The Team Approach to Forest Fire Research

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A HALF DOZEN decades have passed since many public and private agencies took an organized stand on wildfire on forest and rangelands. As the years went by, a critical appraisal of the fire control management job has been made by more and more land managers. This critical appraisal has brought into sharp focus the need to know what makes fires behave as they do. Most of us are still perplexed at the unexpected behavior of the occasional fire which defies our most determined efforts to control. Thousands of free-burning wildfires have been *observed* but they are difficult to really *study*. We cannot hold specific behavior factors constant while we concentrate on studying the effects of another. Furthermore, we cannot duplicate the combinations of these factors for further study under identical situations.

It was clear that a more detailed and fundamental approach was needed if we were to step up our rate of obtaining knowledge of the interactions of fuel, terrain, and weather variables. The forest fire had to be brought to the laboratory where it could be studied one component at a time. No adequate forest fire research laboratories were available. The Southern Forest Fire Laboratory, opened in 1959, represents the first major research facility of its kind in the country. Constructed and maintained by the Georgia Forest Research Council and staffed by scientists of the U. S. Forest Service, this center of research is located near Macon, Georgia. The Georgia Forestry Commission furnishes workshop facilities. The Council and the Commis-

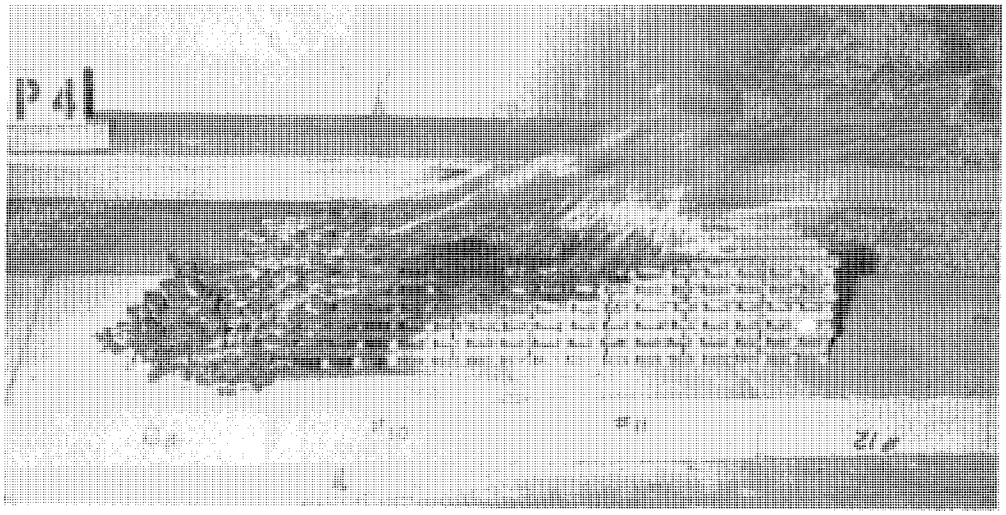

Fig. 1. Test fire in a wind tunnel with wind speed of four miles per hour.
U. S. Forest Service Photo.

sion both contribute funds. Administration of research studies is provided by the Southeastern Forest Experiment Station with headquarters in Asheville, North Carolina. It is readily apparent that here is another excellent example of the cooperative federal-state approach to a national problem.

Within the framework of five carefully analyzed and described projects, between forty and fifty individual studies are generally being carried on simultaneously. These studies may require from only a few months to several years. Some of the more basic ones will undoubtedly continue for many years; there is so much to be learned.

One of the basic projects at the Southern Forest Fire Laboratory deals with modelling of fires in reproducible fuel beds. Studies under natural outdoor conditions have resulted in little more than qualitative descriptions. Theoretical work combined with modelling under controlled conditions provides quantitative data.

Cribs of wood of square cross-section are burned, using a steady-state technique to learn the effects of fuel size, spacing, moisture content, and density on such behavior characteristics as rate of spread, intensity, and fire-induced convective activity. From analyses of data, scaling laws applicable to natural fuels can be identified. Thermal and aerodynamic properties of burning embers are studied because of the fire spotting potential involved. Work on application of various fire retardants under forest conditions is complemented in the laboratory through retardant evaluation using the same type of wood crib employed in basic modelling studies.

Another basic project at Macon deals with the mechanisms of energy release in free-burning fires. The rate of energy release is a most fundamental fire variable. On a five-mile front of a large forest fire the energy output is roughly equivalent to the house heating requirements of the U. S. during a severe winter cold wave. We need a better understanding of the complex interactions among the fire, the fuel energy source, and the environmental topographic and atmospheric factors. This increased understanding is necessary if we are to predict whether a fire will behave in what we call a "normal" manner or will suddenly increase its rate of energy output to the "blowup" level. The objective of this project is to study the basic physical processes governing rate of energy output and to develop this knowledge toward ultimate prediction of fire spread and behavior. This will significantly help in improving fire control management and fire-fighting safety. Future work will include studies on structure of convection patterns and the effect of vertical profiles of wind speed and temperature on convection structure, updraft speed, and column temperature. This is the area which includes the "fire whirlwind" phenomenon. Fortunately, fire whirlwinds occur in a small percentage of forest fires but when they do occur the project-type fire may result.

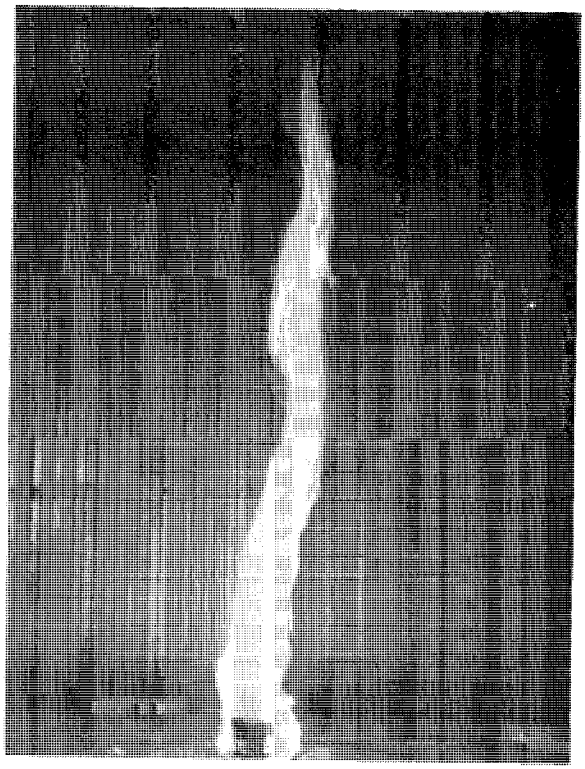

Fig. 2. This fire whirlwind is produced by air jets arranged in arcs around the central fire. The burning rate of the 6-inch wood crib may be increased several times by this 7-foot whirl. U. S. Forest Service Photo.

A third project, largely of an applied nature, includes studies with the emphasis on weather, although weather we all know is something which makes itself felt in any forest land management activity. Our weather studies at the laboratory are headed up by a research meteorologist as project leader. A fire-weather forecaster, meteorological technicians, research foresters, and forestry aides work on studies directed at identifying the influence of weather and climate on fuel and forest fire behavior. We need a better understanding of the effect of vertical dimensional variations of wind, temperature, and moisture on stability, convection, and subsidence. Research is pointed at improving daily forecasts of fuel moisture, relative humidity, and wind speed as related to fire danger measurement. Examples of the type of information needed by fire control managers are: accurate predictions of elements entering into fire danger estimation, the probabilities of weather changes in the cases of going fires, weather favorable for prescribed burning, and warning of the development of atmospheric conditions conducive to blowup fires. This last item of needed information is highly significant. Present knowledge makes it doubtful if these adverse conditions could be predicted with a fair degree of accuracy. This area of research is exceedingly difficult but there is urgency for obtaining results which will increase advance warning time.

A major project is devoted to the use of prescribed fire as a management tool. Prescription fire is being discussed in another section of this Conference.

The ultimate objective in any fire control management study is probably to recognize the type of fire control organization (people and things) which will do the best job at least cost. At Macon, we have a major project dedicated to this objective.

It is evident that the diversified types of projects and studies already mentioned briefly require scientists with diversified disciplines. No single project or study can be effectively carried on without coordination with other projects and studies. All of the scientists are concerned with the same forest resource. To do needed research toward management of this resource, it is highly important that the work is not located at widely scattered geographic locations. Each individual research activity cannot economically afford the diversity of disciplines required. Neither can it afford the complex of facilities

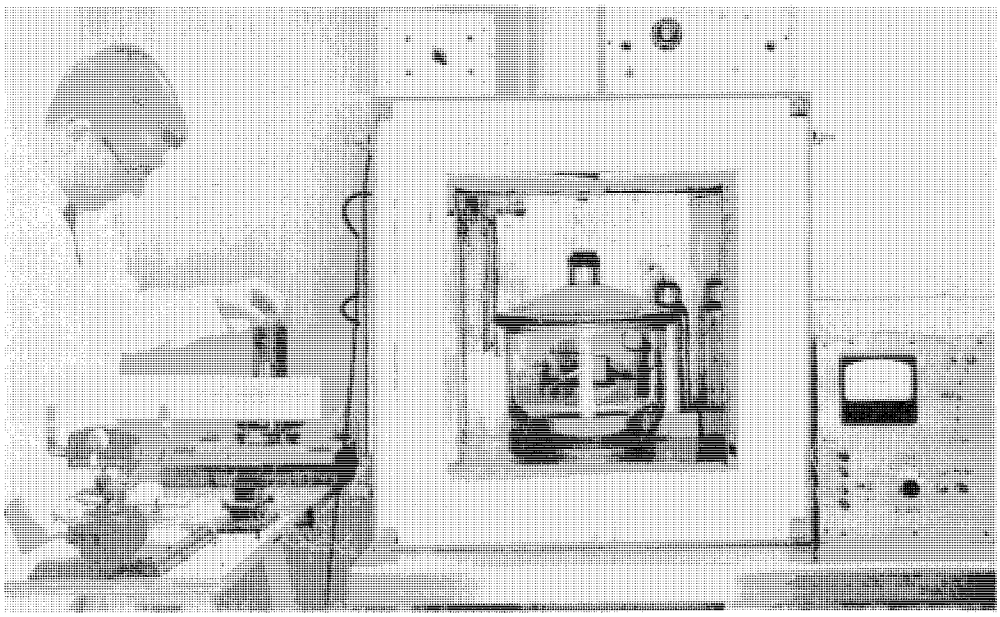

Fig. 3. Thermal conductivity of bark is being measured to obtain better insight into the fire resistance of trees. U. S. Forest Service Photo.

necessary. At times, each of the projects will need the knowledge held by research foresters, meteorologists, chemists, physicists, mathematicians, statisticians, soil scientists, technicians, aides, clerical personnel, and administrative people. One way to provide these needs is to pull these disciplines and skills together at one place and approach the job as a team effort. This has been done at the Southern Forest Fire Laboratory.

It is not reasonable to assume that *all* forest fire research needs on a national scale (or national research needs in any other functional field) can be carried on at one location. Therefore, a logical step is to have several team approaches at carefully selected sites. The coordination then is between the teams at different locations in a manner similar to that needed between the projects and studies at any one team location. This has been done in the case of forest fire research.

The second major forest fire research laboratory in the United States was dedicated in September 1960 at Missoula, Montana. This facility, the Northern Forest Fire Laboratory, is owned and operated by the U. S. Forest Service, administered by the Intermountain Forest and Range Experiment Station, with headquarters at Ogden, Utah. As at the Southern Forest Fire Laboratory, basic and applied research work is directed at solving problems in areas of study as-

signed so that its activities are coordinated with those at other laboratories with a minimum of duplication and missing links in the overall research program.

At the Northern Forest Fire Laboratory, fundamental work on Project Skyfire includes studies on the basic characteristics of the mountain thunderstorm and its lightning discharges. This means finding out where, how, and when these storms form and how they grow and move; how the precipitation process functions, how electrical fields develop and change, and how lightning strikes occur. On Project Skyfire, investigations are being made on the possibility of reducing lightning severity through weather modification. Studies at Missoula in the fire physics program include research on fire spread and fire aerodynamics. Physical and chemical properties of forest and range fuels are studied. Detection research is pointed toward tracking of lightning storms with specialized equipment. Prescribed fire research is naturally directed toward meeting the management objectives in western timber types.

The third and last of the planned network of major fire research laboratory facilities is under construction at Riverside, California, and is scheduled for completion in July 1963. This laboratory is owned and will be operated by the U. S. Forest Service and administered by the Pacific Southwest Forest and Range Experiment Station, with headquarters in Berkeley, California.

The research work at this western laboratory is coordinated with that of the other two facilities and is both basic and applied in nature. Long-term fire behavior studies are under contract with the Office of Civil Defense. A fuel moisture study has been started. Studies continue on marine air and fire weather analyses. New fire and fuel measuring instruments have been developed. Recent studies indicate that viscous diammonium phosphate may be an economical and effective roadside fireproofing material. Field work on a conflagration control project has started. This is a joint research-demonstration project involving the Experiment Station, Region 5 Fire Control Division, and the Stanislaus National Forest. The object is to supplement land management practices with hazard reduction measures which will break up critical fuel areas. Preliminary analysis of data emphasizes the extreme cost of hand operations on fuel break construction: about three times the cost of tractor clearing.

Operations research techniques are being used in a study of fire control systems. A mathematical equation has been developed to describe a pattern of fire behavior, in which growth accelerates until some point after attack and then decelerates until control is effected. This model is in its early stages but shows enough promise to warrant further development.

In the field of physics and chemistry of combustion, more detailed experiments are under way to look into the role of mineral content in combustion of cellulose and related fuels. There is evidence that nature and rate of combustion may be drastically altered by small changes in inorganic salts present in the fuel.

Forest fire research is not limited to only these three laboratories mentioned. Work is carried on at seven forest and range experiment stations other than those administering the major laboratories. The Forest Products Laboratory has long been active in fire research with special emphasis on forest products in various stages of manufacture. Research at each of these additional locations is coordinated with that at other locations.

Forest fire research is truly a team effort.