FIRE CONTROL NOTES

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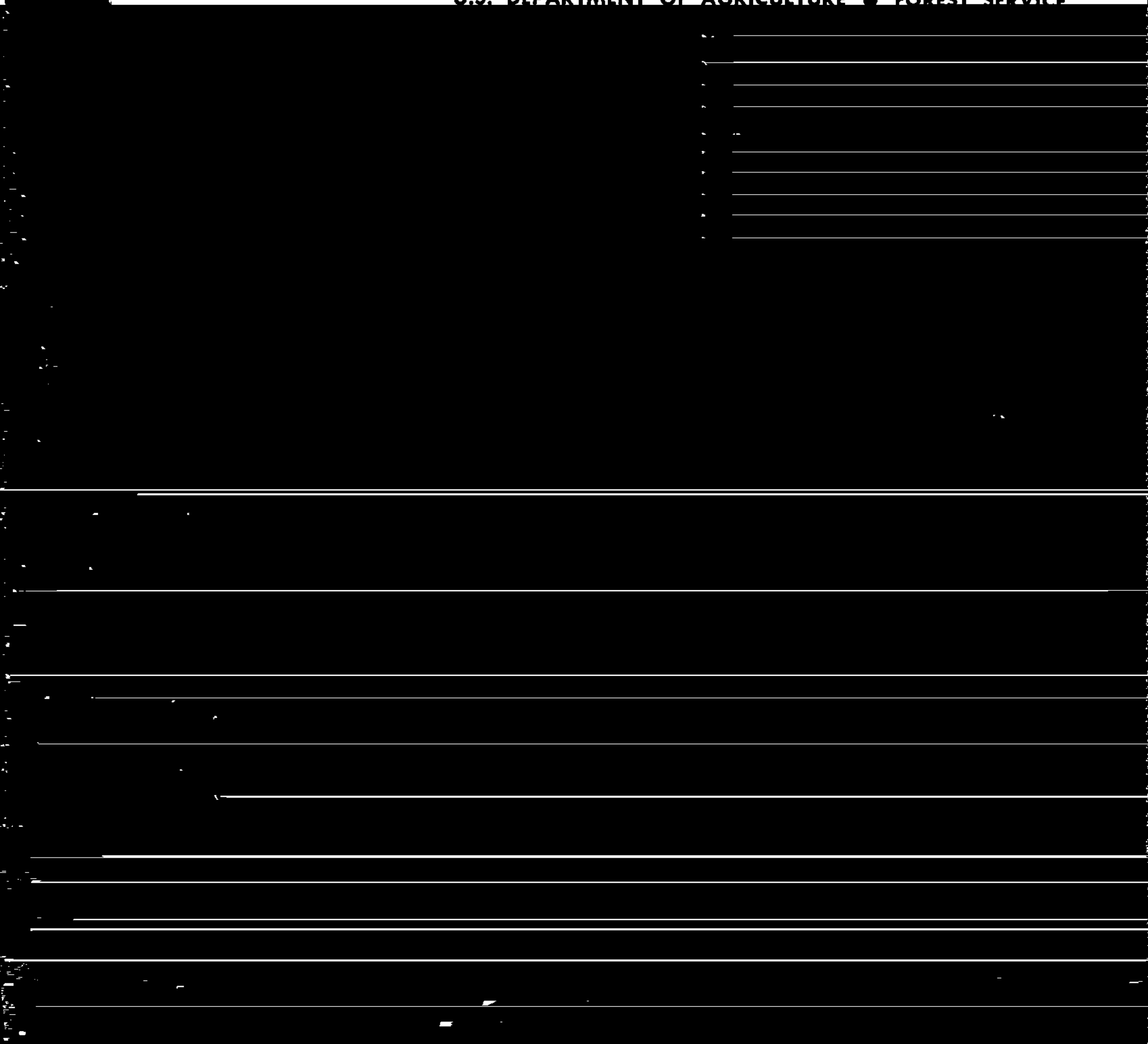

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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COVER—Smoke from slash burning may contribute to air pollution. See story next page.

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Slash Burning: Pollution Can Be Reduced

JAMES L. MURPHY,
LEO J. FRITSCHEN, and
OWEN P. CRAMER[1]

Current research on the effects of slash burning on air quality is concerned with the reduction or dispersal of gaseous emissions and particulates. Guidelines for accomplishing these goals are being developed. The use of other disposal methods is also under study, particularly better utilization of logging waste.

The forest figured early in the history of air pollution, both as a cause and as a victim. Damage to forested areas by smelters was reported in Europe as early as 1884, and throughout the early Twentieth Century in British Columbia, Montana, Tennessee, and various parts of California.

In 1912, Fred Plummer, in a Forest Service Bulletin, called forest fires "the most frequent cause of widespread pollution of the atmosphere." At about this time, the Oregon State Legislature passed a law requiring burning of logging slash, hopefully trading smoke from prescribed fire for smoke and damage from wildfires.

Air Quality Act

In 1967, public concern about the polluted atmosphere resulted in the Air Quality Act, Public Law 90-148. The Engineers' Joint Council policy statement on air pollution and its control has defined air pollution as:

> the presence in the outdoor atmosphere of one or more air contaminants in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.

Attention was focused on the forestry sector, particularly in the Western United States, where fires in the forest caused smoke (cover).

Theoretically, these fires might contribute to photochemical smog such as is found in southern California. Consequently, by 1968, there were six separate research projects in the West investigating, directly or indirectly, the problem of air pollution caused by emissions from the burning of woody materials, and it looked as if the problem and need for research would soon spread to other parts of the country.

Current Research

Three universities in the Pacific Northwest, Oregon State University, Washington State University, and University of Washington, have important research efforts investigating the effects on air quality of burning in the forest. In addition, the Forest Service's Fire Laboratory in Riverside, Calif., is doing research on the air pollution problem.

Forest Burning and Air Pollution Potential

Gaseous emissions from combustion.—Some primary emissions, fumes, exhausts, smokes, vapors, may be the components of further reactions that take place in the air which may cause secondary products which may further contaminate it. In the Los Angeles basin, where natural air movement is restricted vertically by layers of very stable air and horizontally by mountain ranges, secondary products thus formed result in photochemical air pollution which may be even more objectionable than the original emissions. Such pollution is important in areas of great concentration of auto exhaust and intense sunshine; it has not yet been demonstrated whether concentrations of wood smoke under similar conditions support photo-

Figure 1.—Mechanical crushing of slash can reduce fire hazard.

[1] Respectively, research forester and associate professor, Cooperative Fire Research Project, Pacific Northwest Forest and Range Experiment Station and University of Washington, Seattle; associate professor, Forest Resources, University of Washington, Seattle; and principal meteorologist, Forest Fire Laboratory, Pacific Southwest Forest and Range Experiment Station. Stationed at Portland, Oreg.

chemical activity.

Particulate matter.—Of the emissions from forestry burning, the particulate or visible part of the smoke is probably most important—people don't like their mountain views obscured. In comparison with other sources, prescribed burning accounts for less than 2 percent of the particulate produced by all urban/industrial and rural/agricultural sources. Forest fires are more serious, producing possibly five times the particulate from prescribed burning. So the greatest threat of smoke from the forest resulting in reduction of sunlight, visibility, and effects on various plantlife would seem still to be from wildfire.

Evaluating Pollution

Intensity.—The most valid comparisons between air pollution situations must be based on concentrations and durations at locations where the pollutants may become a problem.

Different emission sources will have different effects at different times on the pollution in an airshed. Usually the greatest concentration will be at low elevation in the urban/industrial part of the airshed. Burning on forest or range land around the periphery of the airshed may, under some conditions, contribute smoke to the urban concentration.

Meteorological considerations.—For many years, fire weather meteorologists have been predicting the weather conditions that affect fuel moisture and fire behavior. The fire control specialist's decision to burn or not to burn a given slash area in the Pacific Northwest, for example, has depended on (1) a delicate balance of fuel moistures such that the slash was sufficiently dry for the fire to burn well but sufficiently damp in the surrounding forest so that spread from spot fires would not be a problem, (2) calm or light winds, (3) warm, sunny days and cool nights, (4) a prospect of rain within a few days, and (5) minimum risk of severe fire weather for at least several days following the fire. These conditions usually occur in late summer and early autumn.

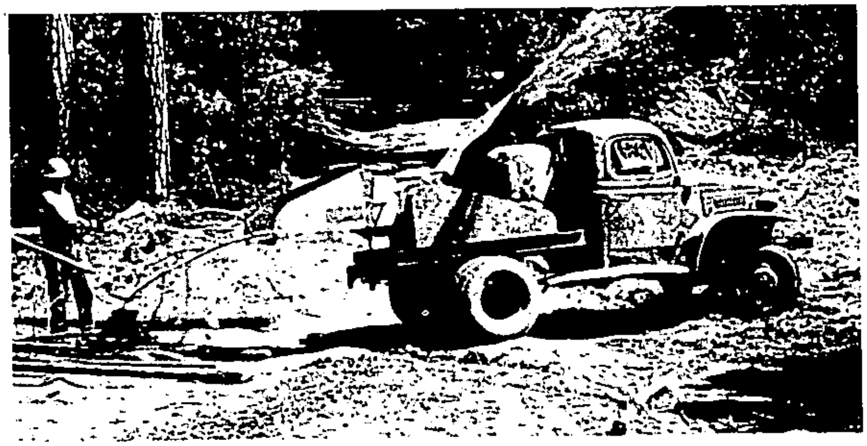


Figure 2.—Chipping slash eliminates need for burning.

Specifications for a good burning situation should also include conditions for adequate smoke dispersal. The most desirable condition is that the wind carry the smoke away from populated areas. Alternatives are that the smoke either should remain aloft, separated from the surface by a stable layer through which it cannot descend or should be greatly diluted by mixing through a deep unstable layer. The smoke dispersion advantage from mountain locations is often further aided in the Pacific Northwest by a persisting, protecting layer of cooler, heavier marine air in the valleys.

Smoke dispersal conditions are usually unfavorable at night and sometimes during the heat of the day in the valleys. So now, during slash burning season, the fire-weather forecaster may have the additional task of predicting winds aloft and stability conditions during night and day over the mountains and valleys.

Pollution Index

Oregon State University scientists have developed a preliminary potential pollution index, a daily numerical statement based on temperature differences between two levels of the lower atmosphere, as observed two or more times per day. In addition, meteorologists say that the bulk of emissions from combustion of wood either are water soluble or act as condensation nuclei. Thus burning into an active rainstorm, while often causing timing problems, would provide a convenient cleansing agent.

Management for prescribed burning.—Relying on meteorological recommendations and scientifically based indications that emissions from burning of woody materials do affect air quality, scientists and managers are cooperating to produce preliminary burning restrictions and management guidelines. These rules vary with the area and fuel involved but generally include time of year and day, weather conditions — including windspeed and direction — and fuel moisture content. Also included is the determination of restricted areas where additional smoke from forestry burning would be undesirable. Such specifications will require detailed weather predictions of atmospheric properties which are not currently predicted, such as new surface and upper air weather conditions from the forecast areas.

Mathematical Models

A new venture like this presupposes backup by research in developing the necessary analysis and forecasting tools for the forecaster and the decision-making aids for the burning coordinator. Along these lines, scientists at Oregon State University have been developing mathematical models of smoke plumes from slash fires. The higher the smoke plume rises, the better the chance of dispersal by upper winds. Estimates are given for the rate at which fuel must be burned in order to achieve a given smoke plume rise under a known set of atmospheric conditions. "Real life" values plugged into the model suggest that the rate of heat generation, important in achieving good plume rise, is usually too small on many slash fires.

Burning and other dispersal methods.—Researchers are studying burning methods which can produce an acceptable plume rise. During the summer of 1968, scientists at the University of Washington, using an electrical ignition and fuel booster system, burned a 20-acre unit of second-growth Douglas-fir slash averaging 50 tons per acre. An estimated 37 tons per acre were consumed by the prescribed burn. The major phase of emission output was over in 1 hour and 15 minutes. The smoke plume broke through a fairly strong low-level inversion and rose to 5,000 feet where it was advected well away from the fire by upper winds.

Alternative methods of slash disposal have been developed. These include:

(1) Use of a machine-loaded *portable burner* which can burn up to 10 tons of slash per hour and costs only about $8 per hour.

(2) *Mechanical crushing* of thinning slash, which reduced hazard rating from extreme to medium at a cost of about $20 per acre (fig. 1).

(3) *Chipping slash* along roads and on more moderate slopes (fig. 2).

Timber sale contracts are concentrating on increased wood utilization also.

Conclusions

Foresters are concerned about the air pollution threat. A serious research effort is underway to determine the extent of the problem and to find solutions. Preliminary indications are that the particulate in slash smoke may be of greater importance than the gaseous components. Management of local fire behavior by fuel treatment and manipulation including sophisticated ignition techniques and fuel booster systems will provide the slash-burning manager with tools for minimizing harmful effects on air quality. Meteorological timing in management of slash burning will do much to reduce the threat of air quality impairment from burning in the forest.

Considerable emphasis is being given to disposal of logging slash by methods other than burning. Total wood utilization is improving, and this means less need for slash disposal in the future—by burning or any other method (fig. 3). And there is a growing sensitivity among foresters to the impact that drifting wood smoke may have in the next air basin—or even on the other side of the mountain. Foresters recognize the problems, and scientists and forest managers are working together to minimize the threat of impaired air quality from forest burning. △

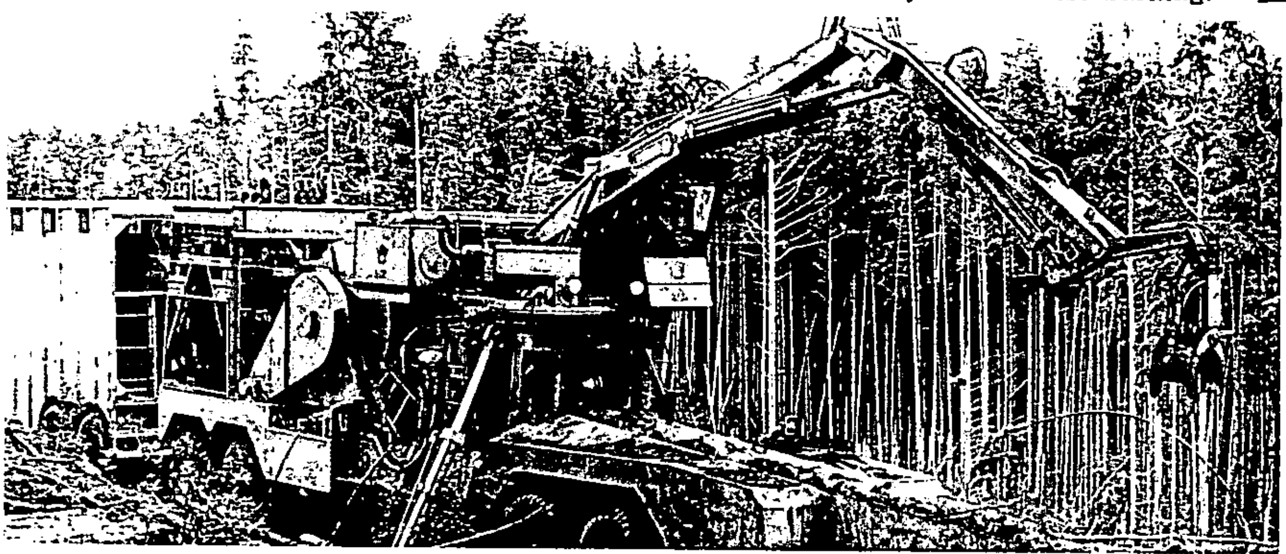


Figure 3.—Greater utilization will reduce the amount of slash and debris left in the forest, a basic solution to the problem of air pollution. Instead of adding to slash fuels, these small hemlock logs are headed for the pulpmill via Crown Zellerbach's Utilizer II chipper. (Crown Zellerbach photo.)

Timelag Useful In Fire Danger Rating

JAMES W. LANCASTER[1]

The timelag principle, applied to natural fuels, has proved to be very useful in fire danger rating. Timelag provides a satisfactory key to fuels classification. Use of an established relationship between actual drying conditions and standard laboratory drying allows evaluation of moisture trends in natural fuels. Field applications are feasible.

Men concerned with wildland fire control have classified fuels for many years. Until quite recently, these classes were fairly general and usually based on physical factors. Adjectives such as flash, fine, light, medium, and heavy have been used as descriptive fuel terms. Fuels are a major factor in the behavior of all fires. Davis (*2*) has included three chapters that are basically concerned with fuels and fire behavior. This book should be included in every fire control reference library.

During recent development of the National Fire Danger Rating System, researchers have investigated the drying rates of various natural fuels. Fuel responses to drying conditions can furnish a means of grouping them into classes. Timelag, a measure of drying rates, provides the key to the classification problem.

Timelag

A more definitive method for considering fuels was stimulated by general acceptance of the timelag principle, proposed by fire physicist George M. Byram.[2] Current practice in fire research and in danger rating has been to use this principle to systematically evaluate moisture responses. Its use has simplified the problem of working with fuels in a wide range of sizes and forest floor depths.

Timelag is an expression of the rate at which a given fuel approaches its equilibrium moisture content, a condition wherein a fuel is very close to being in equilibrium with the moisture content of the air immediately surrounding it. At this stage, no further significant net exchange of mositure will take place. Actually, in nature this is a transitory situation, since the atmospheric conditions surrounding the fuel seldom remain stable for long. The concept, however, is valid and very useful. Byram's concept defined a timelag interval, or response time, as the time required for dead fuel to lose approximately 63 percent of the difference between its initial moisture content and equilibrium moisture content. Usually timelag is expressed in minutes or hours; days have also been used. For clarity, hours are preferred.

For research investigations and comparison purposes, researchers established standard drying conditions of temperature and relative humidity. These have been generally accepted as a relative humidity of 20 percent at a temperature of 80°F., and, depending upon pressure, a dew point of about 56°F. Through laboratory evaluation of moisture responses to standard values, fuels may be compared and conveniently grouped into timelag classes.

Fuel Classes by Timelag

Fuels with very small diameters should respond quickly to changes in the surrounding atmospheric moisture. These fuels are said to have a short timelag. Exposed mosses, lichens, and cured grass have timelags of less than one hour. The uppermost layer of dead, weathered conifer needles in the forest floor probably has a timelag of less than 2 hours. Dead twigs, up to about ¼-inch diameter, will generally respond within 2 hours.

The next logical breakpoint in grouping fuels by timelag falls at about 20 hours.[3] Fuels whose timelags range from 2 to 20 hours occur in a shallow litter-duff layer of the forest floor and also include twigs and branchwood from about the ¼-inch to 1-inch diameter class.

Moving up the time scale, the 20- to 200-hour class consists of a deeper portion of the litter-duff fuels and cylindrical fuels in the 1-inch to 3-inch size range. Larger wood, logs, and very deep duff or organic material constitute the 200-hour plus timelag group.

There is always some uncertainty in specifying exact timelags of fuels. Timelags may vary in natural fuels of the same size but of differing species or condition. Timelag variations in wood can often be tied to structural differences in fiber cavities and pit systems (*6*). Even within a given species, timelags may differ due to surface weathering, rot, locality, exposure, and other conditions. Heartwood and sapwood differ in wood from the same source (*5*). Surface coatings or impregnations of waxes, resins, and other materials also influence timelag (*8*).

Logical Dead Fuel Classes For Fire Danger Rating

Some research has identified timelag ranges for specific fuels —much more is needed. The

[1] Forester, RM Forest & Range Exp. Sta., USDA Forest Service, Ft. Collins, Colo.

[2] Byram, George M. 1963. An analysis of the drying process in forest fuel material. Paper presented at the 1963 Int. Symp. Humidity and Moisture, Washington, D.C., May 20-23. 38 p. (unpublished)

[3] Fosberg, Michael A., Mark J. Schroeder and James W. Lancaster. Classification of dead forest fuels by moisture timelag. (Manuscript in preparation for J. Forest.)

timelag concept can be very useful, however, even though values have not yet been identified in most field situations. By means of timelag classes, proper weighting may be assigned each fuel portion in a heterogeneous natural fuel bed to assist in fire behavior interpretations.

Spread and energy release components for danger rating may be calculated and values assigned to certain timelag classes. These values can be entered into fire danger indexes according to the appropriate fundamental relationships. The physical laws that govern fire behavior mechanisms may thus be fully considered, and the resulting danger rating system will be sound. As fire research provides additional answers, they may be similarly fitted into the structure of the danger rating system.

Fuels with a timelag of 2 hours or less will respond sharply to the normal daily fluctuations of atmospheric moisture. These fuels can best be represented by using the midpoint of their range and classifying them as 1-hour timelag fuels. Such fuels have also been referred to as the *fine fuel* regime (7).

Fuels around the 20-hour timelag show much less response to daily changes in atmospheric moisture content. It is therefore reasonable to use this characteristic to define another breakpoint in a logical fuel grouping system. Fuels in the range of 2 to 20 hours can thus be represented by the midpoint of 10 hours. The 10-hour timelag class may then be termed the *light fuel* regime.

Beyond the 20-hour-class fuels are the deeper duff materials, included in the larger branchwood and stems of the 100-hour or *medium fuel* class. These fuels show very little response to daily moisture cycles, but a definite response to moisture changes over the recognized 30-day cycle. Their midpoint was set at 100 hours.

The next fuel regime, including large logs and very deep duff or organic soils, may require several to many months to dry out. Fuels in this category may be placed in the 1000-hour timelag, or *heavy fuel* class. Heavy fuels respond to extreme drying or drought conditions and to annual fluctuations in the weather.

Because fire control people frequently use the adjectives fine, light, medium, and heavy to describe fuel-size regimes, these terms are proposed for application to the 1-, 10-, 100-, and 1000-hour timelag classes, respectively. The timelag descriptors are preferred but may require some years to gain wide acceptance.

Standard and Field Drying

The preceding concepts help to form the basis and background for a fire danger rating answer to the familiar and important question: "How dry are the fuels?" For a fire manager to get a feel for the timelag principle, however, he needs some basis to relate local field drying conditions to standard defined drying conditions. He will want to know how dead fuel drying in his area today or last week or so far this season might compare to the standard. The National Fire Danger Rating Project recently completed a study that provides the bridge between laboratory and field drying conditions (4).

In laboratory experiments, fuels are often first exposed to specified temperature and humidity values until they reach equilibrium. In our study, we examined the related theories and used mathematical techniques to relate standard to field conditions. We demonstrated that the relationship between the average moisture content of a dead fuel on any given drying day and that of the same fuel under

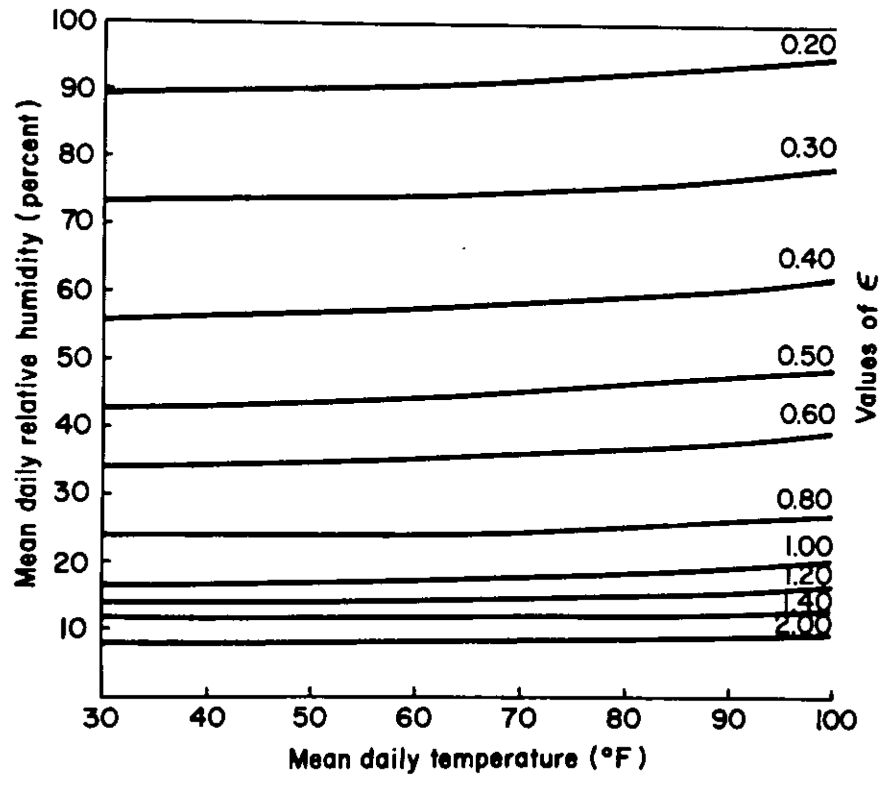


Figure 1.—Graph to obtain epsilon (ε), the relationship between standard and field drying of forest fuels.

standard drying conditions is predictable. This relationship, expressed as a ratio, may be used to evaluate moisture changes in natural fuel beds.

Figure 1 presents this relationship.[4] The resulting ratio, or epsilon (ε) from the graph may then be compared to the standard. A ratio of one means that the drying conditions equaled standard and this was defined as a standard drying day; less than one indicates that drying was less than under standard conditions. A ratio of more than one means that more than standard drying has taken place.

Three or four timelag periods are usually required in nature before most fully saturated (200% M.C.) dead fuels reach the flammable stage, (about 30% moisture content). An additional graph (fig. 2), may then be used to obtain the moisture content at the end of subsequent timelag periods. The beginning moisture content of the fuel must be known, as it is used as one entry to the graph. The other entry is the epsilon value, derived from figure 1. Repeated entry to this graph will enable the user to follow a fuel moisture trend through consecutive timelag periods.

Under standard drying conditions, the following example traces a fuel drying from fiber saturation, about 30 percent moisture content:

Timelag Period	*From*	*To*
1st	30%	14%
2nd	14%	8%
3rd	8%	6%
4th	6%	5%
5th	5%	4½%

If standard conditions are maintained, the minimum moisture content reached will be about 4½ percent. This represents an epsilon value of 1. The minimum moisture content that can be reached at given epsilon values are shown below as M_e.

ε	M_e (%)	ε	M_e (%)
0.15	30.0	0.8	5.6
.2	23.0	.9	5.0
.3	15.0	1.0	4.5
.4	11.0	1.2	3.8
.5	9.0	1.4	3.2
.5	9.0	1.6	2.8
.6	7.5	1.8	2.5
.7	6.4	2.0	2.3

It should be emphasized that drying in most places is usually less than standard. A rule of thumb to follow would be that the epsilon value in a dry climate usually ranges from 0.6 to 0.8; in a humid climate, the values will usually be within the 0.2 to 0.5 range. For any given day, of course, epsilon values may be con-

See TIMELAG, p. 10.

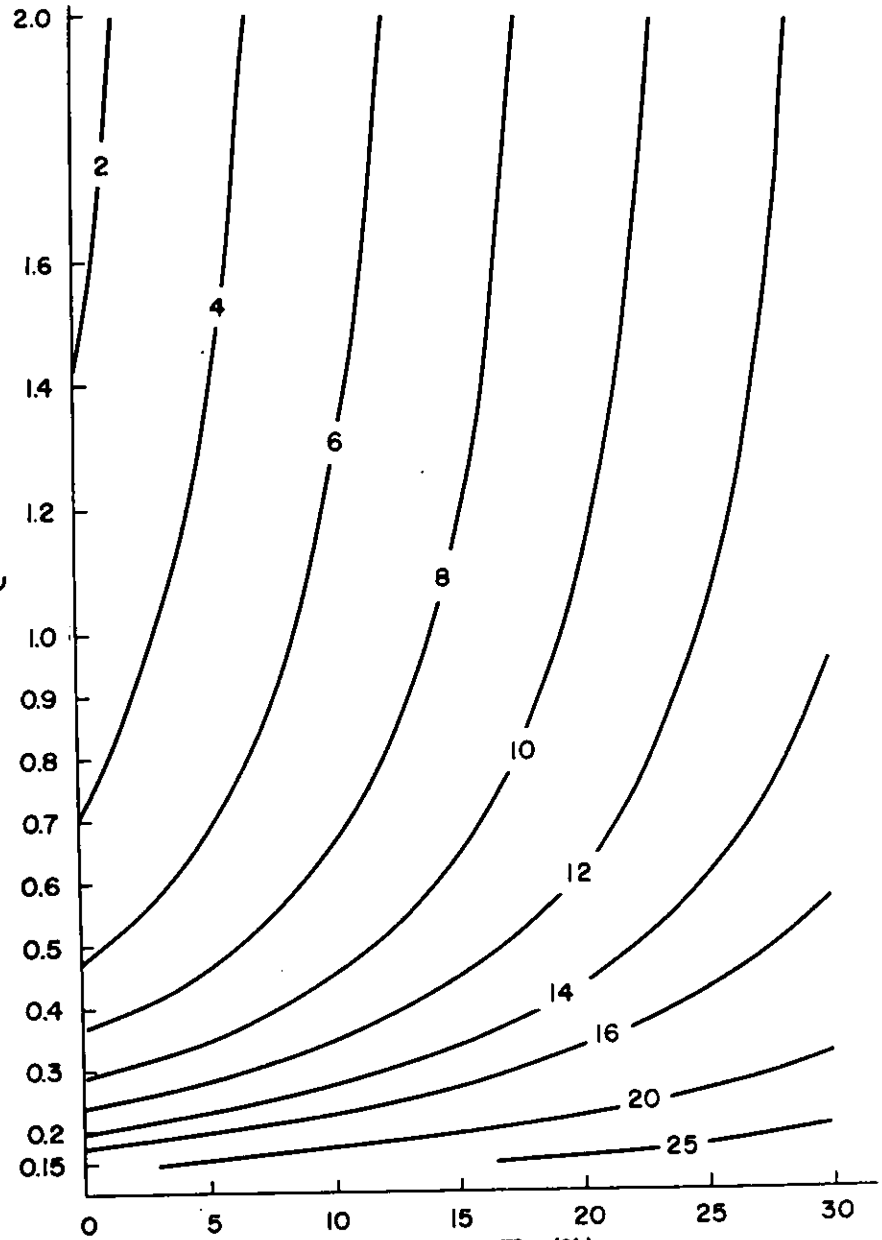
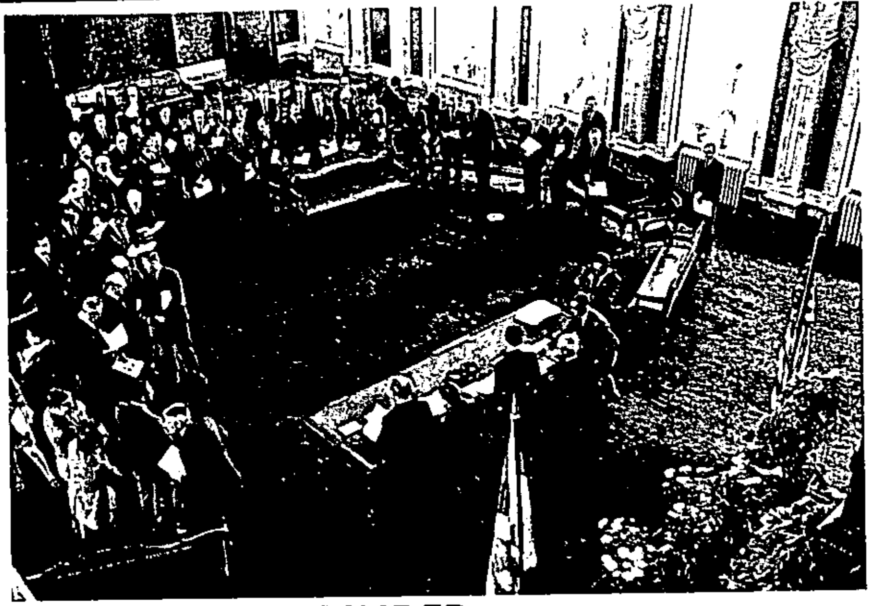


Figure 2.—Graph of moisture content of fuels at the end of a timelag period. m_0 = beginning moisture content; ε = drying relationship obtained from fig. 1. Read moisture content result from curves.

[4] Entries are the averages of daily temperature and relative humidity. Usable averages may be computed by adding the maximums and minimums for the day and dividing by two.



THE QUEBEC JOINDER
Quebec Becomes A Member Of Forest Fire Protection Compact[1]

A. E. ECKES[2]

The Province of Quebec has joined the Northeastern Interstate Forest Fire Protection Compact. Other members of the Compact are Maine, New Hampshire, Vermont, New York, Rhode Island, Connecticut, and Massachusetts.

The annals of forest fire control must record September 23, 1969, as a great, not black, day. All too often, the historical records of forest fire control emphasize the big burns but fail to include significant developments leading to the prevention of fire disasters. Beginning with the Peshtigo Fire of October, 1871, in Wisconsin and continuing through the Sundance Fire of September 1967 in Idaho, there is a long list of fire disasters.

Without smoke, flame, or heat, September 3, 1969, has become a significant date in the world of forest fire control: The Province of Quebec became a full-fledged member of the Northeastern Interstate Forest Fire Protection Compact.

Back when . . .

Throughout the northeastern States and eastern Canada, October 1947 was dry, hot, and dark. A summer drought became an autumn nightmare. In Maine, three major fires — Alfred, Brownfield, and Bar Harbour — burned more than 250,000 acres. Numerous lesser fires burned in the New England States, New York, and Canada. Property losses ran high: homes burned, numerous small industries and businesses wiped out, family possessions lost, and villages and schools destroyed. After the fires, there was a realization that no single State could afford to employ and equip a forest fire organization adequate to cope with such a holocaust.

A Governors' conference, followed by studies by representatives of interested agencies, led to a decision to employ the Interstate Compact device to provide the suppression forces and facilities which would be required should another catastrophic fire situation occur. The 81st Congress enacted Public Law 129 granting consent and approval of Congress to an interstate forest fire protection compact. "Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled, that the consent and approval of Congress is hereby given to an interstate forest fire protection compact, as hereinafter set out; but before any province of the Dominion of Canada shall be made party to such compact, the further consent of Congress shall be first obtained." In 1952, the 82nd Congress enacted legislation which gave consent and approval for joinder of the Canadian Provinces.

A First

These Acts made it possible to establish the first interstate compact for prevention and control of forest fires. The six New England States and New York, along with any State or Canadian Province contiguous to a member State, were specified in the law as eligible for membership. Six states enacted necessary legislation in 1949 and the Northeastern Forest Fire Protection Compact became effective. The legislature of Rhode Island met in 1950 and approved a measure that enabled compact membership.

For 20 years, 1949-1969, membership in the Northeastern Forest Fire Protection Compact remained at seven States. The Canadian Provinces of Quebec and

[1] This article is used with permission from *American Forests* in which it appeared April, 1970.

[2] Forester, Northeastern Area, State & Private Forestry, USDA Forest Service.

New Brunswick indicated interest in membership but encountered obstacles which prohibited an early joinder. But representatives of the forest agencies of these provinces kept working to remove the obstacles. Persistence paid off, and by mid-1969, it was quite clear the Province of Quebec would soon be ready for joinder. September 23, 1969, was the day Quebec was to become a full partner in the Northeastern Forest Fire Protection Compact.

The Ceremony

Invitations were sent out to selected forest fire control people in the United States and Canada to participate at the ceremony in the Legislative Council Chamber and in the presence of the Prime Minister of Quebec, the Honourable Jean-Jacques Bertrand.

The agreement was signed by the Honorable Claude G. Gosselin, Minister of Lands and Forests, representing the Province of Quebec, and Austin H. Wilkins, Forest Commissioner, Maine Forest Service, who is current Chairman of the Northeastern Forest Fire Protection Commission. The Province of Quebec is now a member of the first forest protection compact, and the compact has become an international fire control agency.

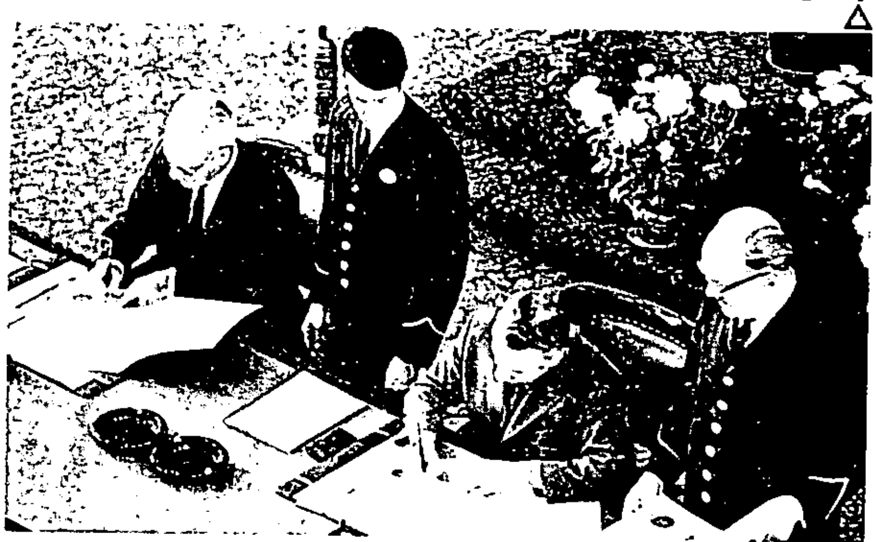


Figure 1.—Ceremony marking the Joinder of Quebec to the Northeastern Forest Fire Protection Compact—September 23, 1969. (Government of Quebec photo.)

TIMELAG, from p. 8.

siderably outside these ranges.

Although standard drying days are not frequently encountered in nature, epsilon values were near 1.0 in 1967, during the large fires (Sundance, Trapper Peak, and others) in the Pacific Northwest. Low humidities and high temperatures close to standard drying were recorded then at many high elevation stations (*3*). Unusually warm, dry nights are often the tipoff that drying conditions are severe.

The days following very warm nights have been identified by Bates as troublemakers in the Southwest (*1*). Since relative humidity is dependent upon temperature, it follows that most such nights also have low humidities. In this situation, fuels with short timelags probably do not partially recharge with moisture at night as they usually do. Many experienced fire people have been aware of this relationship and have used it to advantage in fire control activities.

Conclusions

An understanding of the timelag principle is essential to knowledgeable use of fire danger rating. Certainly in the future, much more use will be made of this concept in fire control work.

Fire managers and others who wish to follow or investigate moisture trends in natural fuel beds now have an additional tool available: the established relationship between laboratory and field drying conditions.

The relationship may be used to evaluate the moisture change of a specific fuel during a time period. It may also be used to compare the time required for a fuel to reach a specified moisture content, under field conditions, with the time required under standard drying conditions. A fuel regime of known moisture content may be followed through several timelag periods to establish its flammability at any point in time.

Fuel classes based on timelag will continue to be a major aid to systematic fuel appraisals. A fundamentally sound fire danger rating system, tied to timelag, should serve fire control purposes well for many years.

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Fire Potential Increased By Weed Killers

CAPTAIN O. L. FORMAN[1]

D. W. LONGACRE[2]

A spray solution of sodium chlorate and metaborate applied to grass and weeds increases their ignitibility in comparison to the same ingredients applied in pellet *form.*

The occurrence of 22 fires along a divider stretch on a freeway in Los Angeles prompted Los Angeles City Fire Department officials to be suspicious of a weed killer used by the Road Department. Tests conducted on this brand of weed killer by the Los Angeles City Fire Department determined that the application of the weed killer did abruptly change the ignition characteristics of grass and weeds.

This report is the result of tests of brands of weed killers consisting of the same basic ingredients in common use by road departments, utilities, and governmental agencies.

It was found that the application of weed killer *sprays* with basic ingredients of sodium chlorate and metaborate to standing grass and weeds abruptly changes the ignition characteristics of grass and weeds to the point that they should be considered highly flammable. Grass and weeds treated with these chemicals can be instantly ignited by cigarettes, and the fire spreads rapidly.

Details of Tests

On April 18, 1969, two separate 10-foot square plots were chosen for the test site. The plots were located near San Dimas Canyon in Southern California on lands of the Los Angeles County Nursery. Ground cover in the plots and surrounding area consisted of assorted annual grasses and weeds typical of Southern California.

Plot #1 was used to test a product with a brand name of Chlorea which came in a pellet form. The chemical composition was 57 percent sodium metaborate, 40 percent sodium chlorate, one percent fenuran, 2 percent inert. This weed killer is commonly used under bridges and other areas where moisture is available. Although it can be mixed with water and applied as a spray, it is commonly broadcast by hand. For purposes of this test, it was broadcast by hand (fig. 1). After broadcasting, it was sprayed by means of a water hose.

Plot #2 was sprayed with a solution of the weed killer by the brand name of Chlorax "40" and water as directed on the package. The chemical composition of this product is 40 percent sodium chlorate, 58 percent sodium metaborate, 2 percent inert.

Inspection

By April 23, 1969, 4 days after treatment, the plots were inspected. Plot #2, the one sprayed with the solution, was already burning brown, but little effect was apparent on Plot #1. On April 29, 1969, Plot #2 had dead weeds lying over, but Plot #1 was just turning brown.

Finally, on May 12, 1969, with the temperature at 73 degrees and a humidity of 62 percent, a lighted cigarette was applied to both plots. The fuel moisture was quite high, and, by scraping a finger along the grass stems, drops of moisture could be squeezed out. The cigarette in Plot #1 simply smoldered until it finally burned out. Immediately upon contact with the fine fuels, the cigarette in Plot #2 started a fast-moving, smoldering type fire accompanied by a hissing sound, similar to the sound made by a burning fuse. Since this fire never broke into an open flame, the investigators finally had to extinguish the burning material to save the plot. Cigarettes were also placed in the grass and weeds outside of the plots during this test but they simply went out.

On July 10, 1969, accompanied by an Engine Company and patrol pumper from the Los Angeles County Fire Department, the investigators again went to the test site. The temperature was 92 degrees, and the humidity was 29 percent. Many lighted cigarettes were laid, buried, and thrown into the dry grass and weeds surrounding the treated plots, but none started a fire. All were allowed to burn out completely, taking approximately 16 minutes for each cigarette.

A lighted cigarette was then placed into the fine fuel in Plot #1. A small smoldering fire final-

Figure 1.—Applying pellet weed killer to Plot #1.

[1] Fire investigator, Los Angeles County Fire Department.

[2] Special agent, USDA Forest Service.

ly resulted but only burned a spot before going out.

Ignition

A lighted cigarette was then placed in the fine fuel in Plot #2, the one which had been treated with the spray solution. Instantly a fire stated and in 6 seconds the fire was well established and spreading rapidly (fig. 2). The Engine Company had to act quickly to save the plot from being entirely consumed. Further tests in this same plot produced exactly the same results. Veteran firemen witnessing the test were appalled at the rapidity of ignition and spread.

Figure 2.—Fire spread 6 seconds after cigarette was placed in plot treated with spray weed killer.

Recommendations

Due to the abrupt increase in ignition characteristics of fuels treated with this type of weed killer, *spray* application along roadsides, trails, and utility pole areas and around camp ground structures should be judiciously practiced. △

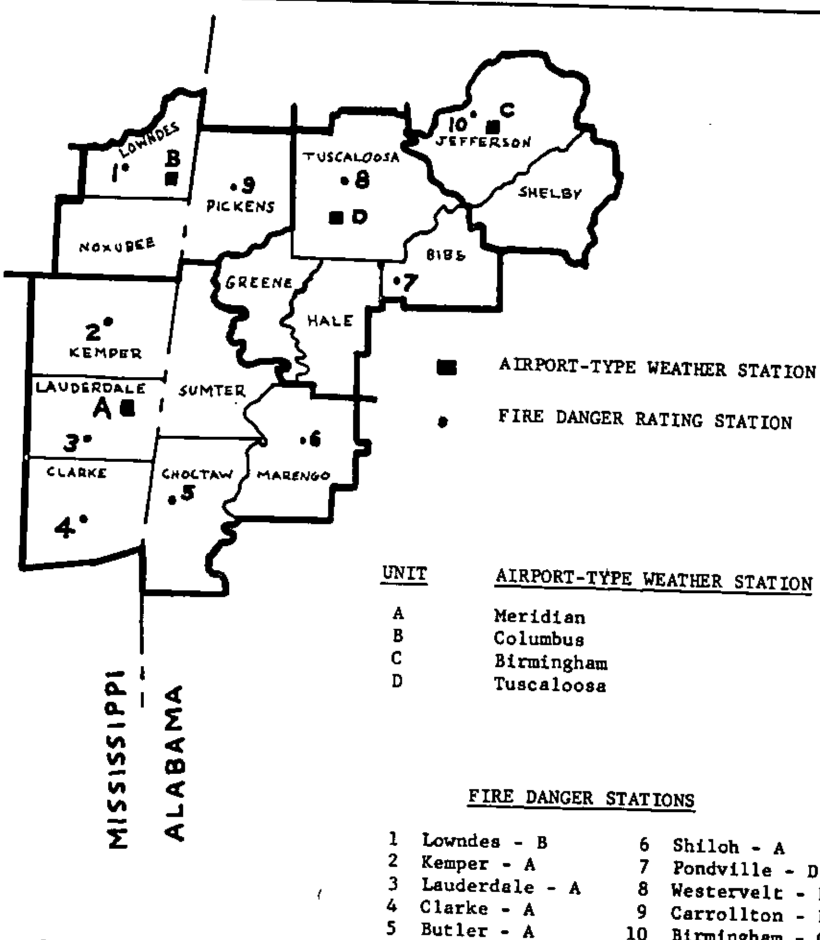

Figure 1.—Fire Danger Rating Study Area.

Can Airport Weather Stations Compute Fire Danger Spread Index Ratings?

RICHARD A. MITCHEM and CHARLES A. PIGG[1]

A comparison was made of the fire danger spread index computed from forest fire danger stations with that computed from airport weather installations to determine if one of these data sources is superior to the other. This comparison was made for each of four unit areas covering parts of Alabama and Mississippi for the time period of February, March, and April, 1966. While exact conclusions are precluded by insufficient data, airport weather installations appear to be an acceptable source of basic information for computing fire danger ratings.

The Object

The object of this study was to compare fire danger ratings made at forest-fire danger stations with those compiled from observations made at standard airport weather installations, and to determine if one of these sources is superior to the other in representing actual fire activity. If forest burning potential is adequately reflected in information gathered daily at airport weather installations, foresters may find it advantageous to incorporate this data source into fire danger measurement planning.

The study area consisted of four unit areas, each with an air-

[1] Respectively, forestry meteorologist, U.S. Weather Bureau and assistant chief fire control, Alabama Forestry Commission, Montgomery, Ala.

port weather installation and one or more standard fire danger stations. Figure 1 depicts the study area and acreage information. The spread indexes were determined by the National Forest Fire Danger Rating System. The 1:00 p.m. data was used at all stations. The spread indexes at the airports were compiled from the 1:00 p.m. weather observations with the exception of 24-hour precipitation that is routinely reported at noon.

The period of time was 89 consecutive days, February 1 through April, 1966. This period of time during the year was chosen since fire activity is usually the greatest and a wide range of burning conditions exist. The data was based on a relatively small population sample. The spread index range was narrow and seldom reached the higher ranges.

Basic Assumption

A basic assumption was made that, ideally, fire activity will increase progressively as fire danger increases. A curve depicting fire activity compared to spread index could take one of a wide variety of shapes, theoretically, but no reversals should occur in its slope. The slope of the curve would be expected to reflect increasing values of fire activity to increasing value of spread index in every instance. Because of the limited data used in this study, other factors not related to recognized elements of fire danger may have distorting effects on fire activity. These factors may include, among others, detection and suppression capability and varying fire risks. The assumption is further made that the effects of these variables do not invalidate, although they may distort, the relationship between fire activity and the fire danger rating.

Procedure

For each unit, the fire danger each day was rated, using two sources of fire danger data: the spread index from fire danger stations and the spread index from airport weather installations.

In order to consider all the fire-danger stations in a unit, a weighted average spread index was determined. The weighting was based on the area served by each danger station in each unit.

In order to facilitate handling of data, the spread indexes were grouped into the following categories: 1-2, 3-5, 6-10, 11-15, 16-20, 21-30, 31-40 and greater than or equal to 41 (≧41).

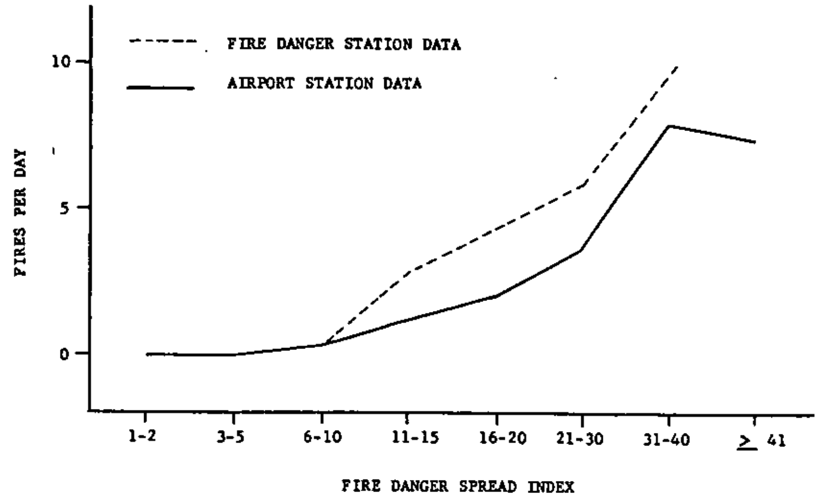

Figure 2.—Comparison of ratings based on forest fire danger station data to ratings based on airport station data, Unit A.

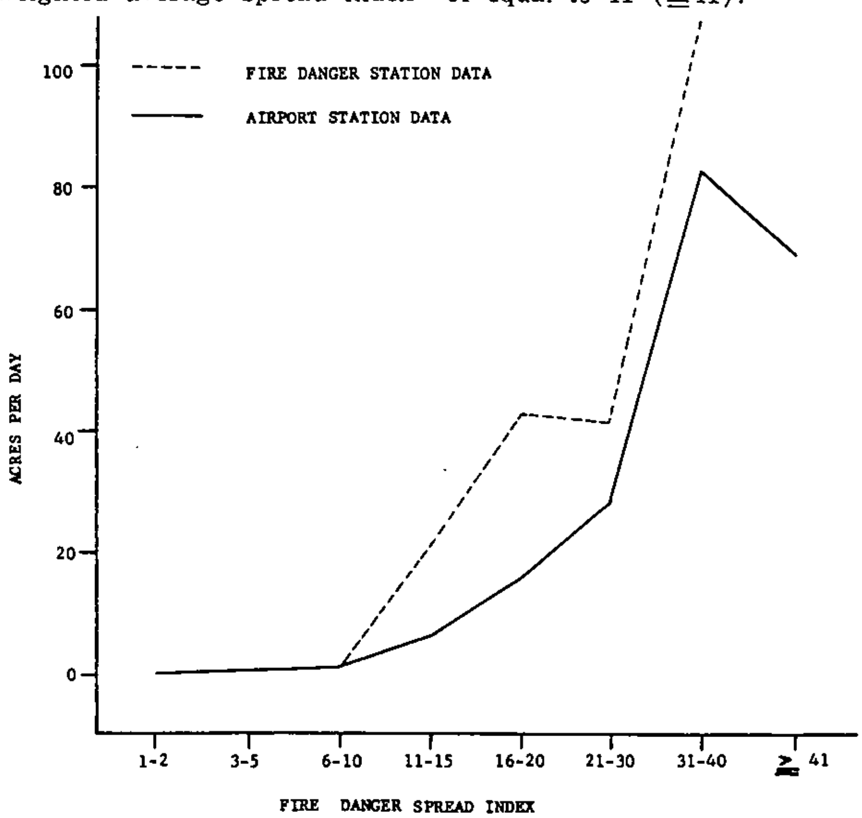

Figure 3.—Comparison of ratings based on forest fire danger station data to ratings based on airport station data, Unit A.

The number of wildfire starts reported and the area burned each calendar day was determined for each of the four study units. Then for each fire danger data source, this information was tabulated for each Spread Index Category.

From these tabulations, average number of fires per day and average acres burned per day were computed for each Spread Index Category. For brevity, typical results for the study units are characterized by figures 2 and 3, which depict the actual values for Unit A. Specific descriptions and values for the units are available from the author on request.

Results

With some deviations, all four units show essentially the same results: in the great majority of cases, ratings based on forest fire danger stations depict higher fire activity per spread index category than ratings based on airport data.

Difference in wind speeds for airport stations and forest fire danger stations are thought to be the reason for the differing curves. Wind speed is an important factor in spread index—the higher the wind speed, the greater the spread index.

Wind speeds at airport weather installations are generally greater than at forest fire danger stations. This would make the spread index for any particular day usually higher for ratings based on airport data than for ratings based on forest fire danger data. Consequently for most days the spread index based on airport data would be thrown into a higher category than that based on forest fire danger stations.

Thus, for airport data ratings the spread index categories of 16-20, 21-30, and 31-40 would collect a number of days when only a small amount of fire activity occurred. This being the case, spread indexes for these categories would show less fire activity on the average for airport based data than for forest fire danger based data.

Additionally, because of greater wind speeds at airport-weather installations, ratings based on this data would have more days which fall in Spread Index Category of ≧41. Airport based data had spread indexes in the category in all four units, while forest fire danger based data had spread indexes in this category in only one unit.

Short Range Data

Due to the rather short range of data, the authors hesitate to state definite conclusions. In general, the danger rating curves based on airport data follow a more theoretically logical form than that based on forest fire danger stations. Additionally, the airport data curve is smoother and shows fewer reversals. The airport based data curve does show a reversal in some units at Spread Index Category ≧41. This dip may result from public awareness and therefore guardian action on critically hazardous days.

Even though the airport data curves indicate greater smoothness and theoretical applicability, the forest fire danger data curves seem to be more valid when the spread index ranges used to define Class of Day are applied; i.e., Class Four days are usually bad burning days, which is quite clearly depicted in the forest fire data curve but not in the airport data curve. △

Portable Calibrator Developed For Anemometers

PAUL W. RYAN[1]

Establishment of anemometer turning-rate curves can be easily accomplished by using the portable instrument described. Through use of centrifugal blowers, the calibrator generates discrete turning forces which are calibrated in terms of true laminar windspeed. The calibrator was built to accommodate Stewart anemometers but can be used with any anemometer of that size or smaller, or it can be enlarged for larger types. Parts to duplicate the instruments should cost approximately $50.

Calibration of anemometers used in fire-danger stations must be performed routinely if accurate windspeed readings are to be maintained. Periodic recali-

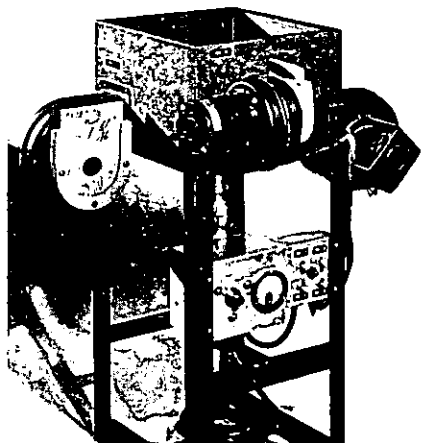

Figure 1.—The portable calibrator: air restriction devices mounted over the fan inlets control the rotational force applied to the anemometer cups.

[1] Fire systems analyst, Southeastern Forest Experiment Station, Southern Forest Fire Laboratory, Macon, Ga.

brations are not done by many organizations simply because they do not have access to an adequate calibration system. Wind tunnels which generate closely controlled, accurately known windspeeds are ideal for anemometer calibration but are not generally available.

Portable Calibrator

A portable calibrator for anemometers (fig. 1) has been developed which may be used when other, more sophisticated systems are unavailable. It does not rely on true windspeed, but employs what can be called a "calibrated turning force." This instrument has been used in Georgia since early 1966 when a pilot program of periodic anemometer recalibration was instituted. The anemometers in 36 of Georgia's fire-danger stations have been marked for identification and every year are overhauled, including stripping and cleaning, replacement of parts as necessary, lubrication, reassembly, and recalibration with the portable instrument.

Advantages

This process takes less than 1 hour per anemometer and has resulted in substantial improvement in the accuracy of windspeed readings taken at these fire-danger stations. The first checks on some of the anemometers, for example, revealed calibration errors as high as 28 percent. The maximum change in calibration detected in subsequent yearly checks has been about 5 percent, with an average for all anemometers running around 2 percent. Portable calibrators similar to the ones used in Georgia would be helpful to other organizations in maintaining their anemometers.

Construction

The portable calibrator was built to accommodate Stewart anemometers. The calibration chamber is a Bud box (type Cu881) and measures 12x11x8 inches. This is supported by a framework of $1\frac{1}{2}$-inch angle iron. Detailed construction plans are not presented since the size of the calibrator would be altered for other anemometer types. Little trouble should be encountered in duplicating the unit or in building a similar one after examining figures 1, 2, and 3.

The "turning force" of the calibrator is provided by four motor-driven centrifugal fans mounted so the airstream emanating from them crosses the path of the rotating cups tangentially. The anemometer is aligned and held in position by means of a bushing in the center of the chamber bottom and a pipe support clamped at the base of the unit. Care should be used so that anemometer cups are always in the correct position, i.e., directly in line with the airstreams

Versatility

The inlet from each fan is fitted with a wooden frame which accepts any one of several air restrictors. Various combinations of energized motors and air restrictors can be selected to cover the range of the instrument. For example, our calibrator develops a turning force equivalent to a true wind of 8.8 m.p.h. when motor number one is energized, and it has a restrictor with a $1\frac{3}{16}$-inch hole in place. All other motors are deenergized with solid restrictors in place. The highest speed generated by the calibrator is 23 m.p.h.

The four fan motors are parallel wired and have individual switches so that any combination may be activated at one time. Voltage to the motors is controlled by a variac and monitored by a meter. Line voltage should be set at the same level each time the calibrator is used.

Cost

New parts to duplicate this calibrator should cost approximately $50. The blowers represent the largest single cost; they are 60 c.f.m. units, available for about $7.50 each.

After the calibrator is constructed, the "turning forces" generated by various combinations of energized motors and air inlet restrictors are calibrated with the aid of a "standard" anemometer. This standard must be one of the general class to be calibrated and must have known turning rates for given true windspeeds. Preferably the standard anemometer's turning rate characteristics should be accurately determined in a wind tunnel. If this is not possible, the standard could be a new anemometer with no defects. A new anemometer will probably follow, within a given tolerance, the general calibration curve established for its type by the manufacturer. Lower calibration accuracy may result if this alternative is followed. Once the standard anemometer has been selected it should only be used for maintaining a check on the accuracy of the portable calibrator.

The Design Theory

The design theory behind the rotational characteristics of anemometers is based on the assumption that the cups will be turning in laminar airflow. This type of airflow is created in the test sections of well-designed wind tunnels and is found in natural wind fields when there are no turbulence-producing obstructions. This calibrator does not produce a laminar windflow; however, the "turning force" it generates can be calibrated in terms of true laminar windspeed. Instruments calibrated in the unit will therefore read true windspeed under operating conditions. △

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OFFICIAL BUSINESS

Mobile Communications Centers Tested

DIVISION OF FIRE CONTROL[1]

Large fires require extensive and complicated communication. A self-contained, mobile communications center has been suggested as one way of meeting this need.

A number of these vehicles are already in use by police, fire departments, civil defense agencies, and others. Several were investigated by the Beltsville Electronic Center to determine their suitability for use on large fires. The following ten categories were used to evaluate the mobile centers:

1. Acoustics within vehicle.
2. Ventilation, air conditioning, and lighting in operator's area.
3. Readiness of communication equipment for use:
   - (a) Radio (including all nets used on fires).
   - (b) Telephone.
   - (c) Public address system.
4. Mobile antennae.
5. Masts for raising antennae.
6. Provisions for extending controls to another operating center.
7. Adequate space to operate base consoles.
8. Self-contained power source.
9. Flexibility of movement—either under its own power or towed.
10. Fixtures and equipment permanently mounted to protect against damage in transit.

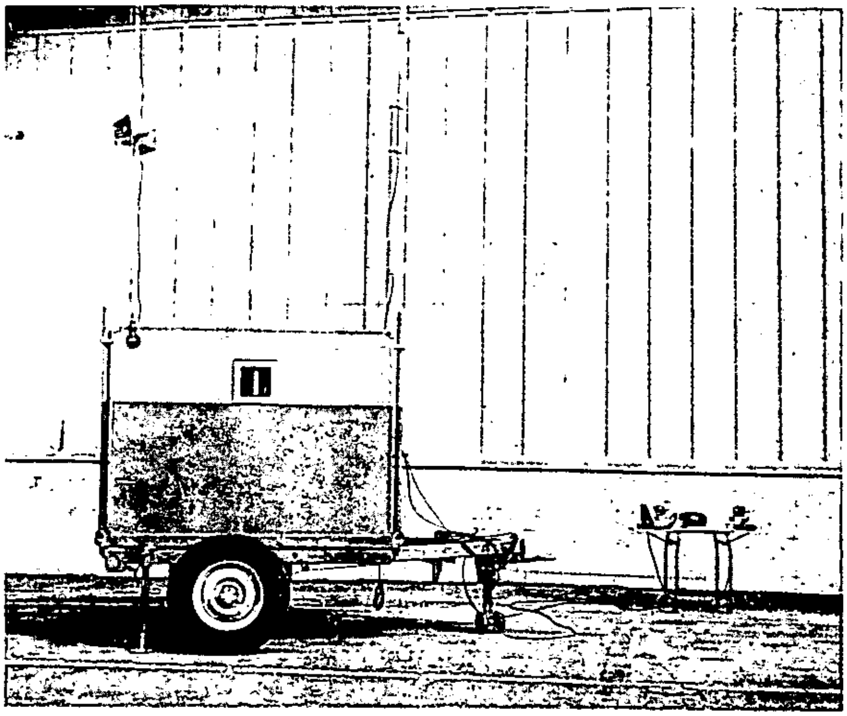

Figure 2.—Top view: the anemometer cups inside the test chamber rotate in response to the airstreams produced by the blowers.

Large Buses Used . . .

Large buses, vans, and trailers are often used as communication centers. The mobile center designed by Kenneth P. Green, electronics technician on the Mendocino National Forest appeared to meet best the requirements of the Forest Service in California. The Beltsville Electronics Center, Bldg. 419 ARC, Beltsville, Md., can provide more information on this mobile unit.

Fire communication needs will determine the most effective type of mobile center for each individual agency. Equipment criteria will vary according to the agencies' protection responsibility and wildfire load. △

[1] USDA Forest Service, Washington, D.C.