. Despite many studies of this unique fuel type, there is still much to learn. We have good evidence, though, that chaparral poses formidable problems in fire control.

For example, fuel classification and measurement procedures devised during Operation Firestop[4] showed that representative ovendry weights

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[2] ssistant Director, Pacific Southwest Forest and ange Experiment Station, Forest Service, USDA, Berkeley, Calif. He is stationed at Riverside, Calif.

[3] ultz, Francis M. The elfin forest of California. Los ngles Times Mirror Press, 267 pp., illus. 1923.

[4] Operation Firestop was a cooperative experimental program conducted in 1954 by the agencies and research organizations in California. The sponsors were: Los Angeles City Fire Department, Los Angeles County Fire Department, California Division of Forestry, U.S. Forest Service, and Federal and California civil defense agencies.

for typical stands were:

1. California sagebrush (mixed about 50-50 with white sage): Average height of 4 feet and about 5 tons per acre.

2. Chamise (83 percent of the stand): Average height of 4 feet and nearly 7 tons per acre.

3. Scrub oak (99 percent of the stand): Average height of 7 feet and about 21 tons per acre.

Let's examine the fuel values more closely. If we take 20 tons per acre of scrub oak at 8,500 B.t.u. per pound, we find that we have about 340 million B.t.u. per acre. Therefore, only 40 acres of dense scrub oak is required to produce the equivalent of 20 kilotons of thermal energy. That's equivalent to the energy of a bomb that could destroy a major city. Of course, this energy isn't released as rapidly as that of an atomic bomb. However, the Conejos Fire of 1950 in San Diego County burned about 63,000 acres in 63 hours. Assuming 20 tons of fuel burned per acre, that's equal to 25 bombs per hour. That's a lot of energy.

However, the ease of ignition, rate of combustion, and total thermal energy depend not only on weight but also on the arrangement, species, and, very important, on the amount of moisture in the dead and living fuels.

The moisture in light, dead brush fuels is closely related to the current humidity and temperature. However, the moisture of living chaparral in southern California usually follows a definite seasonal pattern (fig. 1). In late winter and early spring the plants put on new growth, and the moisture content of the plant increases quickly to its highest seasonal level. The new growth then matures and becomes relatively dormant during late summer and ea fall. The plant's moisture content then remai near the minimum seasonal level until new grow starts again. As an extreme example, living chami can contain 100 percent moisture in May or Ju —about 2,000 gallons of water per acre. But l October moisture can drop to 50 percent—1,0 gallons of water per acre. Obviously, the diffe ence in the amount of water in the live brush ca have an important influence on fire ignition an spread.

More recently, fire researchers have also learn that the highest crude fat content of chamise o curs when the moisture content of the plant is lo est. This is another reason why this fuel is so e plosive during extended dry periods.

ACTION AGAINST BRUSH HAZARDS

We have a hazardous vegetative type, but wh can we do about it? There are three possibilitie (1) Replace the existing hazardous fuel wi "fire-resistant" plants, (2) "light burn" the chapa ral regularly, or (3) do selective fuel-hazard redu tion.

First, let's take a look at what have been call "fire-resistant" plants. A report of studies by t Los Angeles State and County Arboretum says:

"The term 'fire resistance' refers to the bur ability of certain species in comparison to th of chamise or scrub oak, two common chaparr species. The species being compared must grown under similar conditions. Otherwise, fa tors of soil moisture and climate may lead to e roneous conclusions. The studies at the Arbor

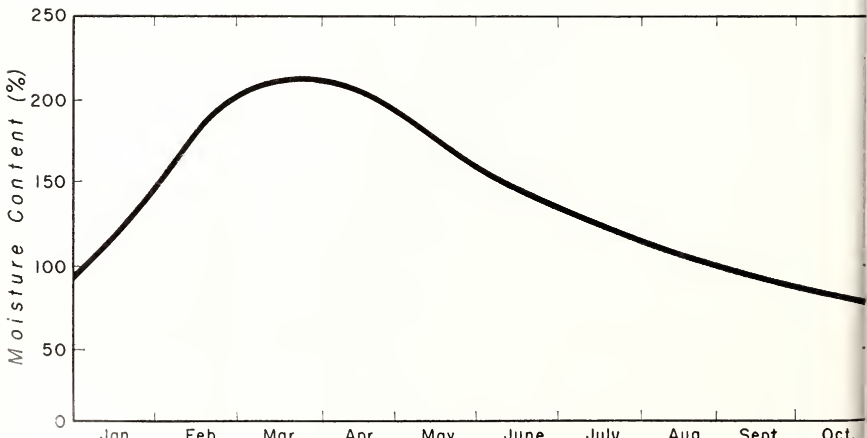

Figure 1.—Moisture content of chamise new growth, percent (typical curve).

tum have been made with this point in mind. And burning tests are made with plants grown under comparable conditions."[5]

Researchers at the Pacific Southwest Forest and ange Experiment Station are conducting limited idies on purported slow-burning plants such as stus. But they have been unable to identify plants at they can class unequivocally as "slow burning." ne Station staff is also looking for plants that are v in stature (less than 1 foot high) and fuel lume, that resist drought and damage caused by imals, and that will control soil erosion.[6] This not a very simple order.

Our researchers have selected some shrubs to nt on fuel-breaks to test flammability. The most eresting shrubs are a low-growing saltbush *triplex canescens*) and squaw carpet (*Ceanathus ɔstratus*). But rodents eat the saltbush, and squaw rpet doesn't seem to grow well at lower elevans. We aren't proposing, however, to stop seeking producing "slow-burning" or "low-fuel-volume" nts. We think there are opportunities here, but do not believe there is any present possibility t we will be able to replace all the native species h introduced species. Neither nature nor the taxer would permit it. In any case, it is highly unely that this type of plant will be the panacea all brush problems in southern California.

Vhat about light burning? Why don't we burn the brush every few years so that a stockpile of ardous fuels doesn't accumulate in our waterd?" This question has been asked by numerous men and scientists. Here's our partial reply.

n 1954, during Operation Firestop, we measd fuels before and after light burns on three test s. These burns were conducted in August and tember under ideal fire control conditions.[7] ative humidities were higher than 30 percent, winds were less than 10 m.p.h. The fires were ted with drip torches, and all were set to burn the wind. Under these easy and safe condis, only the lightest fuel types burned comely. Burns in chamise were spotty, and scrub burned slowly.

he spotty chamise burns actually increased the hazard by killing some plants without consumthem. Also, the heavy fuels, such as scrub oak, ch can develop the most intense wildfires, would not burn under weather conditions when safe control could be assured. We think our answer today for the enthusiastic proponents of wide-scale light burning is about the same as it was in 1954: largescale light burning in southern California straddles a fireline between twin risks:

> *(a) burns which increase the hazard rather than reducing it and (b) "controlled" fires which cannot be controlled.*

A few successful light burning tests have been conducted in southern California during the past decade. They suggest that light burning may be useful in developing fuel-breaks or safety zones for firefighters, particularly if we modify the fuels prior to burning. But this technique has not been tested enough to warrant extensive use in southern California. More studies are needed to determine the range of weather and fuel conditions under which prescribed burning can be used safely and effectively.

Thus, the most logical of the three alternatives is fuel hazard reduction. Fuel is reduced or removed from areas where fire is most easily kindled—along roads, around residences and structures which are adjacent to or in the brushfields, and where there are vast expanses of chaparral. In the long run, we think this is the best answer.

In line with this, the California fire agencies have been conducting a cooperative research and action program called "Fuel-Break" since 1956. Its primary aim is to modify the brush fuel at strategic locations to break up the large unbroken areas of chaparral (fig. 2). On carefully selected sites, the brush is permanently changed to vegetation of light weight, low fuel volume, or low flammability, or all three. These areas, called "fuel-breaks", are at least 200 feet wide. They facilitate fire control because they can be manned soon after initial attack is started on a brush fire.

Fuel-breaks are constructed to aid in the control of fires under extreme burning conditions that ordinarily hinder control in unbroken brush fields, especially on steep terrain. But unmanned fuel breaks are not necessarily intended to *stop* a fast moving fire because spot fires commonly occur well beyond the head of such fires. These prepared breaks, however, can be safely manned for offensive action against headfires, and can help stop the lateral spread of the fire. Therefore, the fires can be confined earlier, and the area burned reduced.

More than 500 miles of fuel breaks have been constructed in southern California; about 63 percent are more than 200 feet wide. Also, 5,624 acres of brush has been converted to grass for range or wildlife management. These areas, where possible, are tied into existing fuel-break systems. Much more

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Findings of Governor Brown's Study Committee on flagrations, California. 1965. (Unpublished report).

Green, Lisle R. The search for a "fire resistant" plant outhern California. California Div. of Forestry Fire r. Exp. 10, 12 pp., illus. August 1965

Chandler, C. C. "Light burning" in Southern California . U.S. Forest Serv. Calif. Forest and Range Exp. Res. Note 119, 2 pp., 1957.

Figure 2.—Grass-covered fuel-break in the North Mountain Experimental Area, east of Riverside, Calif.

needs to be done, and fortunately guidelines are now available.[8]

For the selective fuel hazard reduction program to move ahead rapidly and to be most effective, everyone must "get into the act!" Public utility agencies should study, design, and develop fuel-break systems in their high-risk areas. Planning commissions should consider the use of treated sewage effluent for the irrigation of "green belts such as golf courses, cemeteries, and fuel-breal around mountain communities. Public fire agenci must also remain alert to the need for protectir the lives of the millions of people who visit park picnic areas, and campgrounds, and who trav along highways in the brush-covered mountain Safety zones and safe entrance and exit rout should be an integral part of their overall plan Finally, each resident (1 of 20 Americans no live in southern California) must maintain his ow property. He must assume the responsibility fo

Continued on page 1

[8] Fuel-Break Executive Committee. Guidelines for fuel-breaks in southern California. Fuel-Break Rpt. No. 9, 25 pp., illus. Pacific Southwest Forest and Range Exp. Sta., Berkeley, Calif. 1963.

THE RESOURCE LOCATOR—A DISPATCHER'S AID

James W. Jay[1]

Dispatchers and fire managers must maintain a nstant inventory of available firefighting re- urces. They must also keep an up-to-the-minute cord of mobilization and dispatching actions. Usu- y logs, notebooks, and clipboards are used to pport their memory.

Most dispatchers experience peak periods when ese records and their memory are inadequate. eeded data are buried by records of subsequent tion. Items are forgotten. Dispatchers are es- cially handicapped during shift changes—a 1- or hour shift overlap is common during fire busts permit relief dispatchers to become acquainted th the status of dispatching action.

CRITERIA FOR A SATISFACTORY SYSTEM

A system capable of overcoming these difficul- s is needed. Certain basic data should be visually splayed. Storage, updating, and recall of informa- n should be rapid and uncomplicated. The sys- n must be quickly adaptable to various situations d levels of operation. It must be dependable and nple enough to be used with minimum instruc- n.

Cost is equally important. Electronic computer uipment could probably fill most requirements, the necessary investments would severely re- ict the number of units in use. This would defeat basic aim—a simple system with widespread plications at all levels.

To be useful, the system must permit some choice what information is displayed for quick refer- e, and what is stored for ready recall. The data layed should be limited to that which can be dily comprehended and used in making decisions. every relevant item were shown, the mass of in- mation would be too great to be of value.

THE RESOURCE LOCATOR

A system meeting the general requirements has n developed. While the basic concepts are not v, their application provides a simple yet effec- e means of maintaining a current inventory and ord of the mobilization and dispatching of man- ver, equipment, and supplies.

The prototype model consisted of a set of card wall racks and blank cards. Eight racks were used; each had a capacity for twenty-five 5- by 8-inch cards. The racks were mounted in a specially constructed carrying case (fig. 1). Other sizes could readily be designed to meet specific local needs. In dispatching offices the racks could be mounted on the wall. For field use, such as in fire camps or for lookout-dispatchers, a compact model using smaller cards may be more suitable.

USE OF THE SYSTEM

Each resource item is represented by a card. The name, number, etc. of the item is written along the top edge. This is the "displayed" information when the card is in the rack. "Stored" information, including any necessary permanent data (rental rates, specifications, home base, etc.) and current dispatching information are written on the lower portion and back of the card. Color coded cards can be used for the various categories of resources. However, excessive coding may destroy simplicity.

The basic system can be easily adapted to various situations. At a dispatcher's headquarters, the card racks can be labeled "Inventory", "In-Transit", and "Assignment." When resource items are known before they are ordered or dispatched, cards would be prepared and placed in the Inventory rack as a display of available resources.

As a resource is requested or is dispatched, its card is pulled from Inventory, or a new card is made. Appropriate dispatching data (fire order number, time, destination, ETA, method of travel, etc.) would be posted on the lower portion, and the card

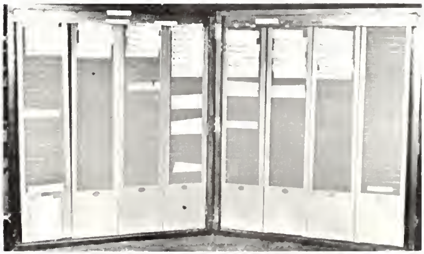

Figure 1.—These eight card racks in a carrying case can display 200 resource cards.

[1] Formerly Fire Control Specialist, Washington Office, Division of Fire Control (Retired).

would be placed in the In-Transit rack. On confirmation of its arrival, the item's card is posted and placed in the Assignment section. This provides a constant display of the resources assigned individual fires, by Forests or other category.

When demobilization occurs, the process is reversed.

The same system, with only minor revisions, could be used at a fire headquarters. Racks could be labeled "Ordered," "In-Transit," and "Assignment." Here, the assignment grouping could be by Sectors, Divisions, day or night shift, etc. Thus, the top fire overhead would have a constant visual display of the current status of all resources relevant to the situation.

The flexibility of the basic system permits it to be used in many individual situations at various levels. However, if too many items are displayed, the value of quick visual reference is lost. Where many resource units are involved, it must be decided whether summaries or only segments of the mobilization should be displayed. If only summaries of the resources are displayed, the detailed data on the resources can be stored on individual cards kept in tub files for quick reference (fig. 2). For example, if it were necessary to maintain a record of a large number of crews, the display would show the total number available, in-transit, or assigned by appropriate category (fire, Forest, etc.). Detailed information on each would be recorded on cards stored in similar sections of the tub file. As the crews were shifted, the summary cards would be updated, and the individual card posted and moved to the appropriate file section.

The resource locator system was tested and used during the 1967 fire season, and personnel were generally enthusiastic. In two cases, the system was set up without card racks—once even by using shipping tags thumbtacked to cardboard cartons when cards are not available.

CONCLUSIONS

Use demonstrated that the system is an effective aid in several operations, and can significantly assist dispatchers and others in keeping control of past and current mobilization action. The basic concept of the system is simple and easily understood.

a. Prepare card identifying each resource

b. Post all actions pertaining to the item o card.

c. Move the card to the appropriate display the item moves.

By recording and displaying the data in this ner, a permanent record of action is availab quick recall. The chances for double order rors, and oversight are reduced, and manag and decision making are improved.

ASSEMBLING THE SYSTEM

Standard 5- by 8-inch cards are used for re ing the resource item information. Blank card be used, with all headings, etc., handwritten time of use, or the cards can be printed w standard format. Gummed labels or embossed tic tape can be used on the racks to identify res categories.

The wall racks should provide for 1-inch sure of the card. Suitable racks can be obt from office suppliers. Each 25-pocket rack about $10.50.

Figure 2.—Tub files can be used to store up to 2,000 c the number of items becomes too large for all of the to be displayed.

PRECOOKED FROZEN MEALS FOR FIREFIGHTERS

ARTHUR H. JUKKALA, *Forester*
Missoula Equipment Development Center

During the 1967 fire season, many firefighters the Northern and Intermountain Regions en- yed hot meals prepared by excellent chefs in odern kitchens hundreds of miles away. This was ade possible by several years of testing of military d commercial meals by the Forest Service Equip- ent Development Center in Missoula.

In the fall of 1965, the Center and the Armour ompany began work on precooked frozen meals r firefighters. These meals contain U.S. Choice eats, or Grade A fish and poultry. Menus are entifically selected in Armour's basic foods lab- atory and are prepared by expert chefs. After oking, the individual food items are vacuum aled and flash frozen to –70° F.—a big factor retaining flavor. Before being served, the meals quire only heating in boiling water or steam.

Several hundred of these meals were tested dur- the summer of 1966. Very favorable results were ained. A larger quantity was ordered for the lowing season, and in 1967 about 16,000 meals re eaten by personnel of Forest Service Regions nd 4 and the Bureau of Land Management— h in firecamps and on the fireline.

n 1967 the following menus were tested:

Breakfast	*Dinner menu 1*	*Dinner menu 2*
nadian bacon	Sliced roast beef with gravy	Sirloin beef tips with mushroom gravy
liced fried potatoes	Peas with butter sauce	Peas with butter sauce
erry compote	Bread (3 slices), buttered	Bread (3 slices), buttered
rench toast (4 slices)	Potato tots (deep fried)	Potato tots (deep fried)

ls were packed 12 per case in an insulated car- n (fig. 1). Beverages and desserts were not in- ed. Cups, serving trays, and utensils were ked with the meals. Each meal had 1,500-2,000 ries and weighed about 1½ pounds. The ave cost was $2.70.

t 0° F., the storage life is 2 years. When re- ed from the freezer, the meals should be eaten in 36 hours (recommended for Forest Service se) MEDC engineers devised a simple steam er from a 32-gallon G. I. can. It will hold 33 els (fig. 2). In field tests the heater proved e practical and efficient.

Figure 1.—Twelve individually vacuum-sealed, precooked meals.

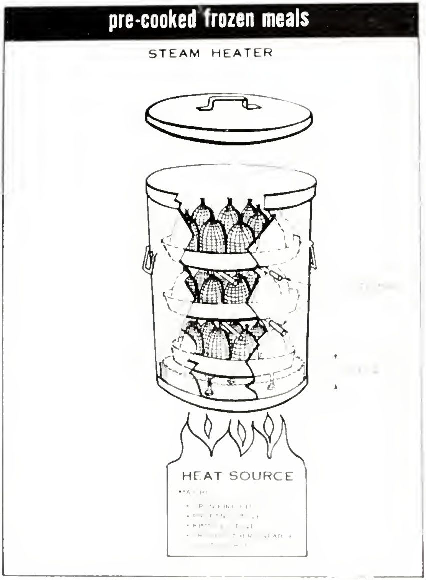

Figure 2.—Steam heater for precooked frozen meals.

Precooked frozen meals have many advantages for feeding firefighters. Since they are packaged in proper proportions, there is little or no waste.

Continued on page 16

PENNSYLVANIA'S NEW CUSTOM-BUILT FOREST FIRE TRUCK

E. F. McNamara, *Chief*

Division of Forest Protection
Department of Forests and Waters

The Pennsylvania Department of Forests and Waters received 10 custom-built forest fire trucks in early 1967. These trucks were received as a result of 4 years of work with manufacturers of specialized firefighting equipment (fig. 1).

The chassis is a 1-ton military power wagon with a custom-built body. The standards and design were developed by personnel of the Division of Forest Protection in cooperation with personnel of the Automotive Bureau, Pennsylvania Department of Property and Supplies. Each truck is equipped with the following:

1 300-gal. tank
1 Hale model 20T pump
1 Hale model FZZ pump
300 Ft. of ¾-in. hose on live reel
500 Ft. of 1½-in hose (rolled)
2 Hose laying platforms
1 ¾-in. nozzle
1 1½-in. nozzle
3 10-ft. sections of 2½-in. suction hose
1 10-ft. section of 2-in. suction hose
Miscellaneous hose adapter, connections, and valves
8 Backpack pumps
1 Chain saw
12 Fire rakes
2 Shorthandled shovels
3 Axes
1 Brush hook
3 Sandvig brush axes
1 Backfire torch
4 Hardhats
2 Fire extinguishers (CO_2 and dry powder)
1 First aid kit
1 Dual-frequency radio transmitter

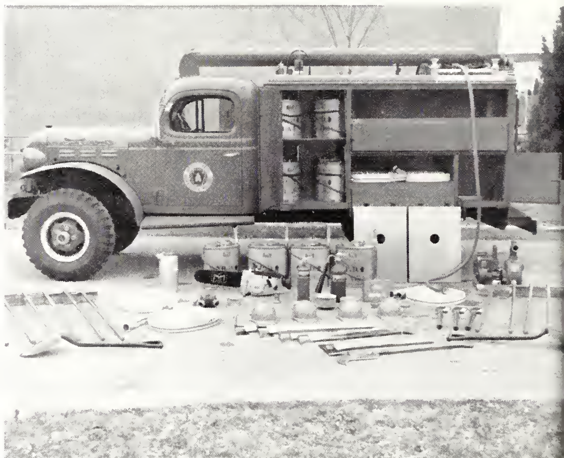

Figure 1.—The new trucks easily carry an assortment of firefighting equipment and 3 gallons of water.

The vehicles are painted red and are equipped with warning lights. The custom body is made of 16-gage steel, with 11-gage steel bottoms in the tool compartments. The interior of the compartments have wooden slats on the bottom to protect the handtools.

The hard suction hose is carried in an easily removable ho rack mounted on top of t truck. The spare tire is located the top of the 300-gal. tank. Tw portable spotlights are recess in rear compartments.

Each of the vehicles has be assigned to a high fire haza area. The units will respond to a fire call in areas with limit volunteer fire company coverag

The easily identifiable truck readily available for all fire call are definite fire-prevention a sets and comprise an effecti fire-suppression unit.

SIMULATING PRESCRIBED FIRES—A NEW TRAINING TECHNIQUE

Robert W. Cooper[1] and Archer D. Smith[2]

Prescribed burning, now an [i]mportant forest management [to]ol in much of the United [St]ates, requires an adequate sup[pl]y of trained personnel if we [ar]e to realize maximum poten[tia]l from its use. In past years, [ho]wever, difficulty in scheduling [fi]eld exercises during favorable [bu]rning weather has limited de[ve]lopment of competent trained [fo]rces.

The principle of simulation [se]emed to provide a partial an[sw]er to this training problem. In [19]66 for the Forest Service-con[du]cted research seminars in [pr]escribed fire at the Southern [Fo]rest Fire Laboratory, we de[cid]ed to use the Fire Control [Si]mulator[3] for the important [bu]rning exercises (essential sup[ple]ments to classroom sessions). [Th]e Forest Service Simulator [wa]s sent to the Laboratory at [M]acon, Ga., and Forest Service [So]utheastern Area and Southern [Re]gion personnel developed pre[scr]ibed fire exercises.

The results justified the ef[for]t. Simulation of prescribed [fir]e bridged the gap between [cla]ssroom and field. After hear[in]g general principles in seminar, [tra]inees were divided into burn[in]g and critique teams and faced [wit]h a variety of burning situa[tio]ns under certain fuel and [we]ather combinations (fig. 1). [We]ather was no problem—it was [c]reated as needed. Ground rules

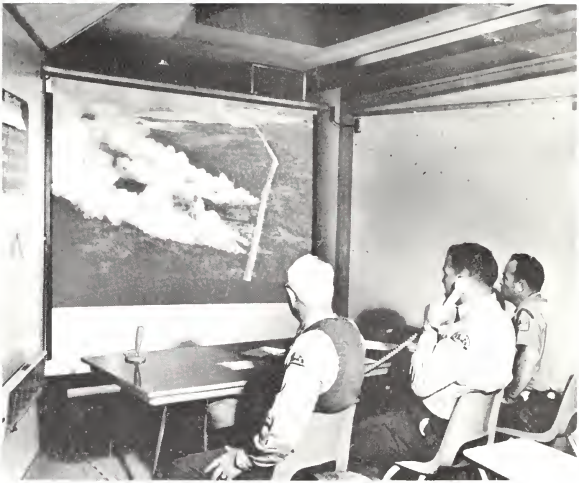

Figure 1.—Trainees make decisions concerning the prescribed burning operation as they observe fire behavior and strategy on the Simulator screen.

were laid down, and slides of the problem area and closeups of fuel conditions were projected on the screen. Trainees were also given a sketched map (fig. 2) and briefed on the situation. The burning team's role was to consider and decide on feasibility of burning, proper firing techniques, advance preparations, and control strategy. A day's burning schedule, including planning, preparation, execution, and evaluation, was compressed into a 1-hour exercise through a fast clock where 15 minutes of exercise time equaled 1½ hours of fuel time. Upon completing the exercise, the burning team conducted an evaluation and critique.

The burning team maintained radio communication with the dispatcher and the field crew (Simulator crew) and had a view of the field operations throughout (fig. 3). For training purposes, the dispatcher and the field crew could not contact each other directly.

To keep the exercise moving and to force prompt decisions, the dispatcher and Simulator crew generally ended radio messages with a question. All decisions and instructions were simulated without regard to their applicability. Initial anxiety of the Simulator team about their ability to respond to directives quickly disappeared. As they gained experience and confidence in simulating prescribed burns, they were able to follow dictated actions promptly and precisely, as well as to enliven the exercise with additional stress situations.

The critique team watched from the rear and, after the evaluation and critique by the burning team, discussed the exercise and the decisions made. The Simulator director, or a designate, led the critique. No comments or suggestions were per-

[1] Research Forester, Southern For[e]st Fire Laboratory, Macon, Ga. The [L]aboratory is administered by the [S]outheastern Forest Experiment Sta[ti]on, Asheville, N.C.

[2] Forester, Southeastern Area, State [a]nd Private Forestry, Atlanta, Ga.

[3] O'Neal, N. C., and Holtby, B. E. [T]he fire control simulator. Fire Con[t]rol Notes 24(2): 25–31. 1963.

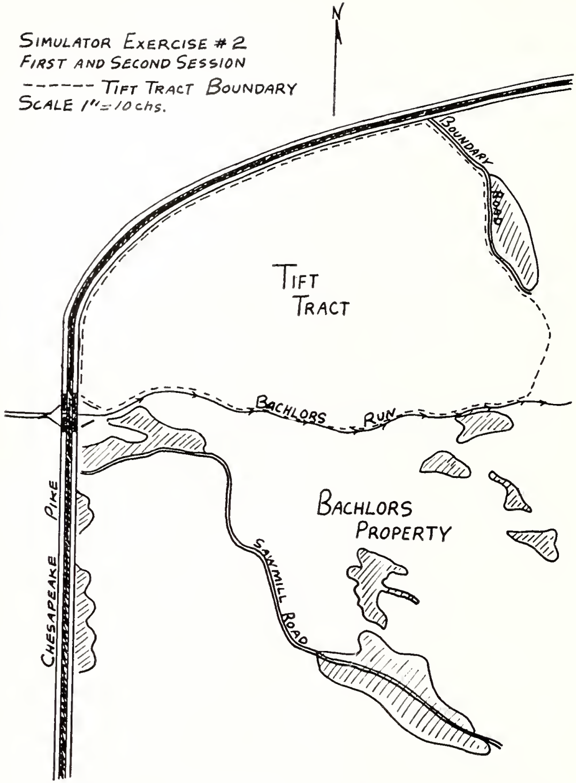

Figure 2.—Sketch of company's holdings (Tift tract) used in prescribed fire exercise.

mitted by the critique team while the exercise was in progress.

The following script is a sample exercise:

SIMULATOR PROBLEM

Hardwood Control—Seedbed Preparation

You are a forester with the Dry Branch Paper Company and are responsible for planning and conducting prescription burns on its land. Your right-hand man is a technician who does most of the field burning under your guidance. In this year's work schedule, a tract of forest land has been set for spring burning. It is now the last week of April. The tract is in southeastern Virginia. It supports a merchantable stand of loblolly pine ready for harvesting, but also has a well-stocked understory of undesirable hardwoods. Regeneration will be by the seed-tree method. You have decided a burn for hardwood control and seedbed preparation is needed before cutting. Today you are in a tower overlooking the area to be burned. You have asked your technician to check it and be prepared to burn if things agree with yesterday's favorab weather forecast. The tract is fl with gentle hills. Free of fire f at least 10 years, it has mostly pi litter fuel—moderate to heavy, tons per acre—with only min herbaceous material available f additional fuel. The cast characters includes the foreste technician, dispatcher, and T crew leader.

Scene 1: (Explain scale, d rection; hand out map. Slides 3, and 4 show aerial oblique a closeup shots.)

Set clock: (It is now 10 a.m

Start Exercise

Technician to Forester—Th is Al. We'll reach the Tift tra about 10 a.m. You asked me check in with you before we sta any burning. What are your c ders?

Fade in Scene 1

Forester—(Would probab ask for onsite weather and fu conditions. Should check wi dispatcher concerning weather may call technician and tell hi where to put lines).

Dispatcher—According to th morning's forecast, we shou have northwesterly winds abo 8 m.p.h. Afternoon, clear ski maximum temperature 68° minimum relative humidity percent, estimated fuel moistu 10 percent, buildup index 16, a spread index 12. I think this m be the day you've been waiti for. You asked that I send thr men and a tractor operator w the technician. Our other fo men are out on Jackson's F doing TSI. Our other tractor is headquarters.

Technician to Forester—Thin look pretty good. Most of t dew is gone. Winds in the sta are light, mostly from the west doesn't look like they'll be a problem. It's clear and the feels dry. What do you want to do? (If so, where?)

Forester—Yes, I think thin look okay. We can go ahead w

[Fig]ure 3.—Closeup slides of fuel conditions and firing techniques kept viewers abreast of onsite developments.

n operation. (He proceeds to e the technician where to put n lines or whatever he wants ce, and how to fire.)

Dispatcher to Forester—You ember that Sug was replacing n tracks on our other tractor. He reports that it's ready to go o, but wonders whether he uld make the 100-hour overal today while the Cat is in the p.

Forester—(Should say no—ep it on standby).

Dispatcher—TSI crew just ed in and said that the surface ind had picked up on their area the extent that the mist blow r wasn't doing much good. I told m to secure operations there n move over to Route 49 where rman is grading—there are some culverts there that need cleaning out. Okay?

Forester—Okay. (Might suggest to dispatcher that he keep in touch with this crew in case it's needed. Probably should ask for a later weather report. If asked for forecast, dispatcher will say that he hasn't anything beyond the 10 a.m. prediction—should he ask for a special forecast? Forester should say yes. Special forecast should indicate winds of 10, gusts to 15.)

Forester—(Should call technician and tell him about the special forecast; ask him how the fire is doing. If forester doesn't ask for forecast, technician should call in.)

Technician to Forester—Looks like the wind is picking up here. Has the forecast changed?

Forester—(In one way or the other, he gets special forecast from dispatcher).

Technician—This wind has really started to blow. My strips are beginning to crown—we may have trouble.

Technician to Forester—That last strip jumped. We've got something going in Bachlors Plantation (6-years old) and it may give us a run.

Forester—(Probably will ask technician if he can manage it or whether he needs help.)

Technician—Think we need help. Is the other tractor ready to go?

Forester—Believe so—will have dispatcher get it on its way right now. Do you want the crew, too?

Technician—Yup, looks like we can use 'em.

Forester—Crew is on its way.

Technician to Forester—We may be able to plow around this spot before it moves out or we might better go back to the saw mill road, plow it out, and backfire from there. What do you think?

Forester—(Makes a decision on plowing and firing technique.)

TSI Crew Leader to Forester—This is Ernie. We're here on the Tift with the TSI Crew and the tractor. What do you want us to do?

Forester—(Gives orders to TSI crew leader.)

Control Action Is Successful!

Technician or TSI Crew Leader to Forester—Fire is controlled! What about mopup and patrol?

Forester—(Suggests action.)

Exercise Complete

The prescribed burner has had to learn his trade the hard way. As with the wildfire control specialist before the days of the Simulator, this has required years of experience and sometimes in

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INDEX, 1967

U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C. 20250

OFFICIAL BUSINESS

U. S. DEPARTMENT OF AGRICULTUR
POSTAGE AND FEES PAID

Brush in Southern California—*Continued from page 6*

reducing the fuel hazard outside his residence as well as inside it.

CONCLUSIONS

Well, what about brush? We enjoy seeing the chamise fields in full bloom, in smelling the pungent fragrance of sagebrush on a summer's day, and in watching the dark green scrub oak reclothe the bare hillsides following fires. But this brush-covered watershed is undoubtedly the most treacherous forest fuel known to man. Under some conditions the chaparral is virtually impossible to ignite; under other conditions a tiny spark can turn it into a nuclear bomblike holocaust.

In conclusion, there is no single, simple, inexper sive way to solve the southern California brus problem. Prescribed burning may be appropria under some fuel and weather conditions. But it generally too risky, and the results are unpredict ble. Low-growing and slow-burning plants may als be promising. But they must compete with the hard natives and withstand the ravages of drought an animals. Selective fuel modification (fuel-breaks along roads, around residential areas, and on ridg tops and in canyon bottoms appears to hold the mo promise at present. Meanwhile, much more r search needs to be done to obtain the best solutio to the overall problem of chaparral manageme in southern California.

Meals For Firefighters—*Continued from page 9*

Needs are easily estimated. Since the food is free of bacteria and is not touched during preparation, contamination is unlikely. Labor and equipment needed for preparation are minimal; the meals can be served easily, even on the fireline. Transportation costs, particularly by air, are reduced because meals are light and compact.

Precooked frozen meals cannot replace all meth ods now used for feeding firefighters. But they d offer a method for furnishing hot, well-balance tasty meals quickly, easily, and economically.

Improvements planned for the 1968 fire seaso include a serving tray with compartments and th addition of frozen juice, desert, instant coffee, an powdered milk. Three breakfast and six dinne menus will be offered.

Training Technique—*Continued from page 13*

volved costly mistakes. When training burns were scheduled the weather all too often failed to cooperate and little was accomplished.

Simulation now offers an excellent method for quick, inexpensive, and realistic training in the use of prescribed burning. As simulation technology improves, training procedures will be refined.

Fire Simulators are becoming available in most of the United States, with State forestry agencies assembling their own units and intending to make them accessible to interested parties. Instead of outdoor training sessions at the mercy of the weather, we can now by means of simulation create our own weath er to fit the training need. Hun dreds of fire control personn have experienced lifelike situa tions in handling wildfire throug simulation. The same opportun ty exists for prescribed fi training, and use of the Simulat for this purpose will enable be ter advantage to be taken of it capabilities.

FIRE CONTROL NOTES

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/APRIL 1968/VOL. 29, NO. 2

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire cont

CONTENTS

COVER—Slash reduction using a rolling chopper on the Medicine Bow National Forest. **See story on page 7.**

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

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A BREAKTHROUGH IN EFFECTIVE LOW-COST FIRE SIMULATION

SOLOMAN ZIMMERMAN, *Electronics Engineer*
Forest Service Electronics Center
Beltsville, Md.

he value of simulation as a fire control training is well established. This realistic "classroom" hod of portraying the variety of problems en- ntered in actual fire situations has been widely pted. Personnel from Federal, State, and local ection organizations have gained extensive ex- ence, and therefore knowledge, during simulated exercises. The initial development of fire control ılators has been basically oriented toward the er "command" models.[1] By using these sophis- ed simulators, with elaborate optical, commu- tion, and sound systems, trainees are placed in alistic, complex fire management situation.

owever, the command models are expensive. many problems have been encountered in devel- g a system capability. This has limited to seven number the U.S. Forest Service has been able to ure. Also, except for one trailer-mounted sys these simulators are difficult to disassemble reassemble; therefore, they are not easy to e from place to place. Because of these disad ages, the number of personnel who have been to receive simulator training has necessarily limited. Generally, only personnel operating e higher positions in the large fire suppression nization could be accommodated.

cause the Forest Service recognizes that simu- n is an effective training device for all fire con- personnel, it has been investigating the feasibil- f developing an effective, low-cost model for ral years. General criteria for the proposed m have been: (1) Cost of less than $2,000; weight of less than 200 pounds; (3) simulation bilities to produce changes in fire and smoke rns, smoke motion effect, and char; (4) a one- vo-channel communications network; (5) and kground sound effects system. Desirable, un- tial features included the capability to show motion and a symbol effect to portray fireline ruction.

e Beltsville Portable Simulator recently devel at the Forest Service Electronics Center s all these criteria. Preliminary evaluation of pabilities and performance indicates that the n has the potential to greatly increase the nt of simulator training which can be carried t.

e total cost of the prototype model is approxi- ty $1,000. The components weigh less than 175 pounds. When disassembled, it can be carried by one man and then transported in a station wagon. Assembly and operation of the system is uncomplicated and easily learned. Simulation of fire, smoke, and char effects is excellent, and is completely manageable. Realistic fireline is easily introduced into the scene.

The heart of the Beltsville system is a set of three overhead projectors. The first is used for fire, the second for smoke, and the third for the background scene, char, and fireline or other symbols (fig. 1). A rearview screen projection is used. The operators and all equipment are in a curtained enclosure behind the screen, out of sight of the trainees. With rearview projection, total darkness is not required; exercises can be conducted in a room where direct outside light is subdued.

The fire projector has a dark orange filter covering the writing stage. The filter is covered by a sheet of opaque Vu-Graph film. As the film is scraped away with a stylus, the filtered light is transmitted through the opening and appears on the screen. By controlling the size, shape, and location of the opening, a fire of the desired size and shape is created at the appropriate location on the background scene. Smoke is created similarly by a second projector without a colored filter.

The illusion of motion and direction of movement is imparted to the smoke and flame projec-

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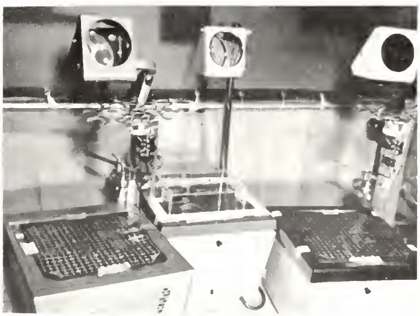

Figure 1.—The simulator optical system consists of three overhead projectors. The perforated disks mounted on the upright arms of the projectors on the left and right revolve to give the motion effect to fire and smoke simulation

[1] Neal, N. C., and Holtby, B. E. The fire control simu- r. Fire Control Notes 24(2): 25-31. 1963

A PRELIMINARY REPORT ON THE INFRARED LIGHTNING FIRE PATROL STUD

B. John Losensky, *Research Forester*[1]

Intermountain Forest and Range Experiment Station

The key to efficient fire suppression is early detection. Between 1940 and 1949, in U.S. Forest Service Region 1, holdover fires[2] that reached the D and E size classes (burning more than 99 and more than 299 acres, respectively) accounted for 41 percent of the total acreage burned, although representing only 0.13 percent of the total fires.[3] Thus early detection could substantially reduce the total acreage burned.

Forest Service aerial patrols are obtaining faster detection; however, holdover fires have not decreased proportionately. Analysis of 4,073 lightning fires in Region 1 between 1960-65 indicates that 45 percent burned more than 8 hours before discovery. Infrared scanners may be effective in reducing holdover fires. These scanners detect fires from heat radiation rather than by visual means and are therefore usable at night as well as by day.

INFRARED STUDIES

Research in infrared fire detection started at the Northern Forest Fire Laboratory in 1962. Tests in eight major western timber types related infrared detection probability (the number of fires detected expressed as a percent of the total scanned) to such variables as canopy cover, scan angle,[4] and fire size. From the data collected, the major timber types of the Western United States have been grouped into three general detection probability classes (fig. 1). The curves will be used for planning detection flights.

An infrared patrol study was started during the 1966 fire season to scan lightning fires under natural conditions following thunderstorm activity. The study was aimed to find some answers to questions associated with an operational infrared detection system. For example:

1. Do ground conditions affect detection pr ability?
2. Do all lightning fires provide enough rac tion for detection?
3. Are the detection probability classes signed to the various timber types valid?

Two areas with high lightning occurrence w selected for patrol tests:

1. Montana-Idaho test area—located betw latitudes 45°20′ N. and 47°00′ N. and longit 114°25″ W. and 115°35″ W.—including parts of Bitterroot, Clearwater, Lolo, Nezperce, and St. National Forests (fig. 2).
2. Oregon test area—including parts of Wallowa-Whitman, Umatilla, and Malheur N tional Forests. No usable data were obtai from the area, and it will not be discussed in t report.

STUDY PROCEDURES

The Montana-Idaho test area was divided i strips 8 miles wide and 100 miles long. Flying 15,000 feet over terrain provided 10-mile-w coverage and permitted 1-mile overlap on e edge. To fly large areas with a minimum of ov lap or gaps between strips requires highly sopł

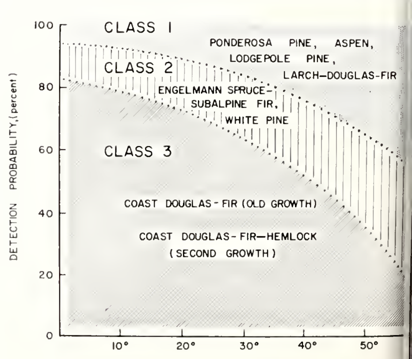

Figure 1.—Infrared detection probability classes. On the basi individual probability curves for each timber type, general class groupings indicate results that may be expected. angle has definite influence in most timber types but relati little in ponderosa pine. In class 3 types, the infrared met is not likely to be an improvement on conventional method

[1] Stationed at Northern Forest Fire Laboratory, Missoula, Mont.

[2] Here defined as fires not detected within 8 hours after origin.

[3] Data on fires based on Individual Fire Reports (form 5100-29) submitted by U.S. Forest Service personnel. These reports include estimated time of origin, discovery time by conventional detection methods, position, size, etc.

[4] Scan angle—the angle expressed in degrees between the vertical nadir and line of sight from scanner to observation point.

ted navigation. A Doppler radar system
sured true groundspeed and drift angle of the
raft. Heading was obtained from the aircraft
pass. From this information a computer con-
ously supplied the latitude and longitude of
plane. After lightning occurrence in the test
, night patrol missions were flown as soon as
ther conditions permitted. So that there
ld be no unnecessary flying, the extent of
y thunderstorms was determined from Po-
id slides of the weather radar display obtained
n the U.S. Weather Bureau in Missoula. This
—together with reports from each forest on
mated time of lightning occurrence, general
affected, and relative storm intensity (light,
lerate, or severe) was placed on an overlay
he patrol zone. As determined from the over-
, only the segments of the strips affected by
tning were flown.

continuous strip picture was taken of the
ared imagery on Hyscan Plestar film and was
eloped with a rapid processor. At the beginning
end of each strip a slate unit, including a
k face, was photographed on the edge of the
gery and discovery time determined. Devel-
d film was available for any point on the
und about 3 minutes after the point was
nned. Rapid film processing provided control
mage quality, and allowed us to check the
igation system by comparing the imagery
h aerial photos and determining aircraft posi-
. No attempt was made to locate possible
gets on the film until the flight was completed.
he imagery was read at the end of the mission, and targets were reported to the forests affected (fig. 3). The forests in turn reported any fires they had found in the test area.

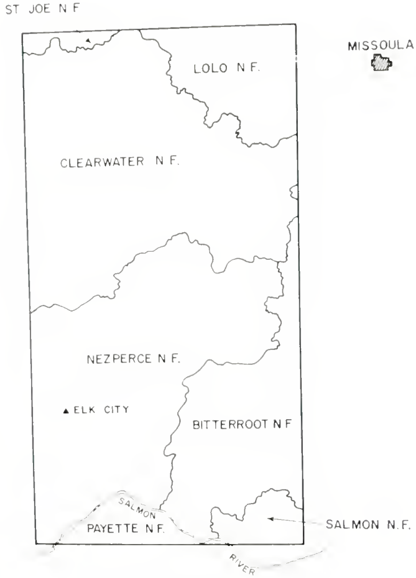

Figure 2.—Montana-Idaho test area.

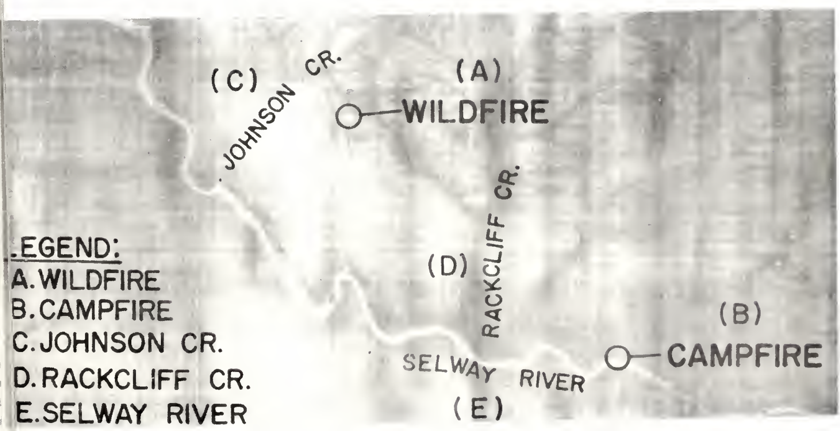

Figure 3.—Infrared imagery showing a wildfire and ground detail.

In the analysis of infrared imagery, an estimate of the fire conditions was attempted as they were when the fire was scanned; also considered were fire size, position (on the ground or in a tree), and heat radiation from the fire. In addition, slope aspect, species composition, and density of the vegetative overstory were estimated to determine their effect on infrared detection. These data were obtained from the Individual Fire Reports, information supplied by the districts, and Fire Laboratory personnel investigating the accessible fires.

RESULTS OF FIRE SCANNING

Seven missions were flown on the Montana-Idaho test area between July 31 and Aug. 15, 1966. Sixty-three targets were scanned and may be classified as follows:

Detected	
Campfires	29
Dwellings	9
Slash Fires	4
Wildfires	12
Subtotal	54
Undetected	
Wildfires	9
Total	63

Of the 12 detected wildfires, four have not been considered in the analysis because of their size; each was larger than one-half of an acre and therefore not a detection problem. The remaining eight are examples of typical lightning holdover fires. Following is a tabulation of fires detected by infrared, showing the lapsed time between origin and infrared detection. These values are compared with the lapsed time for conventional detection. (For example, fire 1 was detected by infrared 8 hours after starting, but it had burned 21 hours before discovery by conventional methods.)

Fire	Lapsed time between origin and infrared scanning	Lapsed time between origin and conventional detection
	(Hours)	*(Hours)*
1	8	21
2	11	24
3	13	17
4 (estimated)	16	Fire went out before found
5	51	50
6	51	15
7	47	40
8	30	13

Fires 1 through 4 were found earlier with infr red; fires 5 through 8 were found earlier wi conventional methods. All fires were detect with infrared the first time they were scanne The lapsed time for infrared detection probab could have been reduced, especially for fires through 8, if flights had followed more close upon the storms from which the fires originate Delays were caused primarily by scheduling pro lems that can be corrected in future testing.

Nine fires were scanned but not detected l infrared; eight of these may be classed as hol over fires. They were discovered by convention methods from 12 hours to 48 days after origi Following is a tabulation of fires scanned but n detected by infrared, showing the lapsed time b tween origin and scanning. The lapsed tin between origin and detection by convention methods is also shown. (For example, fire 9 w scanned but not detected by infrared 52 hou after it started. It was discovered by conve tional methods 4½ days after it started.)

Fire	Lapsed time between origin and infrared scanning	Lapsed time betwee origin and conventio detection
9	52 hours	4½ days
10	12 hours and 31 hours	71 hours
11	17 hours	24 hours
12	6 days	20 days
13	50 hours	5½ days
14	8 hours and 32 hours	49 hours
15	6 days, 17 days, and 18 days	29½ days
16	6 days, 17 days, 18 days and 38 days	47½ days
17	9 hours	1 hour

DISCUSSION

Some questions posed at the outset were a swered, although much remains to be inves gated.

Detection probability.—Present indications a that ground conditions, such as slope, aspect, a fire location on the slope, do not adversely affe infrared detection probability. Validation of d tection probability classes cannot be made b cause of the small number of fires scanned in wide variety of timber types. However, 55 pe cent scanned at angles greater than 40° we detected. This percent agrees with data obtain from the detection probability study.

Radiation.—Reliable data are not available whether or not all the fires scanned radiat enough heat for detection, because determini the exact character of the fires at the time th

Continued on page

DISPOSAL OF LOGGING SLASH WITH A "ROLLING CHOPPER"

S. H. VAN and DALE G. GALLAGHER[1]

\fter an area has been logged, land manager is faced with problem of the many tree-s, limbs, small unmerchant-e trees, and other debris ich remain. It is often neces-· to reduce this slash for fire trol, mistletoe control, aes-ties, and other reasons. Since le, if any, of the material can economically utilized, other atment measures are usually uired. The method most nmonly employed is burning. wever, in recent years a "roll-chopper" has been success-y used in some areas. Treat-nt of slash by the chopper has ven to be less expensive, and offered several other advan-es over other treatment isures.

Figure 1.—Rolling chopper used in lodgepole pine slash disposal on the Medicine Bow National Forest.

EQUIPMENT

he chopper is a hollow-steel nder, with cutting blades on rolling surface. The model vn in figure 1 is 12 feet wide has a drum diameter of 5 The blades are 10 inches , and they are spaced 21 ces between cutting surfaces. en empty, the chopper hs 18,500 pounds, but when l with water, it weighs 32,- pounds.

he chopper is pulled by a model crawler tractor, usu-in the D-7 or D-8 class. It s approximately $6,500 to ,00, depending upon the spe-i model and freight charges.

UTILIZATION

he chopper can be used on ps of up to 20 percent where nitions are favorable. It can-t operate in areas that are swampy or where there are numerous rock outcrops.

The cutter is able to treat an average of 12 to 15 acres per 8-hour day, at a cost of $10 to $15 per acre. This cost figure includes overhead, amortization or rental of the equipment, hauling of the equipment, repairs, etc.

Because use of the chopper will destroy any residual stand on an area, it cannot be employed where it is desirable to save advanced reproduction. However, since mistletoe is often a problem in lodgepole pine, elimination of the residuals is often an advantage there.

RESULTS

Limbs and treetops are broken and partially buried in the soil by the cutter. Larger material, up to 7 inches in diameter, is broken, shattered, or sliced. In addition to this action, the blades also make small furrows in the soil, reducing the potential for erosion and preparing a good seedbed.

Figure 2 shows a logged area before any treatment. This timber stand was mature, even-aged lodgepole pine (*Pinus contorta*). It was clearcut to a tree diameter of 8 inches. Figure 3 shows a typical area after the "rolling cutter" has made one pass over the debris.

ADVANTAGES

There are a number of advantages to using a chopper for treatment of logging slash in lodgepole pine. These also would be applicable to similar timber types.

1. The chopper can be used anytime after the site has dried out, whereas burning can be done only under certain weather conditions, often delaying needed treatment.

2. The cost of $10 to $15 per acre is less than one-third the cost of piling and burning. The treatment is completed in one operation, and supervision time is also reduced.

3. The slash, which is on the ground or partially buried, de-

[1] Respectively, Timber Staffman and Staffman, Medicine Bow National rt, Wyo.

composes rapidly. This decomposition returns organic matter to the soil, rather than consuming it as with burning.

4. The furrows in the soil made by the blades provide a good bed to cach and hold tree seed. Those areas treated with a chopper from 1960 to 1963 were found to have naturally established regeneration averaging 1,830 seedlings per acre in a 1966 survey. These furrows also help to hold moisture and reduce runoff and erosion; therefore, there is minimum topsoil disturbance.

5. After chopper treatment, other equipment can traverse the area for thinning, fire control, etc.

6. The chopper-treated area is always more esthetically desirable than untreated areas, and often more desirable than burned areas.

7. Disposal of slash by the chopper method does not affect air pollution.

SUMMARY

Rolling cutters have been used on the Medicine Bow National Forest since 1960. Both smaller tandem units and single, larger choppers have been used. The single, larger unit is easier to maneuver, and maintenance has been cheaper and less frequent.

We have developed the following guides for using a rolling chopper:

1. Use on lodgepole pine areas within 3 years of the timber cutting. Do not use on spruce-fir stands with well-established advanced reproduction, or on lodgepole stands containing more than 2½ cords per acre of residual stand.

2. Use on mistletoe-infected areas.

3. The optimum minimum size area for treatment is approximately 20 acres. This can be a single area, or several smaller units close together.

4. Use on cutover areas with light to heavy slash.

5. Use on slopes of up to 20 percent that are reasonably free of rock outcroppings and swampy areas.

6. Do not use on areas whe live or dead snags with a diar eter of 10 inches or more excee 5 per acre.

In summary, the rolling cho per has allowed treatment more areas of logging slash less cost per acre. This trea ment has not only reduced fi and erosion potential, but al provided better seedbeds wi resulting satisfactory natur regeneration.

Figure 2.—Untreated slash on mature, even-aged lodgepole pine clearcut area.

Figure 3.—Lodgepole pine slash after chopper treatment.

IMPROVED BASE FOR OSBORNE FIREFINDERS

Missoula Equipment Development Center

hen the lookout's view of a fire is obstructed portion of the lookout building, the stand- refinder must be lifted and moved to the nate set of rails on the base.

employee suggestion for an improved base, n makes this lifting and moving unneces- has been evaluated by MEDC (fig. 1). The base permits sliding the firefinder to either side without disturbing settings or leveling. It also permits the firefinder to be positioned in locations which would fall between the rails of the standard base.

Paraffin lubrication of the base is recommended. Movement in any direction within the limits of the rails is smooth and positive.

A list of materials follows:

Part number	Part name	Quantity	Item	Dimensions (inches)
1	Base	1	Exterior plywood	3/4 x 24 x 24
2	Rail	2	Angle aluminum, 1/4" stock	24 x 1 1/4 x 1 1/4
3	Slide pipe	2	Steel pipe	11 1/2 x 3/4 (1.05" O.D.)
4	Cross rod	2	Steel rod	3/4 x 23 1/2
5	Bolt	4	Steel	5/16 x 1 18NC
6	Nut	4	Steel	5/16 18NC

Figure 1.—Construction plan for improved base for the Osborne firefinder

TIPS ON APPEARING AS SMOKEY BEAR

David C. Phillips
Fire Prevention Specialist
Pike National Forest, Colo.

This report describes the impressions gained during more than 100 impersonations of Smokey Bear within 3 years. These impressions were obtained as Smokey rode a racing car up the Pikes Peak Highway, from publicity photos, and from appearances in parades, in skits with youth groups, in schools for deaf and blind children, and in ordinary schools, etc.

Smokey Bear may be the most universally recognized symbol of fire prevention. He is recognized by young and old, both in this country and in many other nations. (fig. 1) Most people will stop to shake hands and converse with this symbol. Dignitaries, whether political, military, or business, usually welcome a handshake and a few words with Smokey.

The Smokey symbol is not closely identified with any specific organization. Forest Service identification is present, but it is usually secondary to that of the sponsoring organization, i.e., volunteer fire departments, military fire departments, or school administrations. Also, the Forest Service encourages use of the Smokey symbol by all wildland management agencies. Relations with other organizations can be strengthened by inviting uniformed representatives to accompany Smokey.

GENERAL SUGGESTIONS

Fear

Probably the most important suggestion is that the impersonator should be constantly alert for frightened people.

A few adults are frightened by Smokey. Women are affected more often than men. Most adults are startled by Smokey's appearance. Speak carefully to people who are not facing you. Keep as much distance as possible until Smokey has been recognized.

Two- to four-year-old children are usually frightened by Smokey. Only a few 5-year-old children are frightened, and many will come to Smokey if given adequate time. Parents often need to be warned that their child may be alarmed.

Figure 1.—Smokey's friendliness toward children favorably influences children's fire-prevention attitudes.

Reaction of Different Ages

The reaction varies by age. The general reaction pattern is:

0 to 2 years old—This age group usually does not react to Smokey. If children react, it probably will be with fear.

2 to 4 years old—Children often react with panic. It is best to keep some distance from them.

4 years old—Children are very timid. Many cower behind their parents and will not approach Smokey. Stand still and let them walk to you.

5 years old—Most children will approach Smokey and will want to shake his hand.

6 to 8 years old—Children are curious about the suit and try to detect flaws. The impersonator should volunteer the information, "Of course Smokey is a man in a costume." Explain why there is such a costume.

9 to 13 years old—Children are embarrassed to be seen with Smokey. Smokey needs to offer encouragement. It seems best to ask questions and to attempt to establish a teacher-student relationship. It is difficult to control the behavior of a group of boys if rapport is too closely established.

13 to 21 years—This group usually ignores Smokey. Some interesting conversations occur if

roups include both boys and rls.

Adults—Self-confidence is directly correlated with the amount of conversation with Smokey. Conversation should not exceed 0 seconds unless initiated by the other person. Special effort should be made to contact dignitaries.

Attributes of Impersonator

Fewer skills are required to impersonate Smokey while on a parade float than during a question and answer session with a group of sixth-grade students. Summer employees, especially recreation guards who normally contact people, can adequately impersonate Smokey at parades.

At schools the impersonator needs Forest Service experience. He also must have the ability to speak in public and provide suitable answers to the many questions which are asked. The most important need is to like children and to enjoy talking with them.

MEETING PEOPLE

When a large crowd is expected, Smokey must have assistance, for he cannot control those who may press around him and will make effective prevention contacts.

When Smokey shakes hands, he should put his hand where it can be grasped by the other party; he must lower it for small children. Do not grab hands that are extended. For children, it is often effective to ask if they want to pet you rather than shake hands.

Contact with each individual is normally brief. Usually there is only time to shake hands and exchange a word or two. Speak to as many individuals as possible. Some typical comments are: "Isn't this fun to pretend?"; "I have more fun than people."

A specific fire prevention message may be difficult to get across unless time is taken to establish rapport. Such a strong impression is made by the Smokey suit itself that it often takes at least 1 minute to gain the necessary attention.

Figure 2.—Blind girl "sees" Smokey.

Visits to Handicapped Children

Approach these children slowly. Emotional problems are occasionally associated with physical handicaps. The child, or an adult accompanying the child, will usually indicate the behavior pattern Smokey should follow.

Blind children need to touch Smokey (fig. 2). Encourage the blind children to "see" the entire suit, from the hat to the furry feet. Special interest is created by the ranger's hat, moveable mouth, and the shovel.

Parade Appearances

When Smokey appears on floats, he is usually the main attraction. Simple floats featuring Smokey are effective. Elaborate floats may lose some of their effectiveness to Smokey. Smokey should be at the front of a float so he can be viewed as the float approaches. An unobstructed view of Smokey, which allows the crowd to see him waving to both sides, is most effective.

However, many Forest Service floats are on trucks where it isn't possible to put Smokey at the front of the vehicle. In this case, put Smokey at the rear of the float, facing the direction of travel.

Balance is a problem. A hand hold, or a brace to help keep balance, is essential.

School Appearances

Smokey's appearance at a school assembly is not nearly as effective as his visits to classrooms. In classrooms, close rapport can be established between the children and Smokey if an atmosphere for fun is maintained. Smokey's appearance is effective with or without advance preparation by the class. Smokey is an effective tool when he is used to reinforce material already learned. Clear distinction should be made between the real bear named Smokey and the symbol of Smokey which is in the classroom.

Typical classroom appearances have four steps: (1) Establishment of rapport, (2) explanation of need for Smokey, (3) Smokey's rules and items suggested by local fire department, and (4) a question period. Smokey's appearance must vary from grade to grade and class to class.

THE SUIT

The Smokey suit must be in first-class condition for each appearance. The suit is closely examined by the public, and every flaw detracts from the overall impression. The fur of the suit should be brushed regularly. A hairbrush is adequate. Dry cleaning by a commerical cleaner is satisfactory.

Padding worn under the suit improves the appearance. One approach is to make a "corset" of 1 inch of foam rubber and to pad the seat with 3 more inches. Most impersonators perspire freely in the suit. Lightweight absorbent clothing should be worn.

Continued on page 16

THE LINCOLN HARNESS

Abel A. Zamora, *Electronics Technician*
Lincoln National Forest, N. Mex.

The Lincoln harness (fig. 1) was devised to fill the need for an inexpensive method of simultaneously monitoring Air Net and Forest frequencies and instantly communicating to either while on air observation.

The portable radios, harness, and strap-on antennas make a compact, self-contained kit and enable the operator to fly in any available craft.

The control box is simple to build and parts (fig. 2) are inexpensive, many being available on surplus.

		Cost
P 1	U-93A/U (Military surplus)	
P 101	Microphone plug, Motorola #28A16370	$0.53
P 201	Microphone plug, Motorola #28A16370	.53
J 1	U-92A/U (Military surplus)	
J 2	Microphone jack, Motorola #9B16345	.62
J 3	Phono plug, Motorola #9B54664	.05
S 1	Switch, pushbutton, DPST, Type 35-1 (Allied #56A4964)	1.20
S 2	Switch, rotary, 4-pole, 2-position, Type 3142J (Allied #56A4306)	1.05
S 3	Switch, SPST, miniature	1.10
	Housing, bud type 2102A (Allied #42A7618)	.80

Figure 1.—Air observation scout using Lincoln harness prepa for patrol flight.

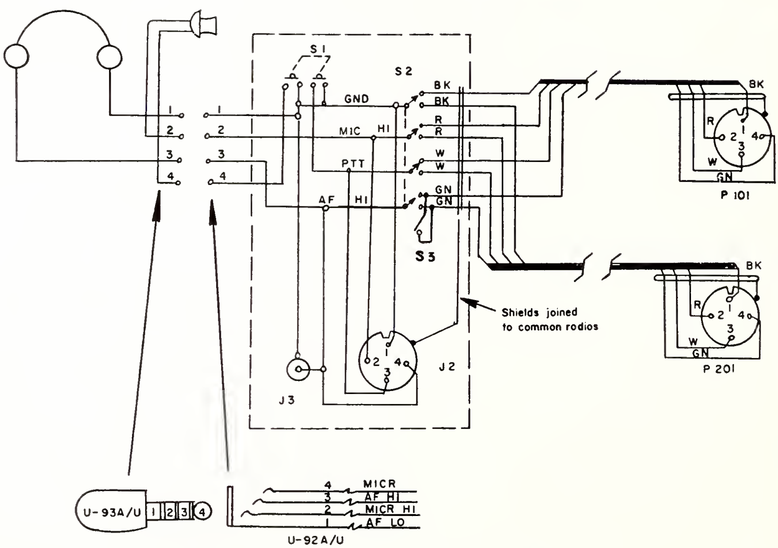

Figure 2.—Wiring diagram and parts for the Lincoln harness are shown.

The harness can be used with Motorola type NMN6009B eadset or with a military head- et with carbon microphone pre- erred by this Forest. It can also e used with a crash helmet head- et. Advantages offered by the ilitary headset with carbon icrophone include:

1. Cost: The earphones are enerally available through sur- lus as complete headsets includ- ng the boom microphone.

2. Flexibility: Government rplus flying helmets with the eadset built in are also usually vailable.

3. Impedance Matching: There no need for a matching trans- rmer as the earphones offer inimum mismatch to the output ansformer. Therefore, audio loss and distortion are negligible.

Though no attempt was made to provide for dual transmission, another pair of earphones can be paralleled for dual reception.

The net selector on the control box (fig. 3) gives the operator a selection of Forest or Air Net frequencies. No provision has been made to switch channels at the control box as this would require modification of the radio units. Channel selection, however, can easily be accomplished due to nearness of the radios to each other and to the operator. The length of the control cables, 6 feet maximum, governs this distance. Normally, most of this length is alongside the operator for comfort in operation.

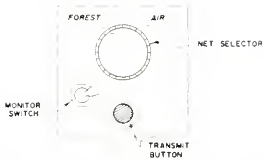

Figure 3.—Control box showing net selector.

The monitor switch provides for reception of both frequencies regardless of net selector setting. To transmit, though, the selector switch must be set to desired service.

The control box is mounted on a pilot's kneeboard. The kneeboards are also usually available on surplus and make an ideal base.

HOOK IMPROVES MOPUP WAND UTILITY

PHILLIP C. HICKS, *Forester*

Rouge River National Forest

The pipe nozzle extension, or and, in the standard mopup kit a valuable tool for the efficient e of water. Its use facilitates e direct application of water to e burning material, especially hen the material is in hard-to- ach spots such as in deep duff d under logs and debris.

For the most effective use of ater, an extra man with a ovel or some other tool usu- ly must work constantly along- le the nozzleman. He turns aterial over when necessary to pose the burning side. The ed for this second man can be duced, however, by the addi on of a small hook to the noz- e end of the wand (fig. 1). This dition makes the wand a light- ty pike pole, and the operator n easily turn small poles and unks without assistance. Then e shovel man can turn the

Figure 1.—The addition of a small hook to the mopup wand permits the operator to move small material easily without assistance

larger material for two or three wand operators.

The hook is fabricated by welding a pointed steel rod onto a steel ring. The ring is slipped over the wand and held in place just above the nozzle by an Allen screw. When the wand is used for boring into deep duff, the screw is loosened, and the hook assembly is slipped up the wand and refastened out of the way so that it will not hang up on matted roots.

The improved wand was tested during the past summer in Region 6, and it was enthusiastically accepted. The hook has been adopted as a standard accessory for Region 6 mopup kits.

The cost of making each model hook assembly was $3.50. However, when produced in quantity, this figure should be much lower.

A PORTABLE STAND FOR LARGE SMOKEY BEAR SIGNS

Nathan Dauchy, *Assistant in Charge, Fire Control*
Vermont Department of of Forests and Parks

The Vermont Department of Forests and Parks has designed a portable stand for use with the large Scotchlite Smokey Bear roadside signs. With this stand, the signs can be moved more often; in turn, they are seen by more people (fig. 1). Two weeks is usually the optimum exposure time for each location.

The stand is constructed of pine and spruce; it has sufficient strength and is light in weight. The base skids are mortised to a depth of 1 inch to hold the feet of the upright frame when the stand is erected. Each foot is secured in place by a lag screw through an iron plate bolted to the foot. (fig. 2). The sign is fastened to the frame by seven screws. Paint on the screw heads makes them inconspicuous. The entire stand is stained dark green.

To prepare the standard for moving, unscrew the two lag screws, raise the uprights to free them from the mortise, and pull the bottom forward; the frame pivots on the back braces. When folded flat, the assembly is about 9 inches high, 56 inches wide, and 96 inches long.

The best location for the sign is on the outside of a curve at the end of a long straightaway. It should be placed a few feet higher than the road, and the background should be woodland. The base can be staked or weighted down to prevent the sign from being blown over by wind. To discourage vandalism, it should be placed near an occupied dwelling.

Figure 1.—This portable stand permits optimum use of Smokey Bear roadside fire prevention signs.

LIST OF MATERIALS

	Item	Quantity	Dimension (inches)
Lumber			
	Base:	2	4 x 6 x 96
		2	2 x 4 x 52
	Braces:	2	2 x 4 x 56
	Frame:	2	2 x 4 x 73
		3	1—⅛ x 4 x 52
		2	1—⅛ x 4 x 60
	Head stay:	1	2 x 4 x 24
Hardware			
	Machine bolts:	2	⅜ x 9
		2	⅜ x 9
		4	¼ x 3
	Lag screws:	2	¼ x 1½
	Screws:	7	3 roundhead iron, 10 ga.
		4	2½ flathead iron, 12 ga.
	Washers:	8	⅜
		4	¼
	Iron plate:	2	⅛ x 3 x 6

ow-Cost Fire Simulation—*Continued from page 3*

ons by motor-driven perforated disks rotating cross the paths of the light rays in out-of-focus ositions. By varying the speed and direction of otation, and the location of the disk, the comlete ranges of both fire and smoke effects can e obtained. Realistic simulation is very satisactory over a wide range of background scenes.

A 7½- by 5-inch color Vu-Graph transparency s used for projecting the background scene. The mulsion side of the transparency is protected by n acetate sheet. Firelines and other symbols are rawn directly on this sheet.

Char is put on the scene by shading with a hina-marking pencil on a plexiglass char plate et 2 inches above the transparency. Since the encil and operator's hand cast a shadow on the creen if char is added directly during the exerse, acetate sheets on which the char has been remarked can be quickly positioned on the plate s the burned area increases.

Telephone and radio communications are both provided with the prototype model. Inexpensive equipment is used. The telephone is a simple two-station intercom. The radio network consist of a pair of two-channel Citizen's Band walkie talkies and a small base station. The base station is modified slightly to reduce power to conform with FCC requirements, and to enable it to be used as a public address amplifier. Two low priced tape recorders provide a variety of back ground sound effects, and a third is used to record the exercise for later critique.

The Beltsville Portable Simulator, with its low cost and portability, permits greatly increased use of simulation for training at all levels. While the original concept in the development of a small model was to provide a method for initial-attack training, the system produced has the capabilities to effectively be used for sector size fire training. Only minor additions to the communications equipment are needed to handle more complex situations. Structural fire simulation is also possible; the system may also be used in training urban and suburban fire units.

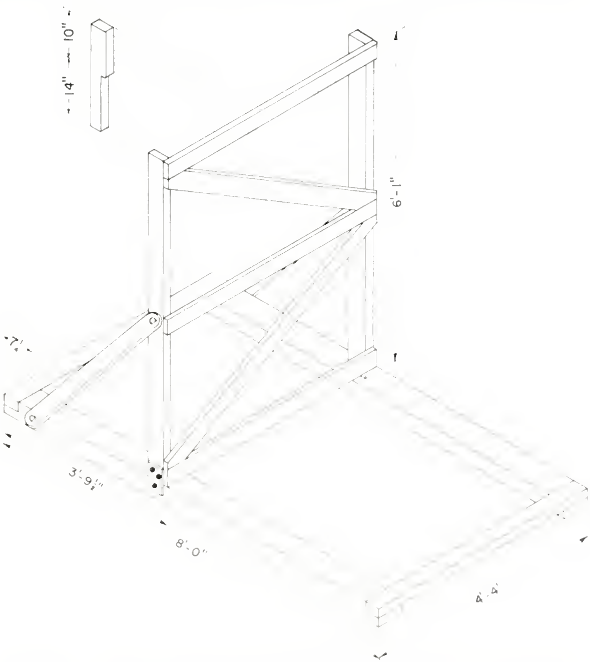

Figure 2.—Isometric plan of a portable stand for large Smokey Bear fire prevention signs.

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Infrared Lightning Fire Patrol Study—
Continued from page 6

were scanned is difficult. We judge that all fires scanned probably had sufficient intensity for detection. The infrared system is almost certain to detect 0.25 square foot of unobscured fire source under these operational conditions.

Fire position (on the ground or in a tree).—An important element previously overlooked by us is fire position. We had assumed that a fire burning near the top of a snag would be easier to detect with infrared than a fire on the ground because obscuration from tree canopies would be less. This study tends to contradict this premise: of four fires (5, 9, 15, and 16) known too be confined to a snag at the time they were scanned, only one was detected with infrared. Examination showed that the three undetected fires were burning inside the snag when observed and the one detected was burning on the outside.

Nature of holdover fires.—Infrared detection probability seems correlated with the time a fire is likely to burn before discovery by conventional means. If the fires scanned are tabulated according to the time they hold over, the following breakdown results.

Time interval between origin and detection by: conventional methods	Fires scanned	Fires detected by infrared	Fires undetected by infrared
(Hours)	*(Number)*	*(Number)*	*(Number)*
8-24	4	3	1
24+	8	0	8

(Fires 5 through 8 are excluded from the tabulation because they were discovered before being scanned and therefore may have been atypical of holdover fires.)

Thus, as proposed by Alan R. Taylor, Associate Research Forester at the Northern Forest Fire Laboratory, the difficulty of detecting holdover fires by any means may be caused by the special nature of such fires; that is, fires that go undetected for extended periods may be those burning within a snag or live tree, and the lapsed time between origin and detection by either infrared or conventional methods may depend in part on when the fires break out onto the exterior or firebrands drop to the ground.

Vegetative cover (timber and brush canopies) and fire position are the most important limiting elements in infrared detection.

CONCLUSIONS AND FUTURE PLANS

Infrared scanners have been shown to detect fires under natural conditions, and sometimes do so sooner than conventional methods. Apparently fire position is more important than was originally thought, and its relation to detection should be studied further. Additional data are needed to evaluate the system in general, and tests on a larger scale were conducted during the 1967 fire season. Data from the 1967 season are now being analyzed, and a report will soon be published. The results appear to be encouraging and operational testing may be initiated.

Smokey Bear—
Continued from page 11

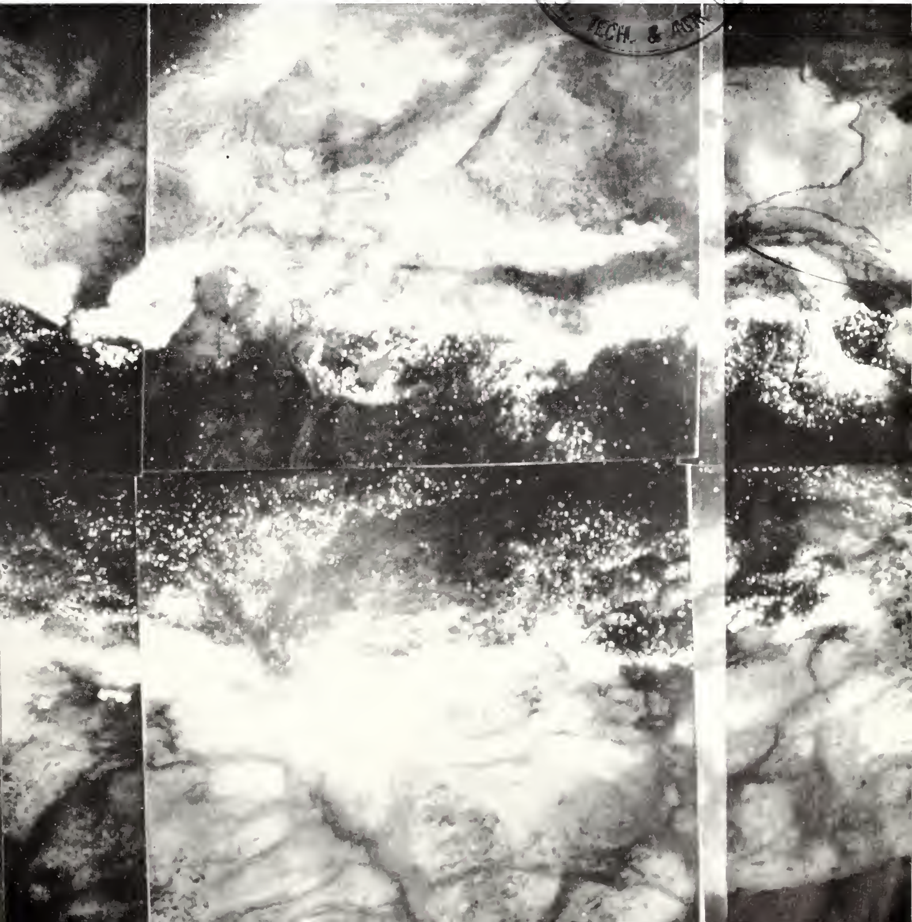
Help is needed to get into the suit because there is a zipper up the back and a drawstring. Before a public appearance, answer the following:

1. Is the drawstring tucked in? 2. Is the zipper out of sight in the hair? 3. Is the belt firmly fastened to the pants? 4. Are the pants cuffs neat? 5. Are the pants long enough to cover Smokey's ankles when he is leaning over a small child? 6. Has the head been set straight on the shoulders?

Most pictures depict Smokey with a shovel. The shovel has become a part of the symbol and should be carried at all times.

FIRE CONTROL NOTES

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/JULY 1968/VOL. 29, NO. 3



FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire cont

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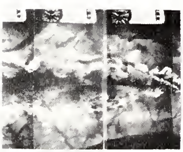

COVER.—Infrared imagery mosaic of a portion of the Sundance Fire, Kaniksu National Forest, Idaho, Sept. 2, 1967. The head of the fire is shown. The fire area is approximately 7 miles long by 3½ miles wide.

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

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FIRE HAZARD MANAGEMENT IN THE BITTERROOT— A FURTHER REPORT

JOHN MORRISON, *Forester*
Bitterroot National Forest

In the fall of 1962 the Bitterroot National Forest rted developing a hazard management plan for 0,000 acres of high-hazard, over-mature, and sect-killed lodgepole pine stands. Objectives of e plan are to:

1. Minimize the possibility of conflagrations;
2. Salvage available merchantable timber;
3. Reduce the fire hazard; and
4. Return the area to timber production.[1]

The plan was initially implemented in 1963 when helispots and 5 miles of access road were conucted. Three fuel-break areas totalling 160 acres re prepared for burning. Merchantable timber s salvaged, with 10 to 20 lodgepole pine seed trees t per acre. Unmerchantable trees and snags were led. Burning of these areas in 1964 resulted in good clean burn with minimum control problems. t there is now insufficient natural regeneration to ck the areas even though seed trees with serotins cones were left.

Because of the high cost of preparing the areas, d the failure to quickly establish a satisfactory cking of seedlings, a search was begun for other thods of establishing fuel breaks in the highzard, heavy-fuel areas.

THE NEW PLAN

Plans were made to develop strip fuel breaks at o of the largest and most hazardous blocks on Forest—along the Meadow-Tolan Creeks die and the Sleeping Child-Skalkaho Creek divide. Ech of these planned fuel breaks consists of a ntinuous strip 1/4 to 3/8 mile wide on which all the edily burnable fuels are to be consumed and a ung stand of timber re-established. When the ung trees reach a height sufficient to shade the ound and close their canopy, the area will become ually fireproof.

On the merchantable timber types, all salable terial will be removed by commercial sale and h residual burned. Non-merchantable areas will lined and burned to make the break continuous.

Access roads have been built by the timber operaos and the Hazard Management Project. The adow-Tolan fuel break will be 7 miles long and h Sleeping Child-Skalkaho break will be 8 miles og. Others are being planned.

FOUR METHODS TRIED

In an effort to find an economical way to build the fuel breaks and reforest them naturally, four methods were tried in 1967:

1. In July, half of the standing material on two blocks was laid down using a D-8 dozer working on the contour.
2. On one block *all* standing material was laid down.
3. One block was helicopter-sprayed with one part 2-4-D (4 pounds acid equivalent) to nine parts diesel, at the rate of 10 gallons per acre.
4. Two other blocks were left in their natural state except for control lines.

Exterior firelines approximately one chain wide were constructed with a D-8 dozer. Lines between blocks were one dozer wide. The access road was used for the bottom line on all blocks. Snags that would fall across the road were cut before burning.

The treated blocks were burned on Sept. 18, 1967, and the untreated blocks on Sept. 20 (figs. 1, 2, and 3). All blocks ignited readily and burned well. The sprayed block burned somewhat violently, possibly because flash fuels were supplied by the low shrubs killed by spraying.

SEED FALL IS ADEQUATE

The day after firing, seed traps were placed in all blocks except the 100% laydown block. The traps

(*Continued on page 16*)

Figure 1.—Untreated area ready to burn.

[1] Morrison, J. Fire hazard management. Fire Control Notes 25(2) 13-15, 1964.

TRAIL BIKES EFFECTIVE IN FOREST FIRE CONTROL

Earle S. Williams, *Forest Ranger*

Maine Forestry Department

A major problem of forest fire control in the "back country" of Maine is making simultaneous and rapid attack on numerous lightning fires resulting from a single storm. Men walking in with hand tools from the nearest road or lakeside have been used in past years.

The increasingly popular use of rough-country motor bikes by recreationists along many abandoned skid roads led to their trial use for firefighters in 1965. After reviewing available equipment, two Trail Breaker bikes were selected which have the following features suitable for forest fire control agencies:

1. Two-wheel drive
2. Good flotation (670x15, 2-ply tires)
3. Ground clearance—15 in.
4. Fording depth—24 in.
5. Transmission ratio 70 to 1 (maneuvers 90% slopes)
6. Adaptability to a variety of ground conditions (swampy areas, rocky and rough areas)
7. High load-carrying capacity (back pumps, power saws, hand tools, personal gear)

The weight of this bike, 180 pounds without load, is greater than most. Although this may be considered a disadvantage, it is offset by the desirable flotation, transmission ratio, and load-carrying capacity features of this equipment. All-around performance has been very good in comparison with other units. Some current uses offering the greatest potential are:

1. *Initial Attack.*—Up to now, ground crews with packs on their backs have been guided into lightning fires from float-equipped aircraft overhead. It may take several hours for a crew to walk to a remote fire, tying up a plane that could be urgently needed in other areas. The speed of the bike over abandoned hauling roads and skid trails puts a man on the fire earlier and in better working condition with more equipment and supplies.

2. *Line Supervision on Larger Fires.*—Good supervisory personnel are probably needed more with today's crews than ever before. Once lines are constructed, the bike could be helpful in making better use of sector or crew bosses for more rapid coverage of the line. In later mopup stages, a firefighter may be used to patrol a large amount of line from the bike, and report by radio on li[ne] conditions. Other uses, such as deliveries of su[p]plies and small tools, are evident.

3. *Prevention.*—Inspections of occupied rec[re]ation areas, woods operations, and similar sit[ua]tions—which may be reached now only by walki[ng] —will be speeded up. Rangers will be able [to] keep up with visitors and others using trail bik[es].

4. *Service.*—Servicing of remote lookout to[w]ers with supplies, communications, and main[te]nance gear can be done more efficiently.

5. *Other Uses.*—General administration acti[vi]ties on State lands not serviced by roads a[re] facilitated by use of trail bikes. As with a[ny] machine, safety hazards are present and traini[ng] must be provided to avoid personal injur[y] through careless use.

Operating cost figures are not yet available. [A] tankful of gas gives 8 hours of running time, a[l]though the original cost of $800 appears high, ti[me] savings translated into dollars can be impressi[ve]. Large savings should result from the bike's abil[ity] to get that first man to the fire fast while there [is] still a chance of economical control. The possibilit[ies] for reducing damage and suppression costs a[re] great.

Figure 1.—Bike with some firefighting tools for spring fires.

A FIELD TRIAL FOR REGULATING PRESCRIBED FIRE INTENSITIES

STEPHEN S. SACKETT, *Research Forester*
Southern Forest Fire Laboratory
Southeastern Forest Experiment Station

ertain firing techniques can be used to control intensities of prescription burns. When lines of e are set to permit spread with the wind, fire ensities are generally greater than those produced lines of fire moving against the wind. Flank es generally create intensities somewhere between se generated by head fires and backfires. Spot es often generate the entire range of intensities— leading edge behaving as a head fire, the sides as nk fires, and the rear as a backfire.

Multiple lines or spots of fire are often necessary en a large area has to be burned in a specified e. The lines or spots of fire have a "drawing" ect on each other where they converge, and their ividual intensities become magnified in the junc- n zones. Since most fire damage occurs within se junction zones, the interval between fire sets ital in regulating overall intensities.

PROCEDURE AND OBSERVATIONS

workshop on prescribed burning was held re- tly on the Francis Marion National Forest, South olina. All burns took place in an open, mature nd of loblolly and longleaf pine averaging about feet in height. Litter fuel consisted mainly of a o 3-year accumulation of needles, and the vege- ve undergrowth was composed of wiregrass *ristida stricta* Michx.), gallberry (*Ilex glabra*) Gray), titi (*Cyrilla racemiflora* L.), and other or shrub species.

Iild February weather prevailed: air tempera was 68°F. and the average relative humidity 34 cent; wind was light and from the southeast in stand, with gusts up to 19 m.p.h. in the open. spread index was calculated at 33, and the dup index totaled 16. Three days had elapsed e the last rain (0.34 inch). Although the sur fuel was moderately dry, the soil was still damp.

our 4-acre blocks were allotted for spot fires, five for strip head fires. In order to evaluate effect of distance between fire sets on behavior intensities of the resulting fires, particularly in tion zones, the number of sets per block in the spot fire blocks was varied as follows: 2, 4, and 60 spots.

n the five strip head fire blocks, the strips were ed about a chain apart. All plots were burned same day. Estimates of the resulting crown ch served as gages of fire intensities. Scorch classified as follows:

Class	Percent Crown Scorch
A	None
B	1-33
C	34-66
D	67-100

From observations of rate of spread, flame height, and vegetative fuel consumption, fire intensities appeared to increase directly with the number of ignition points, and were inversely related to the spacing between fire sets.

When examined for scorch 2 months after burning, the condition of the crowns supported preliminary observations. The strip head fire blocks had a greater percentage of Class C and D tree crowns than did any of the other treatment blocks. Scorch was negligible in those blocks that had been burned with 2 or 4 spots. In those with 30 and 60 spots, the percentage of scorch approached that in blocks burned with strip head fires (fig. 1). As the number of spots increased (spacing between decreased), the chances for convergence and greater intensities also increased.

Not all crown scorching results in damage to those species studied, but excessive amounts may be harmful. Scorching does, however, indicate the level of fire intensity. Because of the relatively large bole sizes and tree heights involved, observations made during this demonstration probably resulted in conservative interpretations. A younger stand would likely have suffered greater crown scorch and thus more potential damage.

CONCLUSIONS

The interval between fire sets appears to strongly influence the fire intensities created by prescription burning. Data from this demonstration indicate that, with many sets placed close together, it should be possible to produce a high intensity burn. Conversely, a low-intensity fire should result from fewer sets and wider spacing.

In the South, most fire prescriptions in pine stands call for low-intensity fires that do not damage the crowns of crop trees. Sometimes, however, higher intensities are necessary; for instance, in clearcut areas where fire is used for slash disposal, or in mixed stands where hardwoods are undesirable and need to be controlled.

If further study shows that interpretations made in this demonstration are applicable for a normal range of fuel and weather conditions, another useful means will be available to regulate prescribed fire intensities.

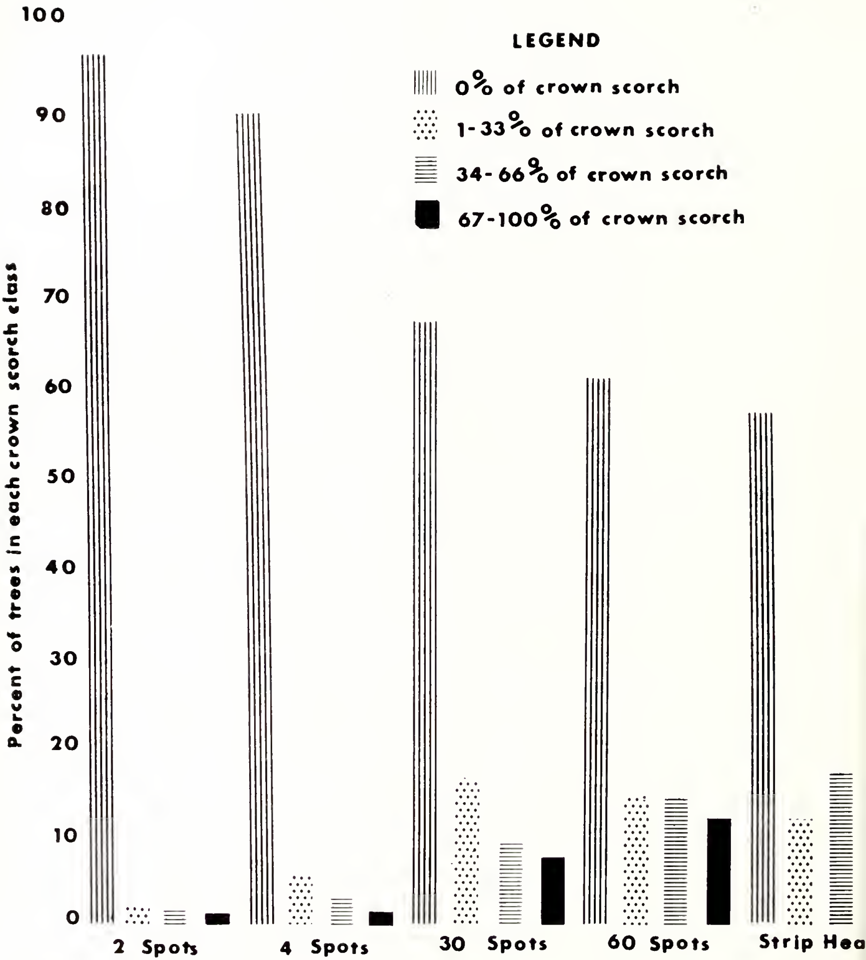


Figure 1. Crown scorch associated with a variety of firing techniques.

NFRARED MAPPING IMPROVES EFFICIENCY, CUTS COSTS OF FIRE SUPPRESSION

ROBERT A. COOK and RICHARD A. CHASE[1]

"Intense smoke prevented effec-e scouting, either by ground or . By use of infrared imagery in ·ly stages, spot fires were picked that were unknown to ground rces . . . perimeter imagery owed 720 chains of fireline to ild rather than the 400 chains eviously estimated. As a result, ews and equipment were re-signed to "beef-up" the north d south side . . . additional npower and retardant drops re ordered. Use of infrared apping saved 1 to 1½ sections virgin timber . . . suppression sts were reduced at least $100,-0."

This report from a Northwest e indicates the value of the In-ared Mapping Unit.[2] Using it, Fire Boss can readily obtain rent intelligence on fire behav- at night, or in spite of dense oke cover, and direct his forces re efficiently.

The prototype mapping unit, re-lting from 5 years of joint re-arch by the Forest Service and Office of Civil Defense, was eased from the Fire Research boratory at Missoula as an op-tional tool in July, 1966, and s mapped many fires since.

Previously, Fire Bosses had to pend mainly upon daytime ob-rvations. While helicopters or connaissance planes greatly aid servers in gathering needed in-rmation quickly, they can be d only until it becomes too oky, windy, or dark to fly. hen these conditions prevail, it been necessary to rely solely ground scouting, which can be y, and may provide sketchy and inaccurate information, since scouts must avoid the hazards of fire, smoke, and precipitous terrain in walking the fire perimeter. The data also may be obsolete when it reaches fire headquarters. By supplementing such methods with infrared mapping (fig. 1), Fire Bosses may now quickly acquire current information under almost all conditions.

OPERATION OF THE UNIT

The infrared mapping unit consists of a scanner, detector, printer, and associated electronic circuitry and controls; all units are mounted in a light twin engine aircraft, with a crew consisting of pilot and operator.

As the aircraft flies over the fire area, infrared energy emissions from the ground are picked up by the detector and converted to an electrical signal, which is amplified and converted to a visual signal displayed on a cathode ray tube. This thermal picture is recorded on Polaroid film. The prints appear similar to aerial

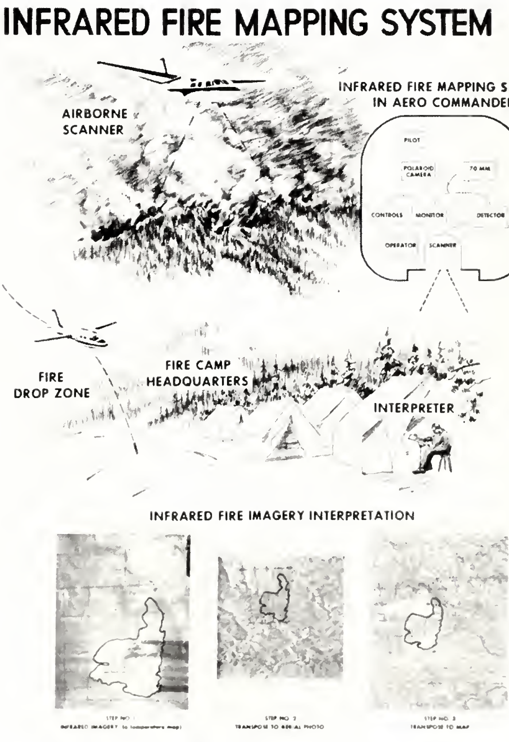


Figure 1.—Illustration of steps involved in infrared fire mapping

[1] Respectively, Fire Control Techni-ia, Western Zone Air Unit, Region 4, n Staff Specialist, Division of Fire trol, Washington, D.C.

[2] Bjornsen, Robert L. Infrared a e approach to wildfire mapping. Fire trol Notes 26(3), pp. 3-4. 1965.

photos, with shades from black to white. The burning areas are white; brightness varies with fire intensity. Roads, buildings, open areas, timber types, and many topographic features are in various tones of gray because they emit infrared energy of lower signal strengths.

A mapping mission for the Forest Service begins with a request to the Regional dispatcher for the unit. This request, including details on fire location, fire headquarters, nearest airport, etc., is relayed to the crew. Usually the initial flight is made before the plane lands at the local airport. The imagery is delivered to the fire headquarters, where a trained interpreter transfers the fire perimeter and other data to aerial photos and maps. Subsequent mapping missions over the fire are coordinated by radio, and imagery prints may be dropped to the interpreter at the fire headquarters in a special plastic tube minutes after being made.

The best imagery is usually obtained at night, but satisfactory imagery can be made during daylight. Dawn and dusk are the poorest time for mapping. Though unaffected by smoke, imagery cannot be made through fog or cloud cover.

USED ON 21 FIRES IN 1966

The base of operations for the infrared mapper was established at Boise, Idaho, under supervision of the Division of Fire Control, Intermountain Region of the Forest Service, Ogden, Utah. The first operational use of the unit took place on July 29 on the Cottonwood Fire, Lewis and Clark National Forest, Montana. Before the summer was over, 21 fires in five States were mapped for the Forest Service, the Bureau of Land Management, and the California Department of Forestry.

An excellent example of the mapping unit's value was on the Indian Ridge Fire, Klamath National Forest. This fire was completely smoked-in for several days; helicopters and other reconnaissance planes were unable to operate. However, infrared imagery was obtained regularly at noon and midnight, furnishing vital information to fire personnel.

The largest fire mapped was the 20,000-acre Round Fire in August on the Mendocino National Forest, Calif. Here also, the smoke pall was extremely bad, and imagery was important in providing needed fire intelligence.

Redding, Calif., was the base of operations from Oct. 10 to Nov. 8. Some imagery was obtained for Civil Defense purposes, and an electronic technician was trained to operate the scanning equipment. Two California fires were mapped near Oroville during this period.

1967 OPERATIONS: 47 FIRES

During the busy 1967 fire season, the infrared plane flew near 400 hours serving Federal and State fire control agencies throughout the western United States, including Alaska, where it proved effective in detecting hot spots in tundra fires. A total of 47 different fires was mapped, many of them several times. Once during the August fire emergency in the Northwest, 14 fires were mapped in one night. The total area mapped each day varied, but reached nearly 100,000 acres several times. An example of the imagery obtained is shown in figure 2.

In addition to these fire missions, the unit participated in a Civil Defense exercise in Los Angeles and was used to obtain imagery of insect-killed timber in South Dakota for research purposes.

(Continued on page 1

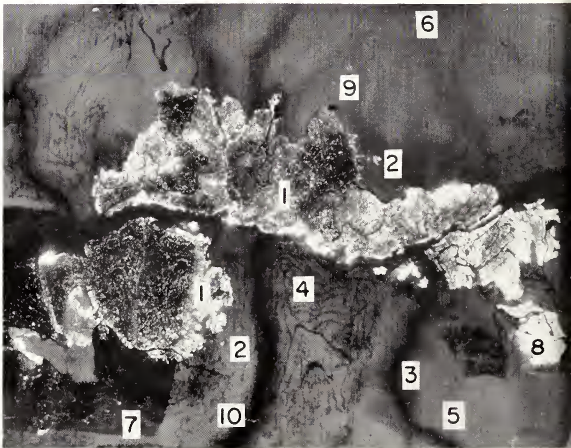


Figure 2.—Imagery—Shoepack Fire, St. Joe National Forest, Idaho, 9/26/67, at 221 5,000 feet over terrain. 1-burned area; 2-spot fires; 3-stream; 4-roads; 5-timbe 6-scan lines; 7-timber removed; 8-extreme heat; 9-fire camp; 10-flaw.

NATIONAL FIRE TRAINING CENTER

by EDWARD G. HEILMAN, *Forester*
Fire Control Training Field Support Unit
Marana, Arizona

As forest fire control becomes more complex, rough the use of tools such as aircraft, fire re-rdant chemicals, electronic and other equipment, e training needs become correspondingly more volved. Sink-or-swim training methods will no nger serve fire control goals.

Although for years the Forest Service has en-avored to improve fire training, having introduced ch breakthroughs as fire simulators, programed struction (including teaching machines), vastly proved films, and other means, it has recognized e need to keep fire training on a par with ever-panding educational technology.

FACILITIES

In February 1967, the Forest Service's Division Fire Control established a Field Support Unit at arana Air Park, Marana, Ariz. (fig. 1). Because the Service-wide scope of its activities, the train- unit receives program direction from the Chief's fice, Division of Fire Control. Individual regions have access to the Marana unit through this division.

Located 30 miles northwest of Tucson, the unit leases offices and classroom space to accommodate 100 trainees (fig. 2). Availability of housing and meals provides a live in environment conducive to better learning.

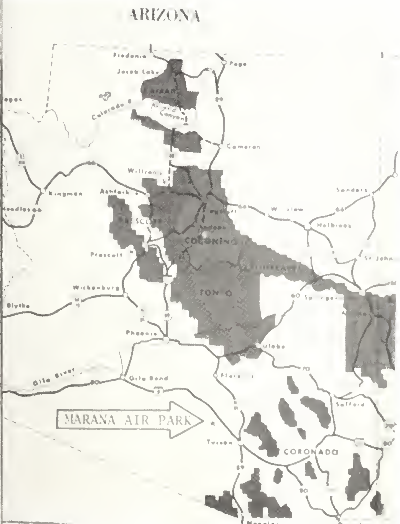
The runways and other flight facilities at Marana offer on-the-spot opportunities for air operations training. The Air Park also serves as an air tanker base during the local Region's fire season from May through July.

MISSION

The Marana Unit serves fire control training needs by using modern learning techniques. Its main goal is to provide support to regional fire control training programs through:

Development and Use of Instructional Tools.

In contracting with instructional technologists, the Unit's position would be, "Here's what we want to teach," expecting the technologist to reply, "Here's how to teach it and the training aids needed." While most instructional tool development will probably be contracted, there will be in-house efforts involving regions and the Marana Unit. Examples of some instructional tools developed elsewhere are the programed texts: *Fundamentals of Fire Behavior, Ten Standard Firefighting Orders, Fire General Policy Review,* and various slide-tape programs.



e 1.—Map showing location of Marana Air Park, site of the National Fire Training Unit.

Figure 2.—Classroom facilites at the Marana Fire Control Training Center.

Development of Service-wide Courses.

The unit will provide assistance in preparing and conducting such Service-wide training courses as Advanced Fire Behavior, Fire Generalship, Advanced Command Air Operations, Fire Prevention, Law Enforcement, and others. A large teaching staff is not envisioned. Instructors will be drawn from the field for temporary assignment as the course requires.

Distribution of Fire Training Aids.

During field trips and other contacts, the unit will evaluate locally developed fire training aids for Service-wide use.

Establishment of a Fire Training Library.

A technical fire control library has been established to provide field units, contractors, researchers, and trainees with a comprehensive reference library for assisting the fire training effort.

Assistance at Regional Schools.

With coordination by the Division of Fire Control, the unit will furnish on-site assistance at some regional schools, including qualification of fire simulator instructor teams. The Marana facilities are also available for regional courses. Training officers are encouraged to visit the unit.

Pilot-Testing New Training Methods.

The program includes evaluation of new "hardware" such as television systems (fig. 3), new teaching machines, and cartridge-loaded movie projectors; and it includes appraisal of "software" such as written or filmed programs. The unit maintains contact with the latest developments in both educational ideas and equipment.

The newest command system fire simulator has been installed at the Marana Center to furnish regular and advanced fire simulator training on both national and regional levels (fig. 4). It will also be used to develop and test new simulation procedures and equipment.

One example of this is a recently prepared air-oriented fire simulator exercise. In this exercise, observer-trainees are actively involved with the trainee fire team in decision-making through a parallel teaching system using Edex student-response equipment. The system uses programed audiovisual instruction and individual responder units where trainees indicate their answers to questions by pushing one of four buttons. By monitoring indicator dials, the instructor can immediately determine both individual and group responses. Using this information, he can furnish additional instruction as needed by the individual or group.

Figure 3.—Using television equipment to supplement classroom instruction.

Forest fire control today offers new challenges to the wildland manager. To meet them, improved fire training is necessary. The Marana Fire Control Center will help furnish this training to the field fireman.

Figure 4.—Umpire-Director booth, Marana command system simulator.

FOREST FIRE PREVENTION—THE VITAL ROLE OF COMMUNITY LEADERS

M. L. Doolittle, *Research Forester*
Southern Forest Experiment Station

Key men in rural communities are often enlisted in forest fire prevention programs. They include elected officials, successful businessmen, farmers, and others influential in education, religion, economics, and government. A recent study by the Southern Forest Experiment Station's Forest Fire Prevention Research and Development Project at State College, Miss. indicates that the success of fire prevention programs may be related to the pattern of leadership in the community.

In the study, a rural community with a relatively low fire-occurrence rate was found to have general leaders who had the positions, records for action, and reputations associated with leadership. In a second community with a much higher fire-occurrence rate, there were many in high positions, but none whose influence was widespread, or who were regarded as leaders by most other residents.

STUDY COMMUNITIES

The two study communities were chosen for comparison because, while similar in such characteristics as land-ownership and use, and economic composition, their rates of forest fire occurrence differed sharply. The approximate boundaries of each were determined by asking residents to which community they belonged. As finally delineated, the study communities contained about 200 families each. The *High Rate* community was having over 10 times as many forest fires as the *Low Rate*. In both communities, incendiarism accounted for well over 50 percent of the fires. In *Low Rate*, fire occurrence had decreased sharply in the 10 years preceding the study. In *High Rate* it had been excessive for longer than local foresters could remember.

An investigation into the reasons for the contrast in occurrence rate disclosed that, in the *Low Rate* area, the forest protection agency had done nothing revolutionary to prevent fires, but, partially as a result of key-man contacts, residents spoke of fire prevention as a first-person activity. "We just showed people that fire setting wasn't the thing to do," said one prominent citizen. "We had regular forestry programs three or four times a year. We showed films to the school kids too, and that seemed to really help. Then we did a lot of just sitting and talking to people. We got a few people convinced, and the rest followed."

In contrast, people in the *High Rate* area discussed the Government and fire protection in the third person. For example, a successful dairyman said, "The Government has me surrounded on three sides. I don't know how they ever got hold of all this land, but a fellow can't buy any for love nor money. People around here don't get anything out of the Government land but a big headache. Why, it's got to where you can't even let a fire get out without the Government coming and trying to put you in the pen!"

LEADERSHIP PATTERNS

Leaders in the two communities were identified through their positions, community activities, and reputations. Positions normally associated with leadership included appointive and elective offices. Community activities included participation in public programs of importance to the whole community. Reputation, perhaps the most significant of the criteria of leadership considered, involved recognition as a leader by community residents. Names of those in important positions and those active in public programs were noted. People with a reputation for leadership were identified through interviews with community residents. In singling out leaders, emphasis was on area of influence.

In the *Low Rate* community, a few leaders with wide general influence emerged, regardless of identification criteria. Two of the four people most often named as leaders were elected officials, and a third had just completed a term in an elective office. One had demonstrated community action by encouraging voter turnout in a special county election to approve the building of a pine plywood mill. As an advocate of the building plans, he was almost certain to support forest protection programs. In this community, foresters had little difficulty in finding the right people to aid in a prevention program which proved very successful.

In the *High Rate* community, on the other hand, a large number of people emerged as leaders, but none was named often enough to be regarded as such in the whole community. One individual was influential among his immediate neighbors; another, the respected elder among a large, close-knit kin group; still another was recognized because of his vast land and cattle holdings. Such people were named as leaders by fellow residents more often than elected officials and others in positions normally associated with leadership, the effect being that the *High Rate* area had no general leadership at the community level.

Those regarded as key contacts by county forestry and agricultural officials attended State and regional agricultural conferences, participated in the county forestry association, and represented the local political unit on the county soil and water conservation board. They were not, however, considered leaders by the other residents of the community. It is not surprising, therefore, that they had little influence over those who were causing forest fires, and prevention programs directed by them may even have been resented.

CONCLUSIONS

Where people of high position have little influence, and there are no general community leaders, local fire protection agencies face difficulty. When diffuse leadership is the only kind available (as is often true in the South), forest protection contactors must recognize and work with it, if he is eve to get effective fire prevention action.

The real question, of course, is, "How do yo obtain assistance and support from such leade once you find them?" To answer this questio scientists at State College, Miss., are making tw studies. The first is of such things as leadershi qualities, information sources, dissemination pa terns, and areas and levels of influence. The othe prevention activities—ranging from personal contac to community organization and development—wi be made under carefully controlled condition Scientists hope to determine how effective suc activities are, both singly and in various combina tions. Their findings certainly will not replace th effectiveness of personal contacts, but they may hel those involved to increase their efficiency.

FLUORESCENT SIGNAL STREAMERS WORK WELL

ALBERT E. BOUCHER, *Smokejumper Foreman*

Redmond Air Center

Good communications is the key to smooth aerial operations. During busy fire periods, radios are at a premium, and ground personnel must communicate with support aircraft by visual signals. This is usually accomplished by laying 1-ft. by 8-ft. strips of colored material ("streamers") on the ground in signal patterns.

Those now in common use are made of crepe paper, cambric cloth, or thin plastic. Certain features of these materials can reduce their effectiveness. Coloring fades rapidly, wind makes it difficult to keep the streamers in position, and reflective qualities are inadequate under poor light conditions.

A vinyl-coated pennant cloth in bright fluorescent colors has proven very effective for this use. Available commercially at reasonable cost, it eliminates or greatly reduces the inadequacies of present products. Being colorfast, it will not fade. The material is stiff enough to remain flat in moderate winds, yet it is easy to roll or fold. The cloth is available in 38-inch-wide rolls and can be cut to size and shape with scissors.

The 40-man smokejumper unit at the Redmond Air Center, Oregon, was issued the new streamers on a trial basis for the 1967 fire season. They were used to signal aircraft for tools, food, water, et All comments were favorable. Pilots and observe reported being able to see and "read" the fluoresce streamers much more quickly and easily than th ordinary ones. Slight breezes didn't disturb them no were they confused with small red cargo parachute

The Redmond Air Center smokejumpers hav now adopted the new streamers and have also co structed message droppers using the fluoresce cloth.

The color used at the Air Center was calle "Blaze Orange," but material is also available i "Arc Yellow," "Blue," "Signal Green," "Rock Red," and "Saturn Yellow." The cost varies fro 63 cents per yard for 500 yards or more, to 88 cen for less than 100 yards. The streamers tried by th Redmond smokejumpers were 9½ inches wide (t fully utilize the roll) by 12 feet long—equal to abou one square yard. This material may be purchase from United Tent and Supply Co., 759-61 N Spring St., Los Angeles, Calif. 90012.[1]

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[1] Trade names and commercial products or enterprise are mentioned solely for information. No endorsement b U.S. Department of Agriculture is implied.

LARGE HELICOPTER USE IN FIRE SUPPRESSION

DIVISION OF FIRE CONTROL
Washington, D.C.

The value of helicopters for various fire control sks has been established for 20 years. These ver-tile and efficient aircraft are now employed almost utinely on most large fires, and many smaller ones well.

Most helicopter use has been with the light utility or 3-place models with a load-carrying capacity approximately 1,000 pounds. Large helicopters ve been used only infrequently due to lack of ailability. The high investment and operating sts of the larger models have discouraged com-ercial operators from purchasing them until op-rtunities for expanded use were more certain. ius, they have generally been available to fire ntrol agencies only in emergencies from military urces, necessarily limiting investigations into their tential for fire suppression work.

This situation is changing. In recent years, sev-al western commercial helicopter operators have ade large models available for fire use. Experience th these aircraft during the 1966 and 1967 fire asons has clearly indicated that they offer an portunity to significantly improve the efficiency fire control forces in certain situations. Although cost per hour for these larger models may run much as 3 to 4 times that for lighter helicopters, s is more than offset by their larger capacities d improved performance (table 1).

BLE 1.—General characteristics of some large helicopters w in use. Actual capacities will vary with local conditions d fuel weight.

odel	Passenger capacity	Payload (pounds)	Retardant Capacity (gals.)
ll 204-B	8	4,130	3-400
orsky S-58	13	5,040	3-400
orsky S-61	(a)	7,400	7-900
man H-43-A	(a)	2,400	2-250

(Not approved by U.S.F.S. for personnel transporta-ti.

OPPORTUNITIES FOR USE

valuation of the performance of large helicop ts during the past two fire seasons has pinpointed siations where they have definite advantages over o er types of equipment. On personnel transport a cargo hauling missions, the performance char-aeristics and load capacities of these aircraft pmit large volumes of men and equipment to be mved rapidly into a remote fire. With the Sikorsky S8, for example, no more than three trips would be required to deliver a complete 25-man organize crew and its equipment. For a 5-mile ferry, th entire operation could be completed by one copte in approximately 20 minutes (fig. 1).

During the 1967 fire "bust" in Northern Idaho, three U.S. Army HUEY helicopters, the military version of the Bell 204-B, flying a total of 34 hours, moved 174 men and more than 12,000 pounds of equipment and supplies to four large fires in road-less areas. More than a dozen light helicopters would have been required to accomplish this task in the same time.

HELITANKER OPERATIONS

While fixed-wing airtankers offer advantages of high speed and large load capacity, necessary in many circumstances, the large helitanker has also proven an important tactical tool. With its great maneuverability, the helicopter can accurately pin point drops, and has achieved excellent results in close support of line workers. Also helicopter drops can often continue after fixed-wing operations have been curtailed by smoke and reduced visibility.

The relatively small load capacity of even the large helitankers, as compared to fixed-wing air-tankers, is often offset by their ability to operate from water or retardant-mixing sources close to the fire. The "dip buckets" developed for these air craft make it possible for them to load easily from

Figure 1.—The large capacity of the Sikorsky S-58 enables it to quickly move fire suppression forces to remote areas

small ponds or portable retardant mixing plants in the fire vicinity without landing (fig. 2). Thus, little time is wasted in ferrying, and the helitankers can actually drop greater quantities than fixed-wing aircraft operating from distant bases.

In 3 days on the Airstrip Fire, Willamette National Forest, Oregon, one S-61 helitanker applied 147,000 gallons of water and 26,000 gallons of retardants. At the peak of operations it was delivering water at a rate of 9,000 gallons per hour! An additional 34,000 gallons of water and 10,000 gallons of retardant were dropped on this fire by a Bell 204-B and a Kaman helitanker (fig. 3).

LIMITATIONS

In contemplating use of large helicopters, their limitations must be considered and fire control personnel should consult closely with Air Officers. Much care must be taken to select suitable landing sites, since these larger craft have different requirements than the light helicopters familiar to most fire people. Also, the large models cannot hover at altitudes as high as those of some frequently-used small helicopters.

FUTURE POTENTIAL

Use to date confirms the large helicopter has definite place in the fire suppression force. Tl high operating cost per hour is offset by the ai craft's ability to transport larger loads at fast speeds than lower-cost, smaller models; and in a propriate circumstances it can be much more ef cient. Conversion from personnel transport to carg carrier to helitanker can be rapidly effected, givi fire managers a versatile, increased-capacity pie of equipment.

Further improvements in the helicopters or r lated equipment, such as the lightweight helitank buckets pioneered by the Pacific Northwest Regio will further increase their adaptability to many fi jobs. Because of present military requirements, tl number of large helicopters available for purcha by commercial operators is limited. Some operato may still be reluctant to make the large investme required. It appears certain, however, that tl availability of large helicopters for fire work increasing. Fire control personnel should becom acquainted with the potential benefits—and limit tions—of large helicopters so they may consid their use in appropriate situations.

Figure 2.—A Bell 204-B helitanker loads its drop bucket with retardant mixed by a portable mixer near the firelines.

Figure 3.—The Kaman helitanker, with 250-gallon bucket.

INFORMATION FOR CONTRIBUTORS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be typed in duplicate, double spaced. The author's name, position, and organization should appear directly below the title.

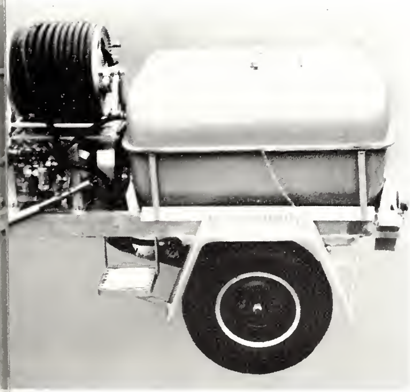
Articles covering any phase of forest, brush, or range fire control work are desired. Authors are encouraged to include illustrations with their copy. These should ha clear detail and tell a story. Only glossy prints or Ind ink line drawings can be used. Diagrams should be draw with the page proportions in mind, and lettered so as t permit any necessary reduction. Typed captions should b attached to the illustrations, or included in the text follow ing the paragraph in which they are first mentioned.

IEW TRAILER-MOUNTED FIRE RETARDANT MIXER SUCCESSFULLY FIELD-TESTED

Franklin R. Ward, John D. Dell and William C. Wood[1]

A new trailer-mounted chemical fire retardant ixer (fig. 1) was successfully field-tested in the acific Northwest Region during the 1966 slash irning season. The test was done on seven high-ad or tractor-logged units on the Umpqua National orest in Oregon. We used the unit to apply a fire tardant to perimeters of clearcut blocks for extra otection during broadcast burns; the retardant as also used to slow down rate of fire spread at itical points within blocks.

A 1½ ton stake-side truck towed the trailer and rried bags of retardant and water. On firelines accessible to trucks, a tractor did the pulling. Ma-pulation of the live-reel hose over slash was diffi-lt and slow. The unit performed best on roadside plication above slash units and on treating acces-le draws and chimneys below the road level. The timum crew size was three to five men, depending amount of slash, topography, and distance hose d to be laid. When towed by a tractor or 4-wheel ive vehicle over firelines on moderately steep ter-in, the unit handled satisfactorily.



Fire 1.—The trailer-mounted chemical fire retardant mixer can hold 300 gallons.

The mixer unit consists of a 300-gallon fiberglas tank equipped with an impeller for mixing, a 12½ horsepower (at 3200 rpm) engine, a 250-foot capac ity live reel, and a Seeger-Wanner Model A201 positive displacement piston pump rated by the manufacturer at 22 gpm. at 578 rpm, and up to 500 psi. These components are mounted on a heavy-duty, single-axle trailer. The equipment was assembled for the Forest Service by Mitchell, Lewis, and Staver Company[2] of Portland, Oregon, at a develop ment cost of $2,127.

Engineers from the San Dimas Equipment Devel-opment Center made laboratory tests to determine if this unit could adequately mix the fire retardant Phos-Chek 259. They also tested Phos-Chek 202 and Gelgard M.[3]

The tests showed that the unit *could* mix Phos-Chek 259. It was the only retardant used in the field tests. Although no difficulty was experienced with the pump in the laboratory trials, even when pump ing Phos-Chek 202 at 800 plus centipoise, both Phos Chek 202 and Gelgard M were more difficult to mix than Phos-Chek 259. Changes have been made in the mixer to correct this.

The unit generally performed well in its first field trial, although a need for certain equipment modifications became evident. The live reel was not large enough to handle the amount of hose used, nor did it have a handle for rewind; a larger live reel with handle has been installed. The trailer did not have ample protection for belt and flywheel on the mixer shaft. A metal plate attached to the under carriage corrected this problem. A maintenance kit and spare tire have been added and other minor re pairs and modifications made. Further field use of the mixer is planned.

[1] Ward and Dell are associated with the Pacific South west Forest and Range Experiment Station, Berkeley, Calif.; Wood with the Pacific Northwest Region, U.S.F.S.

[2] Trade names and commercial products or enterprise are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

[3] U.S. Forest Service. Mitchell retardant mixer. 1966 (Unpublished report on file at San Dimas Equipment Development Center, San Dimas, Calif.)

Fire Hazard Management—*Continued from page 3*

Figure 2.—Same area as figure 1. Firing completed 2200—Sept. 20, 1967.

Figure 3.—Same area as figures 1 and 2. 2200—Sept. 21, 196

were checked on Nov. 13 with the following results:

50% laydown blocks . . .	58M seeds per acre
Spray block	50M seeds per acre
Natural area	132M seeds per acre

The traps were left in position for checking in the spring to determine later seed fall. The seed fall to date appears sufficient to establish a new, fully stocked stand.

Because the untreated areas cleaned up as well as the treated ones, we believe that *no treatment other than control lines is necessary to establish satisfa tory fuel breaks in our high-hazard fuels.*

In merchantable stands, the salable material wi be removed and the residual burned. The slas from the cut material will make ignition easier her Standing stems will be killed by the fire and wi furnish shade for the new seedlings.

Strategically located fuel breaks for controllin potential conflagrations are being given first priorit as roads are developed through high-hazard units They will be rehabilitated to develop full timber pro duction potential as well as to fireproof them.

Infrared Mapping—*from p. 8*

Despite heavy use during the summer, the mapper functioned well. Minor electronic repairs were required only once, and the detector failed on one mission due to ice accumulation.

SUMMARY

Infrared imagery can reduce firefighting costs in many ways. In addition to accurately locating fire perimeters and spot fires, it reveals the relative intensity of the fire on the different sectors. Rate of fire spread can be accurately calculated from successive imagery made at timed intervals. Topographic and cultural features can be identified. All this information can assist the Fire Boss in establishing priorities for suppression on various parts of the fire and in selecting suitable control line locations. Manpower and equipment needs can be better estimated. In the mopup stage of the fire, new imagery pinpoints hot spots, permitting better schedulin and use of manpower.

Accurate interpretation of th imagery, and the subsequent trans fer of information to aerial photo graphs and maps, is very importan to its successful use. To facilitat broader application of infrar mapping, the Forest Service h trained 58 interpreters from F eral, State, and County protecti agencies in Western States. Mo will be required.

FIRE CONTROL NOTES

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/FALL 1968/VOL. 29, NO. 4

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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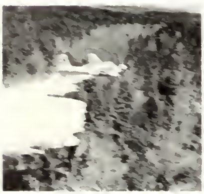

COVER—A B-26 air tanker attacks a small fire. Air tankers are an effective and efficient element of the fire control force when used on a planned, selective basis. See related story on page 6.

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COMBINATION HELITANKER-AIR TANKER ATTACK ON THE PINE CREEK FIRE

TROY KURTH, *Forest Research Technician*
Pacific Southwest Forest and Range Experiment Station[1]

combined helitanker-air tanker attack can ly and effectively help control a forest fire if munication is constantly maintained between ircraft and the ground and if operational pro- ures are followed. Excellent helicopter control be maintained if all drop missions are directed n Air Tanker Boss in a lead plane. These two its were demonstrated during the Pine Creek of Aug. 9-11, 1967, on the Cleveland National est, Calif. The primary mission of the air tank- was to reduce fire intensity. Helitankers were gned to specific targets that threatened to spot ss or burn around retardant drops, to make the attack on spot fires, and to support handline truction crews. An Air Tanker Boss in a T-34 plane directed all retardant drops.

AUGUST 9

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AUGUST 10

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However, by 1030 the situation had become critical. The rapidly rising temperatures and rapidly falling humidities on the east exposure made the flashy brush and grass highly receptive to spot fires and flareups. The Fire Boss realized that low-volume helitanker drops would not be able to contain the flareups and spot fires.

With an Air Tanker Boss in a T-34 lead plane, additional air tankers were ordered.

Air-Attack Organization

The Fire Boss decided to set up an air attack organization. He knew the hazards created by unorganized fixed wing and helicopter operations over a fire area. The Air Attack Boss position was established. Then the Air Attack Boss established a pattern. The pattern utilized two frequencies:

1. Air net between all aircraft and the Air Attack Boss.

2. Forest net among the Air Attack Boss, fireline personnel, and the Helicopter Manager.

The Air Attack Boss and the Air Tanker Boss decided to combine all retardant aircraft, deploying helitankers in the same manner as air tankers. They established the following operational procedures:

1. All inbound air tankers would report to the Air Tanker Boss. When he was 3 minutes from the fire, the Air Tanker Boss would inform the Air Attack Boss.

2. Air tankers would maintain a minimum altitude of 1,500 feet over the fire until the Air Tanker Boss led them in on a target assigned by the Air Attack Boss.

3. The normal altitude at which helitankers would fly over the fire to the assigned target areas was 500 feet.

4. An air tanker would not be led in for a drop without the Air Tanker Boss clearing the drop with the Air Attack Boss.

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6. All operations would immediately cease if for any raason, both the Air Attack Boss and the Air Tanker Boss did not know the exact position of any aircraft.

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Information from the fireline personnel was transmitted to the Fire Boss and the Air Attack Boss on the forest net. The Air Attack Boss and the Air Tanker Boss determined the correct type of aircraft for deployment on every target.

Air-Attack Operation

In operation, all helitankers were [cut off] the fire base heliport while an air t[cut off] being led in for a drop by the Air Ta[cut off] The helitankers were cleared for takeoff[cut off]

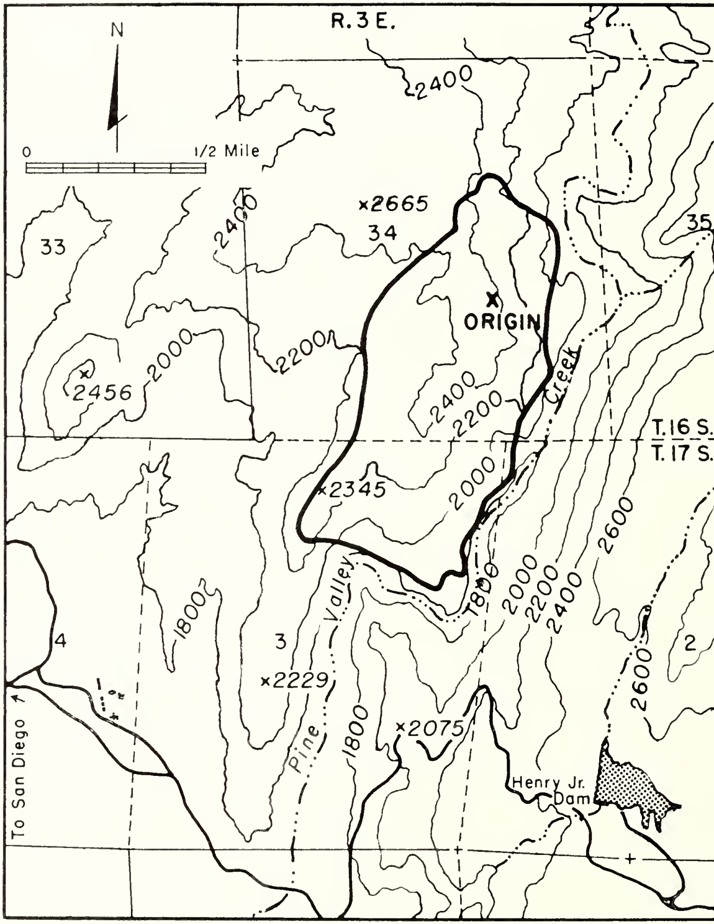


Figure 1.—Firefighters were confronted by rough terrain and were hampered by limited access in the Pine Creek Fire. The fire occurred on Aug. 9-11, 1967, on the Cleveland National Forest, Calif.

e air tanker completed its run. The Air Attack oss, in turn, ordered the helitankers to the drop ea, where the Air Tanker Boss directed them to ecific targets. The helitankers were to knock own pockets of flame and spot fires that threated to burn around or through the fixed-wing ops. This tactical maneuver almost eliminated e need for more than one air tanker drop at y point.

On several occasions, two air tankers would be l in, one behind the other, on a simultaneous n. One would drop immediately after the other the most fire would be knocked down in the ast time. The helitankers would follow up the tanker drops to strengthen the lighter ends of e drop patterns and to assure an overlapping the retardant line.

When air tankers were not over the fire, the litankers assumed control. The Air Tanker Boss w at an elevation that permitted him to view entire situation. He would direct the helikers to targets within their individual or comed capacity. This plan assured the Air Attack ss that priority targets were being attacked.

During the brief lulls in air activity, the Air tack Boss and the Air Tanker Boss would establ target priorities and would decide on the mbinations of integrated attacks to be used when the loaded air tankers reported back to their. Several times during the day, helitankers were ordered to fast-breaking spot fires and flareups at the same time as ground forces were being notified of their existence.

Summary

By 1630 the three helitankers had dropped more than 18,000 gallons of retardant, had ferried 280 men to and from the fireline, and had delivered 7,900 pounds of urgently needed supplies to the ground crews. Four pilots were assigned to this operation, as the helicopters were in almost continuous use from 0600 to 1630. The average round trip required about 5 minutes; however, some of the flights to and from the north end of the fire were completed in less than 1 minute. Personnel transport was done as efficiently as possible and, under most conditions, two men were carried in and two men were carried out during one round trip.

The one B-17 and five TBM air tankers dropped 37,700 gallons of retardant on the fire. The last TBM tanker drop, at 1635, extinguished the last visible flames on the fire. By sundown, the fire was contained within an adequate fireline at 310 acres. The fire was announced as under control at 0900, Aug. 11, 1967.

TRAINING PAYS OFF

John E. Boren, *Investigator*
Kisatchie National Forest

One year in jail—that was a cent sentence imposed by a uisiana State judge on a man o intentionally set three fires the Kisatchie National Forest. is judgment resulted from ilance on the part of a Forest vice employee.

For the past 2 years the Kisate National Forest has been essing the need for Forest vice personnel to be observant. law enforcement training sesons, the Forest Investigator has red foresters not just to look, to "see", what evidence may may not be present at the ches of fires or other possible minal violations occurring on National Forest.

Early one dry morning, a Catahoula Ranger District fire prevention technician answered the office phone. A voice said, "There's a ground fire at the Stuart Recreation Area." The technician notified a fire suppression crew, then left in his pickup. Arriving at the area, he saw a man trying to stamp out a fire. Then two more fires—very small. He also noticed there was no one else around. A moment's discussion revealed the helpful man who called about the fire had then come back to help put it out. (The nearest house was over a mile away. Two of the fires were only as big as a hat when the technician arrived.)

This man muttered a name and that he was from Olla, a small town 50 or 60 miles away. He then got in an old model, light-colored car and drove away. The technician did not see the license number, but did observe a name written on the driver's door.

This information was relayed to the Kisatchie Investigator, who launched an immediate investigation. Local inquiry revealed no likely suspects who could have set the fires. But a check with other local law enforcement officers disclosed that several families with last names similar to that of the "helpful" man lived in the vicinity. The Deputy Sheriff at Olla advised that he knew of two men by that name, and that one of them *did* own an old model car with his name writ-

(Continued on page 16)

AIR TANKER USE: A 5-YEAR APPRAISAL

Division of Fire Control
Washington, D.C.

More than 45 million gallons of water and fire-retarding chemical solutions has been dropped on forest fires by the Forest Service since its air tanker program was started about 12 years ago. A comparison of the National Forest protection area burned during this period with that of the previous 10 years shows a reduction of more than 20 percent. Certainly intensified prevention efforts and many improvements in equipment and techniques have contributed to this reduction. But it generally has been felt that air tankers have played an important role in effecting it.

The Study

In order to better measure their value, in 1962 the Forest Service initiated an administrative study to appraise the effectiveness of air tanker drops on going fires. During the 5-year period from 1963 through 1967, a sample consisting of 922 individual drops was evaluated.[1] Data studied for each drop included information on the fire (size, fuels, topography, spread characteristics, etc.), weather, tactical objective of the drop, and how much it helped ground forces bring about control. If rated less than a "definite help," the reason for the drop's ineffectiveness was also noted.

The fires and individual drops represented in this study were selected by chance rather than by a systematic sampling method. Evaluation was done by selected fire control personnel, and at times they were needed for fire suppression duties at the sacrifice of making the evaluations. However, the data gathered reflects a variety of fire and drop conditions, and is, therefore, felt to be representative.

Results

Overall, the benefits of the air tanker drops sampled were impressive. Seventy-nine percent were reported to have been of "probable" or "definite" help to ground forces in controlling fires (table 1). Seventy-one percent were "on target," and 15 percent were reported as "partial misses." The remainder (14 percent) were "complete misses," caused mainly by such factors as height or speed of the aircraft, poor visibility, difficult target, and mechanical failures. Misses due to mechanical problems noticeably declined over the 5-year period, reflecting the continuing improvements made in tank gates and related equipment.

TABLE 1.—*Air Tanker Drops Evaluated and Their Reported Effectiveness*

Evaluation of Effectiveness	Number of Drops	Percent of Total
Definite help	576	62
Probable help	155	17
Doubtful help	73	8
No help	118	13
Total	922	100

Complete misses accounted for two-thirds of those drops evaluated as being of doubtful help or no help. Another 12 percent of the drops rated ineffective was judged by evaluators to have been unnecessary, i.e., even though the drops hit the target, ground forces could probably have readily controlled the fires without them. The remainder of the "ineffective" drops was so rated because the fire subsequently *burned through*, *spotted across*, or *flanked* the retardant line.

Evaluation

Results of this study indicate that air tanker drops have the greatest chance of being a definite help in control of smaller fires (fig. 1). Better than two out of three drops on Class B and C fires (0.26-99.9 acres in size) were rated as being a "definite help." On fires 100 acres and larger, only two of five were so rated. The relatively low-rated effectiveness of drops on Class A fires (0.25 acre or less) may be explained by the fact that their small size makes them a difficult target. Being small, they are also likely at times to have been controllable by ground forces alone, and thus the air drop was rated ineffective because it was unnecessary.

Of the drops evaluated, the highest percentage rated as a definite help were those made on the head of the fire (table 2). Where character of the fire is a concern, air tanker use is generally of least value on fires with a slow rate-of-spread (fig. 2). More than one-third of the drops studied were made on "smoldering" and "creeping" fires, with only 46 percent rated of definite assistance, undoubtedly because they were often unnecessary for control.

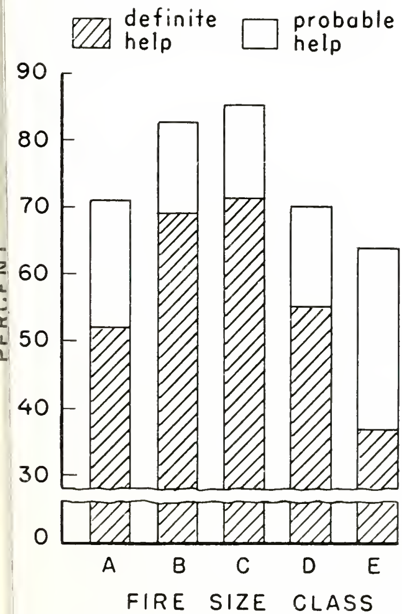
[1] Drops by helitankers made up only 3 percent of the sample studied; therefore, results reported are generally most applicable to fixed-wing tankers.

TABLE 2.—*Retardant Drops by Target Area*

ire rget	Total Drops, percent	Definite Help Drops, percent
ad	51	73
ınk	24	50
ar	3	38
ot fire	22	52

While these data might imply that retardants e most effective when used on the *head* of *st-moving* fires, some caution is wise. Both logic l experience indicate that such drops will be ile in situations where the fire will burn or ot across, or flank the retardant line before equate followup action can be taken.

n general, there was no marked variation in ported effectiveness of the drops by type of el in which the fire burned. The percentage of tanker drops reported to be of definite help ged from 56 to 66 for grass, brush, litter, and erstory fuels. In slash fuels, 76 percent were so luated.



gıe 1.—Percent of drops rated of definite or probable help, by fire size class.

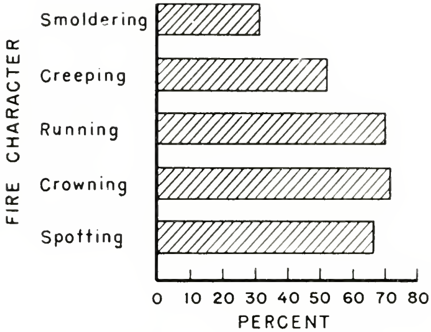


Figure 2.—Percent of drops rated a definite help, by character of fire at time of drop.

Slope gradient of up to 70 percent does not appear to be significant to the effectiveness of air tanker drops. The sample did not include enough drops on steeper slopes to be meaningful, but there is an indication that the chance of such a drop being effective decreases, particularly on those slopes with greater than 80 percent gradient.

No correlation was noted between percentage of drops rated a "definite help" and windspeed up to 14 m.p.h. Above that rate, effectiveness decreased with increasing windspeed. While the sample included relatively few drops made with windspeeds greater than 25 m.p.h., only about one-third of those evaluated were believed to have materially assisted ground forces.

Reports indicated the highest percentage of "definite-help" drops occurred when the tactical objective of the drop was line building in direct attack (table 3).

TABLE 3.—*Retardant Drops by Tactical Objective*

Tactical Objective	Total Drops, percent	Definite Help Drops, percent
Line building, direct attack	23	79
Line building, indirect attack	4	69
Delaying	29	62
Cooling to hold line	21	58
Cooling spot fire	15	51
Reinforcing weak line	8	37

Use of air tankers generally was less effective during periods of high fire danger. With burning indexes of 0-50, 63 percent of the drops were reported to be of definite help; above that index level the average decreased to 54 percent.

(Continued on page 13)

CHAPARRAL CONVERSION PROVIDES MULTIPLE BENEFITS ON THE TONTO NATIONAL FOREST[1]

J. J. Baldwin, *Forester*
Tonto National Forest

Chaparral vegetative types on the Tonto National Forest are at 3,000 to 5,000 feet in elevation. At this elevation range, annual precipitation is 15 to 25 inches. Here temperatures during the summer are more than 100° F. during the day and relative humidity is often less than 10 percent. In heavy stands the volumes of this chaparral fuel range from 30 to 50 tons per acre.

The grazing capacity of chaparral is low for both wildlife and livestock because of the impenetrable cover and little herbaceous growth. It is difficult to manage cattle in the dense brush. Local livestock operators often must rely on cattle traps around the few watering areas to capture their animals for branding or marketing.

Watersheds in dense chaparral produce little water because of both high plant transpiration and high evaporation loss when rainfall is intercepted by dense vegetative cover. Soil erosion and offsite soil movement are common under the brush cover.

Wildfires in this chaparral type are frequent, and they often burn with explosive intensity. The cost of suppressing these fires may easily exceed $30 per acre. As a result, a prescribed burning program has been underway since 1961.

Burning plans included coordination of all land uses. The objective of this project was to burn the dense chaparral and to convert the area to open Savannah-type grassland, retaining islands of chaparral for wildlife cover. Riparian vegetative types were also to be protected because of their value for wildlife and for use by recreationists.

Figure 1.—Typical cover conditions in Brushy Basin prior to prescribed burning treatment.

Experimental burns were conducted in 196
and 1962. In accordance with Forest Service fu
hazard reduction policy, it was decided to u
fire as a management tool in large chaparral area

The Brushy Basin Project

About 5,000 acres in Brushy Basin, 50 mil
northeast of Phoenix, Ariz., in the Tonto Nation
Forest, were selected for the first major prescribe
fire treatment of chaparral in the Southweste
Region (Arizona and New Mexico) (fig. 1).

Plans were made to control-burn small segments
all burning of the Brushy Basin area was to b
completed in 3 years. A study of fire weath
was initiated prior to burning to establish criteri
for safe burning. Late September and all o
October were chosen because the most favorabl
burning weather occurred then. Individual period
lasted from 1 to 8 days. In later years, applicatio
of new, special safety precautions extended th
period of safe burning.

Early in 1963, fuel breaks, designed to be perm
anent, were selected and constructed in the mos
strategic locations. Where possible, these fuel
breaks were built with bulldozers to widths vary
ing from 75 to more than 200 feet. When topog
raphy prevented the use of bulldozers, lines wer
built by hand and widened just prior to the majo
burn by burning out on the side toward the are
of the controlled burn.

Experiments were also started to determine i
the application of plant desiccant chemical
(2-4-D and 2-4-5-T mixed) would materiall
aid burning. These experiments are continuing.

All new employees of the Tonto National Fores
were introduced to prescribed burning as a train
ing measure during their first year on the Forest
Because of this training we believe these men ar
now permanently better prepared to cope with
fire situations. Burning crews were assembled when
weather conditions met established criteria. Excep
for key people, these crews were not experienced
in fire control or fire behavior.

Initial burning was completed in 1965, and a
grass cover was established by 1967. It is now
apparent even to the average viewer that conver
sion of chaparral to grass is practical.

[1] Adapted from a paper presented at the Tall Timber
Fire Ecol. Conf., Tallahassee, Fla., March 1968.

The public has been kept well informed since ie early stages of the program; this effort was iade to gain and then increase understanding and cceptance of the burning project.

Firing Methods

Burning procedures changed as improved com iercial ignition devices became available. The rip type and pressurized diesel torches were re laced by grenades and electrically detonated replaced "squibs." Our main tools now include apalm grenades, grenade launchers, Very pistols, isees, handheld butane torches, large butane eed burners, and electrically detonated grenades. lectrically fired devices are becoming more opular because they provide greater flexibility in nition and increase safety for the firemen.

To obtain proper consumption of chaparral iels, a crown fire is required. Thus, burning con- tions must be high if the desired results are to gained. Wildlife islands and streamside vegeta- on are saved by skillful burning ahead of the ain burn. This is usually done during the after- oon and night before the main burn by firing way from and through these desirable areas.

Firing for the main burn is begun from the tps of ridges using a backing fire. This widens te control line. Firing then progresses downhill ong the sides of the areas to be burned. Once te margins have burned to a sufficient width, rip head-firing is started. The entire bottom of te slope is ignited for an uphill sweep. All steps ust be in sequence and properly timed. Crews ust be in constant communication.

A favorable 5-day weather forecast is desirable ior to any burns which will last for more than 1 lay. During all burns, weather must be observed cntinuously and reported, and forecasts must b interpreted so the fireman may be kept fully iformed on the possible effects of weather. De- cions to proceed or to halt the burn depend on tese forecasts.

Revegetation Successful

When the burn is completed, the area is ready f seeding to grass (fig. 2). Seeding has been scessful both immediately following the burn in th fall and in the next July just prior to summer rins, but the latter time appears to be better. Re gdless of seeding dates, germination does not our until after August rains. Livestock grazing mst be deferred during grass establishment, and th area must be properly managed following eablishment of the grass.

Figure 2.—A view of the Brushy Basin area immediately after prescribed burning.

Within 18 months after the burn is completed, the burned area must be sprayed with herbicides to prevent resprouting of the brush. Spraying is repeated annually for at least 3 years to obtain a successful sprout-kill and to maintain the open Savannah-like type. All but 3 of some 20 species of brush involved are prolific sprouters. Three other species readily produce new plants from the seed left on the ground after burning (fig. 3).

Multiple-Use Benefits

Studies on the Brushy Basin and adjacent areas indicate that water production increases about 1.5 inches per acre. Good-quality water is now per manently flowing in the area. During years of heavier precipitation, water yields increase from 1.5 inches per acre per year to as much as 6 inches per acre per year.

After observing the results of burning and sub sequent treatment from 1961 through 1963, the Salt River Valley Water Users Association is now contributing financial support to chaparral con

Figure 3.—Established grass cover on treated area. Application of herbicides will check the brush regrowth.

version projects using prescribed fire as the initial treatment. The association believes the benefits will be sufficient to meet the cost.

Prior to treatment, annual grazing use in Brushy Basin was approximately 20 head of wild cattle. Beginning in 1967, 200 head of cattle was placed on the area under a rotation system of range management. Based on observations, it is clear that more cattle could be grazed if the forage being produced is to be fully used. It is too early to determine exactly how much grazing capacity will have been increased.

White-tailed and mule deer also use the area. The burn-and-spray treatment has improved the deer habitat, but further study will be needed to fully evaluate how much the total wildlife habitat has improved. Increases in the quail population after treatment have been noted; also, this spring's songbird population increased notably.

Conclusions

Chaparral conversion on the Tonto has proven to be an economic success. With increased water production and beef production, and reduced fire suppression costs, $3 is being realized for each $1 spent. This analysis does not place an economic value on increased wildlife use, or on use by recreationists for camping, picnicking, and general outdoor enjoyment. Another intangible benefit is the training we are able to give all personnel who have worked on the Tonto since the conversion program became a reality.

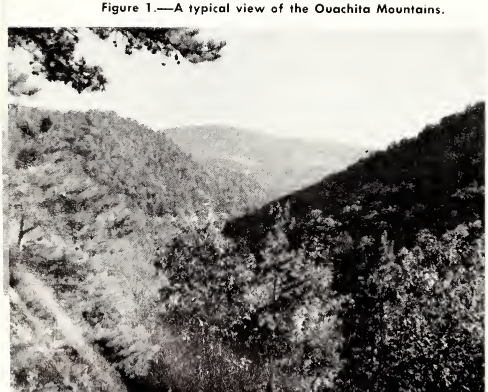
FIRE PROTECTION ON THE OUACHITA

Louis L. Davis, *Fire Staff Officer,*
and Robert C. Roberds, *Forest Dispatcher*
Ouachita National Forest

The Ouachita National Forest, established by Presidential Proclamation in 1907 as part of the Arkansas National Forest, has a gross area of 2.5 million acres with 1.5 million acres of National Forest land. It is located in the Ouachita Mountains of Arkansas and Oklahoma, a system of long, narrow ridges, lying to the east and west (fig. 1). The area is subject to periodic prolonged drought, occurring at 8- to 10-year intervals.

The area's original fire control organization, composed of guards and patrolmen scattered thinly over the Forest at strategic mountaintops, patrolled assigned areas daily throughout the fire seasons. Communication was by word of mouth and travel by horseback or on foot. Tall trees served as lookout towers. Fires were attacked as found. The main suppression tool was often a pine top.

Figure 1.—A typical view of the Ouachita Mountains.



By 1925, the situation had greatly improved. A telephone net spread over the Forest. Roads and trails were being developed, lookout towers and guard dwellings were built, and motor vehicles were in use. There was a large rural population, with communities in every valley. Trained warden crews were the backbone of the fire control organization in these valley communities. Each warden was on the Forest telephone net, had a tool and ration cache, and transportation.

During the depression years of the 1930's, the rural people began migrating from the area. Row crop farming did not provide necessary subsistence, and there was little or no market for timber. The warden system began to break up. The impact was not extensively felt at the time since the Civilian Conservation Corps took over the fire suppression job.

World War II stripped the Forest of needed manpower with military service demands, industrial labor requirements, and the closing of the CCC. After World War II, improved equipment, such as radio communications networks and the mountain fire plow, absorbed some of the responsibility. Intensive timber stand improvement under the Knutson-Vandenberg Act helped to beef up the area's manpower resources. The Ranger District then served as the fire control unit. Initial attack was made by regular Forest Service personnel with backup by volunteers recruited from local towns and communities. But in bad years, the manpower situation was critical.

A New System

By 1960, it was apparent that a reorganization as necessary if the Forest was to continue to eet its responsibility. Accepting the facts that rge numbers of firefighters would not be available on short notice and that the Forest had small ews of skilled firemen on each District, the oblem was how to make the most of available sources.

After much research and study, the following eps were taken:

—Supplemental air detection was activated in early 1963; most of the towers were abandoned, releasing the lookouts for ground service. This system consists of two contract aircraft with pilot and obesrver flying planned routes (fig. 2).

—The Master Plan was revised, dividing the Forest into two fire control units of six Ranger Districts each. The dispatching organization consists of a forest dispatcher and two zone dispatchers. The action plan authorizes zone and forest dispatchers to dispatch the nearest crew and equipment to the fire regardless of district boundaries, without the time lost in having to request such help from the Ranger involved. It also provides specifically for shifts in responsibility from zone to forest dispatcher, or reverse, as conditions change.

—An air tanker base was established at Fort Smith, Ark., within 30 minutes flying time of most of the Forest. Multiengine tankers, carrying from 1,200 to 2,400 gallons of retardant, are used.

—The Weather Bureau began daily fire weather forecasting at Fort Smith in early 1964. The forecaster is in direct radio communication and usually gives revisions as soon as changes become apparent. He also provides spot forecasts for going fires and for prescribed burning.

—The communication plan was revised to provide for a separate frequency for each zone instead of a single frequency handling heavy traffic. This system, with all new V.H.F. equipment, gives ground-to-ground direct contact, zonewide, through repeaters. The dispatchers have both frequencies.

hese changes required much training and practic Weaknesses that appeared were ironed out by plan revision and more training.

he 1967-68 fire season showed the new organiza on was functioning as planned.

Figure 2.—The Fire Detection Team, Ouachita National Forest.

Air-Ground Detection

The air-ground detection system meets detection time standards, eliminates false alarms, and provides prompt scouting of going fires. A side benefit is the aircraft's preventive effect.

Dispatchers know the location of every crew and piece of equipment in their respective zones each day. Dispatching is prompt and attack fast and aggressive. During a multiple fire situation in 1966, one blowup fire was hit by top fire fighters and equipment from five Ranger Districts. It was controlled at 900 acres in 12 hours 10 hours before the next burning period.

In 1963, the air tankers, directed by ground forces with no experience in their use, performed extremely well. At least five fires were prevented from becoming project fires, saving hundreds of thousands of dollars in suppression costs and damages. The tankers have become even more effective as people become more experienced in their capabilities and limitations.

Rangers express a sense of security, knowing that skilled help is available that an aircraft is only minutes away, and that the air tankers are warmed up and ready to go. Direct radio contact with their people and other Rangers has eliminated the need to relay messages.

Method changes are difficult and sometimes painful, but the Ouachita will continue to change as needs indicate. With the intensive mechanization of agriculture and the timber industry, firefighting manpower will continue to be scarce. Thus, adjustments must be made to take advantage of new developments in fire control.

MARKING TEMPORARY HELISPOTS AND DROP SPOTS ON PROJECT FIRES

Reid Jackson, *Fire Staff Officer*
Boise National Forest

Many project fires involve extensive use of both helicopter and paracargo aircraft. It is not unusual for six or eight helicopters to be working on a single major fire at any one time. Also, it is not unusual to have four or five spike fire camps, serviced primarily by helicopter or/and paracargo, for one fire.

Current Deficiencies

To help minimize flight time and to improve the efficiency of helicopter and paracargo operations on project fires, an effective system of marking the numerous helispots and paracargo drop spots is needed. The present marking method varies from little or no marking (only written or verbal description to pilots) to marking with colored streamers. The streamers are frequently blown out of shape and are difficult to locate and identify. Helicopter pilots use limited, expensive flying time locating helispots used to deliver men and supplies. Paracargo pilots, besides using expensive flying time locating drop spots, occasionally are unable to identify the drop spot and have mistakenly dropped cargo in the wrong area. When such mistakes are made, fire managers cannot provide vital supplies for their firefighters at the proper time and place.

Improved Marking System

A marking system that has minimized the flight time and prevented mistaken drops is now being used on the Boise and Payette National Forests. The markers are constructed of Herculite, a plastic-impregnated nylon cloth obtainable in various weights and colors. Large, high-visibility standard marker symbols are sewn onto a sheet of this material. The colors of the material and markers contrast. The Boise uses red on yellow for helispot markers and red on white for drop spot markers. The markers are square and measure 100 inches on each side; therefore, it is easy to spot them and to correctly identify them by number (fig. 1).

The markers are assembled in a kit. The kit consists of the marker, eight 12-inch metal tent pegs, nylon cord for tiedowns, and a small canvas carrying bag. The kits are manufactured by smokejumpers during the winter. The helispot markers and the canvas carrying bags for the Boise are numbered consecutively, from 1 to 16. Fewer drop spot markers are needed; the Boise keeps 8 in its cache, and these, too, are numbered consecutively, from 1 to 8.

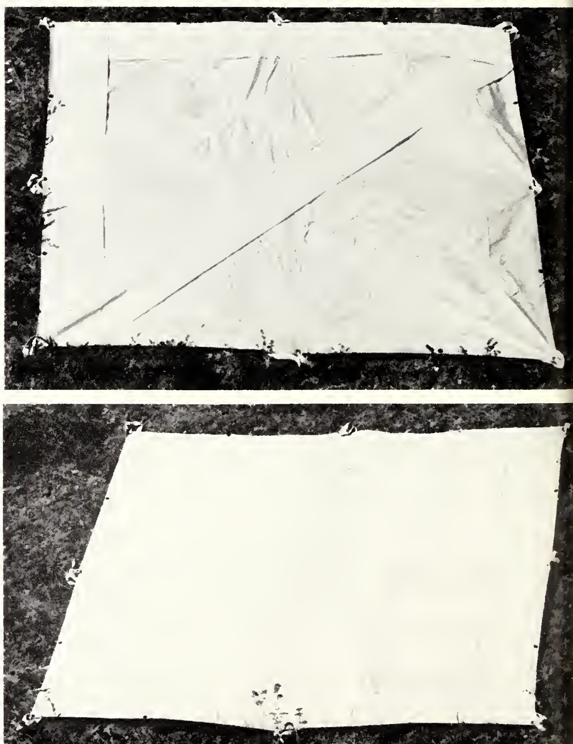


Figure 1—Temporary helispot marker (top) and drop spot marker (bottom).

Advantages of New System

By assigning a numbered iarker to each helispot and drop)ot, dispatch of pilots is simpli- ed, control of two phases of air perations is improved, and flying)sts are reduced (fig. 2). The ivings could be several hundred ollars on a single project fire here numerous helicopters or/ nd cargo aircraft are involved.

The Herculite is strong and ashable; thus, the markers can e placed directly over the touch-)wn pads and help reduce the ust problem associated with any emergency helispots. Mark- 's must be securely tied down, ing tent pegs and nylon cord ovided with the kits. This will iminate the damage resulting om blade down-wash blowing e markers into the rotor blades. ying the markers also insures at symbols and numbers will be sible at all times.

The initial investment in the arkers is somewhat high— 34.50 each—due primarily to e high cost of the Herculite. owever, the markers can be sed repeatedly; thus, the price a fairly minor consideration.

Figure 2.—Markers are easily located and identified from the air.

The savings in reduced flight time would quickly offset the cost of the markers.

Additional Information

Formal specifications have not yet been developed for the mark- ers, but units interested in obtain- ing kits can now order them from the Boise or Payette at the follow- ing addresses:

Forest Supervisor
Boise National Forest
413 Idaho Street
Boise, Idaho 83702

Forest Supervisor
Payette National Forest
Forest Service Building
McCall, Idaho 83638

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ir Tanker Use—*Continued from page 7*

Conclusions

Although this study is based on some neces- rily subjective judgments by individual evalua- rs, it shows that air tankers have provided sub- antial assistance to ground forces. But it also)ints up the necessity for using them on a se- ctive, planned basis for the utmost efficiency nce they are a relatively expensive fire suppres- on element.

Air tankers are, in general, most effective in e early stages of a fire. On larger fires, the iances of effectively aiding ground forces with tardant drops tend to decrease significantly un- less very sound judgment is used in selecting appropriate targets. In all cases, the decision to use air tankers must be based on careful analysis of the particular situation. Fuels, weather, fire be- havior, topography, followup action, and the dif- ficulty the air tanker may have in hitting the target are all factors that must be considered in deciding *first*, whether the retardant drop is actu- ally needed for control, and *second*, what the prob- ability is that it will, in fact, accomplish the de- sired results. This is particularly important on larger fires, where the study data show the low- est percentage of retardant drops to have been effective.

REMOTE MEASUREMENT OF WET AND DRY BULB TEMPERATURES

ERWIN H. BREUER, *Research Technician*
Intermountain Forest and Range Experiment Station[1]

Measurements of wet and dry bulb temperatures that are obtained using mercury thermometers and a sling or fan can vary among individuals because of incorrect readings of the thermometers or because of failure to achieve minimum wet bulb temperatures. A system providing an accurate readout and an easy determination of wet and dry bulb temperature is desirable. Also, the ability to read the measured values 200 yards from the weather station can offer advantages.

The sensors best suited to these requirements are thermistors. They have high sensitivity to temperature changes, and their signal is relatively unaffected by the length of the signal line.

Thermistors are "thermal resistors," i.e., resistors with a high negative temperature coefficient of resistance. As the temperature increases, the resistance decreases; and as the temperature decreases, the resistance increases. Thermistors were chosen because their large resistance change (78 ohms per degree Centigrade) provides good accuracy and resolution compared to that of a platinum resistant bulb with the same basic resistance (only 7.2 ohms per degree Centigrade).

A useful circuit for measuring temperature with thermistors can be made by using a Wheatstone bridge. As the temperature changes, the resistance of the thermistor changes, and the flow of current through the meter can be calibrated in terms of temperature. The thermistor may be mounted a great distance from the meter, and ordinary copper wire may be used to complete the circuit. This capability met part of the test requirements of the weather station, which was the effect of long transmission lines on the signal level from various fire-weather instruments.

The Wheatstone bridge circuit (fig. 1) is described as follows: Switch 1 (SW 1) is the master power switch; it sends 6 volts across the bridge to the thermistors. The two 1.78K resistors are fixed to provide balance for the bridge. Meter sensitivity was selected to match the current change as the bridge unbalances. Switch 2 (SW 2) is a double-pole, double-throw switch with a 537-ohm resistor for a null balance and a 333-ohm resistor for span adjustment. The 2K dial variable resistor is within the range of resistance as the thermistor; i.e., 1,000 ohms. The 1K fixed resis-

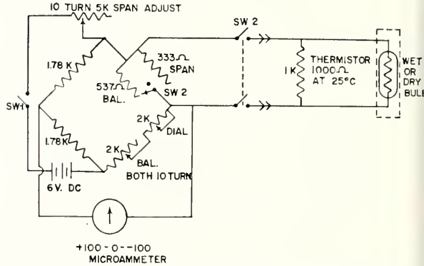

Figure 1.—Wheatstone bridge circuit. One is required for each of the thermistors.

tor is in parallel to the thermistor; it is used to linearize the thermistor because the thermistor resistance change is not linear to temperature change. The two thermistors used in our design have a resistance of 1,000 ohms at 25° C. and a maximum operating temperature of 150° C.

One requirement is that the two 6-volt batteries in series be close to the fan motor to produce the speed and airflow required for the wet and dry bulb. These batteries are actuated by a relay (fig. 2) as is the battery for the solenoid valve. The switches to activate the relays are located on the console.

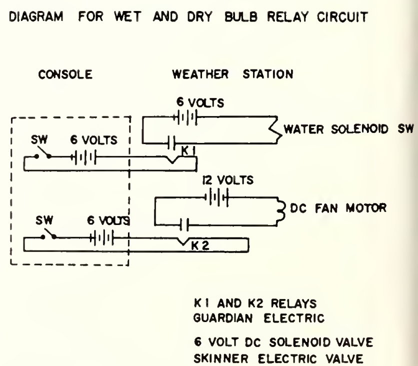

Figure 2.—Circuitry for fan and water relays.

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[1] Headquarters for the Station is Ogden, Utah. The author is stationed at the Northern Forest Fire Laboratory, Missoula, Mont.

The two thermistors are mounted in place outside an air supply box (fig. 3). The water supply line of 1/8-inch tubing is placed directly over the wet bulb thermistor. Inside the air supply box are the fan, a 1-pint polyethylene bottle for water storage, and a 6-volt d.c. solenoid valve with the 1/8-inch water supply tubing narrowed at the outlet to give 3 drops per 10 seconds on the wet bulb. This amount of water will allow full wet bulb depression and maintain it long enough to allow the digital dial potentiometer to be set to the null point.

At most field stations, a remote readout will permit the weather station to be located at the most appropriate spot, even though this might be some distance from the observer. This permits the observer to take frequent readings without leaving his duty post—especially important during periods of high fire danger and heavy fire business.

The operating console is shown in figure 4. Procedures for reading the wet and dry bulb temperatures are:

1. Master panel switch to the *ON* position. (This is not shown in the illustration.)

2. Turn both wet and dry numbered dials to 70.0.

3. Turn both power switches *ON*.

4. On dry bulb, throw calibrate switch to *ON*.

5. Throw balance switch to balance, and null the meter, that is, to center zero.

6. Throw balance switch to span and adjust meter to 83 by turning span knob.

7. Recheck the null point on zero and also span at 83 on the meter.

8. Throw calibrate switch to *OFF*.

9. Null the meter on zero by turning digital dial. Result: the dry-bulb temperature reading is directly on dial.

Use same procedure for the wet bulb temperature, but with the following additions:

10. After calibration is complete, actuate the toggle switch labeled "water" to *ON* for at least 10 seconds; then turn to the *OFF* position.

11. Actuate the fan switch, and null the meter to zero by rotating the digital dial, keeping the meter on zero until the meter will no longer drop below zero. Result: the wet bulb temperature reading. Keep checking the dry bulb zero and hold on zero while fan is running.

12. Throw all switches to the *OFF* position when readings are completed.

13. Refer to wet and dry bulb conversion chart for relative humidity and dewpoint in degrees Fahrenheit.

Conclusions

The thermistor system described herein was checked during a complete fire season and was as accurate as a standard psychrometer. Rapid response, ease of reading, and location of readout near a person's work area make this unit an aid to increased work efficiency. It also provides more complete, accurate records of two important fire-weather measurements. Other measurements that are needed to calculate fire-danger ratings, such as windspeed, could easily be incorporated to make a complete remote readout system.

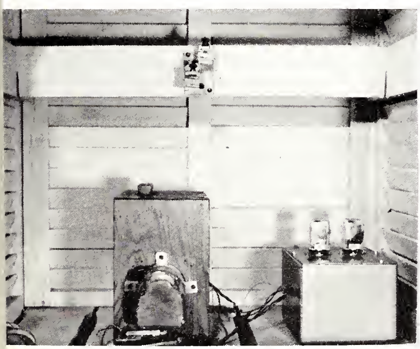

Figure 3.—Equipment is placed in the weather station shelter. The thermistors are mounted below the hood on the front of the air supply box.

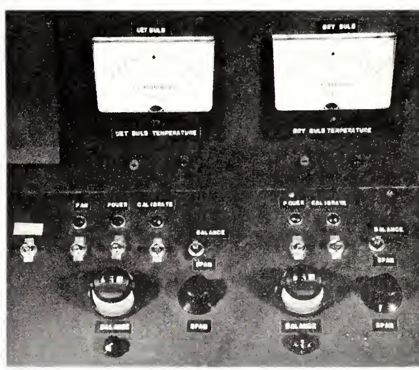

Figure 4.—View of the operating console. Temperatures are read on the two digital dials.

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MAN-CAUSED FIRE SMOKEY SIGN

Rudy Anderson, *Fire Prevention Technician*
Black Hills National Forest

In the ceaseless battle to decrease the number of man-caused forest and range fires, personnel of the Black Hills National Forest combined some existing ideas to provide a new twist in prevention signs.

When a roadside fire occurs, a 6-foot plywood cutout of Smokey Bear is placed near the fire's origin, with Smokey pointing toward the burned area. At Smokey's feet, a plywood cutout of flames with a routed message saying "Man Caused" is mounted (fig. 1). Although the sign is simple, it is quite effective. It also receives many favorable comments from passing motorists.

Smokey and the flame was constructed from one 4- by 8-inch sheet of one-half-inch plywood. Smokey was painted on both sides in full color, and the flames were painted a fluorescent red with white letters. The letters were sprinkled with reflective beads for night viewing. A special support using 1 1/2- by 1 1/2- by 1/8-inch angle iron was constructed to speed mounting and disassembly of the sign.

The main value of the sign is its versatility. It can be put up and taken down in a few minutes. The message can be easily changed to meet changing needs. Or Smokey can be utilized in combination with permanent Forest signs.

Training Pays Off—

Continued from page 5

ten on the side. A check of local police files revealed that our "helpful" firefighter had a record of setting fires.

The suspect was subsequently located and interviewed. When presented with the evidence—small fires, no one else in the area, his name and description of his car, his past fire record—he confessed. He described how he set one fire in the recreation area, went to a phone and reported it, returned to the area, and set two more fires while waiting for the fire crews to arrive.

At 2 o'clock in the afternoon the day after the fire, a complaint was filed with the Grant Parish District Attorney. The subject of the complaint was arrested that night and tried 9 days later.

The Kisatchie Investigator's continual emphasis on "vigilance" at all trespass scenes motivated a technician to "see" what *was* and just as important in this case —what *was not* at the scene of this particular fire.

Because of this teamwork, the Forest Investigator was given good leads to follow, with the result that a woods arsonist was brought to justice.

Good training does pay off.

FIRE CONTROL NOTES

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/WINTER 1969/VOL. 30, NO. 1

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contr

CONTENTS

COVER.—This newly developed high-volume spray effectively applies fire retardant chemicals along a strip up to 60 feet wide. See related article on page 4.

(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 (Aug. 19, 1968).

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THINNING AS AN AID TO FIRE CONTROL

ROBERT H. CRON, *Assistant Regional Forester*
Division of Timber Management
Northern Region

Foresters and fire control people have often de-ated whether the slash created by thinning dense, oung stands of conifers posed a greater threat to ontrolling fires than the original stand. Many have elt that the volume of dry fuel created by thinning ould accentuate the control problem.

During August of the very severe season of 1967 n northern Idaho, northeastern Washington, and ll of Montana, several thinned stands were burned y wildfire. On at least three fires, thinned stands ided in controlling fast-spreading fires under Ex-eme burning conditions.

A large fire in Glacier Park, across the North ork of the Flathead River, crowned rapidly rough dense pole stands of lodgepole, larch, and ouglas fir. At a bend in the river, it spotted across nto the Flathead National Forest into an un-inned lodgepole-larch stand (fig. 1). It crossed is stand as a crown fire, but when it hit an adjacent inned stand it dropped to the ground. Although e surface fire was hot, the spread was much slow- and the fire was checked by dozers and backfire 50 acres (fig. 2). The aspect in both the thinned d unthinned stands was flat to rolling.

Again, on the Miller Creek fire of the Flathead, inned stands aided control actions. The north nk of this 800-acre fire crossed Keith Mountain idge, crowning rapidly through a sapling and pole and until it hit a thinned area. At this point, the re dropped to the ground and spread much slow-, enabling dozers and crews to complete lines on at sector during the night. Again the aspect or pography was no different between the thinned d unthinned stands. Green brush (mostly alder) as growing heavily as an understory beneath the inned larch.

The Cotter Bar fire burned 7,100 acres on the ezperce Forest. On the second day, it reached a ries of clearcut blocks and a thinned area of nderosa pine. Although the clearcuts and planted eas checked the fire and ultimately contributed to s control, it did burn between and over some of e plantations. Crews were able to backfire from e thinned area. The backfire burned hot but did t crown rapidly in adjacent unthinned areas, and became one anchor point of the final control line.

In all three of the cases cited, the thinning slash as left on the ground. All areas had been thinned nce 1962.

Figure 1.—A view of typical conditions in the unthinned stand through which the fire burned.

Editor's Note:—Mr. Cron has written on a controversial subject which we believe is of interest to many *Fire Control Notes* readers. We would like to receive other articles on experiences with thinning slash, particularly articles detailing the effects of its presence on fire behavior and suppression.

Figure 2.—View showing thinned stand where fire was stopped. Cleaned area on left was dozer-piled and burned after the wildfire.

HIGH-VOLUME RETARDANT SPRAYER

ARTHUR H. JUKKALA, *Forester*
Missoula Equipment Development Center

In the past decade, prescribed burning by many land management organizations has increased in both size and cost. Complexity has also increased because of accumulations of untreated logging slash and trends toward summer burning.

As prescribed burning has increased, so has the need for tools to accomplish such burning safely and efficiently. The Missoula Equipment Development Center is currently developing several tools for prescribed burning. One is a high-volume sprayer for ground application of retardants.

Several National Forests, other Federal agencies, and State agencies are now pretreating prescribed burn perimeters with fire-retardant chemicals to minimize problems related to the spread of spot fires. Reports indicate this practice is effective and offers a good chance of saving money. However, the availability of equipment for efficient application of the fire-retardant chemicals has been a problem.

The Missoula Equipment Development Center contracted for the construction of a sprayer that hopefully would improve efficiency in mixing and applying chemicals to perimeters of prescribed burns, high-hazard roadsides, and wildfire control lines.

The sprayer was custom-assembled from stock components to meet performance requirements established by the Center. It was received in the fall of 1967, and used for familiarization trials and on two prescribed burns.

The overall design, construction, and performance of the sprayer exceeded expectations in initial tests. The key design and performance features include:

Tank.—1,000-gallon capacity; double-baked, epoxy-coated to resist corrosion; three-paddle agitator mixer; and three-point torsional suspension for operation on uneven terrain.

Pump.—Two-stage centrifugal; 100 g.p.m. at 200 p.s.i.; double-baked, epoxy-coated; 1½-inch handline outlet.

Blower Assembly.—Manually operated turntable (360-degree horizontal plane); hydraulically operated blower outlet with 90-degree vertical control (45 degrees above the below horizontal); electric solenoid valves for nozzles and bypass line; 50,000 cu. ft./min. air displacement, and four independently adjustable nozzles to insure thorough, even retardant coverage and a wide swath (fig. 1).

Filling and Mixing.—Auxiliary pump is required for filling; total fill and mix time is approximately 15-20 minutes.

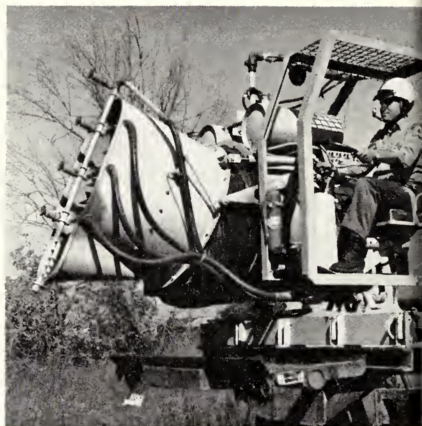

Figure 1.—The sprayer blower assembly. Direction of spray, width of swath, and application rate is readily controlled by operator.

Spraying.—Uniform coverage for swaths up to 60 ft. wide. For a 50-ft. swath at an application rate of 2 gal per 100 sq. ft., the vehicle must travel at approximately 1 m.p.h. One tank (1,000 gal.) will cover 1,000 linear ft.

A few minor additions and modifications were made in 1968. These were:

1. Protective canopy for blower operator.

2. Electrically controlled power traverse for moving blower across truckbed.

3. Larger pump-tank bypass for better pump cooling and mixing of caked retardants.

4. Independent opening and closing for top and bottom pairs of nozzles.

5. Mounting on 6 by 6 military surplus vehicle for greater mobility.

Phos-chek 259 slurry of 360-centipoise viscosity has been sprayed easily. Although Pyro, DAP, or Phos-chek 465 have not been tested, no problems are anticipated. In 1968, the improved model was used on many prescribed burns in the Northern Region. No problems with corrosion, wearing parts

(Continued on page 12)

TRACER SHOTSHELL FIRES: A NEW HAZARD

MARVIN DODGE, *State Forest Ranger, California Division of Forestry*[1]

The recent development of acer shotshells has added a new vist to the fire prevention probm. These shotshells are not a re hazard *when they are used as tended*, primarily for training in ap and skeet shooting. On the over of each packet of shells, ere is a warning stating that ey should be used "at gun clubs nly . . . Use in the field for huntg is not recommended."

But some hunters may be mpted to fire tracer shotshells. n experiments we started fires by ring shells directly into matted ass and punky logs. The shell aves its own evidence: the herical tracer vehicle and a ecial doughnut-shaped wad.

The shells, which are manuctured only in 12-gage. No. 8 ot, include the tracer charge rried in an aluminum alloy vecle—a sphere with a short tail ig. 1). The charge itself, in the il of the sphere, is magnesium wder, a peroxide, and a plastic nder.

The overpowder wad in the acer load differs from a normal otshell wad. Its center is cut out the tracer element can be iged by the burning propellant wder. Shaped like a thick ughnut, the wad is quite disctive.

Many gun clubs forbid tracer ds to be used on their ranges. our experiments at a local gun ib, we had to obtain special perssion from the officers to use cers. We fired several shots rizontally to determine the rning distance; in none of the ts could we detect tracers beynd 60 yards. Apparently any

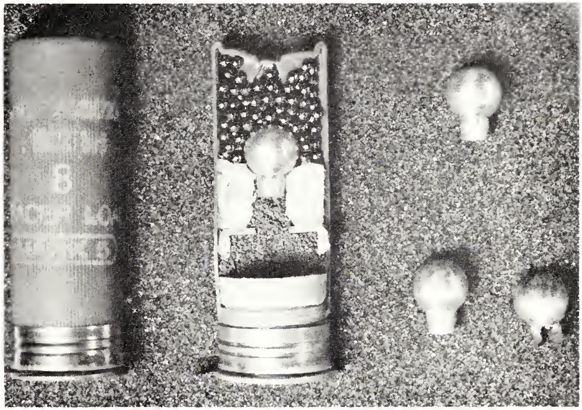

Figure 1.—A tracer shotshell is shown. At center is sectioned shell of tracer vehicle and "doughnut" wadding. At lower right are two fired tracer vehicles recovered from target area. The tail on one of the vehicles was broken when it struck a knot in a punky log and started a fire.

shots fired in the air will safely burn out and cool before the tracer vehicle falls back to the ground. The streak of fire from the tracer is evident at night, but in the day the shooter seldom sees the tracer.

When we fired 12 shots into dry fuels from 5 to 15 yards, we started two fires. One fire flared in heavily matted grass and light brush; the other started in a partly rotted log. In these tests air temperature was 95°. Relative humidity varied from 26 to 28 percent. The ignition index at the two nearest fire-danger-rating stations was 85 and 66.

To determine how far the flame projected from the vehicle, we went to a laboratory and ignited the tracer compound with a miniature heating coil (fig. 2). Flame lengths were scaled from photographs of the burning tracer.

Burning times of the tracer charges ranged from one-fourth to one-third of a second. During this split second, the charges hurled forth an intense flame and cascaded droplets of molten slag from 8 to nearly 40 inches from the vehicle (fig. 3).

Figure 2.—In the laboratory a miniature heating coil was used to ignite a tracer vehicle of the shotshell.

Figure 3.—After ignition, flame projected from tracer vehicle clamped in stand. Streaks are from molten slag.

[1] The author is currently assigned t the Pacific Southwest Forest and Rnge Experiment Station, Berkeley, Cif. He is stationed at Riverside, Cif.

EPOXY ADHESIVES FOR TOOL REHANDLING

EUGENE T. GOULD, *Fire Control Officer*
Shasta-Trinity National Forest

For years firemen have faced the problem of tool handles becoming loose, whether a tool was in use or in storage. The heads of firetools such as Pulaskis, brush hooks, and axes frequently become loose at the most embarrassing or critical times—usually when being checked by an inspector or on the fireline!

Since 1961 personnel of the Weaverville District have been using epoxy adhesives when rehandling tools. Tools may be stored for long periods without the handles becoming loose. Hard use on fireline construction has resulted in very few handle failures and no loose handles resulting from storage.

The following steps are used in rehandling tools:

1. All oil, paint, and dirt is removed from the eye of the tool. A file or wire brush aids in cleaning. The eye must be clean to secure a good bond between the handle and metal.

2. The handle is fitted to the eye in the usual manner, but the handle must fit without forcing. (The epoxy will fill minor imperfections between the handle and the metal.)[1]

3. Coat the section of the handle which fits the eye with epoxy, and put the handle into the eye (fig. 1).

4. Coat the wooden wedge with epoxy and drive it into place. Sufficient epoxy should be put on the wedge to completely fill the slot cut for the wedge (fig. 2).

5. Remove excess epoxy and cut off wedge flush with toolhead.

6. Seal handle at head with coating of epoxy. Usually enough excess epoxy is left to do this job, providing a smooth, weather-tight finish.

7. Let epoxy set for 24 hours before using tool.

New tools may also be epoxied by removing the wooden wedge from the handle, knocking the handle out, and then proceeding as described.

Epoxy filler has been very satisfactory to use, and it is much less expensive than the clear epoxy adhesives. Eight ounces of filler costs approximately $1.50 and will permit 20 to 50 tools to be rehandled.

As with all epoxy adhesives the material must be handled carefully, and the safety precautions on each container must be followed.

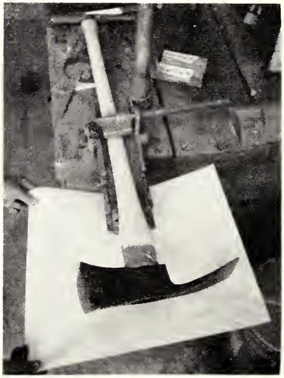

Figure 1.—Toolhead started onto epoxy-coated handle.

Figure 2.—The wedge should be coated with epoxy prior to being driven into the handle.

Editor's note: Studies by the Missoula Equipment Development Center to find improved methods for handling tools substantiate Mr. Gould's findings and conclusions.

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[1] See Forest Service Handbook 5109.12—Firemen's Handbook, Chapter 60, for rehandling instructions.

ADEQUATE PRESUPPRESSION MANNING DEPENDS ON ACCURATE FIRE-WEATHER OBSERVATIONS

ARTHUR R. PIRSKO[1] and PAUL G. SCOWCROFT[2]
Pacific Southwest Forest and Range Experiment Station

Presuppression manning and fire-weather ob-ervations, while distinct entities, are directly re-ated. These two operations are both related to the re-danger rating index. Fire-weather observa-ons are used to calculate the danger index; the idex, in turn, is used to determine presuppression ianning requirements. Therefore, inaccurate fire-eather readings can indirectly result in erroneous ianpower requirements.

The primary reason for inaccurate observations improper maintenance of instruments. Lowering aintenance standards nearly always reduces the anger indexes, and consequently, the manning re-uirement. The relation of these three variables an easily be comprehended if we examine the ore common equipment problems associated with e measurement of three key variables—fuel oisture, relative humidity, and windspeed.

Fuel-Moisture Readings

Fuel-moisture stick readings can be altered from e norm by several factors; the most subtle is ading of surrounding vegetation. Partially shaded icks have a higher moisture content than those illy exposed; consequently, the danger index will lower. Other factors contributing to erratic adings include mud, dust, bird excreta, body oil om hands, and weathering. They can change the eight, hygroscopic characteristics, or both of the oisture stick. For instance, weathered sticks will ways have low readings, causing the danger index be above the actual.

The Region 6 Western Type fuel-moisture scale ay also provide erroneous readings as its bear-g surfaces become worn. The pressure and move-ent of the steel pin of the scale beam enlarges the ole of the U-shaped support bracket (fig. 1). hen the scale is used, the pin will climb the side the hole, changing the fulcrum point and re-ilting in an error in measurement. However, the -shaped support bracket can be replaced with one at has stainless steel inserts for the bearing sur-ce. An accelerated-use test showed no appreciable ear after 2,200 hours.

Relative Humidity Readings

The fan psycrometer—used to measure relative imidity—is another possible source of error. If e wick on the wet-bulb is dirty, short, or crusted

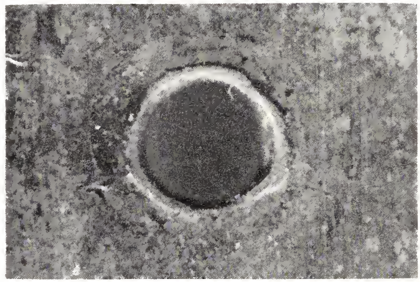

Figure 1.—The hole in the U-shaped support bracket of a fuel-moisture scale shows considerable wear after 2,200 hours of use.

with residue, the indicated wet-bulb temperature will be too high. This, in turn, will give an errone-ous, high relative humidity reading. The same error occurs if the wet-bulb has not been cooled enough by fanning.

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[1] Deceased 1966.

[2] The author(s) were/is stationed at the Forest Fire Laboratory, Riverside, Calif.

Figure 2.—The anemometer is sheltered from the true windspeed by the trees at the left. Raising the anemometer or trimming the trees would correct the situation.

Windspeed Readings

Windspeed is the most critical factor that affects spread and danger indexes. Minor fluctuations will often cause large changes in index values. The windspeed measurement must be precise if an accurate danger rating is to be obtained.

Proper exposure of the anemometer is important if the true windspeed 20 feet above the tallest vegetation is to be measured. Growing vegetation can eventually shelter an anemometer from the true windspeed and thus result in low readings (fig. 2). Consequently, danger indexes will be correspondingly low.

Anemometers can also be slow because of improper servicing. Improperly lubricated bearing surfaces can become partially dried out, impeding the rotation of the cups, and an excessive lubricant will create the same problem. Other causes of low anemometer readings are faulty contacts and wiring, bent or damaged cups, and bent shafts. Each of these deficiencies will result in an incorrect, low reading of the danger index.

The effect of erroneous readings of relative humidity and windspeed on the fire-danger rating, manning, and success of initial attack in the California Region is illustrated in table 1. Comparative measurements at a station under proper and improper maintenance procedures are shown. The crusted wet-bulb gave a temperature 2 degrees too high, in turn, the reading raised the humidity 4 percent to 22. Similarly, the anemometer, which was dirty and sluggish, registered windspeed at 11 m.p.h. instead of a true speed of 15 m.p.h. The two errors compounded the burning index error. Instead of having a true burning index of 38, the improperly maintained station had one of only 25.

This difference of 13 index points can significantly alter the strength of initial-attack forces and their subsequent success or failure. If a fire was discovered on 0.2 acre in fuel type 6 (mixed Douglas-fir-white-fir with brush and reproduction) the number of men needed to control the head of the fire at an overall size of 10 acres could be determined from the chart (fig. 3) developed by Pirsko.[3]

Assuming an elapsed time of 34 minutes from discovery to attack, the number of men needed would be 10 and 19 for indexes of 25 and 38, respectively. Since 25 is lower than the true burning index, 10 men would not be enough to meet initial-attack goals—298 feet of line would be open at the head. However, 19 men would probably catch the fire by the time it reached 10 acres.

The need to maintain your weather stations and instruments is crucial. Proper maintenance habits can mean the difference between a small fire and a conflagration.

[3] Pirsko, Arthur R. Why tie fire control planning to burning index? Fire Control Notes 22(1): 16-18. 1961.

Table 1.—*Measured and computed values for properly and improperly maintained stations*

Item	Maintenance performance		
	Proper	Improper	Error
Dry bulb (°F)	85	85	0
Wet bulb (°F)	58	60	+2
Relative humidity (percent)	18	22	+4
Windspeed (m.p.h.)	15	11	−4
Burning index[1]	38	25	−13

[1] Based on the Wildland Fire Danger Rating System of Region 5.

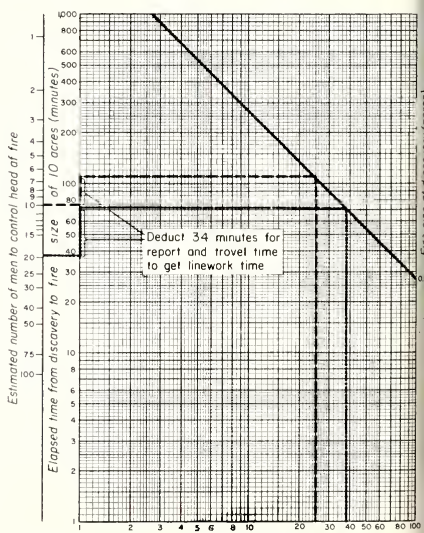

Figure 3.—The chart shows manpower required to suppress fire at 10 acres for mixed Douglas-fir-white-fir with brush and reproduction when the fireline construction rate is 1.1 chain per man-hour.

SUPERIMPOSED LIGHTNING SCARS AND TREE-BOLE IGNITION BY LIGHTNING

ALAN R. TAYLOR, *Research Forester*
Intermountain Forest and Range Experiment Station[1]

This note presents observations on a little-nown method of tree-bole ignition by lightning— fire-setting discharge partially superimposes its urrow upon an older lightning scar and ignites e older injury.

Throughout the world lightning strikes thousands f trees every day. A discharge usually does not ause fire but inflicts structural damage on the ruck tree. Damage ranges from a lack of obvious ijury to virtual destruction of the tree.[2] In coni-ers, the most common damage is a shallow fur-ow from 2 to 10 inches wide that spirals along e trunk, exposing only the outer layers of sap-ood in its path.[3]

Superimposed Lightning Furrows

Occasionally lightning strikes the same tree more an once during the tree's lifetime. A later dis-harge sometimes follows essentially the same path ken by a previous discharge along the tree bole. hus, one furrow is partially superimposed upon e other one. Evidence of this has been seen on 1 live conifer trees in western Montana. Three f the lightning strikes caused fire. In all three stances, ignition evidently occurred in superim-osed-furrow regions on the boles. This article riefly describes these three events; emphasis placed upon the most recent ignition—the only e for which both the fire-setting discharge and s effects were documented.

Three Instances

My first experience with this phenomenon oc-rred on June 30, 1962. The day before lightning d struck and ignited a small (40-ft.-tall, 12-in.-b.h.) ponderosa pine (*Pinus ponderosa* Laws.) ar Missoula, Mont. On the portion of the tree to 30 feet above the ground was a shallow, iral lightning scar several years old, partly closed d containing exuded resin. Superimposed on the wer end of this scar, which terminated about 12 et above ground, was a new lightning furrow. sed on evidence at the scene and an interview with the smokechaser clearly indicated that the more recent discharge ignited the resin-covered fuel in the lower section of the older scar. A burning wood sliver, 3 feet long, was ejected from the old wound and stuck in the ground some 13 feet from the burning tree.

The second event occurred on July 15, 1963, when lightning struck and fired a large (96-ft. tall, 35-in. d.b.h.), live, open-grown ponderosa pine near Missoula. The tree had been struck from 37 feet to about 85 feet above the ground. The new furrow, which had many protruding slivers, was superimposed on the old scar for only 1 foot at the 37-38-foot level. Ignition occurred only in this 1-foot zone of superimposition. Exuded resin had collected at the base of the old scar and evidently was ignited by the most recent discharge.

The third ignited tree was a large (120-ft. tall, 40-in. d.b.h.) western larch (*Larix occidentalis* Nutt.) growing in a cutover stand of western larch, Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), and ponderosa pine in the Lolo National Forest of western Montana. A growth-ring indicated the tree had been struck 6 years prior to the fire-setting discharge. The tree had lost its top many years earlier, and an upper branch had become the terminal leader.

The fire-setting discharge occurred at 1316:02 M.S.T. on Sept. 14, 1966. Its electrical properties were recorded electronically at a station 16 miles from the tree, and the visible flash and subsequent fire were documented by an airborne lightning observer.[4]

The (1) methods and equipment used in the lightning recording system and (2) characteristics of the discharge that caused this fire are described elsewhere by Fuquay et al.[5]

The burning tree is shown in figure 1, photographed by the observer about 1 minute after the discharge occurred. The new damage was superimposed for about 60 percent of the old scar's length. Portions of the new and old damage appear in figure 2. This shows a section from about 50 feet below the tree's tip to about 1 foot above the highest fire damage. Note the ridges of 6

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[1] The Station is located at Ogden, Utah. The author is tioned at the Northern Forest Fire Laboratory, Missula, Mont.

[2] Taylor, Alan R. Lightning damage to forest trees in ontana. Weatherwise 17(2):12 61-65. 1964.

[3] Murray, J. S. Lightning damage to trees. Scottish rest. 12(2):2, 70-71. 1958. See also Taylor, Alan R. ameter of lightning as indicated by tree scars. J. Geoys. Res. 70(22) 5693-5695. 1965.

[4] J. E. Burns made substantial contributions in documenting lightning effects described in this article.

[5] Fuquay, D. M., Baughman, R. G., Taylor, A. R., and Hawe, R. G., Documentation of lightning discharges and resultant forest fires. U.S. Forest Serv. Res. Note INT-68, 7 pp. 1967.

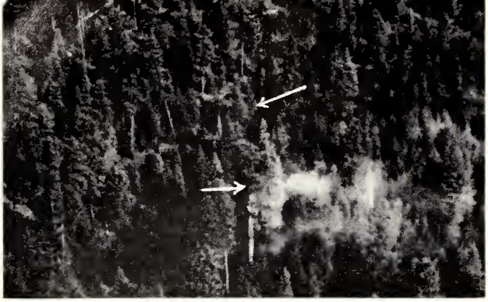


Figure 1.—Western larch struck and ignited by lightning; photographed about 1 minute after discharge. The upper arrow indicates the treetip; the lower arrow shows the highest level of smoke on tree bole. The section between arrows is a volunteer terminal leader.

Figure 2.—New lightning damage partly superimposed on 6-year-old lightning scar. Lighter portion of furrow in upper part of scar is new damage. Callus tissue and thin sapwood strip were removed from this edge of furrow by the later, fire-setting discharge. The top of the tree is 50 feet to left. The ruler is 6 inches long.

Figure 3.—Upper extremity of fire on tree bole, 6 inches above crosscut. Massive char and wood loss on underside of bole, right, corresponds with highest level of smoke (lower arrow, fig. 1).

years' callus tissue and the weathered, exposed sapwood on the edge of the old furrow (lower edge in photo). Compare this edge with the opposite edge where the callus tissue was removed and a thin strip of sapwood was loosened by the fire-setting discharge. This appearance is typical of that of the other 10 trees on which superimposition of scars was observed. Also note that the old and new furrows appear to terminate at the right side of the photograph. Figure 3, however, shows that both furrows reappear about 1 foot lower on the bole. Here most of the evidence of the new furrow was destroyed by fire, but, as in figure 2, the callus tissue of the old wound was removed from the margin of the scar by the recent discharge.

The highest point of massive char (fig. 3, lower right) was about 55 feet below the tip of the tree, near the base of the volunteer main stem, and coincided with the highest point at which smoke obscures the bole in figure 1 (lower arrow). Thus the older lightning scar at this point was a primary ignition site for the more recent discharge. The massive charring in this region precluded determination of the amount of resin exudation, if any, from the old wound. However, the old scar in figure 2 contained only small amounts of such deposits.

Figure 1 also suggests that ignition occurred at other points farther down the bole, either on the old lightning scar or in decayed heartwood of the lower trunk. Evidence from those areas was destroyed by fire and by severe breakage when the tree was felled to suppress the fire.

Discussion

The three instances described in this note show that tree-bole ignition by lightning sometimes occurs in an injury caused by a previous discharge. Therefore, the presence of exuded resin in an old lightning scar may increase the probability of tree-bole ignition by a later discharge. If it does, other types of injuries might similarly increase chances of bole ignition by lightning.

PORTABLE COLLAPSIBLE TANKS FOR DELIVERY OF WATER TO THE FIRELINE WITH HELICOPTERS AND CARGO SLINGS

JACK P. CURRAN, *District Fire Control Officer*
Los Padres National Forest

Since the advent of the helicopter in firefighting, umerous methods have been devised to deliver ater on fires. Varying success has been attained. he biggest drawback of most of the methods has een the need for special attachments—restricting e use of the helicopter.

To devise a simpler method of delivering water the fireline, we secured collapsible portable tanks ith an 80- and 150-gallon capacity that can be ing-loaded and delivered to anyplace on a fire- ne where a helicopter can maneuver close enough the ground to set off a sling load. The 80-gallon nk can be carried in a sling by the small heli- pters commonly employed in fire suppression fig. 1). When full, the larger tank can be carried the larger helicopters now being used on many ajor fires.

When possible, the tanks are delivered on a dge or high point of the fire so that delivery of e water from the tank to the fire can be by gravity w through the hoseline (fig. 2). This situation often encountered when work is done on slop- ers on the back side of a ridge. The tanks have so been used for refilling 4 by 4 pickup pumpers at were holding a fire on a tractor line that was great distance from a water source and was in- cessible to larger water-carrying vehicles.

When gravity pressure is not possible, the water n easily be pumped on the fire with the small, rtable pumps now carried by most helitack crews. ig. 3).

This small tank was designed so that it contained gallons when the water level was at the bottom the overflow line and vent on top of the tank, but will contain 80 gallons when it is filled to the int where the water will flow out of the over- w, a 6-inch piece of garden hose. When a pump to be sent in with the initial load of water, the nk loading should be restricted to 70 gallons to mpensate for the weight of the pump.

With three tanks and cargo slings, one heli- pter can normally keep a continuous supply of ter on any trouble spot on a fire. This system n be particularly effective in backing up back- fing operations that are not accessible to motorized uipment.

This system has the following advantages:

1. A low-cost, lightweight, collapsible tank is ilized.

(Continued on page 16)

Figure 1.—A filled tank, hose, and pump can be quickly delivered to a remote section of the fireline by a small helicopter.

Figure 2.—An 80-gallon tank, hose, and nozzle ready for loading. Where gravity feed can be utilized, the water is available for instant use upon delivery.

Retardant Sprayer—*Continued from page 4*

or maintenance have been encountered. Occasionally debris clogs nozzles during spraying, but it is easily remedied by cleaning the sediment chamber and by temporarily opening nozzles to flush them out. No further modifications are planned. To improve mobility, we intend to study the practicality of mounting the unit on a trailer for towing behind a bulldozer.

Though primarily developed for pretreating prescribed burn perimeters and high-hazard roadsides and for reinforcing control lines on wildfires, the unit has many other possible uses including:

1. Laying temporary retardant firelines in light flashy fuels.
2. Suppressing fire directly by spraying water or retardants onto burning fuels. This can be done with the blower shut off.
3. Spraying water as an aid in mopup.
4. Applying many other chemicals including herbicides, insecticides, and fertilizers for other land management jobs.

The prototype unit cost $8,500. The cost of future units is expected to remain about the same.

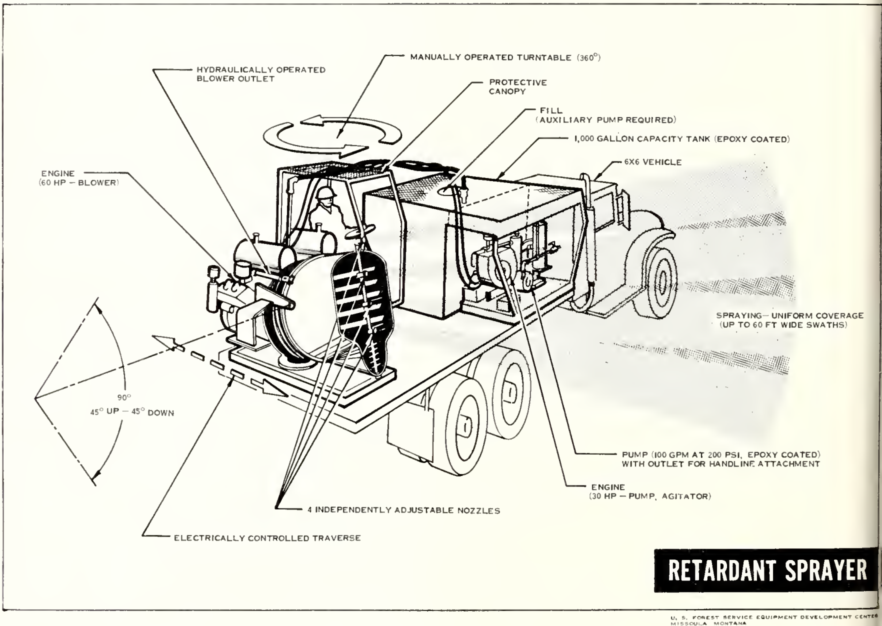


Figure 2.—Schematic of retardant sprayer.

NEW SYSTEM FOR STORING AND MIXING FIRE RETARDANT

Los Angeles County Fire Department

A new demand-type system for storing and mix-ng fire retardant for air tanker use has been de-eloped and installed by the Los Angeles County ire Department at its base at the Hollywood-urbank airport. According to Chief Keith E. lingher, this system is the first such facility in the ation and will increase the county's efficiency n the fast handling of retardant air tankers.

This new "clean" system provides bulk storage nd handling of Phos-chek fire retardant, and re-uces the number of men needed to handle the ixing from 10 to 1. Of course, additional men re needed to load the aircraft. Four planes can e loaded simultaneously at the Department's fa-lity.

Battalion Chief Frank Hamp, the Department's quipment and development officer, designed the new cility. Two 32-foot-long bulk storage trailers ig. 1), both with a capacity of 18 tons of powder, rovide dry storage. Each trailer is equipped with n internal airslide and a compressor.

Air, at a pressure of 1-2 p.s.i., is introduced at e bottom of the tank (at the airslide), and the owder flows to the outlet in the manner a fluid ows. The Phos-chek is carried to the elevated ixing platform under a vacuum; two eductors re supplied with water from a stationary fire umper. At this point the mixing is completed; 600 p.m. is produced. Under this system the quantity of mixed Phos-chek produced is limited only by the capacity of the pump and by the available water supply. The mixed retardants is stored in a 5,000-gallon tank until needed. Two pumps, capable of delivering 900 gallons of retardant per minute, feed the delivery system.

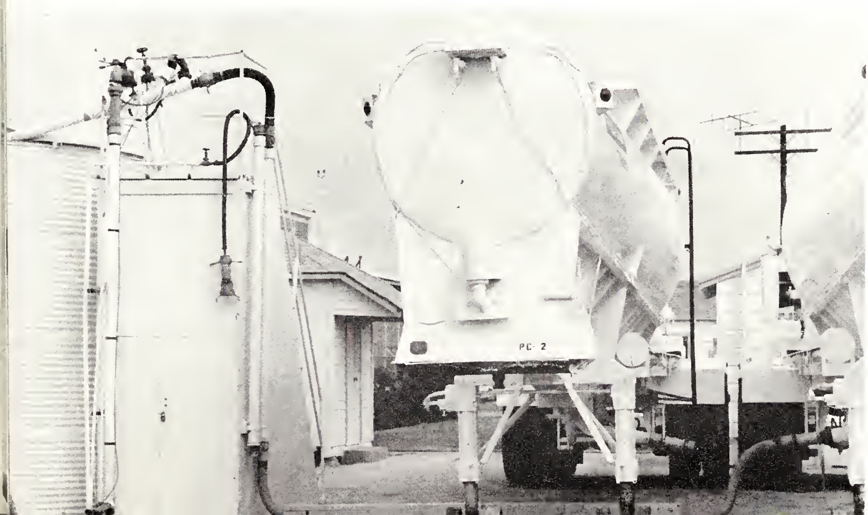
Unique features of the system permit one operator to control the quality of the finished product through a single valve. As retardant becomes needed, he activates the main control valve, which automatically increases the number of the pumper's revolutions per minute to a predetermined level to maintain the desired pressure.

On the delivery pumps, a waterflow microswitch is activated when the nozzles are opened at the aircraft, and the pump engines increase pressure automatically.

The new system alleviates the need for sacked retardant and for a system for opening and emptying the sacks. Its bulk storage and semi-automated mixing features lend themselves to the possibility that an entire mixing plant may someday be able to be picked up and easily trucked to an airfield; there it can supply aircraft at a nearby fire.

The County Fire Department has operated the mixing facility at the Lockheed airbase for 3 years. During the first 9 months of 1968, 234,900 gallons of retardant have been mixed and delivered.

ure 1.—Large bulk storage trailers supply Phos-chek to mixing platform at left. Mixed retardents is stored in a 5,000-gallon metal tank, ready for loading into aircraft.



1968 AUTHOR INDEX

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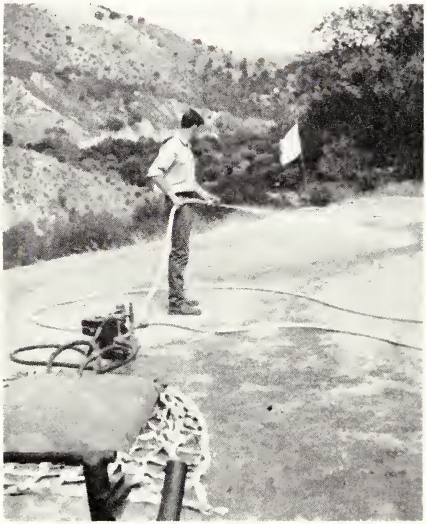

Portable Collapsible Tanks—*Continued from page 11*

2. Such a tank is easy to place in service or short notice without any special attachment to the helicopter.

3. It is easy to deliver to anyplace on a fire where a helicopter can maneuver within 30 feet above the ground.

4. It should secure more widespread use of water or retardants on a fire via helicopter.

5. Water or retardants delivered on a fire via a hose are more efficient and effective than when delivered by an airdrop.

Editor's note: The General Services Administration now stocks these collapsible tanks in five sizes with 50-, 100-, 150-, 250-, and 500-gallon capacity. The smaller (50-150 gallon) tanks are pillow-shaped as illustrated; the two larger tanks are pyramid shaped.

Figure 3.—The lightweight, portable pumps now available are ideal for use with the portable tanks. With positive displacement pumps, the bypass should be connected back into the tank overflow pipe to conserve water.

REMOTE WIND MEASUREMENTS

Many fire-danger stations now use the Ten-Minute Wind Counter to obtain windspeed measurements. However, some personnel may not be aware that when this device is used, the anemometer can be placed as much as 1 mile away. Thus, at stations where obstructions or other factors make onsite exposure of the anemometer unsatisfactory, the instrument can easily be placed at a more suitable location some distance from the station. Number 20 or 22 copperweld twin-conductor wire is satisfactory for connecting the anemometer to the counter. The voltage supplied to the counter should not be increased to compensate for the greater distance because damage to the anemometer contacts may result.

FIRE CONTROL NOTES

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/SPRING 1969/VOL. 30, NO. 2

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire contro

CONTENTS

COVER—A typical lookout of 1912. Communication with headquarters or with other lookouts was by tel phone or heliograph—if the sun was shining. For more current detection methods, see repo on page 8.

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

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BUILDUP INDEX ANALYSIS—AID TO FIRE CONTROL?

PAUL H. HAGERTY, *Supervising Forestry Meteorologist* [1]
E. LOWELL CROOM, *Forestry Meteorologist*
ESSA Weather Bureau Office for Forestry

Man has long used numerical scales to solve s problems. Fire Control personnel are utely aware that a simple solution permitting quick appraisal of the fire-danger situation ross a forested area by such a scale is non-istent and is not even on the horizon. How-er, the National Fire Danger Rating System FDRS), introduced in 1963, presents a rea-nable approximation of the cumulative effects weather across a forested area.

This system has one common denominator, e "Buildup Index" (BUI), for relating and mparing situations across otherwise reason-ly homogeneous forested areas. The Buildup dex has been defined as "a number expressing e cumulative effects of daily drying factors d precipitation in fuels with a 10-day timelag nstant." It is an expression of the moisture nditions of the heavier fuels—those that quire 10 drying days to lose approximately o-thirds of their moisture above equilibrium. the moisture content decreases, the BUI reases—indicating an increase in the sever-t of burning conditions. Therefore, the BUI essentially a numerical value indicating the isture content of the heavier fuels of a tim-red region as influenced by weather.

An examination of the spread-phase tables the NFDRS confirms this belief that the JI depends totally on weather. The vari-es—dry-bulb temperature and atmospheric isture (the latter is expressed as wet-bulb nperature, relative humidity, or dewpoint)— e the primary determining parameters. The portance of antecedent precipitation has en acknowledged in the original definition, d the exact influence can be seen by referring the Buildup Index Recovery Table of the read Phase Tables of the NFDRS. By doing it is easy to see that the BUI can be deter-mined by using observations from urban or nonforested areas as easily as from prime timberland locations if the bookkeeping of drying factors are recorded daily.

Prior to the development of the National Fire Danger Rating System, many danger rating systems were in use. The Lake States and Central States systems were sensitive to the number of days since rain. Fire-weather forecasters plotted precipitation charts daily and ascribed the proper number of days since rain for each reporting station. Analysis of the days-since-rain chart pinpointed areas of concern. In short, lack of rainfall was the forecaster's main criterion for labeling "hot" areas or potential trouble spots. After some experience forecasting for the NFDRS, analysis of BUI values seemed logical to the forecaster for the same reason.

Regional analysis of BUI values can be accomplished once a base map is established to facilitate plotting of the data. The observational input for determining BUI can include regular weather reporting stations as well as observations from the fire-weather station. Routine daily observations from forested locations are taken at the basic observation time, generally at 1 p.m. in the Southeastern States. These observations are an important supplement to the routine Weather Bureau observation input to the fire-weather forecaster. The number of reporting points available to the forecaster varies from State to State. However, in all States the number should be sufficient to assess the situation and to describe the range of BUI values in enough detail to permit decisions on operations, both by the forecaster and a fire control headquarters.

At the ESSA-Weather Bureau Office for Forestry at the Georgia Forestry Center near Macon, Ga., daily samples are gathered routinely from 13 points throughout the State. However, the maximum BUI, if greater than the BUI, at the regular reporting station within each forested district, is added to the routine report. These values are normallv sufficient for

[1] The authors are U.S. Weather Bureau, ESSA, em-lyees stationed at the Georgia Forestry Center, con, Ga., and are cooperators in the U.S. Forest vice Forest Fire Meteorology Project. Mr. Hagerty o serves as Coordinator, Weather Bureau Southern ion Forestry Meteorology Programs.

a representative BUI analysis, but 17 hourly weather reporting stations in and adjacent to the State can be used to complete the analysis if desired.

In response to requests by concerned groups, BUI analysis was initiated by the Macon Fire-Weather Office in 1966. It was necessary to obtain the cooperation of the ESSA-Weather Bureau fire-weather forecasters serving the Southern and Southeastern States and the forestry interests of individual states. Essentially, the Macon office became the clearinghouse and analysis center for data samples collected weekly from the individual fire-weather offices. One such analysis (fig. 1) permits further insight into the procedure and th results.

The analysis is a static picture of the BU situation on a given date. However, by supe imposing the expected precipitation over th analysis, both as to amount expected and tim of occurrence, an estimate of the easemen intensification, or little change in the fi danger rating can be projected. The ESSA Weather Bureau 5-day outlook charts are quit useful for this type of interpretation.

Analysis of the plotted BUI values is helpf to fire control in assessing the burning potenti and permits easy presentation of the situatio

(Continued on page 7)

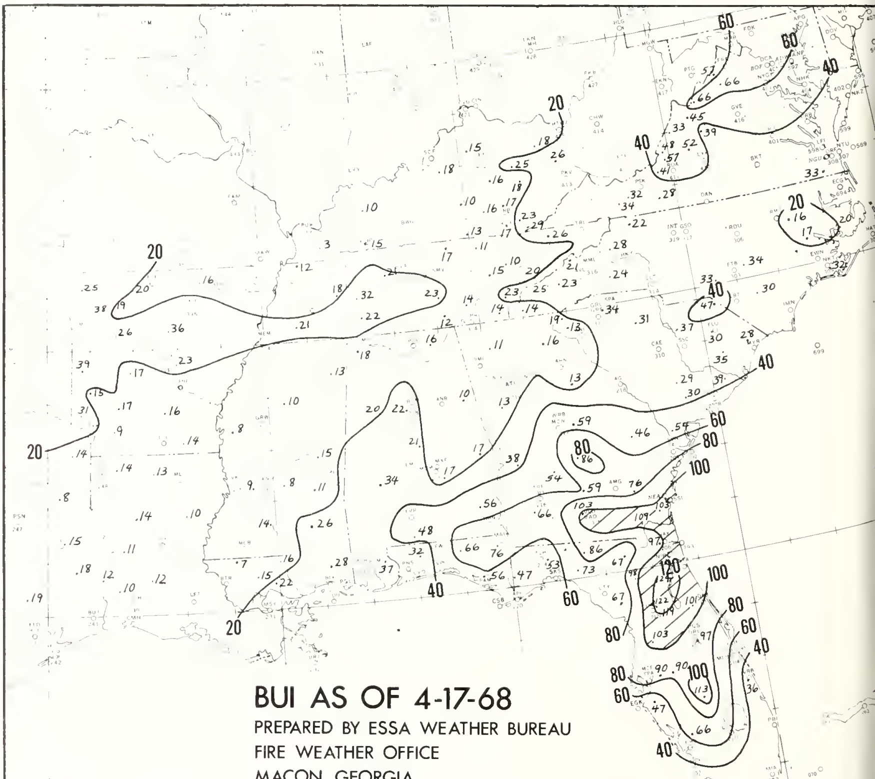

Figure 1.—An onolysis of buildup index volues received from timberland locations in 13 Southern ond Southeostern Stotes. Note the max mum volues in southern Georgio and northern Florida.

REDUCING THE INCIDENCE OF CHILDREN AND MATCHES FIRES[1]

K. R. GOINGS, *Fire Prevention Officer*
California Division of Forestry

Children and matches are a serious risk in ıe Division's primary responsibility areas. hildren utilizing various sources of ignition, ostly matches, are responsible for over 20 ercent of the man-caused forest fires in Cali- rnia each year. These fires are commonly eferred to by the fire services as "C & M" fires. here has been no significant decline in these pes of fires during the past 20 years despite ıe aggressive Fire Prevention Information ıd Education Program that has been directed ward them.

Recent studies have revealed that "C & M" es become a problem at an age younger than at at which fire prevention efforts have been rected toward in the past. (table 1).

BLE 1.—*"Children Fire" starts, by five age groups*[2]

Age	*Percent of Fire Starts*
Under 5	12
5 to 7	34
8 to 10	28
11 to 13	16
14 and over	10

Folkman, William S., "Children With Matches" es in the Angeles National Forest Area: USDA rest Serv. Res. Note PSW-109, Berkeley, Calif., 66, p. 2.

Good Information Alone Cannot Change Attitudes

Since the conception of Smokey Bear over years ago, we have been very successful in tting the message about the dangers of fire the public, but the information received does t do a fire prevention job by itself. The well- own "Only you can prevent forest fires" and any other such phrases have gotten the infor- ation to nearly every person in the land; wever, it has evidently failed to convert the titude of many people concerning their indi- dual responsibilities to reduce the incidence wildland fires.

This "hard-to-influence" attitude phenome- n is not peculiar to fire prevention. It is eident in other campaigns, such as those for te prevention of accidents and diseases.

Adapted from California Fire Prevention Notes, ctober 1968.

Butte Ranger Unit personnel are attempting to break through this attitude barrier by educating the very young child about fire, the cause of fire, and how unwanted fire can be prevented.

By educating the child at the earliest age possible, and by proper followup, the fire prevention information hopefully will be retained as he or she passes through each successive age group. Also, the child may, in his innocence, very effectively act as a second conscience to many of these potential fire starters who are older than he is by parroting fire prevention messages to them. Consequently, with this procedure you are getting the information to many age groups through the young child, and you are also creating within him an everlasting, favorable fire prevention attitude. Thus, it has hoped that good fire prevention practices will become deep-rooted habits.

Establishing a Fire-Prevention Program

After accepting the foregoing as a solution to the children and matches forest fire problem, the Butte Ranger Unit Fire Prevention Officer in charge of the Information and Education program contacted Dr. James F. Lindsey, principal of the Aymer J. Hamilton Laboratory School at Chico State College, Chico, Calif. One of the basic functions of this Lab School is experimentation and innovation in teaching and teacher education.

After hearing an explanation of the Division's problems and the proposed solution, Dr. Lindsey became energetically enthusiastic about assisting in the planning and development of the methods which would serve as a vehicle for attaining the desired solution.

Teaching The Teachers

The first step was in teacher education. In this case, it was teaching the lay-teacher Fire Prevention Officer how to use some of the most up-to-date teaching techniques. This was the first encounter that that Lab School had ever had in teaching lay people professional techniques of early childhood instruction. The 6 hours of classroom instruction proved rewarding for Dr. Lindsey and his staff because the Fire Prevention Officers learned the techniques with surprising rapidity.

The backbone of the instruction consisted of a familiarization with team teaching. In team teaching, children are separated into very small groups of between 5 and 10, and each group is taught a subject according to their speed of learning.

Dr. Lindsey and his staff covered many "do's and don'ts," and some of the more important methods and techniques of presentation that the Lab personnel introduced to the Fire Prevention Officers follow:

1. Save your "attention-getters" until last. Arrange your presentation so that each successive portion is more interesting, more exciting, or more motivating than that which preceded it. Do not, for example, begin with the most interesting part of the presentation—such as Smokey Bear, a fire truck, or a flashy demonstration. For a group of youngsters, your badge, nameplate, and uniform provide enough contrast with the everyday humdrum of a young child's life to be an initial attention-grabber. It would be best if the group of youngsters could not even guess what was going to happen next; if they could, some of them could be distracted.

2. When dealing with very young children, never try to hold their attention any longer than 10 minutes with any gimmick or phase of your presentation.

3. The most important item for holding a group of youngster's attention for longer than 2 or 3 minutes is to keep your group small. Encourage the group to teach themselves by individual, active participation. It is amazing how little help, other than praise for correctly channeled thinking, that the group needed to learn all of the right answers.

4. Avoid all distracting situations. Never allow the students to anticipate what gimmick is going to be used next. For example, do not allow the children to see the projector, some unusual display case, the firetruck, other fire-fighting equipment, or a glimpse of Smokey Bear before these things are made part of the presentation. If you fail to do this, there is a good chance that many youngster's minds and imaginations will be diverted way ahead of you to the more exciting item, and your messag will not even be heard, much less understoo

The First Operational Test

On February 9, 1968, five Fire Preventio Officers (four group discussion leaders and a observing leader) walked into a kindergarte class in the small community of Palermo, Calif for the first operational attempt at using mod ern teaching procedure to teach fire preventio to the very young.

The class was divided into small groups b the teacher. Each group sat in a semicircl around a Fire Prevention Officer, who wa sitting, as were the students, in a miniatu chair for knee-to-knee, eye-to-eye contac commonly referred to by interrogators as th essential periphery of awareness (fig. 1). Onl five basic points were stressed during the co ference leader-type discussion that ensued.

1. Do not play with matches.

2. If you find matches at home, give them t a parent.

3. If you are on your way to school and fin matches, give them to the busdriver or scho teacher.

4. If you see a younger child with matche take them away and give them to an adult.

5. If you see a wildland fire, have an adu call the fire department right away.

Figure 1.—Optimum effectiveness is achieved through small grou with the group leader at the childrens' eye level.

The four discussion leaders stressed these oints for about 8 to 10 minutes. The Fire 'revention Officer leader furnished only inforıation for thought and guidance. In every ase, correctly channeled thinking was obtained rom each respective group through their own, ıdividual active participation.

When the observing leader was aware that he discussion leaders' uniform, badge, name-late, patch, and questions were beginning to xceed the interest span of the youngsters, he dvised all of the groups that a motion picture lm was about to be shown. On this cue, the roup leaders distributed Smokey Bear pins nd praised their individual group members for heir accomplishments (fig. 2).

The motion-picture film was a color fire-revention film which lasted for about 10 ninutes.

When the film was over, the observing leader, omeone who was new to the individual groups, pent about 5 minutes asking the entire group hat they learned during the session. The avorable, enthusiastic response was terrific. hen, as a grand finale, Smokey himself came ı to repeat the inquiry as to what the group ad learned and to express his appreciation for hat they had learned.

Only Time Will Tell

The first operational phase of the progressive aching of fire prevention to youngsters has een completed at 11 kindergarten classes in the Oroville area. Butte Ranger District personnel are now planning to give similarly taught monthly followup programs. The use of regular fire control personnel to fulfill team assignments will be encouraged in the followup programs.

Figure 2.—Group leaders concluded the discussion by praising each child and pinning on a Smokey Bear pin.

The results of this training will probably not be very evident until this type of instruction has been practiced for several years.

However, it is the author's belief that a milestone has been reached in our attempts to reduce the incidence of fires caused by children and matches.

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ildup Index—*Continued from page 4*

ross forested areas so that all factors can be eighed in determining needed action. Also, iefing of concerned but technically unfamiliar ficials is possible.

Fire control chiefs can brief high-level State ficials on the situation across a given State d can highlight the more critical areas so ese officials can consider closing woods, impsing burning bans, or increasing TV or radio ot announcements on fire prevention in "hot" eas.

However, other officials must know the situaon across a combination of States. Researchs documenting wildfires have expressed a ed in this area in order to establish degrees readiness for equipment and manpower. Coordinators of Forest Fire Compacts can use the analysis as an aid in assessing the relative situation among member States. If the BUI can be considered as a partial expression of the potential for large fires, then the analysis can be an important tool in making decisions associated with coordinating manpower and equipment actions resulting from affiliations and obligations of Compacts. Also, in this respect, regional fire control officials who must make interstate decisions should find the analysis a definite aid in fire control preparedness.

The future is bright in this area of BUI analysis. It has been suggested recently that

(Continued on page 15)

AN OPERATIONAL TEST OF AN INFRARED FIRE DETECTION SYSTEM

B. JOHN LOSENSKY [1]
Intermountain Forest and Range Experiment Station

An infrared (IR) fire detection system, developed by Project Fire Scan personnel at the Northern Forest Fire Laboratory, was operationally tested during the 1967 fire season. The system, installed in a Convair T-29B aircraft (fig. 1), included three items not found in other IR systems:

1. A rapid film processor
2. A target discrimination module (TDM) which automatically marks hot targets on the film, and
3. A Doppler radar navigation system which provides accurate, instant information on an aircraft's position.

This operational test was designed (1) to determine how well an IR system could detect latent forest fires under natural conditions, and (2) to investigate problems associated with identifying targets on the IR imagery, locating their position on a map, and quickly dispatching the information to the fire control organization.

For this test, a study area covering 41 National Forests in Forest Service Regions 1, 2, 4, and 6 was established. Personnel of each Forest helped verify the IR-detected targets and provided information about fires detected by conventional methods to help determine whether the IR system had missed any fires.

Forests were ranked by their lightning-fire frequency to help in the selection of each mission area. The Weather Bureau's radar at Missoula, Mont., and the radar net centered

Figure 1.—Convair T-29B aircraft used for fire detection missions.

at Salt Lake City, Utah, provided informat on thunderstorm activity in the study ar Using this information, missions were sch uled over the areas affected that had the high probability of lightning fire occurrence.

All missions were flown at night about 15, feet above the terrain. After each mission completed, the imagery was interpreted; legal locations of possible fires and campf were dispatched to the Forests at about 0 hours. During July and August, 21 missio averaging 2.4 million acres, were flown. fortunately, we could not fly for about weeks (July 27 to August 21) because of aircraft engine failure; half of the plan missions were eliminated.

Imagery recorded from flights inclu 1,434 TDM marks. The number interpreted hot targets was 601 (fig. 2). The remain 833 were interpreted as false alarms. Sho after the test flights began, we found a des error in the TDM that caused it to mark it in addition to hot targets. Since completion the study, the TDM system has been redesig to reduce, if not eliminate, the problem.

Of the 601 hot targets, 213 (35 percent) w interpreted as wildfires (fig. 3). Some w later confirmed as other types of hot targ (fig. 2). Most of the remaining 388 (65 p cent) hot targets were incorrectly identi because of incomplete ground intellige Accuracy of identification should be nearly percent if the location of camping areas, springs, or scheduled slash burnings is av able to the interpreter.

Fifty-five reported fire targets could not found or identified on the ground. These confirmed reports caused suppression units lose valuable time in unsuccessful sea Twenty-one of these 55 fires probably bur out naturally. Unfortunately, no remains c

[1] Research Forester, Bitterroot National Fo Darby, Mont. This article is based on work perfor when the author was Study Leader in charge of Project Fire Scan infrared lightning fire patrol eva tion. He was then stationed at the Northern Fo Fire Laboratory, Missoula, Mont.

e found later to verify this hypothesis; owever, lookouts reported flareups at locations f two of the unconfirmed targets. The re-naining 34 unconfirmed targets could have een small fires that went out naturally or false larms caused by the TDM and incorrectly dentified by the interpreter. Future testing vith the redesigned TDM should indicate the nagnitude of the unconfirmed report problem.

Of the 388 hotspots identified as miscellane-us targets, two were later confirmed as fires. Both were beside a road and were identified by he interpreter as campfires.

During the patrol season, 134 fires, in various tages of control, were scanned (fig. 4). When ontrol action starts, the amount of radiant eat available for detection decreases until the re is extinguished; therefore, only unmanned res were considered in the analysis to deter-nine success of IR detection.

Forty of the 134 fires (30 percent) detected were unmanned when they were scanned. The TDM detected and marked 23 of these 40 fires (58 percent). Five others (12 percent) were recorded on the film, but the TDM did not alarm on them. Redesign of the TDM increased its sensitivity, and we hope these marginal targets will activate it.

Although success of IR detection was lower than anticipated, it compared favorably with conventional detection. At the time the 40 fires were scanned, only 14 (35 percent) had been detected by conventional methods versus 23 (58 percent) for IR. IR detected 14 fires before conventional methods. Several of these fires could have become serious, but early detection by IR prevented such occurrences.

Accurate location of fires is necessary so that suppression units may find them quickly. The interpreter located detected targets to one-

1967 DETECTION RESULTS

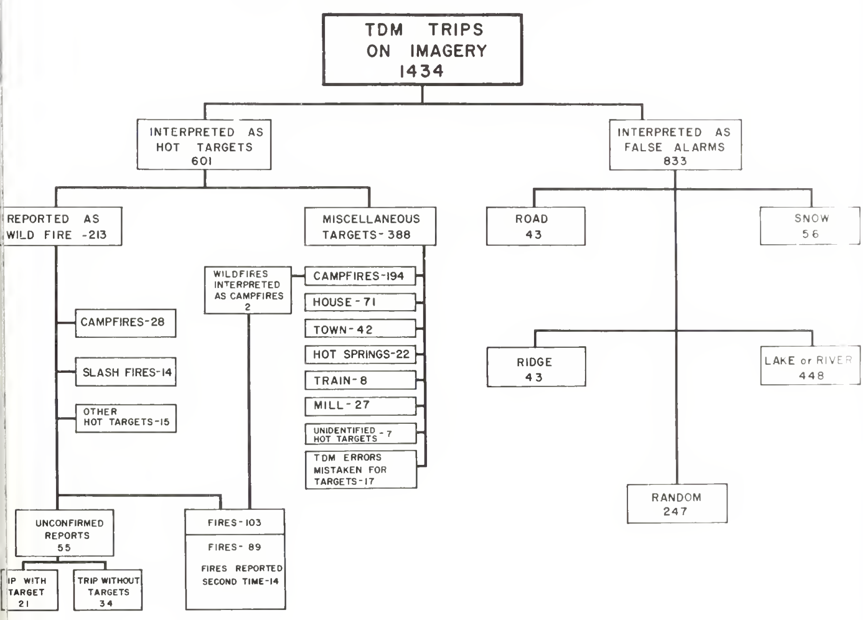

Figure 2.—Summary of imagery from operational test flights in 1967.

sixteenth of a section (a 40-acre block) with the aid of ½-inch-to-the-mile Forest Service maps. To check the accuracy of the interpreter's location of a fire, we compared it with the location shown on the Individual Fire Report compiled by Forest personnel. This check showed that 73 percent of the fires were located within one-fourth mile of the location shown on the official Individual Fire Report; 90 percent were located within one-half mile.

The tests in 1967 demonstrated that this prototype system could detect small wildland fires and that the information could be made available to the fire control group when it was most valuable. An improved system now being developed will increase detection success, reduce the false alarm rate, and provide better IR image detail for more precise fire location.

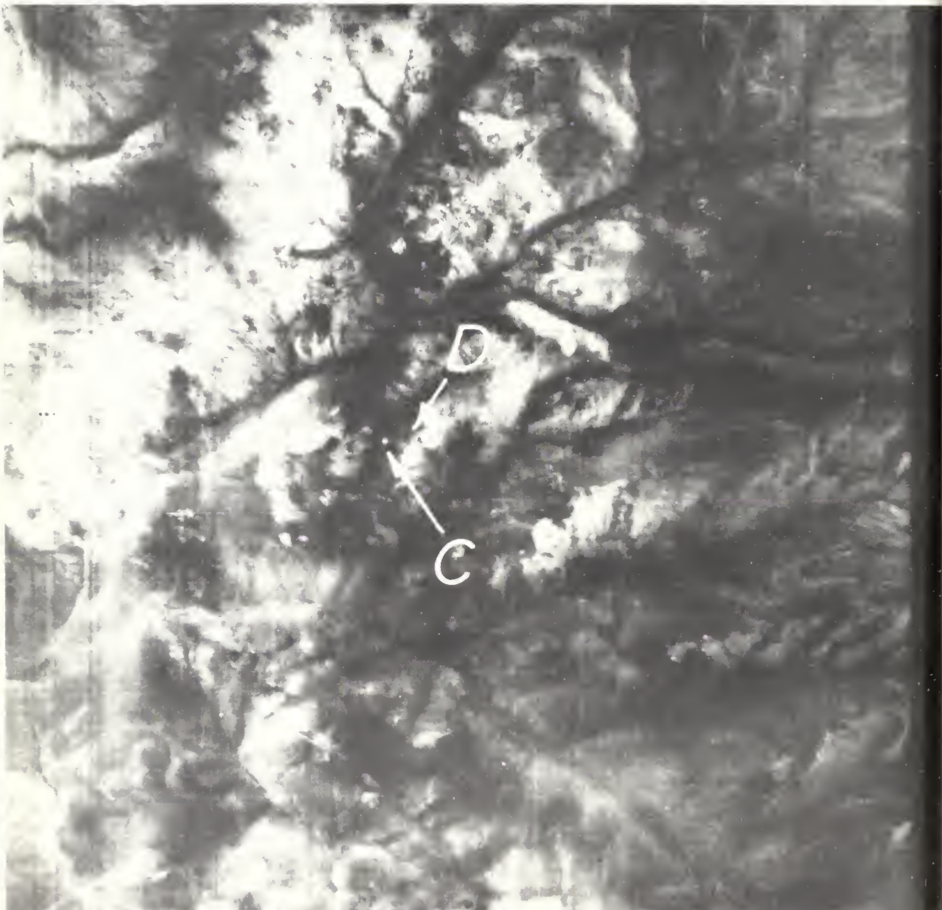

Figure 3.—Infrared image at 12,000 feet over terrain covers about 40 square miles. A, Inserted by the navigation system, these marks show 5-mile intervals along the track; B and C, automatically inserted by the TDM to indicate the presence of a fire target; and D, latent forest fire.

DETECTION SUCCESS

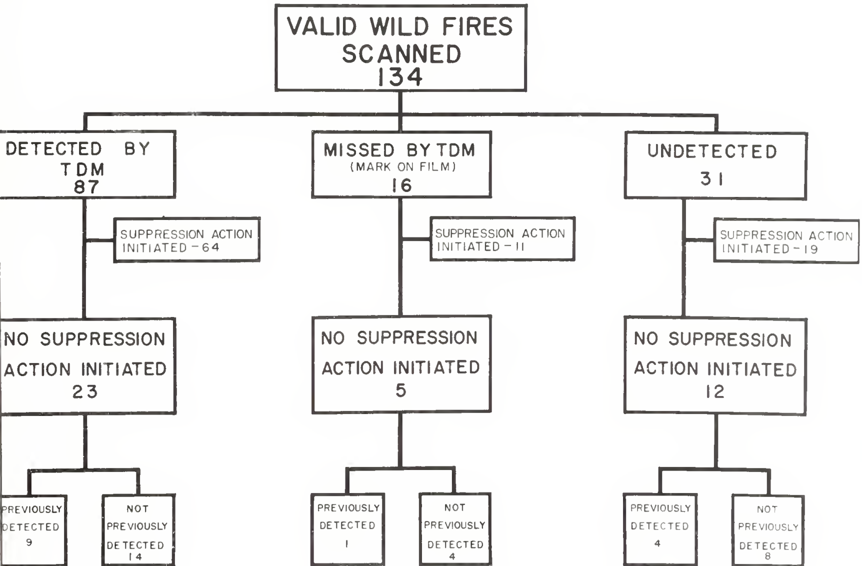

Figure 4.—1967 detection success.

UMP TRUCKS AS A PORTABLE WATER SOURCE FOR HELICOPTER PICKUP

JACK SHERO, *District Administrator, Kelso District*

LLOYD CLARK, *Assistant District Administrator, Kelso District*

Department of Natural Resources, State of Washington

Helicopters with buckets suspended from ieir cargo hooks are being used effectively in ildfire suppression.

One requirement for efficient use is a nearby ource of water of sufficient quantity and depth, nd in a location where a suspended bucket can e dipped. There are many areas in the forest here there is enough water in the small reams, but the water is not deep enough. For vo reasons, it seemed advantageous to try to nd a way of obtaining a useable supply of ater or retardant in such areas. First, the inimization of delivery time would provide ore water on the fire; second, the total fire bill would be substantially less.

One way to provide such a spot is to set up a large plastic or canvas sump or tank and keep it filled using a pump. While these sumps or tanks have been used successfully, they are not commonly available, and are usually stored somewhere other than where they would be needed in an emergency. Also, they can be bulky and difficult to handle.

A more readily available substitute was needed. A check indicated that there were quite a number of large dump trucks available in most of the logging areas in western Washington.

In July 1968, tests were conducted in the Kelso District of the Department of Natural Resources, using these dump trucks as a portable source of water for pickup by helicopter.

The tests were conducted under simulated fire conditions in timber in the Whitten Creek drainage of the South Toutle River in Cowlitz County in southwestern Washington. A turbocharged Kaman H-43 helicopter and a 10-yard dump truck with the bed lined with polyethylene were used for the tests (fig. 1). The helicopter has a maximum allowable gross weight of 7,750 pounds (exterior load) (U.S. Air Force manual.) The weight of the aircraft including fuel and pilot is 4,900 pounds, leaving a load carrying capacity of 2,850 pounds. A washtub-type monsoon bucket 29 inches deep and with a 250-gallon capacity was used. The bucket is slung on wire ropes approximately 8 feet below the aircraft.

Suggested rules for setting up a dump-truck or retardant supply for helicopter pickup follow: Preparation—Use a dump truck with a

Figure 1.—A helicopter prepares to fill its bucket from a dump truck. Conversion of the truckbed to an emergency water tank is quickly done with a large plastic sheet.

capacity of at least 10 yards (approximate 2,000 gallons). Line the box with a large she of polyethylene, and tie down all loose edges keep them from whipping with the downdra from the rotors. Place the dump-truck in cleared area, if possible, on a rise. Point t rear of the truck into the wind and downhill possible. Be sure there is adequate clearan for the rotors and enough runway for the he copter to build up flying speed. A cleared ar (with a minimum radius of 100 feet) for lan ing the helicopter should be available near for refueling and maintenance. Wet down t area around the water pickup source to mi mize flying debris and dust.

Fill the truck with a volume pump. Gelga or other short-term retardant or a deterge can be added, if desired, with the use of a fie chemical mixer as the truck is being fill (approximately 12 pounds of Gelgard for ea 1,000 gallons of water. A dye or coloring age should be added to help the pilot see where made previous drops. The truck can be ke filled while the helicopter is in flight. If a spa tire is mounted on the cabguard of the truck, should be removed.

Ground Control.—A trained signalm should be on the scene to assist the pilot loading the bucket from the truck. All sign men should know the standard hand sign used at heliports and similar facilities. T signalman should wear a hardhat with a chi strap because of the strong wind caused by t downdraft of the rotors. He should also we goggles while working near the helicopter. unnecessary personnel should be kept aw from the area.

Some industry officials who witnessed t tests were so impressed that they volunteer to have each of their dump-truck beds lin with a folded piece of polyethylene. And dum trucks were used quite successfully in fighti a slash fire on private land in October 1968.

LIQUID RETARDANT CONCENTRATES—A REPORT ON OPERATIONAL USE

DUANE W. MYLER, *Regional Air Officer, Region 8*

The Southern Region has used liquid phosphate concentrates for mixing retardant for aerial application for 6 years. In 1962, a trial operation was initiated to test the feasibility of air tanker use in the Southeast. Because it was a trial program with an uncertain future, a large expenditure for the mixing equipment, storage tanks, and other facilities required for the dry powder retardants then in common use was not justified. Therefore, attention was directed toward a liquid ammonium phosphate fertilizer manufactured by the Tennessee Valley Authority. The liquid would permit the retardant solution to be easily mixed in the air tanker as needed, and elaborate and costly equipment and facilities would not be required (fig. 1). Analysis of the liquid phosphate by the Macon, Ga., Fire Laboratory indicated it was as effective a retardant as the dry salt DAP or MAP being used elsewhere.[1] The 1962 spring fire season was brief and the fire load was light; therefore, results of the air tanker trial were inconclusive. Therefore, it was decided to continue the project to gain more experience.

When the 1963 fire season started, the Region was better prepared for an air-tanker operation. More storage tanks (Air Force surplus refueling units) were acquired, and larger pumps for loading were available.

The 1963 spring fire season rapidly developed into the worst since 1942, and the air tanker trial project quickly became a full-scale attack operation. By March 31, four B-26 air tankers were flying on Region 8 fires. All available retardant was soon exhausted and wet water had to be temporarily substituted. More storage tanks were acquired from the General Services Administration on an emergency priority. Also, the Tennessee Valley Authority cooperated by expediting delivery of retardant. And a PB4Y2 arrived from the West to bolster the air-tanker attack force. Initial attack with the retardant on the smaller fires provided almost 100-percent effective containment until ground crews arrived. In a few cases, air tankers were actually credited with full control. Even on larger fires, the liquid concentrate was extremely effective. In a few cases, attempts were made to cut off the head of hot, fast-rolling, project fires. Little success was achieved under these conditions due to spotting and the inability to build enough line ahead of the fire in a brief enough time. However, it was obvious after the fire was controlled that the retardant was extremely effective—the drop areas were easily identified as unburned islands of fuel. This was well established on a number of fires in the southern Appalachians and in Arkansas.

Figure 1.—The Knoxville, Tenn., air tanker base during the early days of air tanker use in the Southern Region. With liquid concentrate retardants, base facilities need consist of little more than a water source, concentrate storage tank hoses, and a pump to load the aircraft.

In the fall fire season, extreme conditions occurred again. Arkansas was in the third year of prolonged drought, and an emergency air tanker base was quickly established at Fort Smith. By this time, tanker crews and the lead-plane pilot were becoming more proficient with the use of liquid concentrate and in overcoming its basic drawback—its invisibility from the air. This was not a problem on initial attack; it occurred only during indirect line-building on larger fires. Lead-plane pilots soon

[1] Johansen, R. W., and Crow, G. L., Liquid Phosphate Fire Retardant Concentrates, Fire Control Notes V. 26, No. 2, pp. 13-16.

found it was not too difficult to keep track of the drops by checking terrain features. Small gaps that did occur were not hard to plug.

Since tanker and lead-plane pilots were all experienced in Western firefighting and in the use of thickened retardants, some were pessimistic about the liquid concentrate unthickened fire retardant. However, by the end of the 1963 fall season, all were enthusiastic.

As a result of the successes attained during the 1963 fire season, the trial air-tanker project emerged as an operational program. Since that time, Region 8 has established permanent air tanker facilities at Knoxville and Tri-City, Tenn., Fort Smith, Ark., and Weyers Cave, Va. (fig. 2).

In 1968, as a result of very critical fire conditions which developed in Florida, an emergency tanker base was also established at Deland, Fla. The first load of retardant was flown from the base 1½ days after work started, utilizing emergency trailer equipment furnished by the State of Florida, and the base was fully operational in 2½ days. The establishment of this base received wide publicity in the local newspapers, and on television and radio. Consequently, fire occurrence declined drastically and far less use was made of the tankers during the rest of the season. (Debris burning is the major cause in this area.) A typical report of the limited use, however, came from St. Regis Paper Company people—"We

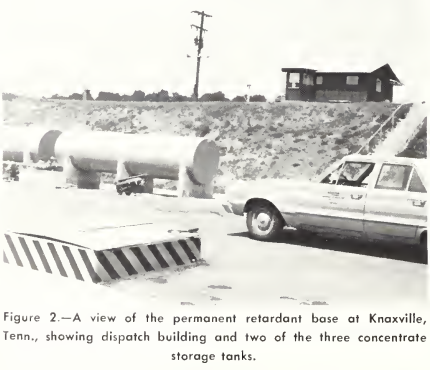

Figure 2.—A view of the permanent retardant base at Knoxville, Tenn., showing dispatch building and two of the three concentrate storage tanks.

could not have stopped the fire short of 2,0 acres without the tankers; as it was, we h it to 80 acres." Region 8 will continue a tr project in cooperation with the Florida St Forest Service.

Based on 6 years' experience utilizing t liquid concentrate fertilizer as a fire retarda Region 8 has reached the following conclusio

1. The retardant penetrates heavy canop very effectively, not only coating the canc itself but also the ground fuel.

2. Where thickened retardants tend to c only the top layer of heavy matted fuels, su as grass, pine needles, etc., the unthicker solution tends to run around, down, a through the fuel, thereby restricting the te ency of the fire to creep under surface fuel

3. The unthickened material flows arou aerial fuels and has more of a tendency to c all surfaces of the fuel, rather than just one side.

4. Liquid concentrate is more flexible th dry-prepared retardants because the formu tion can be varied at will with no detrimen effects. The water can be reduced in dr prepared for heavier fuels, thereby increas salt coating on fuels.

5. Use of the concentrate eliminates cos mixing equipment and manpower requiremen The physical size of the air-tanker base facil is reduced by eliminating the need for la slurry mixing equipment and a warehouse storing dry material, and by reduced stora tank requirements.

6. Storage is not a problem in mild st tanks. However, brass valves should not used since any etching will cause the valve leak. Region 8 has changed to stainless st or cast iron valves on the retardant side of system and has eliminated retardant leaka A regular main-line watermeter has been u for 6 years with no apparent damage to meter. By loading the 200 gallons of conc trate through the pump, and then followi with 1,000 gallons of water, both pump a meter are thoroughly flushed after each lo ing. Consequently, a wide variety of cent fugal pumps (including aluminum impel types) have been used successfully.

7. Overwinter storage of the concentra has presented no problems since the salts

he concentrate act as an antifreeze. Some lushing may occur at extremely low tempera-ure, but not enough to damage the equipment.

8. One of our major concerns at the start of he program was corrosion of the aircraft. Much work was done on inhibitors by the Tennessee Valley Authority, the Fire Laboratories, nd industry. But none would protect all the various alloys of aluminum and other metals ised in aircraft. Despite this limitation, corro-ion problems have been minor. We do not load he plane until we receive a fire call. The air-raft does not sit loaded. At the end of a day's peration, the planes are thoroughly washed lown inside and out, with special attention eing given to the wheels.

The fertilizer industry now has liquid concentrate facilities spotted throughout the United States, thus eliminating the need for the Forest Service to keep large quantities. The one basic drawback (visibility of the drop from the air) has not proven to be the problem first anticipated. While some method of coloring would still be desirable, the advantages and savings in handling and mixing far outweigh the visibility disadvantage. Region 8 has used liquid concentrate fertilizer as a fire retardant in a wide variety of fuels and of climatic conditions, ranging from semiarid in part of Arkansas to semitropical in part of Florida. This fertilizer has been very effective in all areas.

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uildup Index—*Continued from page 7*

omputer facilities could be used to compute ational BUI values and that an analysis could hen be released on the National facsimile veather circuit. Because the BUI is a cumu-ative expression and requires some bookkeep-ng, the memory capabilities of the computer eem ideally suited to this task. However, some roblems in implementing this idea would have be resolved. Although approximately 450 to 0 weather reports are taken hourly through-ut the country and transmitted on weather letype circuitry, the basic observation time eculiar to the National Fire Danger Rating ystem is not uniform throughout the country. lso, the time available for transmission of the mputed data or/and analysis may be difficult obtain on the already crowded schedules of e facsimile circuits. If these problems are lved, a daily aid to fire control during the critical periods will be possible through BUI analyses.

To carry this idea one step further, once the problems mentioned above have been surmounted, it would be a simple operation to add forecast values to the computer input. At present, forecasts of all the weather elements affecting the BUI are already easily obtainable. The computer output would then include not only the current BUI but a series of forecast values corresponding to the time periods covered by the forecasts.

While these BUI analyses and forecasts may not be available in the near future, they are far closer than just a dream. The ESSA-Weather Bureau's high-speed communications systems and the capabilities of its computers are such that only technical problems need be solved to achieve reality.

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A BATTERY CARTRIDGE FOR FLASHLIGHTS

WILFORD L. KEELE
Salmon National Forest

Flishlight batteries have been prepared and wrapped in various ways for field use. They have always been inserted the same way—one by one. When four batteries are required, they must be placed carefully in series, two with the positive contacts up on the same side, and two with the contacts down. Often the batteries must be inserted in total darkness, and it is difficult to get them correctly installed. Time is also lost in the field while inexperienced men are assisted in properly inserting batteries.

Four batteries fastened firmly together in proper series by *pressure sensitive tape* form a *cartridge* that can be placed in the flashlight without a mistake (insert either way) making proper contact immediately (fig. 1).

To implement this idea using the present stock of flashlight batteries, a simple device or "jig" for holding them firmly can be used to make up the cartridges (fig. 2).

The General Services Administration can supply 2-inch pressure sensitive tape (#8135-663-3738) at $1.90 per 60-yard roll.

The jig must be so constructed as to assure firm contact of the terminals by means of pressure from one end as the batteries are placed in the device for taping. If metal is used for this pressure plate or holder, an insulating material, such as tape, must cover the metal to prevent battery discharge during the tape-wrapping process.

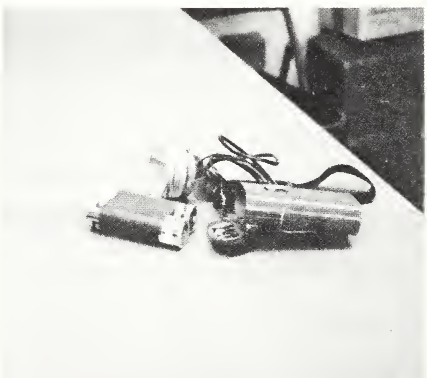

Figure 1.—Four-cell battery cartridge—no error in installation can be made.

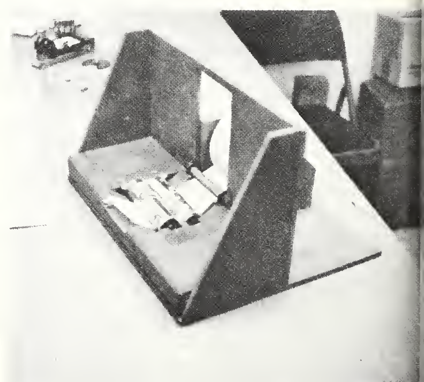

Figure 2.—Jig for quick battery cartridge construction.

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ꞮRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

COVER—A fire starts on the rampage. Article on the next page discusses how atmospheric instability can play an important role in such a fire blowup.

(NOTE—The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such does not constitute an official endorsement or approval of any product or service by the U.S. Department of Agriculture to the exclusion of others which may be suitable.)

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ᛐtmospheric ᛐtability Forecast ᛐnd Fire Control

ᛐOLLO T. DAVIS [1]

Unstable air masses increase hances of big fires. Relative umidity seems to play a maller role than thought beore. Asmospheric stability orecasts, projecting stability or 36–48 hours, can warn fire ontrol personnel when to exect erratic fire behavior and n increase in blow-up potenial.

Have you ever wondered why ome forest fires are extremely ifficult to control while others, nder seemingly like weather nd fuel conditions, are relavely easy to curb? Even durg dry periods when winds are igh and humidities low, some res show no erratic behavior r blow-up potential and are asily checked. But at other mes, under apparently the ame conditions, the wildest ow-up develops. Still more uzzling is the fact that some res are almost impossible to ontrol and become conflagraons even though the soil is et, humidities are relatively igh, and surface winds outside e fire zone are light. Why the ifference?

Blow-up characteristics of rest fires have been attribted to low relative humidities d strong surface winds. Papers have been presented about the relationship between relative humidities below 30 percent and large fires. Daniel J. Kreuger, former Georgia Fire Weather Supervisor, made a study of forest fires in Georgia for the years 1950-1959. He reported in the *Georgia Forest Research Paper* #3 that 77 percent of the fires burning 300 acres or more occurred when the relative humidity was 25 percent or less. Ninety-two percent of the large fires occurred when the relative humidity was 30 percent or less. Mr. Kreuger concluded:

1. Fires when promptly and adequately attacked (barring equipment failure), rarely, if ever, become large unless the relative humidity is 30 percent or less at the fire.

2. Potential for large fires increases rapidly as humidities fall below 25 percent. Fire fighters should increase their vigil whenever these low relative humidities exist or are forecast.

Figure 1—Convection currents visibly at work on a forest fire.

Atmospheric Turbulence

The relationship of atmospheric turbulence to erratic fire behavior has also been studied and discussed. As early as 1951, George M. Bryam and Ralph M. Nelson presented a paper titled "The Possible Relation of Air Turbulence to Erratic Fire Behavior in the Southeast." [2] In this paper, they pointed out the possibility of a direct relationship existing between unstable low-level air and extreme fire behavior in the Southeast.

(Continued next page)

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[1] Forestry Meterologist, ESSA Weather Bureau, Jackson, Miss.

[2] Fire Control Notes 12(3) 1-8; 1951.

Air Stability

Continued from page 3

A review of the weather conditions at the time of the larger fires occurring in Mississippi during 1967 revealed that large, hard-to-control fires did not necessarily occur on the days with the lowest relative humidities. In fact, the largest fires occurred 24 to 48 hours after a day with desert-like humidities. This pattern seemed to be begun by the passage of a cold front. With cold, dry, continental arctic air overspreading the State behind the front, the relative humidities often dropped below 20 percent. One to 3 days later, relative humidities started climbing, but fire severity and size also increased.

Hoping that this unexpected fire pattern might be explained, the daily surface weather maps and the temperatures from the surface to the 5,000 ft. level were critically examined for all days on which fires of more than 300 acres, classed as "E" fires, burned. The examination of the temperature profiles aloft strongly suggested that the atmospheric instability in the lower atmosphere played a significant role in erratic behavior of fires.

To investigate further, information on all 1967 fires of the class "E" and larger was requested from the Fire Control Directors of the States surrounding Mississippi. The requested information was supplied by Louisiana, Arkansas, Tennessee, and Alabama, and a total of 70 fires were investigated. No attempt was made to investigate weather conditions for fires when fire control personnel were unable to attack the fire shortly after it started.

Atmospheric stability in the layer between the surface and the 5,000 ft. level was catagorized for the investigations as follows:

1. *Stable*—Temperatures aloft decreasing with increase in altitude at a rate about 3.5 degrees F or less per 1,000 ft.

2. *Conditionally Unstable*—Temperature decrease with increase in altitude at a rate of 3.5 to 5.4 degrees F. per 1,000 ft. (Conditionally unstable air tends to become unstable if forced to rise. Additional heat supplied at the surface is sufficient to produce the needed rise.)

3. *Unstable*—Temperature decrease with increase in altitude of 5.5 degrees F. per 1,000 ft.

4. *Absolutely unstable*—Temperature decrease with increase in altitude greater than 5.5 degrees F. per 1,000 ft.

Only six of the 70 fires studied occurred when the conditions in the low-levels of the atmosphere were classified as stable. Fifteen, or 21 percent, occurred when the air mass was classified as conditionally unstable, and fifteen others burned during unstable conditions. The greatest number, by a significant percentage, occurred when the air mass was classified as absolutely unstable. Thirty four of the big fires, nearly one-half of the 70 cases studied, burned when the air mass at the fire site was absolutely unstable.

Relative Humidities

Relative humidities in the area of the fires ranged from 18 percent to 80 percent. A large percent of the fires during periods when the atmosphere was absolutely unstable burned when relative humidities at the surface were above the level normally associate with big or erratic fires. Nearl 60 percent of the large fire studied took place when th relative humidity in the are was above 30 percent. Air mas stability, therefore, appears t be as significant, if not mor significant, than low-level moi ture in the behavior of fores fires once they got started.

It seems reasonable that ai mass stability should play very important role in the be havior of forest fires. Unstabl air, from the meteorologica viewpoint, is also convectivel unstable. Once the air start to rise, it will be warmer tha its surroundings. The air co tinues to rise until it reaches level where the temperature o the surrounding air is th same. When unstable air is di placed upward, it is replaced b air moving laterally, creatin an indraft of air, which is als unstable. This air rises. Wit the heat of the fire being th initiating force to start an maintaining convection, a chai reaction is begun. The conve tive column increases in siz and the indrafts increase i velocity to fan the flames whic then increase the heat to in tensify convection, and so o (fig. 1). Fire control perso nel are well aware of many o the direct and indirect effect of air mass instability on fores fires. Some of the more spe tacular effects are rapid crow ing, long distance spottin erratic movement, and blow-u potential.

Conclusions and Recommendations

Most large fires occu when the temperature profil through the lower levels of th atmosphere exhibit some de gree of instability. Fire contr foresters who are furnishe daily with an atmospheric st bility forecast can plan ahea

(Continued on page 15)

hemical Thinning Reduces Fire Hazard

)avid H. Morton and Elmer Fine [1]

Chemicals have been used successfully in precommercial inning operations on the Colville National Forest. Not only oes the method reduce thinning costs, it also prevents the eation of a fire-hazardous situation and subsequent fire protec-on problems (fig. 1).

Since 1962, the Colville Na-onal Forest in northeastern Vashington has carried on an xtensive thinning program in oung, coniferous pole stands 1 about 12,800 acres of over-ock old burns. Both machine-nd hand-thinning methods ave been employed—the latter ethod being used in stands ith up to about 2,000 stems er acre. In stands denser than iis, where trees are usually naller, mechanical thinning ith dozers and choppers is ore suitable and economical.

The fire hazard which may e created by precommercial ainning is a serious problem. or example, the chainsaw iethod commonly employed in and-thinning operations often esults in heavy slash that re-iains a threat to the residual and for a number of years ig. 2).

Chemical Thinning

To overcome this problem, iemicals were used for hand iinning and have been found be a tool that will satisfac-rily meet not only silvicul-ral and economical objec-ves, but also those of fire ntrol by keeping fire hazard nditions static.

[1] Respectively, Forester and Forest spatcher, Colville National Forest.

The chemical thinning process uses a hypo-hatchet injector and Silvisar 510 tree killer. An automatic injection system within the hatchet releases the silvicide into chops made in the bole of the tree. The success of this method in eliminating excess trees and saving time and money has been phenominal. Ninety-five percent of all treated trees are effectively removed as a competing factor in the stand, and total costs of the operation average $21 per acre compared to nearly twice that much for the chainsaw method.

Reaction to Chemicals

The reaction of treated trees to Silvisar 510 is an interesting study in itself. If treated anytime within the growing season, the kill is quite rapid. In warm weather, dying needles can be detected within three days after application, and within two weeks, the entire foliage of a 50-foot tree may be brown. A high percentage of the kill is in this shorter period of time; further studies have shown that kill of seemingly resistant branches may continue into the next growing season. Treatment of conifers in the dormant seasons does not show until spring or when the vibrant growing processes of the tree begins. Douglas-fir treated in January remains

Figure 1—Crown release effect in chemically treated stand. Full, green crowns reduce fire hazard.

green until the growing season begins, then browns at about the same rate as one treated in April. Western larch, when treated with bare limbs, gains almost full needle growth before the needles react to the silvicide, brown, die, and fall.

Needle fall and deterioration of twigs, limbs, and finally the bole itself, of treated trees are the critical factors in the build-up of a slash hazard in this thinning operation. In chainsaw thining, nothing is left in the upper limits of the crowns to provide a fuel, but the mass accumulation of slash on the ground is extremely hazardous. The added drying from sun and wind keeps these ground fuels in a combustible condition for several years until crowns close over, vegetation regrows, and slash deteriorates.

Hazards Eliminated

Chemical thinning eliminates the slash and drying hazards.

(Continued next page)

Figure 2—Three-year-old chain-saw thinned area showing considerable fire hazard still remaining from the slash.

Chemical Thinning

Continued from page 5

An accumulation of slash does not build up anywhere in the stand (fig. 3). Immediately after thinning, needles brown and die on all species treated. Some species, western larch, hemlock, and Englemann spruce, shed needles within three weeks after browning. Douglas-fir retains needles slightly longer but not beyond one growing season. Western red cedar, grand fir, and lodgepole pine retain a significant amount of needles through the first year after treatment, but after two winters, few needles remain. At no time do these dry needles seem to represent significant fire hazard. Fine twigs and branches, pencil size, two years after treatment, have shown very little evidence of deterioration. In some instances, rotting of the boles of the treated trees, especially near the ground line, has begun. It appears, however, that the stem of the tree will remain standing for quite some time. The deterioration rate is so slow that there is no significant slash buildup.

Other Advantages

There are several other advantages to chemical thinning. The killed trees protect the crop trees from sun scald and weather damage. The skeletons of killed trees significantly reduce sun and wind as drying agents. Light meter readings taken in chemically thinned stands show a 30 percent decrease in exposure compared to the stands where excess trees are felled. Although the chemical thinning does increase drying slightly more than in the wild stands, it is far below those conditions created by the chainsaw method.

Standing dead stems, resulting from trees killed in the chemical thinning process, do not represent a significant fire hazard after needle fall. The dead trees in the thinning operations are below or within the canopy of live, green trees. Very few trees are killed whose tops protrude to a position where sparks could be carried for any distance, and, anyway the adjacent, green tops would deflect and catch sparks before much distance could be covered. Spotting, associated with snags or dead trees in wildfire, would not occur to any significant degree.

The likelihood of fire reaching the tops of the dead trees is low. In thinned stands natural pruning removes most fine fuels from the lower quarter of the boles of the trees. Without an accumulation of material under the trees to heat up, a wildfire, in most cases would not be any different than in unthinned stands.

Figure 3—The entire stand pictured has been thinned. The left side was treated by felling excess trees; the right side was treated with chemicals.

ure 1—View of sawdust pile after fire was finally extinguished.

Back to Nature

Returning the chemical inned area to a natural contion, as far as fire control is ncerned, is not an important sue. In chainsaw thinned eas, it is very important that e canopy close to increase ade and wind deflection and r slash accumulations to deriorate. However, in the emical thinned stands, these ctors are insignificant. As anding, dead trees slowly deriorate and fall, the crowns leaves will also be ineasing. An abrupt change ll not occur because the tural spread and growth of e crowns cover the space left dead trees. Normal spacing jective in thinning operans has been 13 by 13 feet. own diameters have genally averaged 6 feet, leavg a space of nearly 7 feet to be filled by growing crowns. Crop tree crowns will probably begin touching within 15 years. At the same time, deterioration and falling of the killed trees should be nearly complete.

An added advantage of chemical thining over chainsaw methods is the lesser impact on the aesthetics of the treated area. Without the accumulation of material on the ground, it is less likely to be apparent to a casual observer that anything has been done to the stand.

Fire Prevention

Although there has not been a wildfire in any of the thinned areas, it is clearly evident that extra suppression effort will be required should one occur in the ax, chainsaw, or dozer-thinned stands. Accordingly, special fire planning and fire control measures have been

(Continued on page 15)

A New Way To Snuff Out Burning Sawdust

HARRY NICKLESS [1]

During the late elk season of 1965, a hunter put out a cigarette in an old sawdust pile. The pile was 10-20 ft. high and covered an area 75 by 100 ft. Surrounding this area was an area of decomposed sawdust 150 by 200 ft. (fig. 1). The pile came to life and burned from time to time during the fall. Winter snows soon followed, and the sawdust pile was covered with 4 to 6 ft. of snow.

Under Snow—Fire!

In March 1966, as the Fire Danger was approaching Moderate, the sawdust pile started burning again. The burning parts of the sawdust were worked over with a fireplow and later with a D-6 Cat. The old sawdust, which was wet, was turned over and mixed with the burning material in an attempt to put out the fire.

During April, the Fire Danger was Moderate. The sawdust pile continued to show signs of fire every time there was a slight breeze. A portable pump was placed in a nearby creek, and two men spent 2 days flooding the burning sawdust pile and working out the burning pockets by hand. But since smoke continued to show,

[1] Fire Control Assistant, Apache National Forest.

(Continued next page)

People Programs For Fire Prevention

RUDY ANDERSON [1]

Fire prevention programs which stress the involvement o people have proven to be a worthwhile approach in the Blac Hills National Forest.

The Black Hills Forest has a high potential for man-caused fire, since most all areas are accessible by road. Private land within the forest compounds the problem with industries, ranches, year-long residences and summer homes scattered throughout. Recreation and tourism raise chances of man-caused fires. Over two million people traveled the highways and backroads during the summer of 1968. More are expected each year.

To counteract increasing fire hazards, a fire prevention technician for the forest was appointed in 1963. The position was to strengthen the fire prevention program by exploring new aproaches and methods of personal contact.

School Programs

School children have been most important to the prevention program. All schools i the Black Hills area, grade one through six, are contacte yearly, and two age-grade programs are given.

Programs receiving the mos favorable response had studen participation. A fire story wa told with cardboard cutout applied by the students to large, magnetic board whic depicted a green forest, show ing a slow change in th scene as a wildfire advance A fire demonstration drama ically showed the children th hazards of pressurized contai ers, gasoline fumes, electric wiring, and hot grease.

After three years of varie approaches, a written progra evaluation test was given to th students and teachers. The retained a surprisingly larg percentage of information. I addition, each student was r quested to take the test hom and go over it with his parent A sample count of 445 studen showed 84 percent of the st dents took the test home.

For the school program i 1968, a life-size robot, name Johnny B. Careful, was co structed from cardboard box and equipped with flashin lights and a sound syste (fig. 1).

Figure 1—Johnny B. Careful helps to dramatize fire prevention presentations.

[1] Fire Prevention Technicia Black Hills National Forest.

Snuff Sawdust

Continued from page 7

one or two men had to be sent daily to the sawdust pile on patrol and mopup.

By May, the Fire Danger was High and approaching Extreme. From time to time, small crews from the Job Corps Camp were dispatched to the burning sawdust pile to put out the burning pockets. Two-man District crews made regular patrol and mopup of the sawdust pile. Among other methods, they put all burning embers in a garbage can and filled the can with water. Still the sawdust pile continued to burn.

The Answer

Finally, a successful tactic was tried. Four 57-lb. bags of dry Phos-chek were mixed into the hotspots. The Phos-chek was raked into the top 4-6 inches of sawdust. After this treatment, no further burning was noted. No doubt any of the long-term retardants would probably have done the job. This method may also be useful in controlling ground fires.

Johnny B. Careful required wo men, one man behind the cene to operate the lights and obot voice and the other man o conduct the program with he student body. The script onsisted of questions answered by the ranger, the robot nd the student body.

A factor to consider in school rograming is involvement of ther cooperative fire agenies. These agencies are usually villing to participate in school programs, and students are impressed to see several agencies vork together.

Displays

Education by displays is anther important area of people articipation and involvement. Two mobile display units, a ear view slide projection sysem (fig. 2) and a miniature awmill (fig. 3) have helped ake the fire prevention mesage to the people.

The sawmill is a working nodel. Small logs are sawed nto boards and the boards tamped: "Prevent Forest Fires—Black Hills National Forest." These are distributed o the audience. The unit alvays draws a large audience vherever it is on display. The alue of this display unit is its hand outs.

The mobile slide projection ystem is versatile. It is comletely self-sustaining with a iewer-operated push button to tart the slides and sound sysems. Two display panels on ach side of the viewing screen re removable. By inserting a lifferent slide tray and tape artridge and by changing the our display panels, the theme an be changed quickly from ire to timber to recreation to vhatever is wanted. The various display panels are stored in he rear of the unit.

Figure 2—This unit is quickly set up, and the display material can be easily varied.

News Media

A prevention program is no better than its news media support. Again, involvement is the key to success. When a fire becomes Class C or larger, the area news media are immediately informed. A public information officer is assigned to the fire area, and he works directly with the news media people, giving fire information and directions for taking photos. If reporters are not on the scene, the public information officer supplies them with information by phone. The newspapers will give space to forest fires when they are given the facts about them.

Personal contact with the news editor has proved to be the most successful contact when specific prevention programs need promotion. The news editor gets information orally or in written outline form, and he presents it to the public. Many times this personal contact has made the difference between an item getting good coverage or not.

The daily fire index reading is currently one of the major programs in the Black Hills Forest area. The leading newspaper in the area publishes daily the fire index on the front page during the fire season. The same index is presented with the local weather report on the major television station in the area. When very high and extreme fire conditions exist, specific emphasis is placed on the index.

(Continued on page 15)

Figure 3—A working model of a sawmill always draws large crowds.

Fire Follow-up Critiques Fight Future Fires

1st Lt. John H. Maupin [1]

Fire follow-up critiques have proven to be beneficial to the fire control effort at Hunter Liggett Military Reservation.

Hunter Liggett consists of 176,000 acres of rugged, grass and brush covered terrain in central California, bounded on the north and west by the Los Padres National Forest. Due to artillery firing and associated military training, fire incidence is high.

After each fire, a fire follow-up critique is held. Short meetings are also held for drills and rolls on suspected smokes. To keep details fresh, discussions are held as soon as practical after the fire is put out.

Who Attends

The fire boss is at all meetings and acts as moderator, leading firefighters and other fire department personnel in a recount of the operation. The dispatcher also attends, since he often has an excellent overall picture of the fire.

If only a few people were involved in the fire, each one is called upon to give his interpretation of what happened. After larger fires, when many more people are involved, the fire boss calls on a cross-section of firefighters. The fire boss is careful to call on new men since many misconceptions are discovered by hearing their viewpoints. Also, the inexperienced men may bring up important items that the experienced men have forgotten or taken for granted.

The Critique

The fire boss opens each session with a brief outline of fire weather and fuel conditions that existed at the time of the fire. Recounts are sequential, and they cover events from the time the fire call was received until the crew returned to the station. Sometimes a blackboard and colored chalk or an overhead projector are helpful in diagramming the life of the fire.

Small fire follow-ups are specific, and such details as response time, hose lays, snag felling, cause and prevention of the spread of the fire, tools used, and line construction are discussed. Large fires demand a much more general discussion, covering topics such as fire weather, line location, and utilization of support facilities or reinforcements. Also, safety hazards and the employment of special procedures, such as backfiring, and equipment, such as bulldozers or air drops, are discussed.

After everyone has given his version of the fire, the fire boss clarifies issues in question and brings up any pertinent topics that he thinks have been omitted.

(Continued on page 14)

[1] Post Fire Marshall, Hunter Liggett Military Reservation.

Marsh Funnel Table Revised

Charles W. George and Charles E. Hardy [1]

Revised table gives flow rates for all currently used fire retardants.

About 3 years ago, the Marsh Funnel was modified so that the viscosity of all forest fire retardants then used could be determined in the field. The data were obtained by comparing viscosity from the Brookfield Viscometer with the flow-through time for the Marsh Funnel; thus "Marsh Funnel time" serves as an inexpensive criterion of actual viscosity.[2, 3]

Revised Table

The revised table includes only products currently used. Newest of these is Phos-Chek 202 X/A (see page 16).

The Marsh Funnel Packet is still available. It contains the table, the instructions for converting a Marsh Funnel, and a list of commercial sources. Separate tables and the Packet can be ordered from Northern Forest Fire Laboratory, U.S. Forest Service, Drawer 7, Missoula, Montana 59801.

(Continued on page 15)

[1] Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory.

[2] George, Charles W., and Charles E. Hardy. Fire retardant viscosity measured by modified Marsh Funnel. U.S. Forest Serv. Res. Note INT-41, 4 pp., illus. 1966.

[3] George, Charles W., and Charles E. Hardy. Fire retardant viscosity measured by modified Marsh Funnel. Fire Control Notes 28(4): 13–14, illus. 1967.

oot Feeder
uppresses Fires

ICHARD J. BARNEY [1]

A root feeding needle, fitted a fire hose, deeply saturates eavy accumulations of fuel nd partially decomposed organic matter better than conventional nozzles, stream or fog pe. Also, less water is used y the needle.

Heavy accumulations of fuels nd partially decomposed organic matter, such as peat, osses, and humus, are abunant throughout the interior of laska. Road construction and nd clearing activities often reate large concentrations of ixed fuel and organic soil. uring periods of high fire anger, characterized by high uildup indexes, these fuels can burn to considerable depth. Extinguishing fires during these periods is often difficult and usually requires large volumes of water. Normal application procedures do not always get water down into the fuel where it is needed. Rather than soak, conventional nozzles, both stream and fog type, have a tendency to throw firebrands and to waste water because of runoff. A nozzle which places water in the center of these organic fuels could reduce the total amount of water necessary and improve the efficiency of the suppression technique.

[1] Fire Control Scientist Pacific orthwest Forest and Range Experient Station; headquarters for the ation is at Portland, Oregon. The thor is located at the Institute of orthern Forestry, College, Alaska.

The Feeding Needle

The idea of using a tree surgeon's feeding needle seemed worth trying. The feeding needle (fig. 1) is normally constructed with 3/4-inch spray hose fittings; it was modified to use a 1 1/2-inch national fire hose female thread adaptor. The needle is equipped with a shutoff valve and is approximately 40 inches in length. The pointed tip has side holes which direct water in four directions (fig. 1).

In use, the needle is easily inserted into the fuel to the desired depth. Sometimes, slightly opening the valve assists the insertion process. Once the needle is inserted, the valve can be fully opened. The period of time the needle is left in each location depends on the specific fuel. The needle is then moved from place to place until the control or mopup job is completed.

Field Evaluation

The needle was given to the Fairbanks District, Bureau of Land Management, Division of Fire Control for two fire seasons. General reaction to the needle performance was enthusiastic. Various personnel and crews reported that the needle was a real help in controlling and mopping up the deep burning fires.

Flow Rates

A flow-rate check was made because crews involved in field testing thought the needle put out more underground fire with less water than their standard adjustable nozzles. This field observation seemed reasonable

(Continued next page)

ure 1.—Feeding needle and spray pattern.

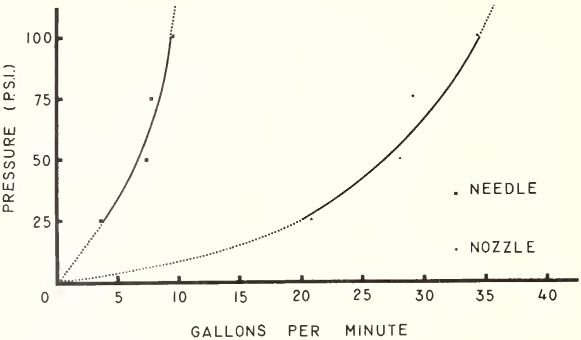


Figure 2.—Needle and nozzle flow rates at various pressures.

Root Feeder

Continued from page 11

since the needle openings were smaller than those of the nozzle. However, an experiment was run to determine how much difference actually existed between units in waterflow per unit of time. This information would also give a tanker operator some idea of how long his supply of water might last using either type of nozzle for control or mopup.

In the flow-rate check, a Western Fire Equipment Co. Nozzle, No. 4A711, set approximately midway between full spray and full stream pattern, was used for comparison since it is more or less a standard nozzle for tankers and portable pumps in interior Alaska. The selected nozzle setting represented a pattern which is used in much of the local suppression work. The Bureau of Land Management's 1,200-gallon tanker truck, equipped with a front-mounted Barton-American centrifugal fire pump, type UA50, was used as the water source. A 32-gallon garbage can was calibrated and used to catch the water. Runs were timed and flow rates calculated for four pressure levels determined by the pump gauge. Pump pressures of 25, 50, 70, and 100 pounds per square inch were selected because they cover the range most used by various crews on both tankers and portable pump units. The 1½-inch hose was selected since it is the standard size hose of the Bureau of Land Management in Alaska.

Figure 2 illustrates the results of the flow test. Obviously, the feeding needle uses considerably less water per minute. At the 25 p.s.i. level, the ratio is about 5 to 1; whereas at 100 p.s.i, the ratio is approximately 4 to 1 with the standard nozzle flow rate compared with the needle flow rate.

Other Tests

In addition to the flow-rate check, some subjective tests were made by actually wetting typical fuels. These tests substantiated the usefulness of getting water into the center of fuels with the needle. In several cases, with the conventional nozzle and essentially similar amounts of water, the wetting went down only a few inches before additional water ran off. The needle, however, completely saturated the vicinity where it was placed, making the are muddy. One explanation f these apparent differences that the organic fuels used the tests have a very hig surface-to-volume ratio and a as a sponge. Therefore, a co siderable amount of water necessary to saturate the ar near the surface before add tional amounts will penetra downward. The needle provid a means to get water at t desired level without having saturate the levels above.

Discussion and Summary

It appears that the need can be an effective tool in co bating fires in deep, orga fuels. This tool not only u considerably less water p unit of time but also places at the depth desired. Modifi tions could possibly impro the performance; however, t needle seems to perform in satisfactory manner as ori nally designed.

Although the manufactu recommends operating t needle at 250–350 p.s.i. usi ¾-inch or ½-inch pressu hose for tree feeding, we c tained good performance lower pressures using 1½-in hose. Higher pressures seem to increase water blowba from underground along t needle shaft thus reducing t effectiveness of getting wa into the fuels at depth. As in nozzle work, caution should taken by operators to av stream explosions caused hitting hot pockets und ground. Drawing the needle of the ground slowly impro the saturation throughout t fuel complex encountered. W a little practice, the operat can use the needle quite eff tively. △

irtanker Tested

or Drop Pattern

RIAN S. HODGSON [1]

/ater-drop tests of the new anadair CL–215 airtanker dicate it has an effective pattrn length of some 240 feet hen a 0.5 second delay seence drop is made.

The CL-215 Airtanker

The Canadair CL–215 airnker has recently completed s water-drop performance ials. The CL–215 is an amnibious, twin-engine, waterombler aircraft. It can pick up 2,000 pounds of water in 15 econds, scoop-filling at 70 iles per hour from lakes as nall as one mile long. The ater bombing system has two nks, each with a capacity of 000 pounds and each consistg of a removable portion oove the floor and a lower xed portion integral with the ull structure. The two drop oors, 63″ long and 32″ wide, orm part of the bottom of each nk. The pilot or co-pilot can igger the water drop by ressing a button on his control heel; he can empty the tanks ogether, individually, or in equence.

Test Measurement

The technique for standarded, impartial measurement sed for the CL–215 is the one eveloped for water-bombing rcraft throughout Canada by e Flight Research Section of e National Research Council Canada in conjunction with e Forest Fire Research stitute in Ottawa. The test program has served as a background for future work to be done on tree canopy interception and also to test a mathematical model developed for the prediction of the ground distribution of water released from an airtanker.

One part of the test program called for calibrating drops of water to determine the ground distribution pattern. The results for the CL–215 in this phase of testing are the bases of this article.

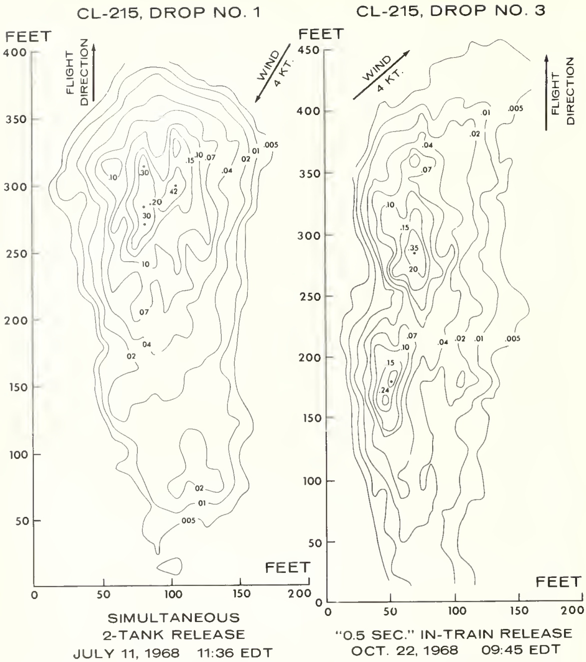
In anticipation of a larger pattern than with other aircraft tested, the ground distribution grid plot was extended to an area of about 680 by 200 feet for the CL–215. The 15 by 7.5 foot grid spacing of the cup holders was retained except for the last two rows where it was increased to 15 by 15 feet. The collecting unit was a 10-ounce paper cup with provision for a tightly fitted lid, the cup being held in a crimped metal can nailed to an 18-inch wooden stake and wire-locked securely.

For each test run, a total of 1,163 cup-can units were used, each stake identified by a letter and number corresponding to its position in the grid. Prior to placing in a holder, the cup was numbered with the corresponding coordinate value. After each test drop, any cups containing water were capped, collected, and weighed.

(Continued next page)

Figure 1—A view of the CL-215 dropping water, with 1 second delay between door openings. Canadair photo.

[1] Fire Research Officer, Department : Fisheries and Forestry, Canada.



	CL-215, Drop No. 1	CL-215, Drop No. 3
TEMPERATURE	72°	46°
REL. HUMIDITY	61%	85%
ALTITUDE	118'	97'
AIRSPEED	104 KT.	94 KT.
GROUND SPEED	100 KT.	97 KT
RECOVERY	80%	74%
ON SITE WIND	4 KT.	4 KT.
GALLONS DROPPED	1200 IMP GAL.	600+600 IMP GAL.

Figure 2—Contour patterns for salvo and sequence drops. Graphs from Flight Research Section, National Research Council of Canada.

Airtanker

Continued from page 13

Evaluation of Tests

The Flight Research Section wrote a computer program to analyze these results to give the coordinates necessary to plot the distribution contour lines in inches of water rather than gallons per 100 square feet. (0.01"=0.52 Imperial gallons of 0.62 U.S. gal./100 sq. ft.)

Drop pattern variations were made with ½- and 1-second interval delays between door openings, producing a longer water pattern than if the two doors had opened simultaneously (fig. 1).

The contour diagrams shown are those for a simultaneous salvo drop and a sequence drop with a 0.5 second delay between door openings. (fig. 2)

If we consider the 0.07 inch contour (4.4 U.S. gal./100 sq. ft.) as that required to retar a fire, then for the salvo dro the effective pattern length about 165 feet and for the se quence drop with 0.5 secon delay is 240 feet. The PB Canso, another airtanker tes ed, had an effective patter length of 150 feet with an 8 pound load.[2]

Results

The preliminary tests ind cate some work will have to b done on the drop system to r duce the peak contours th occur in the distribution pa tern. The water contained these peaks is wasted becau it represents water quantiti higher than those required f fire suppression. Effects on t pattern of a change in t opening rate of the drop doo the extent to which the doo open, or the interval betwe the opening of successive door needs more investigation. ⚠

[2] Hodgson, B.S. A procedure evaluate ground distribution pa terns for water dropping aircra Inform. Rep. Forest Fire Res. Ins Ottawa, No. FF-X-9, 1967.

Fire Follow-up

Continued from page 10

Results

As a result of fire follow-ups fire response time has bee shortened, and new refinement in firefighting techniques hav been developed. Fire safety i strengthened, and fire contro efficiency has increased. Fir follow-ups effectively reinforc the methods of fire control t new men and serve as refreshe for the old hands. These ses sions also provide an oppor tunity for new men to tak advantage of the knowledge o the more experienced men. No least of all, effective fire follow ups yield benefits in acreag saved and accidents preven ed. ⚠

larsh Funnel

ontinued from page 10

Instructions for Using the Marsh Funnel

. Place the appropriate tip in he Marsh Funnel.

. Cover the hole with a finger nd pour a freshly agitated ample into the clean, dry up-ight funnel until the fluid evel *exactly* reaches the bottom f the screen.

. Measure the time in minutes nd seconds for *1 quart* of re-ardant to flow through the unnel (the funnel hold ap-roximately 2 quarts).

. Look up measured time on efthand side of table. Read roper column to the right to nd viscosity in centipoise.

IOTE—A. The viscosity reading depends on time because agitation and temperature of retardant will vary. The viscosity found in the table will be for the retardant at the existing settling time and temperature.

B. For the samples tested, the Marsh Funnel method gave viscosities within 5 percent of the Brookfield method.

C. Numbers included within the boxes indicate the normal usage range. △

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ir Stability

ontinued from page 4

nd use their manpower and quipment better.

Upper air temperature data re readily available at all ESSA Weather Bureau Offices vhere Forestry Meteorologists re stationed. These data en-ble the forestry meteorologist o determine the degree of at-nospheric instability. Using ther meteorological informa-ion available, such as the omputerized lifted index prog-ostic charts, the Forestry Ieterologist can project the tability into the future and ome up with a forecast of the tmospheric stability for the ollowing 36 to 48 hours. Con-idering the value of such fore-asts to the forestry industry, he atmospheric stability fore-ast should be a routine prod-ct of all weather offices, and re control personnel should e trained to use it. △

People Programs

Continued from page 9

Smokey Bear

Smokey Bear now has his day in South Dakota. Each spring, the Governor of the State proclaims a Smokey Bear Day to emphasize the approaching fire season and call attention to Cooperative Forest Fire Prevention. On this day, a mass distribution of CFFP material is made throughout the State by Federal, State, and cooperating fire agencies.

The program has been very successful—and with added benefits. First, the material *is* being distributed, and all key areas *are* covered. Second, in coordinating areas of distribution, other agencies and organizations not previously interested in fire prevention participate. The most valued benefit is news coverage. Spot announcements are periodically aired over the radio three days prior to the CFFP distribution. Television covers Smokey Bear Day, and news articles appear in all weekly and daily papers just before the distribution.

Fire Prevention Week

In the fall of 1968, an air show was organized strictly for fire prevention publicity. All cooperating agencies, the State Forestry Department, National Park Service, State Park Department, the Rural Electrification Agency, volunteer fire departments, and law enforcement agencies, in coordination with the Forest Service, put on a demonstration of fire equipment and related activities. The show was a success because people not familiar with firefighting saw the massive organization needed for a major fire. An aerial tanker retardant drop was demonstrated. The helicopter and helitack operation was explained and demonstrated. Pumps, tools, safety equipment, fire trucks, and communication equipment were all on display and were all demonstrated. A fire story was told, and as it was told, people saw how many tax dollars were spent because of other people's carelessness.

Summary

New approaches in fire prevention are necessary but are not the total answer. Involvement of people is necessary but again is probably not the total answer. The Fire Prevention Program in the Black Hills seems to be successful because new approaches in fire prevention and people involvement have been combined. People are the problem and it takes people to solve it. △

Chemical Thinning

Continued from page 7

required for these areas. In contrast, no similar special precautions have been necessary for the chemically thinned stands.

As a result of these studies, even though their duration has been short, an acceptable method of hand thinning has been established. Chemical hand thinning follows good sivicultural practices and certainly does not increase the fire hazard in thinned areas. △

U.S. DEPA[...]
WASH[...]

OFF[...]ESS

POSTAGE & FEES PAID
United States Department of Agriculture

See article, page 10.

MARSH FUNNEL TIME—FIRE RETARDANT VISCOSITY RELATIONS [1]

Time for 1 quart to flow through a funnel [2]		Fire retardant material						
		Gelgard M		Phos-chek 202	Phos-chek 202 X/A	Phos-chek 259	Fire-Trol 100	
		Large tip [3]	Small tip [3]	Large tip	Large tip	Small tip	Large tip	Small tip
Min.	Sec.	Centipoise						
0	15						930	
0	20				557		1530	
0	25				767		1900	
0	30				966	5	2140	
0	35				1155	20	2330	
0	40			540	1334	43	2480	920
0	45			680	1502	66	2590	1110
0	50			800	1659	89	2680	1250
0	55	520		900	1806	112	2750	1370
1	00	550		1000	1942	136	2800	1460
1	05	580		1080	2067	159	2840	1540
1	10	610	210	1150	2183	182	2880	1610
1	15	640	230	1210	2287	205	2900	1670
1	20	660	250	1265	2381	228	2920	1720
1	25	680	265	1320	2465	251	2930	1770
1	30	700	280	1380	2538	274	2940	1810
1	35	720	300	1420		297	2950	1840
1	40	740	315	1470		320	2960	1870
1	45	760	330	1520		343		1900
1	50	780	342	1560		367		1920
1	55	800	355	1600		390		1940
2	00	820	370	1640		413		1960
2	15	865	410	1755				
2	30	908	442	1855				
2	45	945	477	1935				
3	00	980	508	2010				
3	15	1014	537					
3	30	1045	564					
3	45	1072	591					
4	00	1098	616					
4	15	1123						
4	30	1147						
4	45	1171						
5	00	1188						

Boxed ranges labelled in the table: Gelgard M large tip — Ground (520–800), Air (800–1188); Gelgard M small tip — Ground (410–616); Phos-chek 202 — Air (800–1470); Phos-chek 202 X/A — Air (1502–2067); Phos-chek 259 — Ground (43–112); Fire-Trol 100 large tip — Air (1530–2480); Fire-Trol 100 small tip — Air (1540–1960).

1/ Viscosities by Brookfield Model LVF, at 60 r. p.m., spindle 4 (except spindle 2 for Phos-Chek 259)

2/ Funnel must be FULL to screen before testing begins.

3/ Large tip diameter should be 0.269 ±.002 inch; small tip inside diameter should be 0.187 ±.002.

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FIRE CONTROL NOTES

FALL 1969 ● VOL. 30, NO. 4
U.S. DEPARTMENT OF AGRICULTURE ● FOREST SERVICE

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

COVER—Fire lookout trainee sights smoke during a simulator exercise and gains practical experience. See article on next page.

(NOTE—The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such does not constitute an official endorsement or approval of any product or service by the U.S. Department of Agriculture to the exclusion of others which may be suitable.)

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ire Simulation
ivens Lookout Training

AMES A. BURNAUGH AND
RA T. KITTELL

Provided a simulated smoke ighting and the proper equip- ent with which to report it, he fire lookout trainee gains aluable "actual situation" ex- erience.

The first use of fire simula- ion was the "Command Simu- ator," used to train fire bosses nd their supporting staffs. The rogram was so successful it parked interest to train others n different fire disciplines.

The Shasta-Trinity National orest staff considered the pos- ibility of developing exercises n initial attack, fire size-up, or ecision making for crew fore- nen and fire detectors. Fire etection was selected because f the need for a new approach n training detection personnel.

In February 1968, a program alled "Advanced Training for etection Personnel" was pre- ared utilizing a simulator ex- rcise. The format developed or the detection exercise fol- ows the standards prepared or the Fire Simulator Instruc- or Training, Marana, Arizona, Jovember 1967.

moke Sighted!

The projected scene is a 35 m. slide view typical of the rainee's area. Smoke manipu- ation in simulation is critical: he smoke must conform to the fire behavior conditions of the script. The trainee should be unable to see the smoke at first but should gradually see an in- crease in volume and density.

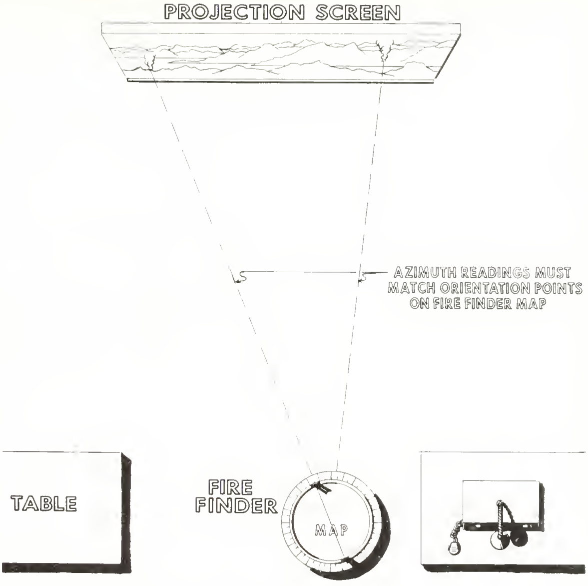

Figure 1—Arrangement of equipment for smoke sighting exercise.

The trainee, upon discover- ing the smoke, should "report" the fire to the central dis- patcher (Cover). His report is expected to follow the pre- scribed manner: An azimuth reading of the smoke; its dis- tance, size, and character; legal description; and geographic lo- cation. Followup reports are prompted by the central dis- patcher.

Emerging situations present opportunities for the lookout to relay messages of importance in a concise, orderly manner and use proper radio code. The exercise has one principal trainee and as many trainee observers as room allows. Trainee observers are encour- aged to follow the actions and keep notes. A District Fire Control Officer is assigned to criticize the exercise and evalu- ate the trainee's performance.

Positioning Important

It is most important to posi- tion the "fire finder" so that azimuth readings will corre- spond exactly with the picture on the screen and the map on the "fire finder." Figure 1 illu- strates the arrangement of the equipment necessary to the ex- ercise. Procedure in orient- ing the alidade to the screen image: From fire finder map, select an orientation point that is recognizable on the screen and identifiable on the map.

→

[1] Dispatchers in the Shasta-Trinity ational Forest, Region 5.

Aluminum Rake Handles Better

WILLIAM ROBERTS [1]

Aluminum broom rakes have long posed a problem to firefighters. Not only do the undersized handles cause blisters because they have to be held tightly, but the metal itself tends to stain the hands black. Firefighters on the Mark Twain National Forest have found that a section of automobile heater hose can solve both of these problems.

A 3/4-inch section of the hose is ideal for the square-handled rakes and a 1-inch section will slide snugly over the round handles (Fig. 2). Increasing the diameter of the handle with a pliable material and covering the metal eliminates both blisters and blackened hands. △

[1] Forestry Aid, Doniphan Ranger District, Mark Twain National Forest, Region 9.

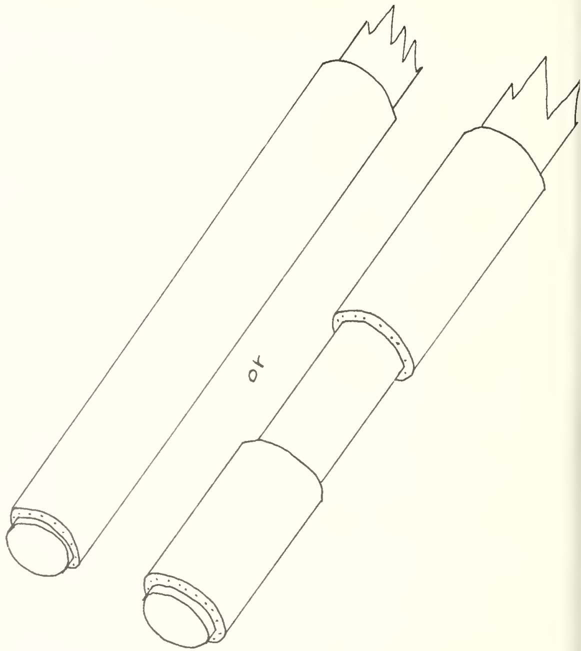

Figure 1—Ways of attaching the hose.

→

Compute the azimuth from the map. Holding alidade sight set on the computed azimuth, move alidade until orientation point lines up in the sights. The reference line is now established along which the alidade must remain.

To complete the orientation, select another orientation point recognizable on the map and the screen. Again measure the azimuth; now set the sights on the new azimuth. Move the alidade along the reference line until the second orientation point lines up in the sights. When both orientation points line up in the sights on the proper azimuths, the alidade is properly oriented in the exact relationship the lookout tower would be to its seen area. Therefore, any other point in the projected image will agree with the fire finder map.

Color slides taken from other than established lookout locations can be used provided the point where the picture was taken can be accurately plotted on a map and orientation procedures described above are followed.

Simulation Educates

There are two types of communication training practiced during this session: (1) The procedural type, when the look out relays coded or non-code messages, (2) the interpretiv type, when the lookout accu rately interprets what he sees

The lookout simulation exer cise provides the trainee a opportunity to actually practic the standard procedure of re porting a fire. It gives th trainee a chance to develo good habits or to correct ba habits.

Knowledge and experienc are gained by trainees and in structors alike while workin under the stress created by thi simulator exercise. △

Drying Rates of Some Fine Forest Fuels

. E. Van Wagner [1]

In a series of laboratory tests, removing waxes and resins rom the cuticles of pine needles and aspen leaves greatly inreased their drying rates.

It seems reasonable to exect that the thinner a bit of ead vegetation is the faster it vill dry. The experiments decribed in this article were rompted by the doubt that this ssumption is true of all imortant fine fuels in eastern Canada.

et-up

The dead, natural materials ested were pine needles, aspen eaves, pine twigs several nches long, grass, and reindeer noss. Also included were two orms of prepared white pine vood that have been used as tandard fine fuels in Canadian orest fire research, namely, natch splints (2 1/2 in. long y 1/8 in. diameter) and slats 10 x 1/4 x 3/32 in.). First, arts of some samples were oiled in xylene to remove vax and resin; then they were varmed gently to expel all ylene. Next, all materials vere soaked in distilled water or three days, and several rams of each were allowed to ry, individual pieces well seprated. The drying materials vere weighed at intervals for to 10 hours and again the ext morning. The room during the tests was 78 ± 2° F. and 35 ± 5 percent relative humidity; air movement was negligible. Finally, the samples were oven-dried for 24 hours at 100° C., and the percent moisture content was calculated for each weighing.

Analysis Procedure

To analyze each drying run. the final or equilibrium moisture content (E) was subtracted from each successive moisture content (M) and the resultant free moisture content (M-E) was plotted against time (t) in hours on semilog paper. This treatment produced a descending straight line for material that dried

Rates, page 7.

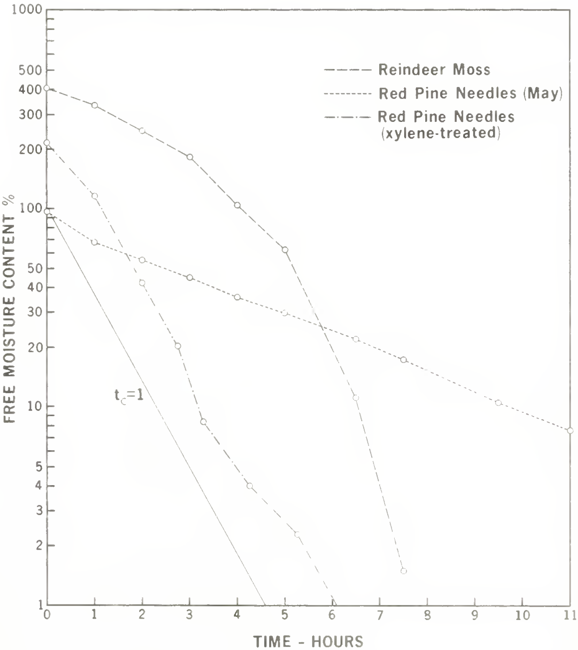

Figure 1.—Drying runs for reindeer moss and for red pine needles with and without xylene treatment. Slope of 1-hour time constant shown for comparison.

[1] Forest Fire Research, Department of Fisheries and Forestry of anada, Petawawa Forest Experient Station, Chalk River, Ontario.

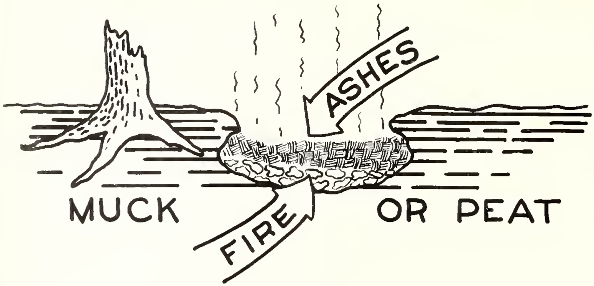

Figure 1—Cross section view of typicol muck or peot fire.

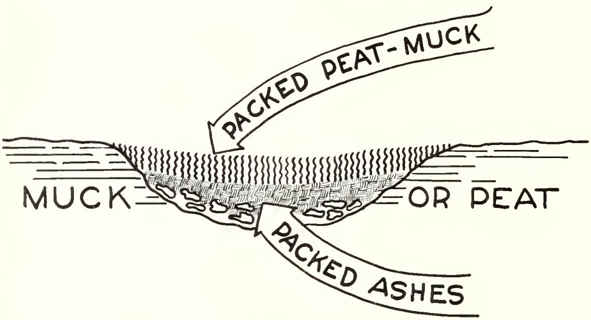

Figure 2—Cross section view of a fire suppressed with a bulldozer.

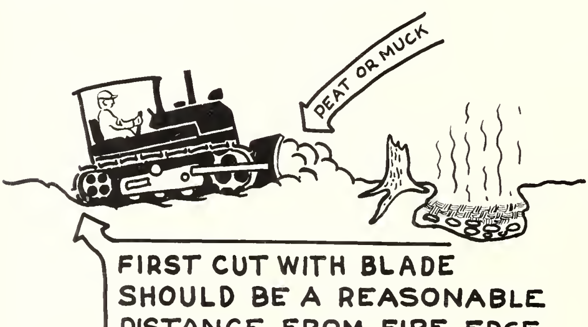

Figure 3—Start of the ottock on o muck fire.

New Answer To Suppressing Muck Or Peat Fires

LYMAN BEACH [1]

Muck fires can be controlled by smothering them with bull-dozed muck. Water trapped underneath the cover also helps suppress the fire.

Have you ever shoveled too much coal onto a fire and nearly caused it to go out? Remember when the oven became too hot in the old coal or wood burning stoves, and Grandmother shoveled on ashes to cool the fire?

Same Techniques Used

This is the basis for the techniques developed to suppress muck and peat fires without pumping water. Tests indicate that muck or peat will sustain combustion even when it contains 70 percent moisture by weight.

This is a lot of water that can be put to work. The new answer to muck fire suppression is simply to bulldoze unburned muck over the ashes and compact them in place. The layer of ashes acts as insulation between the fire and the muck spread over the top. The insulating layer of ashes must remain as undisturbed as

[1] Forest Fire Officer, Forest Fire Division, Michigan Department of Natural Resources.

ossible. The muck over the shes acts as a lid. This lid raps many of the gases vaporzed by the burning muck. Conlensation forms under the bulllozed lid of unburned muck, nd the fire dies. The muck or peat bulldozed over the fire also lrastically reduces available xygen.

Figure 1 illustrates a typical nuck or peat fire.

ulldozer Action

Figure 2 illustrates a cross ection view of what the fire hould look like after suppressng it with a bulldozer. A dozer vith a blade that can be angled vorks best. This enables the perator to drift the unburned eat or muck over the perimter of the fire in long passes. straight blade makes the perator spend too much time n back and forth motions.

The dozer operator must be autious when working at the dge of a muck fire. If he hould break through one of he tunnels of fire usually round the fire's edge, he is in anger of mixing more fuel irectly with the fire. When ot spots develop, they usually ccur along the former fire erimeter. For this reason, the erimeter of the fire requires a enerous supply of well comacted peat.

Figure 3 illustrates the beinning attack on a muck fire. Note the first cut with the lade should be a reasonable istance from the fire's edge.

Figure 4 illustrates that the supply of peat or muck should be taken behind the first cut with the dozer blade.

Covered Fires Die

Covering muck fires is much faster and more efficient than using water. It requires less manpower, and all the equipment and work involved in pumping is eliminated.

The only requirement in using a bulldozer is that the peat or muck must be able to support a working dozer. △

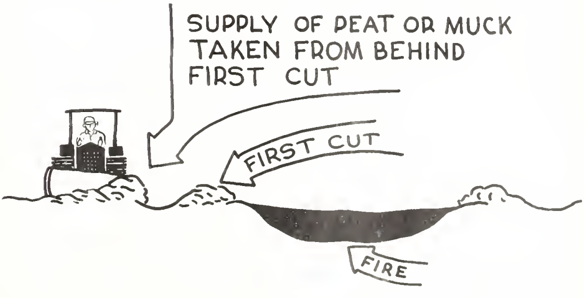

Figure 4—Supply of peot or muck is token behind first cut.

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exponentially, i.e., whose instantaneous drying rate was proportional to the instantaneous free moisture content. The slope of the semilog graph, called the log drying rate, was a measure of the speed of the drying process. Many of the test runs followed this pattern closely enough for practical purposes; two that did and one that did not are illustrated in figure 1. When straight, these graphs have empirical equations of the form:

$$\log \frac{M_0 - E}{M - E} = Kt \quad (1)$$

Where M_0 is moisture content at time zero, M is moisture content after t hours, and K is the log drying rate in log M per hour.

The exponential drying process can also be described by the time constant (t_c), which is the time required to accomplish 1 — 1/e, or 63 percent of the expected change in M. The log drying rate K (in logarithm to base 10) is related to the time constant by the expression

$$K = \log_{10} e/t_c = 0.43/t_c \quad (2)$$

The two measures of drying speed are thus interchangeable and are worked out for each tested material in table 1. Included in figure 1 is a line showing the slope of a drying process with a 1-hour time constant. Some materials, e.g., reindeer moss in figure 1, do not have a true log drying rate or time constant except as an average over the whole run.

Wax Slows Drying

The relatively slow drying rates of pine needles and the marked effect of the xylene treatment suggest that, for some leaf materials, diffusion through the waxy cuticle is the limiting step in the drying process. Once this diffusion step exerts its influence, the

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Railroad Spark Arresters Tested

Donald G. Dowdell [1]

Although there is no written standard for spark arresters for large engines, the State of Washington has recently approved two spark arresters tested and developed by the Great Northern Railway. Use of these arresters will reduce fires caused by carbon particles.

During the last 2 years, there have been many advances in the development of spark arresters for locomotives. Several public agencies, railroads, and spark-arrester companies have acted aggressively in developing efficient arresters.

[1] Prevention & Training Officer, Fire Control Division, Department of Natural Resources, State of Washington.

The Washington State Department of Natural Resources has participated in many meetings and tests and has been the catalyst for the development of efficient spark arresters for locomotives.

No Written Standard

There is no written standard for spark arresters to be used on large engines. The Society of Automotive Engineers is currently working on a standard, but it has not yet been accepted. Washington State has developed its "abbreviated standard" for testing locomotive spark arresters. This standard closely resembles USDA Forest Service Standard 5100–1, which is used for testing spark arresters for medium-sized engines.

The Washington Standard

The Washington "standard" requires the arrester to be at least 80 percent efficient in retention or destruction of all carbon particles 0.023 in. in diameter and larger, for 25-100 percent of the locomotive's engines exhaust flow rate. With the arrester added, the total back pressure on the engine cannot exceed 3 in. of mercury.

Meetings with railroads and the protection agencies have been taking place since the early 1950's, with little improvement of spark arresters for locomotives.

Breakthrough in Arresters

The first breakthrough in efficiency was achieved in 1967 when an arrester was developed that had great potential in carbon retention, but its back pressure was too high. Through further testing and development, the back-pressure problem was solved with no reduction in efficiency.

Another major spark-arrester development occurred in January 1968. A modification for a cyclonic spark arrester was developed, increasing its efficiency to more than 80 percent. Also in 1968, the Great Northern Railway Company led in developing test procedures and in conducting tests for locomotive arresters. This

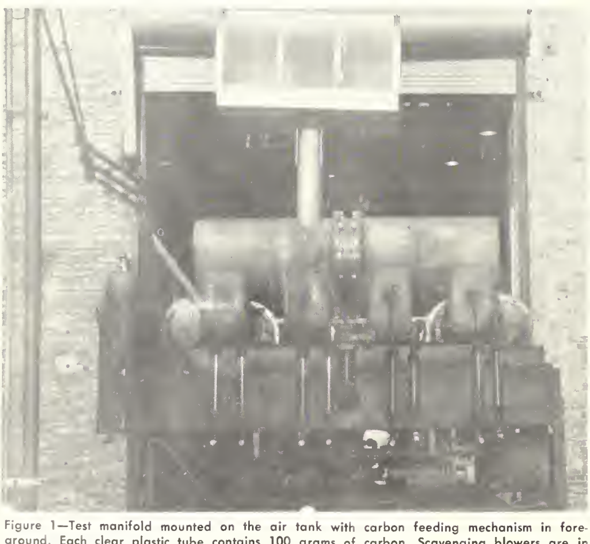


Figure 1—Test manifold mounted on the air tank with carbon feeding mechanism in foreground. Each clear plastic tube contains 100 grams of carbon. Scavenging blowers are in background. The large enclosure trap on the exhaust stack traps particles more than 0.023 in. in diameter.

ompany has conducted bench ests and locomotive tests on nany spark arresters. Great Northern tests were conducted n April, July, and August, 968. This series of tests howed that many of the previously accepted arresters were ess than 50 percent efficient. The Great Northern tests howed three arresters to be nore than 80 percent efficient for carbon 0.023 in. in diameter nd larger throughout the flow ate range of engine idling to naximum r.p.m. The three arresters also maintained the back pressure at less than 3 in. of mercury at full throttle on a GP–9 locomotive.

Figure 2—Test monifold mounted on a GP-9 locomotive. The spork orrester developed by the Great Northern is mounted on the monifold exhoust stock. The spark arrester is topped with a modified 55-gollon barrel thot hos o screen ot the top to trop porticles more thon 0.023 in. in diometer so orrester efficiency con be determined.

Two Large Locomotives

Great Northern used GP–7 nd GP–9 naturally aspirated ocomotives in their tests. They lso developed a bench operaion capable of producing the irflow of a locomotive. The bench test used two scavenging blowers (Root's locomotive blowers) driven by electric motors to produce the large volume of air needed for the ests (fig. 1).

Procedures

The procedure developed for he locomotive spark arrester esting is quite simple, but it loes produce results that can be measured and evaluated to letermine arrester efficiency. Night observation tests were ried but were quickly proven inreliable.

The reliable tests consisted of injecting a known amount nd size of carbon into the ight legs of the manifold while he locomotive was running. About 15 minutes was required o feed 100 grams of carbon nto each leg. Above the arrester a large, 28-mesh wirecreen enclosure trap was placed to catch everything greater than 0.023 in. coming through the arrester. The amount of carbon that escaped through the arrester was compared to the amount injected into the arrester to determine its efficiency. Tests were run at various throttle settings on both the bench and on locomotive engines (figs. 2 and 3).

Two Approved

The Washington Department of Natural Resources has approved two spark arresters for use in Washington. By using either of these arresters, the railroads will greatly reduce or eliminate fires caused by expelled carbon particles. △

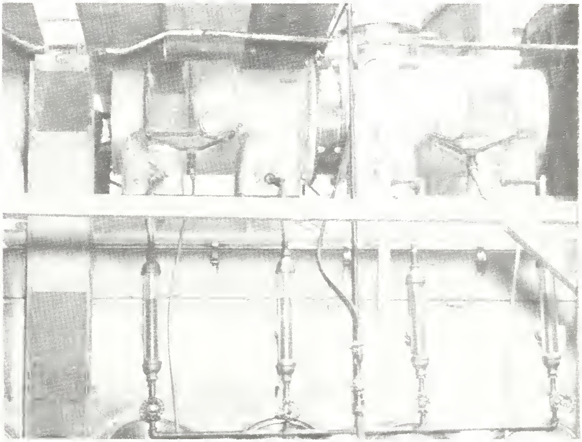


Figure 3—Close-up of monifold mounted on locomotive showing corbon feeding mechonism. Monifold shows a modificotion of the Forr Company "pocket".

Do Smog Reducers Increase Fire Hazards?

Rob Harrison [1]

Because exhaust pollution devices might increase exhaust pipe surface temperatures, thereby increasing fire hazards, investigative tests have been run. Based on the exhaust system's "first bend" temperature, the Equipment Development Center at San Dimas found the smog reducers do not greatly raise exhaust pipe temperatures. However, other factors were found to increase fire hazards.

Fire Control officials have expressed concern over the possible increase of vehicle exhaust pollution (smog) devices on all new sedans and pickups. Any temperature increase could lead to serious fire hazards. The Equipment Development Center at San Dimas has conducted tests to measure surface temperatures of pickup and sedan exhaust systems to determine if such a hazard exists.

Tests on Vehicles

Tests were conducted with Forest Service pickups and sedans, approximately half of which were equipped with smog control devices. The exhaust system of each of the vehicles was instrumented to find its surface temperature. Each vehicle was subjected to a series of test runs on a road course and on a chassis dynamometer. The dynamometer tests indicated the maximum temperature that could be reached by the vehicle, while the road test served to indicate the temperature that would be reached under normal operating conditions.

The Road Course

The road course used consisted of 7 miles of an average grade of 3 percent used for the warmup section and approximately one-half mile of about 7 1/2 percent grade used for the test section. When a 40 mile per hour vehicle speed was used, this 7 1/2 percent grade section was long enough to ensure reaching the maximum equilibrium exhaust system temperature.

Dynamometer

For dynamometer testing, the engine was run at the same speed as for road tests and was loaded to its maximum horsepower. In addition to "heating tests," the exhaust pipe cooldown times were noted, both with engine idling and with engine shut off.

"First Bends" As Indicators

It was found that the most critical area was the "first bend," that bend closest to the exhaust manifold likely to come in contact with ground cover. Table 1 shows the results of tests on 20 Forest Service vehicles of three different makes. Vehicles were equipped with comparable engines and transmissions. The table shows in every category that for only one manufacturer are smog device equipped vehicles likely to develop significantly higher temperatures than those not equipped. However, all the temperatures shown under "Road Test" are well above the combustion temperature (re-

Table 1.—*Average first bend temperatures*

	Manufacturer 1	Manufacturer 2	Manufacturer 3
ROAD TESTS			
Equipped	954°F	873°F	**1080°F**
Unequipped	947°F	855°F	**849°F**
DYNAMOMETER TESTS			
Equipped	1080°F	1050°F	**1210°F**
Unequipped	1070°F	1062°F	**1002°F**

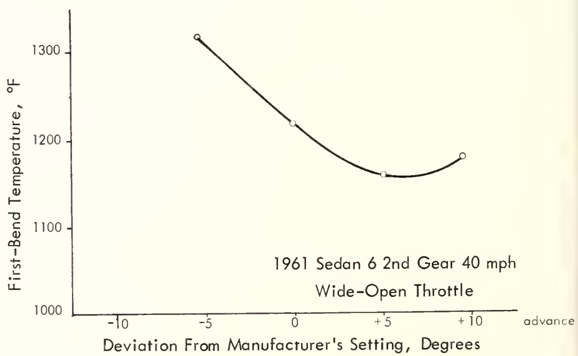


Figure 1—First Bend Temperature as a Function of Ignition Timing.

[1] Mechanical Engineer, Equipment Development Center at San Dimas.

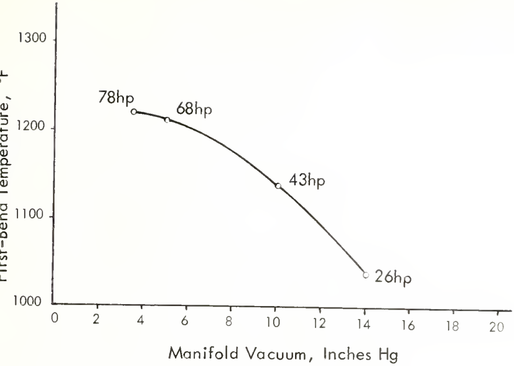


Figure 2—First Bend Temperature as a Function of Engine Load.

ported variously as 750°F and 660°F) for dry grass or pine needles.

Phase Two Tests

The second test phase determined the effect of varying engine adjustments on exhaust system temperatures. This was done by changing such variables as back pressure, ignition timing, etc., on one vehicle and testing to determine the effect of these changes. This provided valuable information about the relationship between engine "tuneup" settings and exhaust pipe temperatures. Figure 1 shows the "first bend" temperature as a function of ignition timing. Note that retarding the timing significantly increases the temperature. It was noted that a 1-psi increase in exhaust back pressure raised the exhaust pipe temperature only 5°F. Changing fuel-air ratio did not cause significant differences.

Results

As expected, engine speed and load had a marked effect on the system temperature. Figure 2 shows the variation in temperature as a function of load (manifold vacuum) and Figure 3 shows temperature variation as a function of the engine speed at three different constant loads.

Another interesting fact developed is that the highest exhaust pipe temperatures are found in situations similar to the road test, involving long, straight, fast, steep pulls. Table 2 shows temperatures encountered on five different types of roads. Note that the temperatures occurring on Forest Service land utilization roads are the lowest seen, because of the slow speed and light load dictated by the nature of the road surface, grade, and turn radii.

In Summary

1. Under actual operating conditions the exhaust system surface temperature of some pickups and sedans reach temperatures in excess of 1,000°F. This temperature is not greatly affected by the installation of an exhaust emission pollution control device.

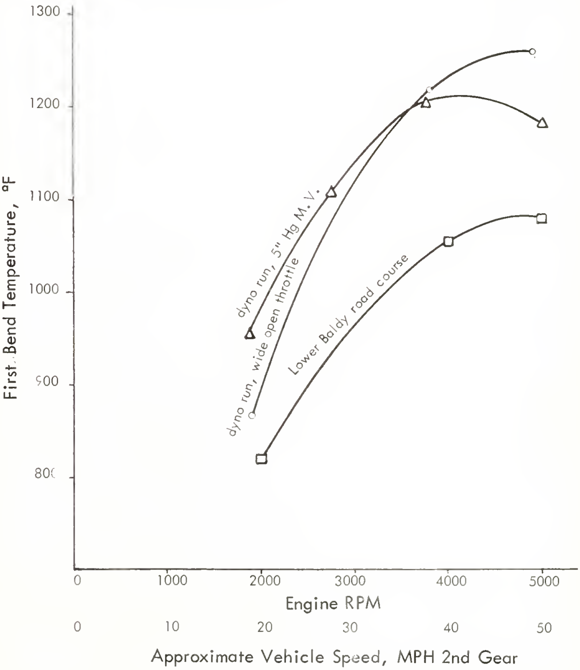


Figure 3—First Bend Temperature as a Function of Engine Speed.

TABLE 1.—*Log drying rates K (log M per hours) and time constants t_c (hours) of some dead, fine materials, untreated and xylene-treated*

MATERIAL	COLLECTION DATE	NUMBER OF RUNS	UNTREATED K	UNTREATED t_c	XYLENE-TREATED K	XYLENE-TREATED t_c
Red pine needles	October	4	.041	10.5	.29	1.5
Red pine needles	May	4	.103	4.2	.41	1.1
Jack pine needles	May	1	.137	3.2		
White pine needles	May	1	.158	2.7		
Trembling aspen leaves	October	2	.201	2.2	.60	0.7
Trembling aspen leaves	May	1	.306	1.4	.60	0.7
Grass [1]	May	1	.22	2.0		
Reindeer moss [1]	May	1	.26	1.7		
White pine twigs 1/16 in. D.		1	.338	1.3		
White pine twigs 1/8 in. D.		1	.274	1.6		
Match splints		2	.226	1.9		
White pine slats 10 x 1/4 x 3/32 in.		2	.277	1.6		

[1] Drying curves of these materials deviated considerably from the exponential; their drying data are therefore questionable.

——→

2. The maximum exhaust surface temperature is reached after sustained operations at high load and engine speed. Such conditions would be encountered climbing a long grade or operating a tanker equipped with a power take-off pump.

3. Exhaust pipe temperature can be significantly raised by maladjusted ignition timing or other engine tuneup setting.

4. Parking a vehicle off-road on a hot day is equivalent to supplying a sustained "heat-sink" or heat source which can provide the time element necessary for a fire start.

Also in the area of the first bend of the exhaust system are the front axle, steering, and other mechanisms, all of which are potential grass snaggers. Since the hazard can still exist after shut-down, drivers should be extremely cautious during fire weather.

For further information see Equipment Development and Test Report 5100–15, available from the Equipment Development Center at San Dimas. △

TABLE 2.—*Effect of road type on maximum first bend temperature*

1961 Sedan Unequipped
Ambient Temperature 75-92°F

Description of Course	Average Grade (%)	Gear Used	Average Speed (mph)	Maximum First Bend Temp. (°F)
Lower Baldy course described in text	+7½	2nd	40	1140
Freeway, straight and constant	+4	3rd	65	970
Around-town driving	0	2nd, 3rd	35	677
Country road, mountainous terrain	+8	2nd, 3rd	30	930
Forest Service L.U. road	+9-11	1st	15	803

Rates, from page 7.

surface presumably remains at or near equilibrium moisture content, regardless of the amount of moisture within. Such a diffusion mechanism would also explain why the curves exhibit no definite break at fiber saturation point (FSP).

Findings

1. Some fine materials, particularly pine needles, dried slower that wood many times their thickness.
2. Removal of wax and resin with xylene greatly increased the drying rate of pine needles and aspen leaves.
3. Several months of weathering distinctly increased the drying rate of dead leaves.
4. In none of the tests was there any apparent change in drying behavior at the FSP.

Application of Findings

The laboratory test conditions do not exactly fit any specific outdoor situation. They best resemble a fine, calm, summer afternoon in a fully canopied forest. In such a place and in most Canadian weather, the test materials would dry too slowly to reach moisture equilibrium in one day. A satisfactory estimate of afternoon moisture content would therefore require knowledge of the moisture content at some previous time. This principle was followed in the design of the Canadian fire danger rating system, which refers to a forest fairly well sheltered from wind and sun.[2] Specifically, in the analysis of the fuel-moisture data collected in the field, the current moisture content was correlated with the previous afternoon's value as well as the pertinent weather elements. The resulting fine-fuel tracer index [3], used with noon weather readings, provides reasonably good estimates of fine fuel moisture content from day to day. △

[2] Beall, H. W. Research in the measurement of forest fire danger. Proc. Fifth Brit. Empire Forest. Conf. 1947. Reprinted as Inform. Rep. FF-X-8, Can. Dep. Forest. and Rural Develop., Forest Fire Res. Inst., Ottawa, 1967.

[3] Beall, H. W. Forest fire danger tables, provisional. 2nd edition. Forest Fire Res. Note No. 12, Forest. Br., Can. Dep. Resources and Develop. 1948. (Now Forest Fire Research Institute, Department of Forestry and Rural Development) Ottawa.

Portable Retardant Mixing Unit

L. E. Rossi [1]

A portable retardant mixing unit recently has been evaluated by the SDEDC. The unit can be set up quickly at any suitable airport to mix and load retardant in fixed-wing air tankers, or at any heliport or helispot with road access. It can service helicopters equipped with either a tank or a sling-mounted, dip bucket.

The Set-up

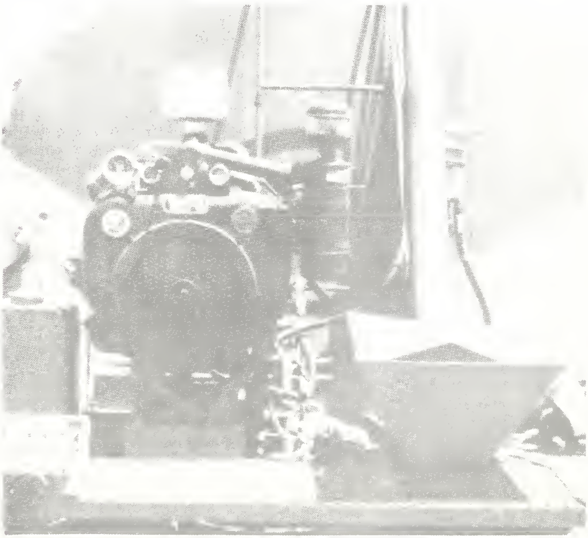
The unit includes a diesel tractor with a 5,000-gallon tank trailer (fig. 1) and a tractor with a 35-foot flatbed service trailer. The service trailer is used to haul up to 25,000 pounds of dry retardant and all hoses and attachments necessary to load the mixed retardant into any aircraft. An Orland mixer and 200-gallon-per-minute loading pump are mounted on the tank trailer (fig. 2). A 1,500-gallon portable open tank is also included. The tank serves as a reservoir for mixed retardant and as a dip tank if helicopters with sling-mounted buckets are used.

Ready Quickly

The unit is set up and operated by a 4-man crew. It can be in operation and the 1,500-gallon tank can be filled with retardant within 20 minutes after the unit's arrival at the mixing site.

Figure 1—The 5,000-gallon tank trailer is set up to pump mixed retardant.

Figure 2—The retardant is mixed in an Orland mixer mounted on the rear of the tank trailer unit.



[1] Staff Assistant, Equipment Development Center at San Dimas.

Fire Kill In Young Loblolly Pine

ROBERT W. COOPER AND
ANTHONY T. ALTOBELLIS [1]

Mortality in young loblolly pine, following exposure to free-burning fires, appears to be more closely related to crown damage than to bole damage. Kill of young trees varies considerably with the type of fire applied; trees larger than 4 inches d.b.h. are not easily killed by backfires or small head fires under moderate burning conditions.

If foresters are to make maximum use of fire as a silvicultural tool, they need to know more about mortality of trees exposed to free-burning fires. How does fire kill trees? Is it by means of penetrating heat on the bole that raises the temperature of the cambium above the lethal level? Or, is it the result of crown kill from excessive heat, i.e., bud damage, needle scorch, or consumption? Answers to these questions would enable forest managers to make more precise fire prescriptions and perhaps improve predictions of expected mortality following wildfires.

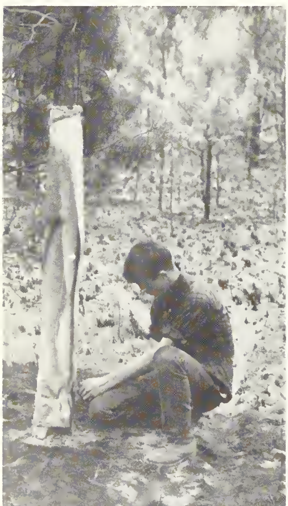


Figure 1—The lower 6 feet of tree boles were protected from heat by asbestos wrappings.

The Search

To find some answers, an exploratory fire study was established in a natural stand of sparsely stocked, young loblolly pine (*Pinus taeda*) in central Georgia. Dominant and co-dominant trees ranged in height from 8 to 28 feet and in diameter from 1 to 6 inches. Within each of three tracts about 10 acres in size, 36 trees representing three diameter classes (2 inches and less, 2.1 to 4.0 inches, and 4.1 to 6.0 inches) were measured and marked for observation.

Protection

On each tract, bole protection was provided for one-third of the trees, crown protection for one-third, and one-third were left unprotected. One tract was burned with a backfire, one with a head fire, and the last with a perimeter, or ring, fire.

Protection for the boles was provided by asbestos wrapped to a height of 6 feet (fig. 1). Crown protection was provided by sheets of asbestos-covered plywood at the base of the crowns (fig. 2).

Tracts Burned

The tracts were burned in May during a period considered favorable for prescription fires. Air temperature was about 85° F; relative humidity ranged from 40 to 50 percent; fuel moisture estimates were 8 to 10 percent, and 20-foot open windspeeds averaged 5 m.p.h. Surface fuels consisted mostly of pine litter and grass, typical of old fields in the South. Bole char, crown scorch, and crown consumption were estimated soon after burning; a mortality count followed 3 months later.

Results

Crown damage was apparently more responsible for tree kill than bole damage (table 1). Only one tree that was provided with crown protection died; five of the bole-protected trees died. The greatest kill was experienced where no protection was provided; perhaps there is an interacting effect when both bole and crown are injured. Nevertheless, crown consumption proved to be the best of all the fire-damage in-

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[1] Mr. Cooper is Principal Fire Behavior Scientist, Southern Forest Fire Laboratory, Southeastern Forest Experiment Station, Macon, Georgia.

Mr. Altobellis is Research Forester, Southern Forest Experiment Station, Starkville, Mississippi. Mr. Altobellis was part of the study team at the Southern Forest Fire Laboratory when these investigations were made.

dicators in predicting subsequent mortality.

Perimeter burning resulted n the greatest mortality (12 rees); backfiring caused the east (1 tree) (table 2). Only wo trees in the largest size lass were killed; both of these nad unprotected crowns exposed to the perimeter fire. Five trees in the smallest size class and ten trees in the intermediate size class died. The best explanation for the greater kill in the intermediate class is that six of the ten dead trees were located in the center of a developing convection column in the perimeter-burn tract.

Conclusions

This evidence indicates: (1) kill of young loblolly pine varies considerably with the ype of fire to which trees are exposed; (2) mortality is more losely related to crown damage than to bole damage; (3) oblolly pine trees larger than 4 inches d.b.h. are not easily killed by the heat from backfires or small head fires under moderate burning conditions; (4) when convection activity levelops, perimeter, or ring, ourning is capable of killing more and larger trees than it otherwise would.

Although additional research and operational trials are necessary before this evidence finds practical application, some interesting possibilities come to mind. For example, hazard reduction burns in young loblolly pine stands appear feasible where backfires and strip head fires can be applied under moderate weather conditions. Prescription fires may also deserve consideration as precommercial thinning ools (thinning from below) in dense stands of young loblolly pine where diameters range from 1 to 6 inches.

Figure 2—Crowns were protected from direct heat by asbestos-covered sheets of plywood.

In this study, no consideration was given to the indirect effects of fire in attracting insects or enabling disease organisms to become established. These factors certainly warrant study in future work. △

TABLE 1.—*Effects of free-burning fires on young loblolly pines*

Protection provided	Bole bark char	Crown scorch	Crown consumption	Dead
	Number of trees [1]			
Crown	29	22	0	1
Bole	4	31	11	5
None	33	36	19	11

[1] Because some trees exhibited varying degrees of damage in both the crown and bole, number of trees in each protection class will not total 36.

TABLE 2.—*Mortality of young loblolly pine in relation to type of fire, protection provided, and size (d.b.h.) class*

Type of Fire	*Number of trees killed*								
	Crown protection			Bole protection			No protection		
	< 2″	2.1″-4.0″	4.1″-6.0″	< 2″	2.1″-4.0″	4.1″-6.0″	< 2″	2.1″-4.0″	4.1″-6.0″
Back	0	1	0	0	0	0	0	0	0
Head	0	0	0	1	0	0	0	3	0
Perimeter	0	0	0	0	3	1	4	3	1

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Figure 1—The Stokes litter disassembled, with corgo rigging removed, showing contents stowed in the two parts.

Stokes Litter Modified

KEN SMITH [1]

In order to eliminate hazards in para-dropping the Stokes Rescue Litter, aircraft technicians on the Boise National Forest redesigned the litter by dividing it into two sections for packaging and paradropping.

The Stokes litter was cut into two sections, one 31 inches long and the other 50 inches long, the latter section long enough to mount the wheel yoke assembly (fig. 1). A length of strap metal was formed and welded into place on each section where the cut had been made; wire mesh was spot-welded to these straps. On the shorter end of the litter, a piece of strap was used for added reinforcement, and a bolt plate was attached for mating to the long section. Two sleeves were machined to size and slid into the top rail. These sleeves were 16 inches long, of which 8 inches were inserted and bolted into place in the short length of the litter. After the sleeves were secured, both ends were placed back together and two 1/4-inch bolt holes drilled on each side (fig. 2). Stove bolts with ring nuts were used to speed the assembly.

Color-Coded

All carrying handle extensions were color-coded to speed assembly, and all crew evacuation harnesses were labeled properly so even an untrained crew would have few problems. A quickly attachable package for Demerol, etc., was located on exterior of the bundle where landing impact would not damage the contents. This first aid package also included instructions for assembling the unit.

During training sessions on the Boise, this modified litter has been put together in 5 to 8 minutes by men with no previous experience in assembling it.

Plans for modifying the Stokes litter are available from the Forest Supervisor, Boise National Forest, 413 Idaho Street, Boise, Idaho 83702.

Figure 2—Shorter section of Stokes Litter showing modifications:

A. Metol strap
B. Reinforcement & bolt-plate assembly.
C. Sleeves
D. Sleeve boles.

[1] Smokejumper foreman, Boise National Forest.

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