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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

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

Volume 18 **Number 1**

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

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

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FIRE CONTROL PLANNING[1]

A. E. SPAULDING

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Although forestry in the United States received attention as early as 1876, it was not until the present Forest Service came into being that a rounded national policy for forestry was developed. Work then began to go forward with long-range objectives to maintain and increase the productivity of forest lands everywhere in the States. Working together, private and public agencies have made good progress in forestry during the last half century. We have effectively demonstrated the values of organized protection against fire, insects, and disease, and of good management and wise use of the Nation's forest resources.

Most of my forestry experience has been in the Northern Region of the U. S. Forest Service. In discussing fire control planning with you, my remarks will be directed at problems we have encountered in providing fire protection to some 33 million acres in Montana, northern Idaho, and northeastern Washington.

To illustrate our progress in fire control, I will divide the last half century into three periods that denote major milestones in fire control planning.

1. During the 1905-30 period our annual average burned area was 252,000 acres. Thus for the first quarter century, forest fires greatly damaged more than 6 million acres. During this devastation the forest was inaccessible and travel was by foot or horse. Fire control planners had long recognized the critical need to speed up attack on fires.

2. During the 1931-40 period, roads into many areas speeded up travel time to 15 miles per hour and the average annual burned area was reduced to 62,500 acres. This was double the destruction that we could afford if we were to meet our objective of managing the area for sustained crops. During this period, analyses proved that much of the excessive burned area was occurring in the remaining roadless areas. Some of these were dedicated to remain roadless and others were not developed due to lack of funds or high cost of road construction. Increased use of airplanes to speed up delivery of supplies during this period logically led to the delivery of fire fighters by parachute.

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[1]Paper presented at the 1955 Annual Meeting of Canadian Institute of Forestry at Saskatoon, Sask. Reprinted, by permission, from *Forestry Chronicle,* June 1956.

3. During the 1941-55 period, the growth of aerial fire control along with the use of smokejumpers speeded travel time to fires in remote areas and assisted in reducing the average annual burn to 8,000 acres.

With only these facts available, we might conclude that for this area the fire control manager has successfully met or bettered his objective and that no additional fire control planning is necessary. Such an assumption would be far from the truth if all the facts are known. A lot of good planning and a lot of good work contributed to the reduction in burned area. During the last 15 years, weather has also been more favorable than during the late 1920's and early 1930's. Smokejumpers in combination with the ground forces and other improved methods have in recent years kept fire losses and damages at a lower level. During the more severe fire years, available facilities are insufficient to man all fires soon enough and during such periods damaging and costly fires can still occur. This is a challenge to fire control planners.

Developments such as the helicopter, as it is improved and becomes available with larger capacity and operational ability at higher elevations; research findings in fire-danger measurements, knowledge and control of weather factors; technological developments such as radar for detection; and improved fireline-building machines and other projects will all receive consideration by the fire control planner to assist in solving this problem.

In the Northern Region of the Forest Service we are using the old methods as well as the new. Men still have to walk across country with packs on their backs; mules carry supplies and equipment over the trail system; travel and hauling by vehicles on roads is an essential part of fire control; pumps, tankers, and available fire-trench-building machines are used; smokejumping has become routine on wilderness-area fires; small helicopters are regularly used—in short, a combination of the old and newer methods of fire fighting is used that best meets the conditions at hand.

During the last half century, we have planned and replanned for adequate fire control. A fire plan must be a *living thing,* subject to change, and I expect that we will go right on revising our plans as we strive to do a more efficient job.

DEFINITION OF FIRE CONTROL PLANNING

Planning for fire control on wild lands presents a different picture to different men. To me it is the determination of an acceptable objective along with the determination of all the measures needed to meet that objective. This is a broad concept of the subject. I believe we must so treat it to prevent an analysis and plan for only one or several of the many facets of fire control from being called a complete fire plan.

In the design of fire plans we usually attempt to provide for average worst conditions, recognizing that a normal plan will not cover the worst fire periods. This is similar to the principles an engineer follows in designing a bridge that will meet needs with a reasonable margin but may not handle the worst flood or greatest possible overload. The plan should, however, go as far as possible in meeting the worst conditions on an emergency basis.

OBJECTIVE

The overall objective of the U. S. Forest Service in the fire protection of national forests is to hold fire damage below the level at which it would seriously interfere with the desired yield of products and services from forest land, and to prevent other serious adverse effects of forest fires, among which are such effects as those of public health, safety, or convenience—and to do the job at least cost. This is a broad objective and not sufficiently tangible to provide a foundation for plans of action.

Objectives for fire control are and have been a controversial topic. The theory of least cost plus damage has many supporters. An objective expressed in allowable annual burn has long been used for forest types, such as 2/10ths of 1 percent, or 1/10th of 1 percent. This objective, when applied to a large area, could mean the total allowable damage for any one year might occur in one local unit, causing untold damage and suffering to a dependent community. We are now making progress in setting up allowable burned area by management units in accordance with values and fire potential involved. When this has been done, the fire control planner can proceed to make an action plan to meet this objective.

In some cases the owners of forest property may have a fixed sum they will spend on fire control. If this sum is insufficient for adequate fire protection and cannot be increased, the fire control planner's job is to provide the best possible protection within the prescribed limits. With a rapidly increasing population, forest resources are becoming more valuable and experience has proved that it is good business for owners to buy good fire protection. The fire planner has a responsibility to inform the owner of the amount of insurance he is carrying on his property.

Many foresters believe that determination of an acceptable objective is a function of the resource manager or owner and not the fire planner. I placed additional responsibility on the fire control planner in my definition to emphasize the need for an acceptable objective as a foundation for planning and that he will need to get concurrence on an objective to do his job properly.

Following a review of the fire history and potential of an area along with values involved and the determination of an acceptable objective, the fire control planner should sufficiently understand the economics of the situation and be in a position to establish some balance between the three major divisions of fire control, namely, prevention, presuppression, and suppression.

I shall discuss each of these major subjects separately.

FIRE PREVENTION PLANS

A fire prevention plan, if needed, should be based on the following minimum analysis:

a. Study of risks.

1. An analysis of man-caused fires by causes for previous 5 years to determine specific reasons why fires start and who starts them.
2. Location of man-caused fires by causes for same 5-year period.
3. Location of areas of special risks, i.e., railroads, sawmills, woods operations, power lines, construction crews, towns, etc.
4. Dates when man-caused fires start.

b. Study of areas of special hazards.

Location of areas of special hazards, such as slash areas, blow-downs, fire- and insect-killed timber, etc., and careful identification and survey of local hazards in special-risk areas.

c. Correlation of all hazard areas with the risk factors.

This is to provide a clear overall picture of the fire-starting and/or spreading potential, to identify the areas and periods of special fire liability, and to facilitate the setting up of priorities.

General Principles in Development of Action Plans

Fire prevention planning, which concerns itself with the problem of reducing total costs and damage, must recognize fire risks, forest fuels, and other fire hazards as critical factors in undertaking remedial action.

The time of day, year, place, and the number of fires that start, usually control the size of the fire organization that must be maintained, and are decisive, too, in the fire-fighting costs and damage that result.

Where these things depend on the exposure of critical fuels to human risks, attainment of the whole objective requires the kind of management that will remove or reduce the risk or the fuel hazard, or that will minimize the potentials of one or both.

Objective

The objective of fire prevention is to eliminate preventable fires. Final attainment of such an objective is necessarily limited by many factors, but levels of attainment far short of this goal are not regarded as acceptable unless the additional cost of improved performance will clearly exceed the benefits gained in reduced losses and suppression costs.

Action Plan

Following consideration of the above factors, an action plan will be developed for each unit. This action plan specifically sets forth *what* shall be done, *where* it shall be done, *when* it shall be done, and *who* shall do it, with provision for recording degree of accomplishment.

The action plan is an annual work plan and should be made each year as changes in responsibility assignments are usually made from year to year.

The analyses that precede the preparation of the action plan should be made once every 5 years, as a minimum, and oftener when material changes occur in the risks involved.

PRESUPPRESSION PLAN

The basic elements involved in presuppression planning are as follows:

a. Meteorological factors including wind, relative humidity, fuel moisture, precipitation, seasonal effects, etc.

b. Topographic factors relating to configuration of the country, such as ridges, slopes, streams, canyons, draws, etc., and the relative location of one to the other, elevation, steepness, soil conditions, barriers, etc.

c. Fuel factors including (1) types of fuels such as mature timber, second growth, slashings, brush, grass, forest litter, down logs, snags, etc., (2) continuity, density, and arrangement of fuels, (3) their resistance to line construction.

d. Occurrence dealing with incidence of fires as to points of origin, intensity of occurrence identified separately for lightning and each man-caused category, times of day and year fires may be expected to start and do damage.

e. Visibility as it applies to distance incipient small forest fires may be seen by detectors, normal daily or seasonal changes in visibility distance, etc.

f. Accessibility. Availability or nonavailability of roads, trails, ways, fire lanes, bridges, airstrips, lakes or rivers for airplane landings, helicopter landing spots, etc., and the travel time, by the most appropriate means, required to reach areas of fire occurrence.

g. Relative values (tangible plus intangible) at stake are one of the considerations in deciding the placement or intensity of the presuppression organization.

h. Rate of production of held line per unit of manpower or machines for different conditions, including delineation of areas where machinery is usable.

i. Water supply for suppression as related to portable pumper chances or tanker-filling facilities.

j. Equipment. Trucks and pickups, trailbuilders, tankers, aircraft, tools and related equipment for fireline work, and other facilitating gear.

k. Communication. Radio or telephone, or in combination, for presuppression and suppression.

While not strictly a basic element of planning, the need for providing plans for recruitment of suitable personnel to fill each planned fire position, including cooperators and their subsequent training to do the job efficiently and safely, must be recognized in order to carry out the master presuppression plan. Provision must be made also for recruitment and on-the-job training of able-bodied emergency fire forces.

Objective

Objective of the presuppression plan shall be to have available, when and where needed, an effective fire control organization, well trained, equipped, instructed and supervised, and capable of handling efficiently the fire suppression situations which sound planning determines to be necessary.

Master Presuppression Plan

In the development of a presuppression plan for each area, all of the basic elements mentioned above must be thoroughly considered as to their effect on that unit. The master presuppression plan is a term applied to a grouping of the following plans dealing with the detection and preparedness phases of the fire control job:

a. Detection

Detection involves consideration of visibility distance; zones of occurrence of fires as indicated by past history, and changes in risk areas due to changing use; maps showing extent of area seen from individual points; selection of points by process of statistical elimination; final map showing seen and unseen area from all selected points; establishment of dates of occupancy and provision for regulation of occupancy in accordance with measured fire danger; incorporation of aerial detection—either primary or secondary.

b. Initial Attack

Initial attack usually involves mapping of fuels to show combined effect of rates of spread and resistance to control; occurrence of fires by intensity zones; accessibility; initial-attack strength by zones required for varying degrees of fire danger;

location of crews to meet travel-time requirements; provision for varying strength of crews in accordance with measured fire danger, to meet initial-attack requirements for each zone; establishment of dates of employment, and recognition of the need for reinforcements.

In the Northern Region of the U. S. Forest Service, we have made major changes in our detection and initial-attack plans. During the early 1930's we intensively mapped fuel types, determined hour-control requirements, and ground detector needs. As a result we constructed approximately 800 lookout houses. Men hired for these stations had a dual capacity as lookout-firemen and other firemen were placed in valley bottoms when needed to complete the hour-control coverage. This system was successful as long as we could hire the number of men needed; men who were rugged woodsmen, capable of finding a fire and putting it out, and willing to live alone all season. Under our current economic conditions such men are not available in sufficient numbers at the salary we can pay and for only a seasonal job.

This placement of men did not provide for needed flexibility in moving men rapidly to another location where more than two or three men were needed for early attack on a difficult small fire. We also found that the comparatively few firemen stationed in the valley bottoms, particularly those on roads, became the initial-attack force on a majority of the fires.

The 800 lookout towers were constructed from untreated native woods obtained close to the site and after 20 years they all began to deteriorate rapidly and many became unsafe for use. In addition we gradually became financially unable to maintain trails and telephone lines to all of these stations. As a result we gradually changed our plan by moving some of the lookout-firemen to double-up firemen positions in the valley bottoms.

In the early 1940's, many of these fireman positions in the roadless areas were abandoned and were replaced by a centralized smokejumper unit. Because of their flexibility, smokejumpers have replaced twice their number of firemen. Two or more smokejumpers can now get to a fire as quickly as one fireman did when we had many of the latter strategically placed in the roadless areas. Where we used to get one man to a fire within one hour, but to get 20 there might take 2 days, we can now put 20 smokejumpers on the fire within one hour when the situation warrants. This is where flexibility pays off. There are times when the number of smokejumpers is insufficient to meet the need. We then resort to use of helicopters as far as they are available and can be used, and then must rely on slow foot travel to meet the remainder of the need. I might well mention here that smokejumping has great public appeal and in our area receives 90 percent of the fire control publicity. Actually smokejumping takes care of less than 20 percent of our fires with the remainder being handled by older conventional methods.

Our detection system has also been overhauled in recent years. We now have a skeleton force of about 200 lookouts who are primary detectors covering the high-risk areas. They are important in charting the course of lightning storms, precipitation, in making burning index measurements, and in serving as radio communication hubs. Planned aerial detection fills in most of the gaps left in the reduction from 800 to 200 fixed detectors. Flexibility gained here is also important as it costs little to leave the airplane on the landing strip when this additional detection is not needed. With fixed detectors only, we had little flexibility, as a station in a remote area could not be occupied only on the days needed and the man not to be paid on other days.

c. Equipment

1. *Small tools.* Determination of types and quantities of tools for each initial attack and cooperator station; also, determination of small-tool and equipment requirements for regional, forest, and district warehouses for followup forces.

2. *Transportation equipment.* Study of transportation needs of each initial-attack station, ranger's and supervisor's headquarters.

3. *Specialized equipment.* Determination of types, quantities, and locations of tank trucks, prime movers, plow units, trailbuilders, portable pumpers, aircraft, and other specialized equipment; involves the types and quantities of specialized equipment required for initial attack, forest and ranger stations, and regional or zone central caches.

d. Communication

Communication—radio and/or telephone. These include:

1. *Detection.* Plan providing communication outlets for detectors—must provide immediate channels for detectors to report fires to dispatching base.

2. *Initial attack.* Provision must be made for immediate communication between dispatching base and initial-attack crews whether cooperators or employed by Forest Service.

3. *Dispatching base.* Must provide immediate communication outlets from dispatching base to all detectors, initial-attack crews, followup forces such as work crews and cooperators, and to forest and ranger headquarters.

4. *Suppression.* A plan must be made which will provide communication both from the fireline to the camp or to other sections of the fire, and from the camp to the dispatching base; numbers and types of radio, emergency phones, or other communication facilities required for these purposes must be determined. Communication between initial-attack crews when away from their stations and the dispatching base must likewise be provided wherever possible and made a part of this plan.

e. Cooperators

Determination of the extent to which cooperators may be incorporated into the presuppression phases of fire control. In many cases cooperators may be used in the initial-attack field, releasing funds for other areas where cooperators are not available.

f. Training

A training plan must be prepared, listing the minimum training needs of each presuppression position—lookouts, suppression crew foremen, crew members, tank-truck operators, patrolmen, packers, tractor operators, fire control assistants, and others who may be assigned full time or temporarily to fire control work of any kind. Provision should be made to maintain a current record of progress in training each individual. This plan should require an annual analysis of each incumbent's experience and training prior to entry on duty, to determine what he or she needs to learn to qualify for the position and to handle effectively and safely the assigned tasks.

g. Dispatching

Annually, a dispatching plan, sometimes termed "emergency fire plan," should be prepared, providing information on the location, strength, and provisions for contacting and mobilizing the following, with the purpose of providing adequate forces to meet the Service suppression policy:

1. All initial-attack stations—Forest Service or cooperator.
2. All Forest Service work crews.
3. All private work crews, i.e., logging, mill workers, railroad, power companies, orchard workers, etc.
4. Initial-attack forces of cooperating protection agencies.
5. Followup forces or facilities of cooperating protection agencies.
6. Forces of adjacent national forests.
7. Pickup fire fighters.
8. Overhead, segregated as to skills from which fire overhead teams may be selected, or from which assignments to individual fire suppression jobs may be made.
9. Cooks, packers, power-saw operators, trailbuilder operators, and others having specialized skills.
10. Tools and equipment, including transportation equipment, trailbuilders, tank trucks, etc.
11. Food, mess equipment, first aid, and other supplies and materials.
12. Communication equipment, including emergency wire, field telephones and radios.
13. Special detectors.

Also the dispatching plan should include ways and means and authority for varying the disposition or strength of the presuppression force in accordance with measured fire danger.

h. Housing

Because of its importance, a housing plan should be incorporated in the master presuppression plan which should indicate the housing facilities required to effectuate the plan and the housing facilities available. Changing patterns of use or fuel conditions should be given full recognition and weight in deciding whether to provide portable, semiportable, or permanent housing facilities, in order to permit ready shifting of forces to meet changed conditions.

i. Recruitment

A recruitment plan must be prepared and revised annually to provide the best possible (1) presuppression force, (2) force for use in fire emergencies.

j. Transportation

Plan usually outlines diagrammatically on map or maps the location and standards of all roads, trails, bridges, airstrips, and helicopter landing spots needed to meet the elapsed-time standards for the area; primary consideration is to provide accessibility for initial-attack and followup forces.

FIRE SUPPRESSION PLANS

Fire suppression plans separate and apart from the presuppression plan are not normally made by us in advance of the actual fire. Most material that would logically belong in a fire suppression plan has already been included above under the heading of presuppression plans. However, we do have a number of situations where an especially high fire hazard may require the making of a special fire-fighting plan in advance of fire occurrence. Such a plan is helpful to the fire boss once the fire escapes control of the first-burning-period attack force. They cannot always be followed but the detailed map of fuels, topography, cover type, roads, water chances, etc., provide an excellent basis for revising the plan to meet conditions immediately at hand.

Policy

Our policy is to require fast, energetic, and thorough suppression of all fires. When first-attack forces fail to attain this, the policy then calls for prompt calculating of the problems of the existing situation and probabilities of spread; and organizing and activating adequate strength to control every such fire within the first work period. Failing in this effort, the attack each succeeding day will be planned and executed with the aim of obtaining control before 10 o'clock of the next morning.

Calculation of Probabilities

Probably a better term for calculation of probabilities is an *estimate of the job we must do to control the fire.* Controlling a fire can be compared to building a road or a bridge. The fire boss needs a plan based on the job he will have to do. This includes evaluation and correlation of the factors affecting fire behavior, knowledge of the probable perimeter of the fire at successive time intervals and the expected number of units of held line per unit of manpower or applicable machine unit or both, to determine the organization—including overhead, manpower, and equipment—he will need. The fire suppression plan of action is then prepared day-by-day to meet actual conditions and revised at shorter intervals when the situation warrants.

Actuarial Planning

Some authorities on fire control planning do not agree with the subject divisions used above in this presentation. Ralph Hand, who recently retired after 15 years in the fire planning job in Missoula, divided the subject into prevention, detection, and suppression. I believe that this has merit and should be considered when preparing for a job in fire control planning. Ralph Hand also developed a system based on actuarial principles for suppression planning that is interesting and highly successful. Briefly, this system provided a series of actuarial tables based on an analysis of 20 fire seasons and 27,000 fires. Each fire was refought on the basis of present-day conditions of transportation, fuels, and methods. In these tables we had the facts that would give us answers to almost any specific question in the field of fire control planning. They were particularly valuable in—

1. Determination of basic needs, such as manpower, machines, and equipment.
2. Determination of facilitating needs such as transportation, communication, supervision, and training.
3. Preparing the action plan.
4. Providing the facts to indicate the amount or level of fire insurance that was being carried on a forest property.

This subject of fire planning by actuarial principles to explain fully would take an entire day; however, I would like to recommend that these principles be investigated before replanning is started where fire records are available for the area for the preceding decade or a longer period.

SUMMARY

To finish this paper and open the discussion period, I would like to state that this is far from a complete coverage of the subject. I have borrowed much of my text from our National Forest Manual and make no claim for originality. In closing, I'd like to again emphasize that a fire plan must be a living thing, frequently modernized, to be most useful.

CARRYING CASE FOR PORTABLE FIRE EXTINGUISHER

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A canvas carrying case for fire extinguishers (fig. 1) has been developed in Region 1 for use by operators of power saws, duffel carriers, scooters, trail graders, and other gasoline-powered equipment. The U. S. Forest Service and most State and private protective districts in western regions require these operators to keep in their immediate possession a serviceable fire extinguisher with contents of not less than 8-ounce capacity by weight.

It is recommended that each man doing mechanized trail maintenance work have immediate access to a fire extinguisher.

Some of the advantages of this canvas carrying case are as follows:

FIGURE 1.—Fire extinguisher case in place on belt. A sharp pull on tab will release extinguisher for emergency use.

1. By having it fastened to the man instead of the machine, "You wear it." If the case is worn, it is readily accessible at all times while the wearer moves about from one machine to another. It does not interfere when working or sitting. It is put on in the morning and removed only after the day's work or when the job is finished.

2. Container is safe from brush and accidental misplacement.

3. "Break cord" is broken only when extinguisher is inspected or used. The method of fastening the cover was selected to ensure fast emergency use.

4. The lace-type break cord holds the package tight and smooth and the carrying case will cover extinguishers of various kinds and shapes.

The canvas case is of simple design. The cost of complete unit (materials and labor) is estimated to be about 80 cents. Substitutions in materials may be made without affecting the use. Several pressurized and "beer can" types of extinguishers with contents of approximately 12 ounces will fit in the case.

Drawings and specifications may be obtained by writing to the Regional Forester, U. S. Forest Service, Federal Building, Missoula, Mont.

PRESENTING FOREST FIRE FUNDAMENTALS

NEIL LEMAY

Chief Forest Ranger, Wisconsin Conservation Department

Young America has returned to the classroom with the advent of the fall season. The schools are charged with a great responsibility once again. In the presentation of the courses employed in the formal education of each student, instruction in conservation of the natural resources of the community, the State, and the Nation is of extreme importance to the student and to all of us. What he or she learns in school on this highly important subject will have an individual and cumulative effect not only on the person and his or her associations in future years but on the destinies of many people.

Those of us in fire control have been vested with a great responsibility. To protect and preserve the natural riches of the country, as well as the man-made and operated developments, we have the job of guarding against that foremost of destructive agents—wild, uncontrolled fire in the forest. To curb this menace we need the full, wholehearted cooperation of everyone, and our fire-prevention programs are highly diversified so that everyone will be reached.

For nearly 30 years, here in Wisconsin, we have been carrying on in the schools an educational program aimed at the forest fire menace. The high degree of success achieved in this venture shows in the strong support that Young America provides in the all-out effort directed toward prevention of forest fires. But the prevention job is not and probably never will be completed. We, therefore, must be prepared for fire control work.

As most of us know, fire control work is a highly technical endeavor. It embraces many fields; meteorology, communications, mechanical aptitude, engineering, personnel management, and public relations, to name a few. This can be confusing to the student even though it may seem simple to those of us who have spent most of our lives working at it. Because successful fire control work is based upon the knowledge of why a fire burns and what makes a fire spread through forest fuels, we start at the very beginning. We have found that a thorough understanding of the fundamentals of why a fire burns is essential not only to the forest ranger but also to the student in school. We have worked out a method of displaying this which we believe may be helpful to other fire control agencies. I am presenting this method of instruction in the fundamentals of forest fire occurrence for your information (figs. 1-6).

FIGURE 1.—Before a fire will start and burn, there must be three elements present in the right combination. They are fuel, air, and heat. Fire cannot exist in the absence of any one of these three elements. The basic principle of fire suppression is to remove one (or more) of these elements.

FIGURE 2.—When I close the "fuel" flap, the "fire" disappears. To demonstrate this, I separate the unburned fuel in the pan from the burning fuel. The fire goes out quickly. This is a common method of control employed to stop forest fires. In the forests we use fireline plows, bulldozers, and handtools to make the separation.

FIGURE 3.—In this scene, I have reopened the "fuel" flap but have closed the "air" flap. Again the "fire" disappears. To demonstrate this, I start a fire in the bowl and then place the cover on the bowl. The fire soon goes out because of lack of air. In forest fire control this method of suppression is used to extinguish burning embers by completely covering them with mineral soil to shut off the oxygen supply. It is used principally on small fires or on parts of a large fire.

FIGURE 4.—After reestablishing the original scene, I close the "heat" flap and the "fire" disappears again. To demonstrate this, a fire is started in the bowl. Water is sprayed on the flames, quickly extinguishing the fire. Water is widely used as a suppression agent by all fire control organizations. Pumps and tanks are mounted on trucks and tractors for use in all types of suppression work. Often independent water-pumping complements are used to extinguish fires.

FIGURE 5.—In forest fire prevention work these three basic fire occurrence elements also play an important part. We cannot control the oxygen supply as "air" is everywhere. Fire protection agencies can control "fuel" deposits to a limited extent only although laws regulating the removal of slash resulting from timber-cutting operations, right-of-way cleanup along roads and railroads, and special forest fire hazard reduction projects are helpful. Also, lightning is one source of "heat" over which we have no control. Quick detection and suppression action is the only answer when this element is present in the right combination with the other two.

FIGURE 6.—We can do something about curbing the man-caused sources of "heat." It is in this connection that our fire prevention programs in the schools, civic clubs, sportsmen's groups, industry, local government, and with people, singly or collectively, will pay off. Past records indicate a need for a never-ending endeavor in this direction.

I hope that this teaching aid will be helpful to you. It has proved to be very useful here in Wisconsin. If you are interested, please feel free to write me for details relating to construction and operation.

FIRE WHIRLWIND FORMATION AS FAVORED BY TOPOGRAPHY AND UPPER WINDS

HOWARD E. GRAHAM

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A fire started at a logging operation during the afternoon of October 1, 1952. Toward evening the size had slowly increased to 20 acres. About 9:30 p.m. the fire suddenly became a raging inferno as whirling winds formed within the fire and abruptly multiplied its speed to such strength that chunks of wood and bark up to 8 inches in diameter were thrown about like straws. Logger fire fighters fled for their lives. Within minutes the fire raced through unburned areas for half a mile, increasing to 240 acres. The whirling winds remained over the fire for about an hour, hurling burning embers for considerable distances and preventing the loggers from pressing their attack (table 1, whirlwind 4).

Fire whirlwind is a phenomenon that has been known to be associated with large fires (whirlwinds 1, 2, and 3) (*4*).[1] It has become more common in recent years in the Northwest as a result of the increase in number of necessary slash burning operations.

In another fire that occurred November 8, 1952, a Crown Zellerback fire patrolman was making a routine 8:30 a.m. visit to a nearly cold 2-acre slash fire on the west slope of the Washington Cascades near the Columbia Gorge. Although the lookout on a ridge a short distance eastward reported east winds from 50 to 60 miles per hour, these winds had not been hitting the fire area. Suddenly an intense whirlwind formed in adjacent green timber and passed over the dormant slash fire. The fire leaped to life with an eruption of sparks and flame and ran for over a mile finally joining a second fire (whirlwind 9).

Fire whirlwinds have received little attention from meteorologists, probably because such winds are usually observed only by foresters and fire fighters who are too busy fighting fires to make detailed weather observations. With greater attention being given to the study of blowup fires (whirlwinds 1 and 4), it is fitting that this particular type of violent fire behavior be explored from both the empirical and theoretical standpoints.

Winds are of great concern to fire fighters. Fire spread is a function of wind speed, although not a simple function. Local violent winds, frequently whirlwinds, have many times caused unusually rapid fire spread due both to direct fanning and to spotting. A typical fire whirlwind frequently has a central tube made visible by whirling smoke and debris. Extreme variations in height, diameter, and intensity are common. Witnesses have described fire whirlwind diameters from a few feet to several hundred feet and heights from a few feet to about 4,000 feet. Inten-

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[1]Italic numbers in parentheses refer to list of references p. 24.

TABLE 1.—*Descriptive details for 28 fire whirlwinds in the Pacific Northwest*

Whirlwind number	Day and hour, Pacific standard time	Whirls				Size of debris picked up	Wind-topography relation	Ridgetop wind	
		Number	Duration	Diameter	Height			Direction	Velocity
				Feet	*Feet*				*M. p. h.*
1	7/20/51 1600	1	2 hrs	1,200	2,500	logs, 30 in. by 30 ft.	lee slope	N	
2	8/23/51 1400	3	10 min.	200	1,000	large tree broken off	,, ,,	N-NE	10-15
3	9/21/51 1300	1	1 hr.	200	4,000	logs, 15 in. by 15 ft.	,, ,,	N-NE	
4	10/ 1/52 2140	(¹)	several min. each for 1 hr.	50	200	6- to 8-in. chunks	,, ,,	E	30
5	10/15/52 1500	(¹)	each 30 sec.	40	150	3 by 4 by 16 in.	,, ,,	NE	10
6	10/24/52 1030	(¹)	each 30 sec.	40	300	log, 12 in. by 16 ft.	,, ,,	E	10
7	10/25/52 1100	(¹)	each 2 min.	20	150	bark, 2 by 4 by 12 in.	ridgetop	W	
8	11/ 4/52 1400	1	few min.	(²)	(²)	(²)	parallel to contours	SW	10
9	11/ 8/52 0830	1	(²)	(²)	(²)	small debris	lee slope	E	50-60
10	11/ 8/52 1500	1	1 hr.	5	100	small sticks	,, ,,	E	10
11	9/ ?/53 1100	1	10 min.	50	100	small limbs and snapped tree top, 8- to 10-in. diameter	flat	calm	
12	9/16/53 1345	1	2 min.	75	125	bark and wood, 4-5 lbs.	lee slope	S-SW	4
13	9/21/53 1530	1	¾ hr.	25	100	6- to 8-in. diameter	,, ,,	SW	15
14	9/29/53 1000	(¹)	each 30-60 sec.	10	50	up to 8 sq. in.	windward	SW	10
15	9/29/53 1130	1	1½ hrs.	400	400	up to 3 by 3 in.	lee	W	2
16	10/ 3/53 1600	(¹)	each 2 min. for 8 hrs.	10	30	up to 15 lbs.	windward ?	E	30
17	10/ 4/53 1150	(¹)	3 min.	40	300	2 by 6 by 18 in. and a cedar post	lee slope	NE	5
18	10/ 6/53 1530	1	1½ hrs.	50	200	(²)	calm	calm	
19	10/ 6/53 1530	(¹)	½ hr.	20	60	bark, 4 by 6 in.	lee slope	E	8
20	10/ 7/53 1500	(¹)	each 30 sec.	30	100	1½ in. diameter	windward ?	SW	10
21	10/ 8/53 1600	(¹)	each 4-20 sec. for 4 hrs.	10	200	under 1 lb.	windward	W	10
22	10/ 9/53 1640	1	8 min.	140	170	2 by 6 by 24 in. and larger	lee slope	NE	5
23	10/ 9/53 2000	(¹)	1-2 min. each for 2 hrs.	75	100	1 by 2 by 3 in.	,, ,,	SW	10-15
24	10/10/53 1730	5	1 hr.	50	125	large sparks	,, ,,	W	5
25	10/13/53 1830	(¹)	1 min. each	30	200	small twigs	,, ,,	W	8
26	10/15/53 1500	(¹)	each 1-2 min. for 1 hr.	50	150	branches and bark	,, ,,	W	5
27	10/29/53 1830	1	10 min.	100	80	bark and limbs, 4 by 5 in.	,, ,,	N	3
28	10/29/53 1500	(¹)	each 10 sec. to 4 min. for 2 hrs.	30	60	large material including a 20-lb. piece of sheet metal	,, ,,	W	5

¹Several.
²Unknown.

sity varies from that of a dust devil to a whirlwind that pitches logs about and snaps off large trees (*3*). Velocities in the vortex are extremely high, and, as in other forms of whirlwinds, the greatest speed occurs near the center. A strong vertical current at the center is capable of raising burning debris to great heights.

FAVORABLE TOPOGRAPHIC FEATURES

The 28 fire whirlwinds that form the basis for this discussion were all observed in mountainous terrain. Their individual characteristics are indicated in table 1. Of the 28 whirlwinds, 20 occurred on lee slopes, 1 on a ridgetop, 1 under calm conditions, 2 with wind at right angles to the slope, and 4 on windward slopes. Of the several additional whirlwinds described to the author and not included in table 1, all occurred on lee slopes. From observations it would appear that the most violent whirlwinds occur on lee slopes.

The mechanical action of airflow over a mountain is a factor in fire whirlwind formation. Aerodynamic theory tells us that favorable conditions for the starting of a whirl occur where abrupt edges of mountainous terrain create shear in the air stream. As has been found true with dust devils, shearing motion is undoubtedly a major factor in whirl formation. Although mountainous terrain provides many topographic situations favorable to fire whirlwind occurrence, the fact that it is not an essential condition is indicated by several examples which occurred on flat land in Eastern United States (*2*).

METEOROLOGICAL ASPECTS

Dust devils are normal in flat areas when the wind speed is low and the lapse rate is steep, i.e., relatively rapid temperature decrease with height. Fire whirlwinds also appear to depend upon steep lapse rates in the layer near the ground. Roy R. Silen, Pacific Northwest Forest and Range Experiment Station forester, moved a fire whirlwind downhill by rolling debris against the fuel in the hot spot over which it had formed. As the hottest portion of the fire was carried down the slope, the fire whirlwind followed. Fire whirlwind occurrence seems to be directly related to the local thermal instability set up by the fire and not otherwise relieved.

The degree of upper air stability as indicated by the lapse rate between 850 and 500 millibars, i.e., pressure surfaces near 5,000 feet and 18,000 feet, at nearby weather stations has little or no effect on fire whirlwind occurrence. Data on the lapse rate at lower levels is unavailable. Obviously the lapse rate in the lower level over the fire is extremely unstable because of intense heating near the ground.

The distribution of upper air wind velocities also was checked from pilot balloon data at the nearest weather station. The results showed that 75 percent of the whirlwinds reviewed occurred with winds of less than 17 miles per hour below the 5,000-foot level.

This is to be expected since the majority of whirlwinds were on controlled burns. The remaining 25 percent showed rapid wind speed increase with height. The wind speed profiles are of variable shape and show no typical occurrence of the "jet point" discussed by Byram (*1*) with relation to blowup fires.

MOUNTAIN BARRIERS AND THEIR EFFECTS ON AIRFLOW

The upper end of a fire whirlwind when on a lee slope near a ridgetop seems to extend into a region of low pressure that occurs in the vicinity of a ridgetop whenever windflow is at right angles to the ridge. This follows the Bernoulli principle which states that changes in pressure are inversely proportional to changes in fluid velocity. Pilots are taught this principle as the explanation for altimeter errors experienced over mountains.

The theory of pressure reduction along a ridge oriented at right angles to the direction of airflow is well supported by evidence. According to a U. S. Weather Bureau study of strong winds over mountain barriers, the pressure reduction over a mountain crest was proportional to the square of the wind speed. Where the air was saturated, the pressure deficiency was nearly doubled. The greatest pressure deficiency occurred along a mountain barrier with a ridge profile corresponding to the upper surface of an airfoil where the maximum drop would be near the topmost part of the airfoil camber. Theoretically a topographic barrier should best approximate an airfoil when the lee slope is less than 33 percent and relatively smooth. This corresponds very closely to the upper limits of the change in direction of airflow over the upper surface of airfoils on slow speed airplanes.

CONCLUSION

Because of the direct relationship between fire whirlwind occurrence and combustion heat, the meteorologist can predict likely areas of occurrence only if he is familiar with both the attendant meteorological and topographic conditions and the occurrence of heavy fuel concentrations. The forester with intimate knowledge of areas under his management will usually be more able to predict combustion heat over a given area.

Fire whirlwinds seem to develop more readily on lee slopes close to ridgetops. It is suggested that this is favored by pressure deficiencies resulting from flow over an abruptly terminating airfoil. The wind velocity above the ridgetop thus becomes an important factor in determining the likelihood and magnitude of a whirlwind.

We may conclude that the most favorable condition for fire whirlwind occurrence is over a hot fire near the top of a steep lee slope with strong winds over the ridgetop. Fire whirlwinds are frequently characterized by destructive violence. Therefore, when any fire—large or small, quiet or running—is on a lee slope, the fire fighters should consider the danger of fire whirlwind formation.

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WESTERN OREGON FOREST LAND ZONED FOR CLOSING DOWN LOGGING DURING PERIODS OF HIGH FIRE DANGER

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The State Forester of Oregon is authorized by law to prohibit the use of fire in any form or the use of power-driven machinery on forest land west of the summit of the Cascade Mountains during periods of critical fire danger. These periods occur when there is a combination of critical fire weather and an excessive amount of forest fuels. The area includes about 10 million acres of forest land and is bounded on the north by the Columbia River, on the east by the summit of the Cascades, on the south by the California State line, and on the west by the Pacific Ocean.

Extremes in elevations, wind directions, temperatures, rainfall, and other factors naturally produce a wide range in climatic conditions. High fire danger may exist in a part of the area while in other sections the danger may be moderate or low.

Climatic and soil conditions in western Oregon result in the growth of heavy stands of timber and a luxuriant growth of underbrush and other vegetation. Logging operations on more than 400,000 acres each year leave an enormous amount of slash and debris on the ground. Unburned slash and areas in the process of being logged can become extreme fire hazards during the summer season.

Closing logging operations results in a tremendous economic loss to the State. Operation close-down orders can be justified only at such times and in such localities where critical fire danger makes the use of fire in any form or the use of power-driven machinery a potential cause of fire that could not be controlled. A careful study of conditions that influence the starting and spread of fire must be made before close-down orders are issued. Obviously the authority to close down all forest operations on so large an area places a tremendous responsibility on the State Forester.

Prior to the 1951 fire season each close-down order was applied on all forest operations in western Oregon. No practical plan had been devised to do otherwise. During the severe season of 1951, operations were closed down a number of times. In some instances all operations were halted within a fire district or two or three adjoining districts. In other instances close-down orders were imposed on all operations within a watershed. While this system was an improvement over that of previous years, many protests were registered by operators in certain areas where the fire danger was not particularly critical during the close-down period.

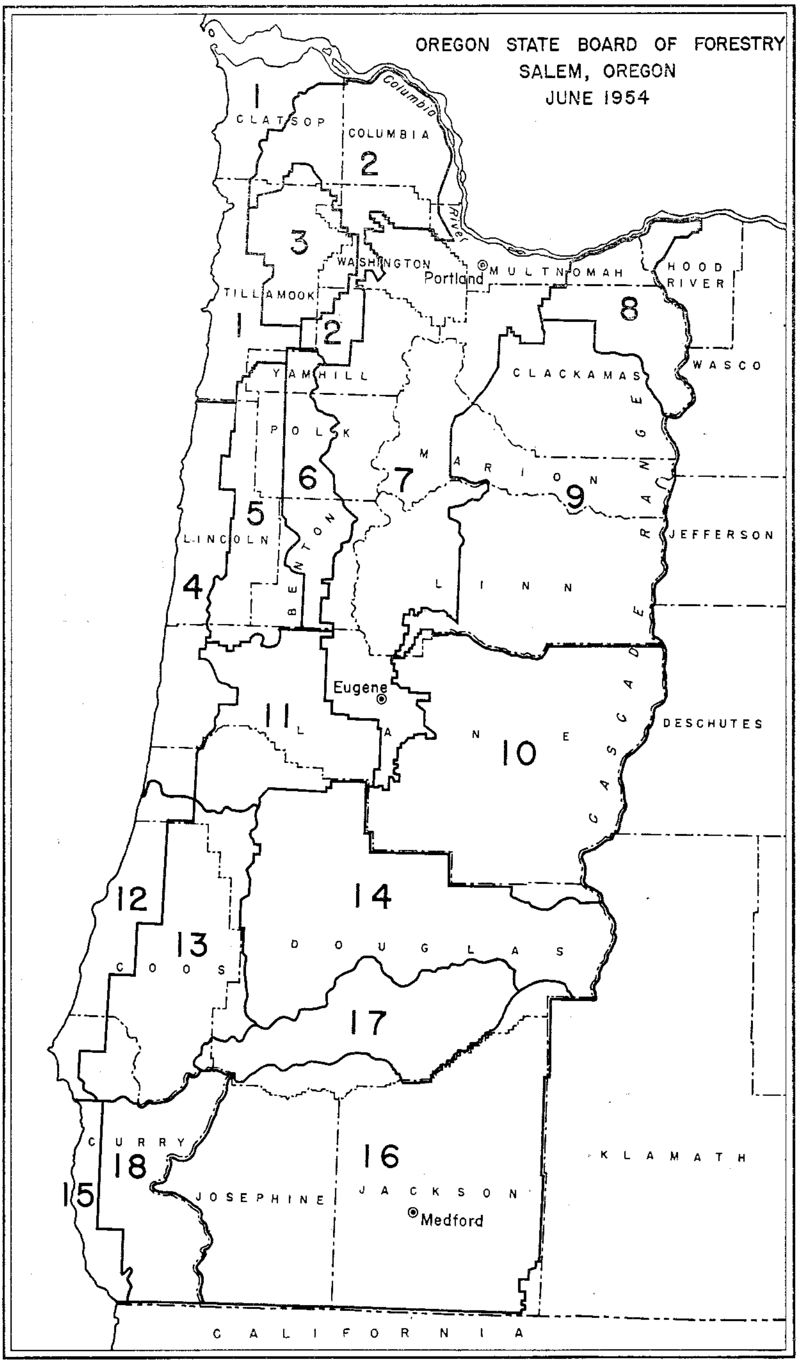

FIGURE 1.— Close-down zones in western Oregon.

During the latter part of the 1951 fire season the State Forester initiated a study of weather and hazard conditions on the area. This study consisted of reviewing weather statistics over a period of years, fire occurrence, fuel hazard such as unburned slash, logging activity, and the knowledge of local wardens. Information obtained definitely indicated that the western part of the State could logically be broken down into smaller areas for the purpose of administering the operation close-down feature of the law.

In 1952 western Oregon was divided into 16 close-down zones, each of which was considered to have a weather pattern of its own that at times might vary from the others. After the first year's experience, two zones were subdivided making 18 zones at the present time (fig. 1). These zones were established on the basis of fire weather, fuel types, operation activities, and administrative boundaries. This was done in order that the close-down periods could be applied as nearly as possible to areas affected by similar fire weather conditions.

In each zone several fire weather stations were established where fire weather data is taken throughout the day. This information is transmitted to the fire district headquarters office and from there radioed to the State Forester's office where it is tabulated for each zone. On the basis of this data, the judgment of the district warden in each zone of general burning conditions, and fire weather forecasts by the United States Weather Bureau, the determination is made of close-down periods for each zone.

Each operating permit issued by the State Forester shows the zone number for the area on which the operation is to be conducted. When a close-down order is issued, the operator need only look at his permit to determine if his operation is affected.

The State Forester may close one or as many zones as appears advisable according to conditions existing.

The United States Weather Bureau at Portland, Oreg., prepares fire weather forecasts by zones, twice daily. These forecasts are broadcast to all fire district headquarters offices over the forestry department's radio network and may be communicated to operators in the districts. During the critical period early in September 1955, operations were suspended in several zones without a single remonstrance from the operators affected. Further study is planned and if the information obtained indicates that changes in zone boundaries may be desirable or additional zones should be set up, these improvements will be made.

ROBIE CREEK FIRE SAFETY NEWS

[Editor's Note: Following is the text of a message prepared and distributed to fire overhead during the action phase of a project fire in the Intermountain Region of the U. S. Forest Service. The technique is worthy of consideration for wider use.]

TO ALL FIRE OVERHEAD:

Congratulations! Your SAFETY RECORD to date has been very commendable. In spite of very hazardous conditions, there have been no serious injuries on the Robie Creek Fire. To date, there have been three men disabled—one by a rolling rock, one due to an eye injury caused by running a branch into it, and another because of an insect flying into his ear.

However, with the fatigue factor now entering the picture, a danger of increasing accidents is more present. It is up to you, the overhead, from the Strawboss up to the Division Boss, to keep accidents from occurring. You are directly responsible for the safety of your men. *You cannot delegate this responsibility.*

FIRELINE SAFETY

The greatest fireline hazard on this fire is from falling snags, rolling rocks, and rolling logs. Be alert to these dangers. Keep lookouts posted for these dangers.

Make certain that every member of your crew knows his immediate boss.

Always have escape routes planned in advance. Remember that a burned-out area is the safest area during blowups.

Be careful of smoke inhalation.

Have your men drink water sparingly and use plenty of salt with their meals.

Immediately release all unsafe workers.

TRANSPORTATION

Do not transport men and tools in the same vehicle. Use your pickup for tools when you have trucks for men.

Designate one man in each truckload of men to insist upon the following:

a. Tools are not being carried with men.

b. Men are seated when truck is traveling.

c. Tailgates, or adequate roping, are used.

Truck drivers must keep a safe distance between vehicles because of smoke limiting visibility.

When traveling through burned areas, one man in the front with the driver must watch for dangerous snags and rolling material.

Depressing headlights, when traveling at night, often increases the visibility in smoky areas.

KEEP IT SAFE

J. M. MILLER, *Fire Boss*
GEORGE LAFFERTY, *Fire Safety Officer*

THE EFFECT OF CERTAIN VEGETATION ERADICATORS ON THE FLAMMABILITY OF VARIOUS MATERIALS[1]

E. J. WARD

Forestry Branch, Department of Northern Affairs and National Resources, Canada

The problem of vegetation eradication is one that confronts many organizations, among whom are railway companies. Their problem is that of reducing fire hazard by clearing potential fuels, such as shrub and herbaceous growth, from rights-of-way. These fuels could be ignited by live coals falling from a passing locomotive. Some chemical vegetation eradicators, however, have been suspected of providing a fire hazard themselves because of their flammable nature. It was also thought that they increase, temporarily, the flammability of vegetation and render railway ties more subject to burning and charring when contacted by hot coals.

In addition to studying the effectiveness of several herbicides, members of the Federal Forestry Branch conducted further tests at the Petawawa Forest Experiment Station in an effort to determine the effect on the flammability of materials with which these herbicides come in contact. For this latter project, railway ties and grass were used as flammability test media. No attempt is made here to assess the effectiveness of the chemicals as vegetation inhibitors.

STUDY TECHNIQUE

Stock solutions of the following herbicides were made up: Sodium chlorate, diesel oil, 2,4-D amine salt, 2,4-D butyl ester, 2,4,5-T, C.M.U., and Atlacide. Some of the concentrations were made stronger than those normally used so that poorly mixed solutions could be duplicated. (In order to reduce the effect of sodium chlorate solution in increasing the flammability of materials contacted, calcium chloride is sometimes added.) One quart of stock solution was used to spray each plot. To each quart of solution, except in the case of diesel oil, was added an extra quart of water. The extra liquid volume did not alter the amount of chemical used per square foot but did ensure more uniform plot coverage. The solutions were applied with an ordinary garden sprinkler can.

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[1]An article of this title appeared in its entirety in 1956 as Forestry Research Division Technical Note 36 of the Forestry Branch of the Canada Department of Northern Affairs and National Resources, Ottawa. A somewhat shortened version is published here through the courtesy of the Forestry Branch.

Tests involving railway tie and grass flammability were made on an open field on which all dead vegetation was burned off early in the spring in order to ensure a uniform coverage of green grass.

Twelve creosoted and 12 uncreosoted 6- by 8-inch softwood ties were used in the flammability tests. Four pairs of one-foot sections of each type were set on the ground in plots measuring 25 square feet each. One plot was sprayed with each type of herbicide. Similar grass-covered plots in the same location were sprayed with the same chemical vegetation inhibitors in order to determine their effect on the flammability of grass.

Matches were used as the ignition agents. First, one match was placed on the tie and ignited with another. If fire did not spread from the first, two matches were placed on the tie with their heads abutting. If only the matches burned, four were tried, and then eight. Flammability tests were made simultaneously on creosoted and untreated ties at intervals of 20 minutes, 1 day, 12 days, and 1 year after application of the chemical.

On the grass plots, attempts were made to burn plots representing each treatment at intervals of 5 minutes, 1 week, 1 month, and 1 year after spraying. Up to three matches were used for ignition. Again, as a control measure, untreated plots were tested at the same times.

TESTS ON RAILWAY TIES

In only a few cases were the results of tests made on creosoted and plain railway ties appreciably different. During tests made 20 minutes after treatment, only the plain ties treated with diesel oil and creosoted ties treated with diesel oil, C.M.U., or 2,4,5-T, appeared more flammable than the untreated ones. When ignited with one or more matches, fire spread across the surface of each of these more flammable ties. They were not damaged as seriously, however, as the untreated, plain tie which was deeply charred beneath the eight matches used in the test. During subsequent tests 1 day after treatment, ties sprayed with 20 percent sodium chlorate and 5 percent calcium chloride, and creosoted ties treated with diesel oil or 2,4-D butyl ester, appeared more flammable than untreated ties. Twelve days later, tests indicated that creosoted ties treated with 20 percent sodium chlorate and 5 percent calcium chloride or C.M.U., and plain ties treated with diesel oil, 2,4-D amine salt, 2,4-D butyl ester and 2,4,5-T, were more flammable.

After 1 year, only those ties treated with diesel oil, C.M.U., 5 percent solution of sodium chlorate, ammate, and 2,4,5-T, still indicated a slight tendency to burn, while the others showed no reaction. The degree of charring and fire spread was insignificant and occurred only near the matches. Of the ties treated with the first two solutions, the plain tie burned briefly, and on some of the creosoted ties treated with the latter three solutions, the creosote coating seemed to burn momentarily. No burning or charring resulted from tests made on the remaining ties, including the untreated ones.

The only treatments which obviously increased flammability during the tests were diesel oil, strong solutions of sodium chlorate, 2,4-D butyl ester, and 2,4,5-T. The latter two caused only slight increase.

In no case was the charring of treated ties more serious than was evident on those untreated. In some instances, fire flashed over the surface of the tie causing ignition of surrounding herbaceous growth. This tendency was noted on ties treated with diesel oil and strong solutions of sodium chlorate, especially 1 day after treatment.

None of the solutions appeared to harm the ties through chemical action.

TESTS ON GRASS PLOTS

During flammability tests made on grass, none of the plots could be ignited 5 minutes after spraying except those treated with diesel oil and C.M.U. Grass treated with the former burned quite vigorously, but grass treated with the latter burned only an inch away from the igniting match. The untreated plot did not burn at all since, like other plots, it contained a very large percentage of green grass.

In tests made 1 week and 1 month after treatment, the relative flammability of the grass plots reflected to a great extent the percentage of grass killed by the chemical and the amount of accumulated dead material. One week after treatment, the plots treated with either Atlacide or a mixture of sodium chlorate and 2,4-D burned somewhat more vigorously than the percentage of green would indicate. Despite the fact that the ammate-treated plot was only 2 percent green, it burned less vigorously than would be normally expected. This may indicate that this chemical had a fire-retarding effect. Two other plots could be ignited briefly, but the fires were insignificant.

One month after treatment, plots treated with 2,4-D amine salt and 2,4,5-T were predominately green, but small fires were obtained on them. Test plots indicating very high or extreme flammability were those treated with 20 percent sodium chlorate and 5 percent calcium chloride, C.M.U. and Atlacide. On all of these plots, however, very little green grass remained. With very little dead vegetation existing on those treated with 2,4-D butyl ester and C.M.U., no fires were obtained. A very small fire burned briefly on the untreated plot.

One year after spraying, the flammability of plots coincided quite closely with the degree of kill and the amount of dead material on them. Test plots which had been treated with diesel oil showed a slightly increased flammability, but on the others any increase of fire activity could not be traced positively to the influence of the vegetation inhibitors applied to them.

SUMMARY AND CONCLUSIONS

In no case could it be definitely assumed that the chemical used actually reduced flammability.

The chemicals which most strongly exhibited a tendency to increase flammability were diesel oil and strong solutions of sodium chlorate. C.M.U. seemed to increase flammability slightly when the sprayed material was still wet. These observations held true for each set of materials tested. Solutions of 2,4-D compounds and 2,4,5-T raised flammability to a negligible extent in some cases.

Any advantages which may result from the use of diesel oil as a herbicide are offset by the increased flammability of materials so treated. Therefore, its use as a vegetation inhibitor could not be justified where fire is not wanted. The same conclusion applies to strong solutions of sodium chlorate unless they are mixed with calcium chloride in a ratio of at least two to one respectively. (It was observed in previous tests that the normal flammability of materials was actually reduced when treated with a mixture of equal parts of the two chemicals.) It was clearly evident that 1 year after application none of the herbicides seriously affected the flammability of either railway ties or grass.

In order to keep fire hazard to a minimum by avoiding an accumulation of dead material, it would seem advisable to do one of two things:

1. Before treatment, cut and burn grass and herbaceous growth in the autumn or early spring. Spray with herbicide during the development of new growth.

2. After treatment, burn the area when considerable browning of the vegetation has become evident. This should be followed by a respray of the area since some new plant growth often appears.

Following satisfactory killing of the vegetation on the treated area, it would be wise to maintain periodic spraying to prevent the vegetation from becoming re-established and providing another accumulation of fuel. Observations made to date on some of the herbicides would indicate that effective control would be maintained only if respraying was done at intervals not exceeding 3 years.

A TRAINING COURSE IN FIRE SAFETY AND FIRE SUPPRESSION TECHNIQUES

A. R. COCHRAN

Fire Control Chief, Region 7, U. S. Forest Service

Land managers face a training problem in common fire safety and fire suppression techniques that must be met by the use of live fire to demonstrate effectively fire's behavior and control. Actual fire conditions must be used, since today many district rangers have had relatively little experience in fire control. Also, the oldtime cooperators with experience in fire fighting are being replaced by a new generation with little background for this work.

To evaluate and to improve on this situation a regional training committee was appointed. This committee, consisting of a district ranger, an experienced ranger assistant, and a fire control specialist with administrative background, was to study training needs of the Region and to develop a fresh approach to training in fire safety and suppression.

The committee consulted with fire behavior experts in research and others familiar with the reaction of fire to fuel, topography, and weather at a specific time and location. They determined that knowledge of basic fire behavior is essential if fire fighters are to understand how natural forces influence fire in a given situation. Also fire behavior must be understood before men can anticipate and meet problems of controlling fire safely and efficiently.

The committee's problem became that of finding an adequate way to teach fire behavior so that the principles could be observed and comprehended. The method of approach finally selected involved 12 lessons arranged within the following three steps: (1) An introduction to fire behavior, since a fire control man must know fire behavior to do a good job of suppression. (2) The preparation of a fire suppression organization, which is concerned with the management of men, including their safety, welfare, and efficiency. (3) Actual fire suppression, which puts to use the knowledge gained under (1), fire behavior, and (2), fire suppression organization.

Outline for a Course
in
How to Suppress a Forest Fire

I. Introduction to fire behavior
   - A. How a fire burns (Lesson 1)
   - B. Heat transfer (Lesson 2)
   - C. Factors affecting combustion
     1. Fuel
        - a. Moisture content (Lesson 3)
        - b. Size and arrangement (Lesson 4)
     2. Weather (Lesson 5)
        - a. Wind
        - b. Moisture
     3. Topography (Lesson 6)

II. Fire suppression organization
   A. Use of tools (Lesson 7)
   B. Fire crew organization (Lesson 8)
   C. Line construction (Lesson 9)

III. Fire suppression
   A. Line location
      1. Factors in selecting point of attack (Lesson 10)
      2. Factors in securing the line—includes backfiring (Lesson 11)
   B. Mopup; fire out (Lesson 12)

The Region held a demonstration training session on September 11, 12, and 13, 1956, on the James River District of the George Washington National Forest. The trainees were young technicians most of whom had been with the Service less than 2 years. These men were divided into seven groups of seven each with a national-forest fire staffman as instructor. In the beginning the trainees were told that the course would test certain assumptions and training techniques and that each of them was to appraise the effectiveness of the training in meeting the objectives set up.

It is important that favorable burning conditions exist and that test fires do not burn too fast or too slowly for good instruction. Such conditions are indicated by the fire danger rating or burning index. During the 3-day session favorable conditions did exist as the 2:00 p. m. burning index showed:

Date:	*Buildup index*	*Fuel moisture (percent)*	*Wind (m.p.h.)*	*Burning index*
9/11	12	9.0	7.5	4
9/12	15	9.0	4.5	3
9/13	18	8.0	9.0	7

The first six lessons covered the subject of fire behavior. Not until these were finished was there an attempt to apply fire behavior in fire suppression. These lessons were taught in an open field. Each group was equipped with a pile of sawdust—about 2 cubic yards in volume—for shaping into desired topographic features, a piece of tin about 3 feet square, a small supply of light natural forest fuels, such as leaves, needles, twigs, and small limbs, and an adequate supply of planer shavings for various tests in the lesson series.

Lesson 1, "How a fire burns," demonstrates in simple manner the four stages of combustion: (1) Preheating, (2) ignition, (3) gaseous combustion, and (4) carbon burning stage. If the piece of tin is bent into a U shape, and a small fire built underneath, fuel put on top of the tin will burst into flame without actually coming in contact with a flame. This demonstrates preheating and gaseous combustion. The heat produced by combustion is important to understand and manage in fire control and is the subject for this lesson.

Lesson 2 demonstrates heat transfer by (1) radiation, (2) convection, (3) conduction, and (4) mass transfer. The lesson critique covers heat transfer not only by one method but also by a combination of two or more of these methods.

Lessons 3 through 6 develop the factors that affect combustion. Fuel moisture content is the most important variable affecting the combustion rate. Lesson 3 readily demonstrates this fact by using dry, normal, and green fuel of a given fuel type.

Lesson 4 demonstrates size and arrangement of fuel affecting combustion. The three sizes are light, medium, and heavy; and the four arrangements, loose, compact, continuous, and patchy.

Lesson 5 demonstrates and explains the factors of wind, moisture, and temperature.

In lesson 6 the final factor is demonstrated—topography as it affects the combustion rate. The information on behavior acquired by the trainee now enables him to tie in these factors with slope and shape. The effect of elevation and aspect are also explained. Interesting and realistic live fire demonstrations are possible with prepared fuel and appropriate topographic features shaped in the sawdust pile (figs. 1-4).

FIGURE 1.—The influence of topography brings about a characteristic two prong advance up the nearest spur ridges from the point of origin (planer shavings fuel).

FIGURE 2.—The steep valley between the ridges burns with great intensity at this stage of the development of this fire.

When the six basic fire behavior lessons have been completed, the trainees should be able to apply the various factors accounting for behavior to particular situations or to set up assumed situations and try them out on the sawdust pile. Many possibilities exist for lively training situations, since with imagination and ingenuity they can be made interesting and realistic.

Lessons 7, 8, and 9 explain and demonstrate recruiting and organizing a fire crew, the crew's relation to the district organization, and its part in an expanded fire organization. The use of tools, here considered as a part of organizing a crew, is followed by actual line construction in the field, including use of line fire in backfiring. The appropriate Safety Code provisions of supervision, use of tools, transportation, and fire fighting form part of the instruction. A previously selected area having a variety of fuel and topographic features is used. Low hills with sharp relief and, of course, adequate fuel types produce the best conditions for demonstration. The area should be mapped to show topography and fuel and a map should be furnished each trainee.

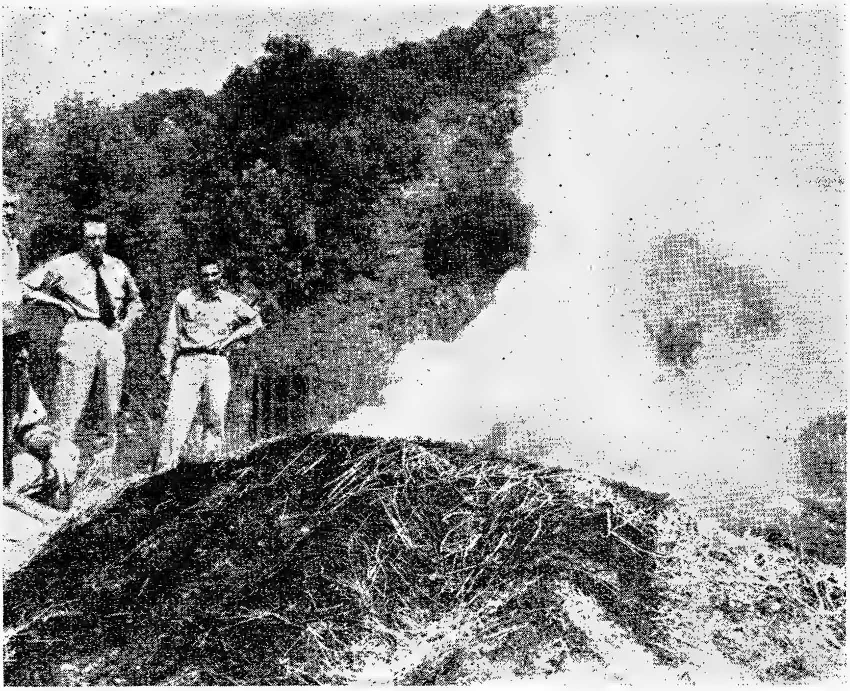

FIGURE 3.—In this simulated situation the fire has burned to the top and is advancing downhill. (Straw chopped in 4-inch lengths is used for fuel.)

FIGURE 4.—Under the influence of a strong wind generated with a hand-operated fan, the fire travels across country. The influence of topography has been counteracted by that of wind (planer shavings fuel).

In lessons 10, 11, and 12 problems covering point of attack, line location, and mopup are solved by demonstrating a variety of topographic and fuel situations. This is fire foremanship at work in applying fire behavior principles to the solution of fire problems. Live fire is used. A special mopup crew moves in and puts out the fires used in lessons 10 and 11 since mopup at this point is not a part of the instruction.

Student performance was evaluated on the basis of FM 21-6—Techniques of Military Instruction, Department of the Army, May 1954, Chapter 11. An examination consisted of 43 true-and-false and multiple-choice problems. The scores for each of the seven groups were quite satisfactory, and ranged from 81 to 90 points out of a possible 99. The highest individual score was 93, and the lowest 67.

Trainee reaction and comments showed an enthusiastic endorsement of this method of training in fire safety and fire suppression.

As a result of this test run, suggestions were obtained from both trainees and committee critique for improving the subject matter and for including certain introductory or supplementary material. These suggestions will be incorporated in revised lesson plans to provide more efficient instruction.

The 1956 session emphasized the value of complete planning, careful selection of instructors, and building a solid knowledge in fire fundamentals. From this point advanced training in overall fire safety and actual fire assignments can be approached with greater confidence.

HONORARY NATIONAL FOREST WARDEN

A. R. Cochran
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Forty-two years have passed since the first national forest wardens were organized in this Region. These wardens were pioneers and key individuals in establishing fire protection. The group was founded as a ready force to defend the country's forests from fire. Most of the oldtimers have been replaced by members of a new generation, but these pioneers remain an active and important influence behind the warden organization.

When the fire crew leaders reach an age where strenuous fire fighting is not good practice, they can still serve well in fire prevention work. Their experience, training, and standing in the community are strong factors in promoting fire prevention. Most wardens want to feel that they are still a part of the protection force and are needed. If appropriate recognition is given, such as by appointing them Honorary Wardens, their continued interest and leadership is retained.

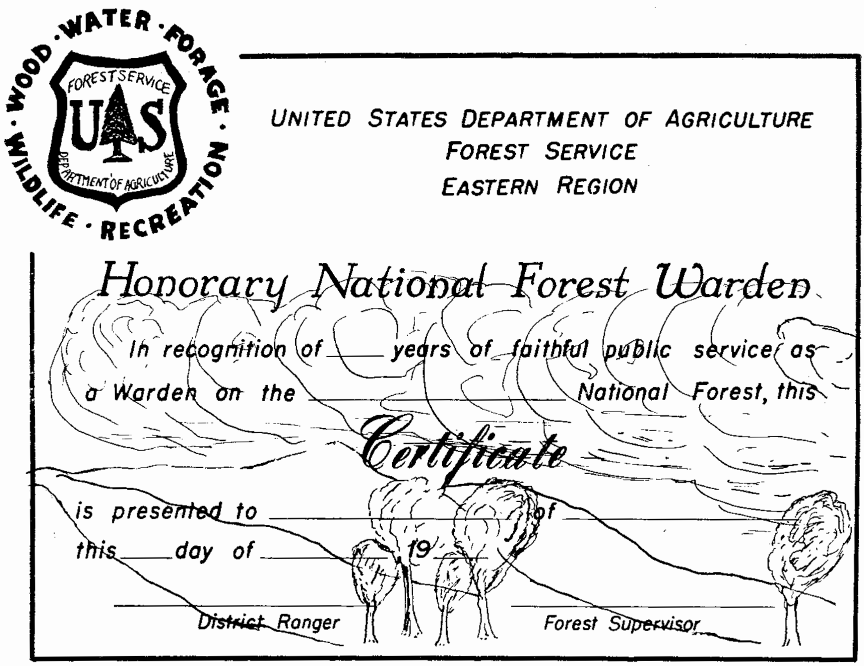

FIGURE 1.—Honorary national forest warden certificate.

The national forests in Region 7 have been quite successful in making the transition from warden to honorary warden. The ranger who promoted the idea held a special dinner at which he presented the "graduating" wardens with honorary certificates prepared especially for the occasion (fig. 1). The press was invited and obtained interesting life stories, featuring battles in the early days to protect the country's resources.

Now it has become standard practice to mark such occasions with ceremony. The retiring warden is presented with a regional honorary warden certificate, appropriately framed, which becomes a prized keepsake because of its association.

FIGURE 2.—Rustic routed honorary warden sign on the Jefferson National Forest.

A routed rustic sign honoring the warden is being used on the Jefferson National Forest (fig. 2). This has been well received. To have an active trained warden organization is good business, but it is also good business to retain the interest and backing of the oldtimers who have played an active part in resource conservation.

OCCURRENCE RATE AS A MEASURE OF SUCCESS IN FIRE PREVENTION

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There is a direct relation between Burning Index, as measured by meter type 8 in the Northeast, and fire occurrence. This is illustrated by the following tabulation of data from District 3, in the northern piedmont of Virginia, for calendar year 1954.[1]

Burning Index range:	Days (*number*)	Fires (*number*)	Rate of fires per day
0-10	164	15	0.1
11-20	88	42	.5
25-40	70	72	1.0
45-80	37	113	3.1
85+	6	38	6.3
Total	365	280	—

The number of fires per day for similar burning conditions varies greatly among districts because of differences in size, seasonal risk, and population trends. However, an increase in fire incidence with an increase in Burning Index, such as in Virginia District 3, is common throughout the Eastern Region. This means that wide fluctuations in fire weather from year to year are usually accompanied by similar fluctuations in fire occurrence. Thus, unless the effect of changing weather on fire occurrence is accounted for, it is impossible to judge whether we are gaining or losing in fire prevention. As an example, District 3 averaged 250 fires per year during the 6-year period 1943-48, and 254 fires per year for the 6-year period 1949-54. Corresponding figures for the State of Virginia are 1,888 fires and 2,151 fires. Such increases in the average occurrence are most discouraging, especially when fire prevention effort has been greatly strengthened and expanded since 1943. An obvious inference is that more severe burning conditions during the latter period increased the average fire occurrence. Although this is a reassuring thought, it does not prove the effectiveness of the fire prevention program, because the fact remains, more fires occurred.

A clearer view of the situation is to compare the annual occurrence to measured fire danger to determine whether the occurrence rate (number of fires per thousand units of Burning Index) is rising or falling. A decrease in the occurrence rate, especially if a downward trend is maintained for a period of years, would be tangible evidence of success in fire prevention.

[1]Data summarized from table 6, 1954 Forest Fires and Fire Danger in Virginia, by J. J. Keetch and M. C. Gladstone, mimeographed report, Southeast. Forest Expt. Sta., December 1955. Selected as being fairly representative of the 68 analysis units in Region 7.

This is illustrated in figure 1 for District 3, Virginia. In the upper graph the total fires and total Burning Index (in thousands of units) are plotted by years 1943-54, the period for which complete records are available. The occurrence rate for corresponding years is shown in the lower graph. Although the number of fires

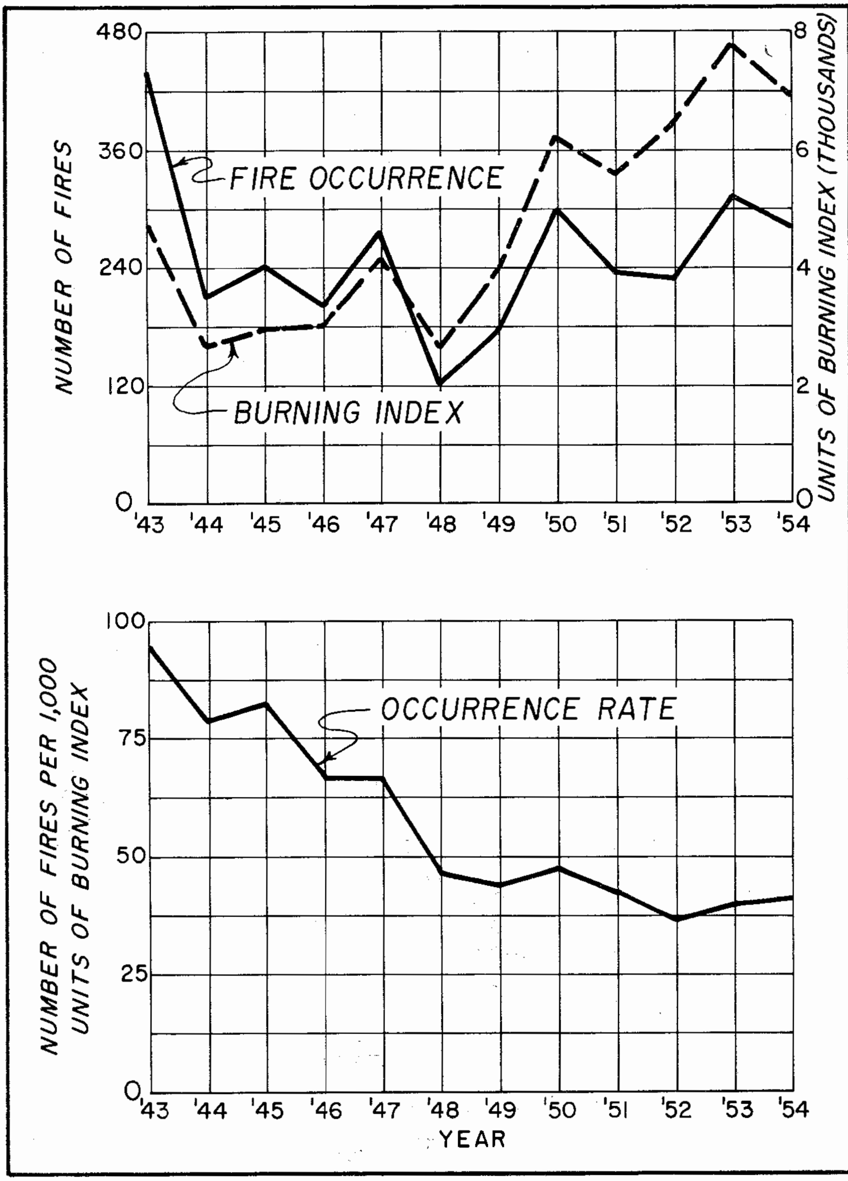

FIGURE 1.—Fire occurrence, Burning Index, and occurrence rate in District 3, Virginia, by years, 1943-54.

varied greatly—from 448 fires in 1943 to 120 fires in 1948, then back to 311 fires in 1953—the occurrence rate shows a fairly consistent downward trend.

Just as the number of fires by districts may be added to derive the total State occurrence, the district occurrence rates may be

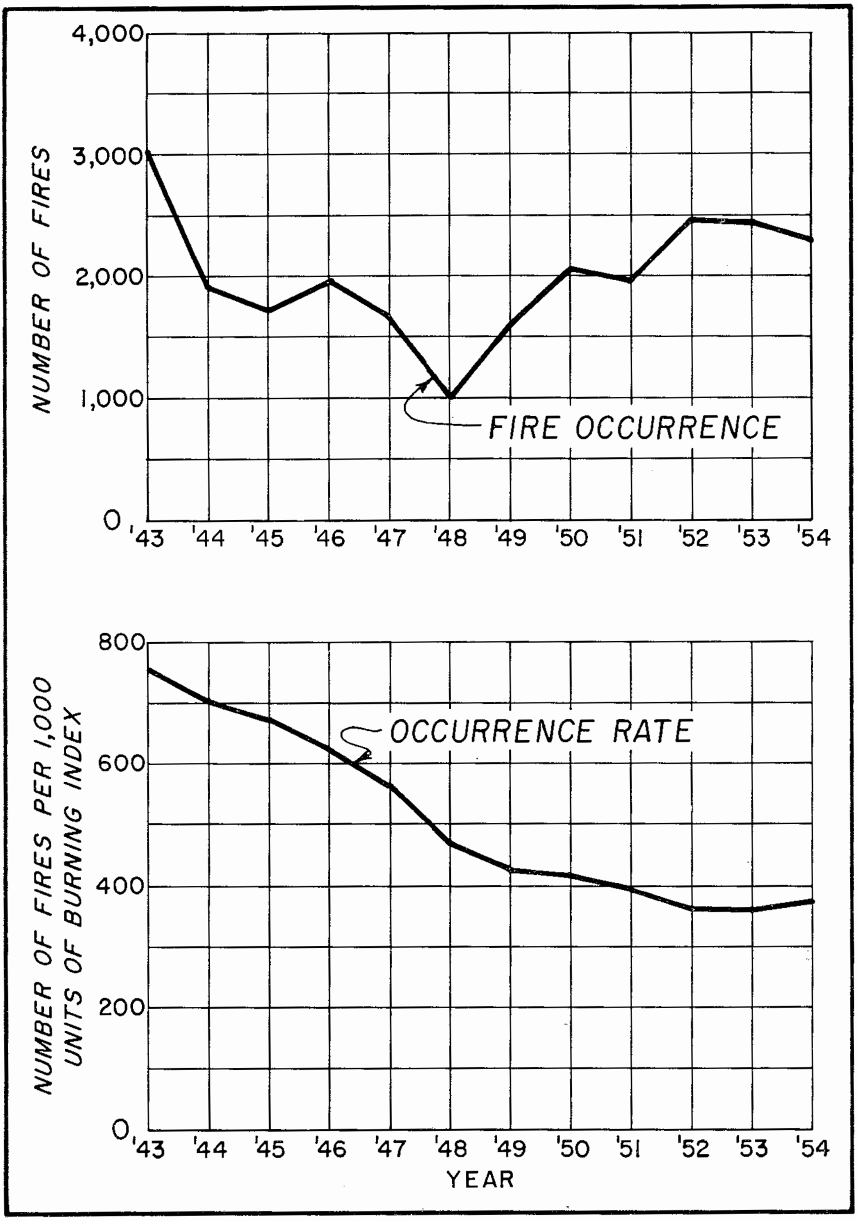

FIGURE 2.—Fire occurrence and occurrence rate in Virginia, all districts, by years, 1943-54.

added to obtain a figure representing the statewide rate. This procedure is illustrated in figure 2, which shows the district totals for the 9 administrative districts in Virginia, 1943-54. After the 1948 season the State Forester could view the downward trend

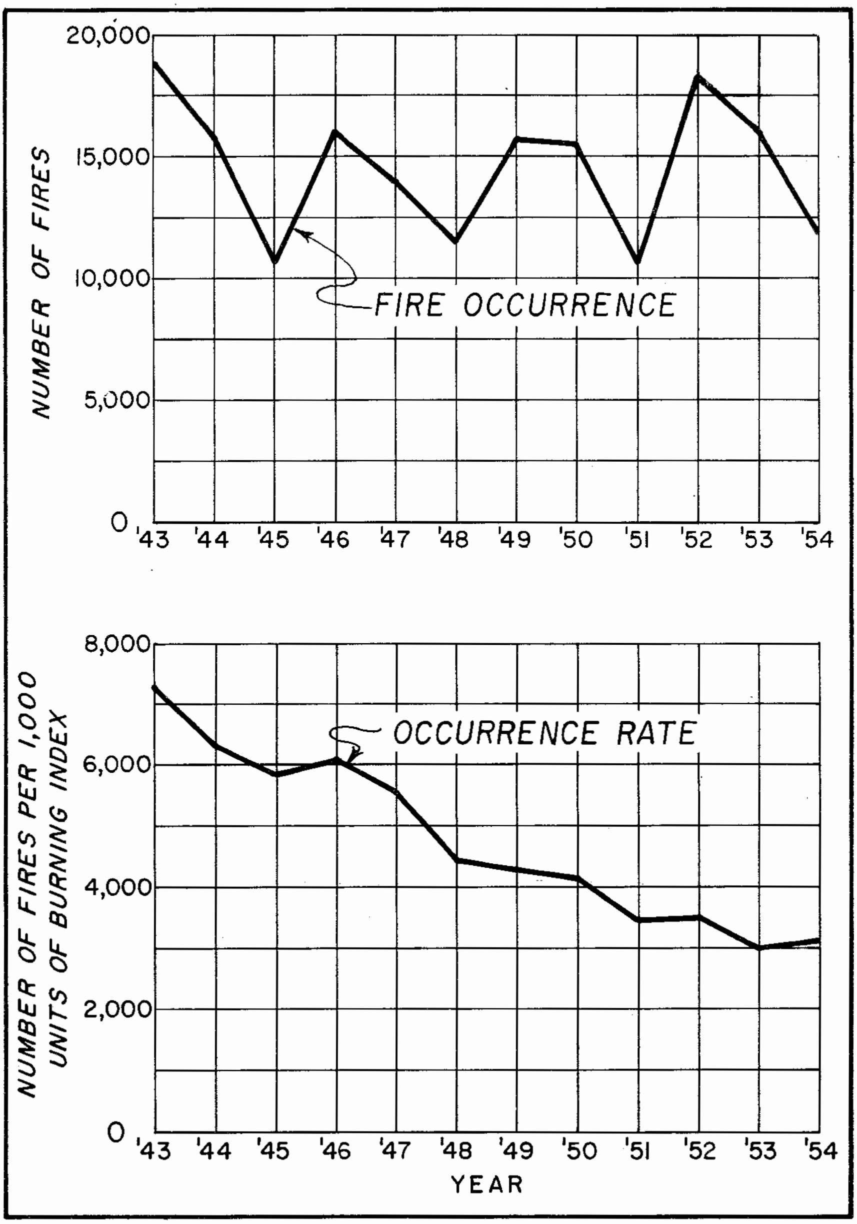

FIGURE 3.—Fire occurrence and occurrence rate in the States of Region 7, except Delaware, by years, 1943-54.

in number of fires since 1943 with considerable satisfaction. However, at the end of the 1954 season he could probably find little comfort in viewing the persistent high level of occurrence since 1948. It all depends from what point in time he chose to evaluate the preceding years of record. The data on occurrence rate in the lower section of figure 2 removes any doubt that the occurrence rate in Virginia, statewide, has been decreasing whether viewed from 1948 or 1954.

Just as the district data build up to State totals, so the State data build up to regional totals. The regional data on number of fires and occurrence rate are shown in figure 3.[2] Regionwide, it would be difficult to claim any success in reducing the number of fires if the top graph in figure 3 is the extent of the record. A trend line averaging the 12-year period would be just about level. The true picture unfolds in the lower graph, where it is evident that the occurrence rate for the last 5 years of the period is much lower than for the first 5 years. The computed reduction based on averages for the two 5-year periods is 44 percent—a definite measurement of success in fire prevention when the effect of weather has been considered. Such a statement is more convincing and is much more useful in fire control planning than to say, "Sure, we are having about the same number of fires as we did 10 years ago, but then, we have more people in the woods and the weather has been worse."

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[2]Fires that occurred on days when the fire danger was not measured are not included. Occurrence in Kentucky was adjusted to the 1954 protected area level. Occurrence in Massachusetts was adjusted to the 1953 and 1954 level of reporting.

INFORMATION FOR CONTRIBUTORS

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

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

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

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

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Remember—Only you can
PREVENT FOREST FIRES!