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Fire Management Notes

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Contents

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Cover: Some of the technology available through the FIRETIP project. Story begins on page 3.

FIRETIP

Marvin Newell

Project Leader, FIRETIP Project, Boise Interagency Fire Center, USDA Forest Service, Idaho.

FIRETIP! Oh no! Another acronym? Or is it a new name for Sparky the fire prevention dog? Oh well, it probably isn't of any concern to me.

But hold on! If you are involved in managing fire suppression programs, FIRETIP may have something for you. Read on!

FIRETIP is the acronym for *Fire*fighting *T*echnologies *I*mplementation *P*roject—a new project assigned to the Forest Service's Cooperative Fire Protection Staff in Washington, D.C. The purpose of FIRETIP is to provide assistance and technical help to transfer new technology in multijurisdictional fire suppression.

The need for such a project surfaced in early 1980 through a review of the FIRESCOPE program in southern California. FIRESCOPE, *Fire*fighting Resources of *S*outhern *C*alifornia *O*rganized for *P*otential *E*mergencies, is a nationally funded project born out of the disastrous fires of 1970. It was designed to meet one of the most consistently complex wildland/urban fire threats in the Nation, and it has achieved spectacular success.

Word of the successful program quickly spread. Interested firefighters and managers from locations across the Nation wanted to know if these management concepts and technologies could make their local programs more effective and efficient.

Situations like the complex southern California one occur in other parts of the country as well. Therefore, the concepts and systems developed for the southern California solution can be adapted to fit other local needs, particularly where problems involve multi-agency jurisdictions. Managers also recognized a need to identify and pass on information about firefighting technologies that exist, or are being developed in other localities.

Thus, FIRETIP was conceived and developed. Primarily, FIRETIP will help State fire protection agencies, local organizations and interagency groups, and multi-agency operations. Information about available technologies and concepts will be developed and distributed. The real payoff will come from working with fire protection managers on a local basis to identify, adapt, and apply these new concepts and technologies in an effort to increase their efficiency and effectiveness.

Initially, the program will emphasize the following management concepts and technologies:

1. The Multi-Agency Coordination System

MACS (fig. 1) is designed to improve multi-agency coordination at

MACS Multi-Agency Coordination System

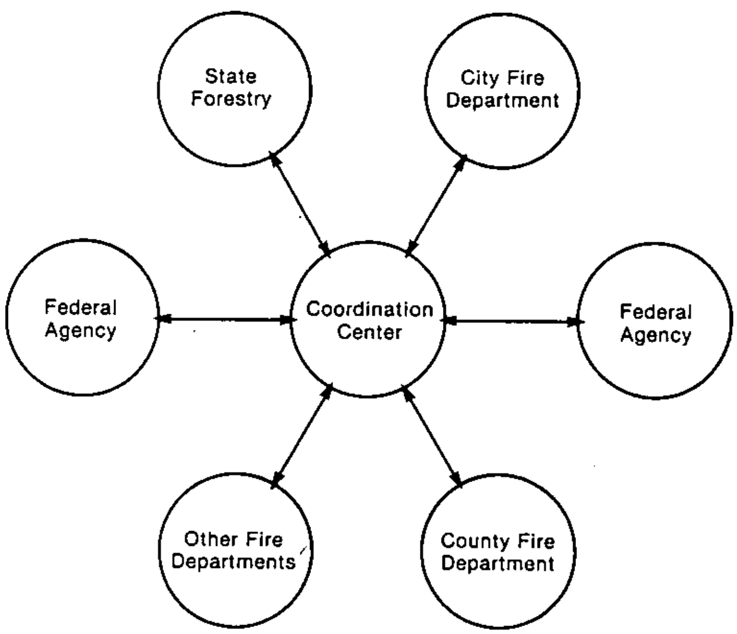

Figure 1.—*Flow of information at a project fire with* MACS.

top management levels. MACS integrates the collection, processing, and dissemination of information pertinent to multi-agency crisis management and provides for rapid allocation of emergency forces to fires. MACS is supported by the information and technologies in items 2 and 3, which can be adapted to fit local situations.

2. Information Management

- Current information on the location, availability, and capabilities of fire suppression or other emergency resources (manual or computer).
- Data storage and display (manual or computer) to assess the existence of, or potential for, incidents within the jurisdiction of participating fire services.
- Information for a variety of planning purposes.
- Coordination of communication equipment and frequencies on a non-interfering basis.

3. Technological Support

- Infrared sensing and telemetry to provide accurate and timely fire intelligence for decisionmakers.
- Orthophoto mapping program to establish and maintain a single, comprehensive map.
- Communications hardware such as synthesized radios, telephone systems, and computer terminals.
- Automated weather-sensing and transfer systems to provide reliable realtime meteorological data for fire-behavior predictions.
- Comprehensive data bases and data base management programs to support decisionmakers during emergencies.

4. Decisionmaking Process

This concept provides a structure and a method that enables agencies to communicate and coordinate to an extent never before realized and still maintain complete agency autonomy and identity.

Development and use of a decisionmaking process accomplishes many things; most importantly, it makes it easier for agencies "to agree to agree." The ramifications of this process are broader than any other concept or technology, including MACS, because through the decisionmaking process, all the technologies, procedures, and concepts are authorized. Since this process is independent of actual fire suppression, it structures, but does not carry out decisions on the ground.

The project headquarters is located at the Boise Interagency Fire Center. Persons interested in finding out more about the FIRETIP project may contact Marvin Newell, Project Leader, at the Fire Center, 3905 Vista Avenue, Boise, ID 83705. The commercial phone number is (208) 334-9455; FTS is 554-9455. ■

A Method for Making Activity-Fuel Management Decisions

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Introduction

Timber harvesting, intermediate cuttings, and other wildland management activities produce quantities of residue (activity fuel). If these residues are left untreated, they will increase fire hazard and often impede future stand management. They may adversely affect regeneration of trees, wildlife and livestock grazing, stream channel flow, and the esthetic qualities of the site. However, residues can also provide shelter for some wildlife species, a suitable microclimate for some tree seedlings, and a medium for prescribed fire for resource management purposes. Residues that return nutrients to the soil as they decompose may also reduce erosion.

When necessary, residues may be reduced in a wide variety of ways with an equally wide range of costs. Current methods include prescribed burning, crushing, and removal from the site. From a fire protection standpoint, the appropriate level of activity-fuel treatment for a particular area depends on fuel quantity and persistence, adjacent fuels, fire occurrence rate, climate, topography, fire suppression capability, fire effects on resource management objectives, and treatment costs. The fire manager usually evaluates these factors subjectively. This often results in a wide variety of treatments for seemingly similar fire hazard situations (McCleese and others 1976).

This paper describes a quantitative fuel appraisal process for consistent weighing of fire hazard factors that affect activity-fuel management decisions. The description of the process evaluates only the effect of fuel management alternatives on subsequent fire size and intensity. However, the method can be extended to compare fuel treatment costs and expected losses if reliable fire-effects estimates are available.

Decision Process

Management objectives, fuel quantities, topography, available suppression forces, and fire behavior under specific weather conditions can be determined with a reasonable degree of certainty. However, whether a fire will occur, what the weather conditions will be, and how successfully suppression efforts will contain the fire are highly uncertain. Therefore, to select a fuel management strategy, the manager must evaluate alternatives that have uncertain outcomes.

Decision analysis—a combination of quantitative modeling and decision theory (Howard 1973)—provides a framework for incorporating uncertainty into the decision process. Important events are assigned probabilities of occurrence, and outcomes are assigned values. The probabilities and values are incorporated in a decision (or event) tree model. Evaluating the decision/event tree estimates the expected outcome—a probability-weighted average of all possible outcomes. Decision alternatives can then be quantitatively compared on the basis of their expected outcomes. Although this procedure cannot guarantee good outcomes, it assures that decisions will be consistent with current knowledge as recorded in the probability estimates.

Decision analysis has proven useful in corporate and public decision-making (Balthasor and others 1978, Barrager and others 1975), and several decision analysis examples have been reported in the forestry literature (Bently and Kaiser 1967, Talerico and others 1978).

A decision analysis framework has been developed for assessing activity-fuel treatment alternatives (Hirsch and others 1981). The framework combines fuel modeling, fire modeling, and decision analysis techniques. The user must supply estimates for (1) fire occurrence rate, (2) fireline intensity, (3) fire spotting behavior, and (4) fire size.

Procedures

Determining the fire occurrence rate is straightforward. It involves examining past fire occurrence rates and adjusting for major expected changes in the number of person-caused fires. All agencies involved with wildland fire suppression maintain records of historical fire occurrence (Roussopoulos and others 1980).

Determining the probability distribution of fireline intensities for each fuelbed is more complex. Fireline intensity varies according to fuelbed characteristics and weather conditions at the time of occurrence. Fortunately, a useful model is available for relating fire behavior to weather and fuel conditions (Rothermel 1972, Albini 1976a).

Rothermel's fire model has been widely used and tested since its development (Albini 1976b, Rothermel and Philpot 1973, Deeming and others 1977). The model output and some empirical relationships can be used to estimate rate of spread, fireline intensity (Brown and Davis 1973), flame length, and tree crown scorch height (Van Wagner 1973). Here the fire model is used to estimate fireline intensity in the activity fuels and surrounding natural fuels. A numerical fuelbed description (often called a fuel model) is required imput to the fire model.

Two procedures are available for obtaining the required fuel information. Albini and Brown (1978) and Brown and others (1977) developed a procedure to predict the characteristics of an activity fuelbed. The prediction is based on stand characteristics and individual tree weight relationships (Brown 1978). For natural fuels, an appropriate stylized fuel model developed to use with the fire model is selected. Various stylized fuel models exist, covering the range of fuel types from grass to dense timber stands (Albini 1976b).

A computer program has been developed that executes the fire model for any selected fuel model over the range of weather conditions at the cutting site (Radloff and others. In preparation). This provides the required probability distribution for fireline intensity.

Whether or not a fire is spotting ahead of itself may greatly influence final fire size. Applicable models of spotting fire behavior are not available, so expert judgment is used to determine spotting criteria. A concensus of fire experts indicated that the following conditions are likely to result in spot fires:[1]

Fireline intensity	700 Btu per foot per second or greater
Wind speed	10 miles per hour or greater
Fine fuel moisture	10 percent or less

An analytic or simulation technique for determining the effect of suppression forces on final fire size is not available for all areas. Therefore, the fire size probability distribution is obtained by quantifying the knowledge of local fire control experts. The process, called probability encoding (Spetzler and Stael von Holstein 1975), has produced useful results in decision problems ranging from development of new pharmaceutical products to seeding hurricanes (Balthasor and others 1978, Howard and others 1972).

Applied to fuel appraisal, the probability encoding procedure relies on the careful selection of an appropriate set of possible fire size outcomes. For instance, it may be reasonable to contain a fire at the edge of a timber-cutting block, or under favorable weather conditions, the fire might be contained at a smaller size. In more severe weather, the fire might burn all of the slash area plus several hundred acres surrounding it. Under extreme conditions, an entire drainage might burn. The probability of containing fires at each selected fire size can be estimated by questioning local fire experts and quantifying their judgments.

Application

The activity-fuel appraisal process was tested on fuel treatment decisions involving precommercial thinning in larch/Douglas fir *(Larix occidentalis/Pseudotsuga menziesii)* in Montana, combined sawtimber harvest and thinning in ponderosa pine *(Pinus ponderosa)* in Arizona, sawtimber harvest in Douglas fir in Oregon, and harvest in jack pine *(Pinus banksiana)* in Michigan. The analysis of precommercial thinning in Montana is by far the simplest and is presented to illustrate the entire process.

Problem Description.—Hungry Horse District of the Flathead National Forest plans to thin part of a 10,000-acre stand in the larch/Douglas fir timber type on Fire Fighter Mountain near Hungry Horse, Mont. Three units, each comprising about 700 acres, will be thinned. About 1,000 stems per acre each of Douglas fir, larch, and spruce *(Picea engelmannii)* will be cut. The silvicultural prescription calls for a residual stand of about 200 stems per acre.

Continuous activity fuel in 700-acre units is unacceptable because of the large fire potential it represents. Therefore, the units will be thinned in smaller blocks, separated by uncut strips. Continuous crowning fires are uncommon in the project area, so the uncut strips will provide a buffer of low fire hazard. The width of the strips and the size of the blocks have not been determined.

A fuel management plan that is commensurate with costs is needed to protect the thinned stand. Four fire hazard reduction options are being considered: (1) thinning in 50-acre blocks, (2) thinning in 100-acre blocks, (3) lopping slash to a 2-foot maximum depth, and (4) removing some post/pole size material from the site.

Mechanical crushing of the slash was not considered because the steep slopes (greater than 30 percent) preclude the use of heavy machinery.

Assigning Probabilities.— Analysis of individual fire reports for the

[1] From a personal comunication with Rod Norum, Institute, of Northern Forestry, Fairbanks, Alaska, formerly of the Northern Forest Fire Laboratory, USDA Forest Service, Missoula, Mont.

Flathead National Forest indicates an average occurrence rate of 0.37 fire per 10,000 acres per year. This agrees with local experience for Fire Fighter Mountain which has had one to three fires per 5 years. Historically, 61 percent of the fires have occurred in the daytime.

The stand data and cutting prescription were used to make a detailed model of the activity fuelbed for Fire Fighter Mountain (Puckett and others 1979). Different fuelbeds were modeled to reflect the effects of post/pole removal and lopping to a 2-foot depth.

Uncut parts of the stand were represented by a "closed timber litter" stylized fuel model. This represents a very low flammability fuel type.

Fire behavior was estimated by combining weather data and fuelbed data in Rothermel's fire model (Rothermel 1972). Using the activity and natural fuel models and weather data recorded at Hungry Horse fire weather station on days when fires occurred on the Flathead National Forest, cumulative probability distributions of fireline intensity were developed for the Fire Fighter Mountain site. Night weather conditions were estimated (Hayes 1941) in order to develop an analogous set of intensity distributions for fires at night. A subset of the weather records—for days when the windspeed was greater than or equal to 10 miles per hour and the fine fuel moisture was less than or equal to 10 percent—was used to determine the spotting probabilities.

District fire experts were interviewed to quantify their knowledge about final fire sizes in the possible fire behavior situations. The fire behavior model indicated that fires in the unthinned stand will burn with low intensity and will be relatively easy to suppress with hand tools. Fires in the slash will burn with high intensity and, if not suppressed at very small size, will be uncontrollable until they reach the slash boundary.

Although expected fire intensity in the unthinned material is very low, a fire crossing the boundary from the slash into unthinned material will not immediately drop in intensity. The extreme fire behavior in the slash will predry the trees in the leave strips and cause some crowning. Fire experts believe crowning will continue for approximately 100 feet beyond the slash boundary.[2] The fire will then drop to the ground and assume behavior typical of uncut stands after a 100- to 150-foot excursion into the leave strips. This indicates that an uncut strip of about 200 feet between thinning blocks should provide a sufficient buffer to contain most nonspotting fires.

Based on the fire behavior analysis, the strong consensus among Hungry Horse District fire experts was that with no spotting, a majority of fires would be confined to one or two 50-acre thinning blocks, but only a small fraction of fires would be stopped before reaching the edge of the block. For the alternative with 100-acre blocks, most fires would still be confined to one or two 100-acre thinning blocks. There was also a consensus that fires would reach 200 acres only under high-intensity burning conditions (700+ Btu per foot per second), and spotting would be required for a fire to grow larger. Most large fires would be confined to one of the 700-acre thinning units.

The above reasoning was used to define seven fire-size classes with average sizes of 10, 50, 100, 200, 400, 700, and 10,000 acres. The 10,000-acre class was included to account for the possibility of a very large fire involving the entire thinning area. Fire experts independently assigned probabilities of occurrence to each of the classes. The responses were summarized and reviewed for consistency by district and regional staff as well as others familiar with fire behavior in the area. All probabilities are based on the assumption that existing fire suppression forces would be available. A change in suppression forces might change some of the probabilities.

Results.—Fire behavior modeling and expert subjective probability assessments provided the information needed to estimate the fire hazard for each fuel management option. Figure 1 shows the structure of the decision/event tree.

The fire size probabilities from the complete decision tree are summarized in table 1 for each of the four options. The expected fire size with 100-acre thinning blocks and no activity-fuel treatment is 120 acres. Reducing the block size to 50 acres reduces the expected fire size to 62 acres. Lopping the slash and post/pole removal have little effect in further reducing expected fire size.

Each year $.37 \times 2{,}100 \div 10{,}000 = 0.08$ fire start is expected within the 2,100 acres of thinning slash. Therefore, the expected annual burned areas for the four options are:

100-acre blocks; no treatment	9.6 acres
50-acre blocks; no treatment	5.0 acres
50-acre blocks; lopped	4.9 acres
50-acre blocks; lopped; post/pole removal	4.9 acres

Using the smaller block size almost cuts the expected burned area in half. Because the thinning costs are about the same for either block size, the 50-acre option is preferred. The effect of lopping is to reduce the expected annual burned area by only 0.1 acre. Over an assumed 10-year period of increased slash fire hazard, this would result in an expected saving of about 1 acre. Assuming a per-acre fire cost plus loss

[2]From a personal communication with Hal E. Anderson, Northern Forest Fire Laboratory, USDA Forest Service, Missoula, Mont.

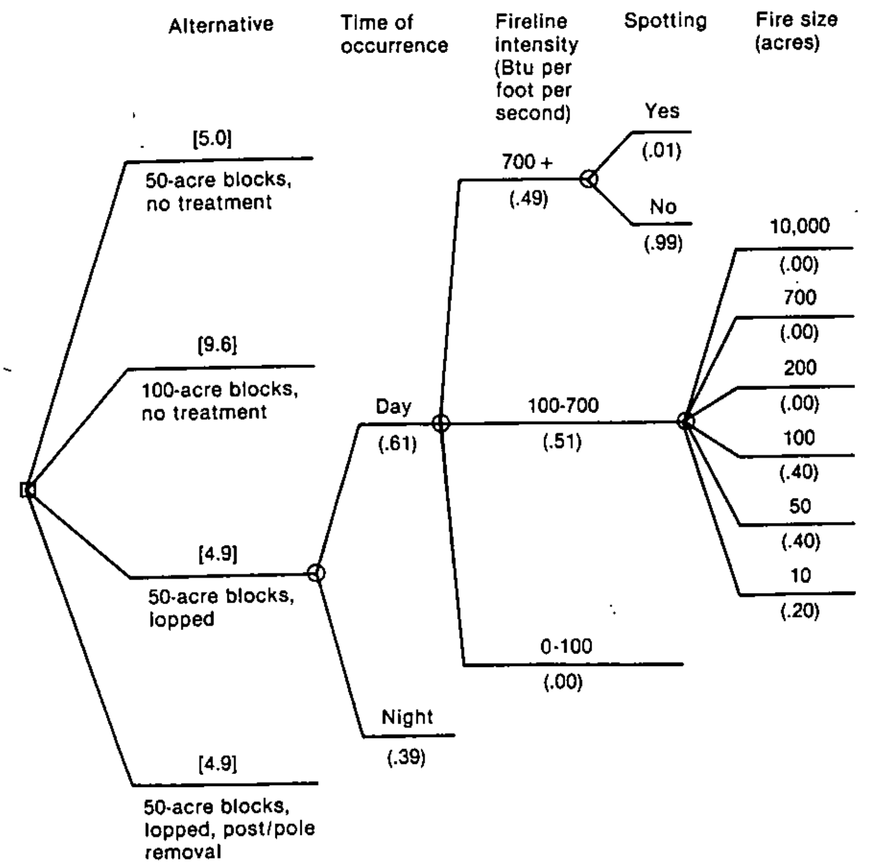

Figure 1.—*Decision/event tree showing the important uncertainties in the fuel treatment decision. For brevity, many branches have been truncated. The first node (box with four branches) is the treatment decision node. Subsequent nodes (circles) are event probability nodes. Probabilities are shown in parentheses. The probability of an outcome (fire size) is the product of the probabilities for all branches leading to that outcome. The expected burned area per fire for each alternative is the sum of all products of fire sizes and their respective probabilities. The expected annual burned area (shown in brackets for each alternative) is the product of expected burned area per fire and 0.08, the number of ignitions each year.*

of $1,000, the savings would be $1,000 over 10 years. Because all 2,100 acres of activity fuel must be treated to realize this saving, the absolute maximum investment in lopping should be 48 cents per acre. Actual costs for lopping slash far exceed this amount. Similarly, the option of lopping with post/pole removal is not jusitified unless the post/pole sale provides enough revenue to offset its costs.

Summary

To consistently evaluate fuel management alternatives, managers need a method that systematically weighs the important variables. Fuelbed characteristics, fire occurrence rate, climate, and suppression capability must all be considered. Because uncertain events are involved, a fuel appraisal process based on decision analysis is a useful framework for comparing alternatives.

Readily accessible data files provide needed fire occurrence and weather information. New modeling techniques provide fuelbed characteristics for a wide range of activity-fuel situations. Fire behavior model-

Table 1.—*Fire size probabilities and expected acres burned per fire for the four alternatives*

Fire size—acres	100-acre blocks—no treatment		50-acre blocks—no treatment		50-acre blocks—lopped slash		50-acre blocks—post/pole sale with lopped slash	
	Occurrence probability	Expected acres burned	Occurrence probability	Expected acres burned	Occurrence probability	Expected acres burned	Occurrence probability	Expected acres burned
10,000	.000087	.87	.000087	.87	.000087	.87	.000087	.87
700	.001657	1.16	.001657	1.16	.001657	1.16	.001657	1.16
400	.0342	13.68	—	—	—	—	—	—
200	.2776	55.52	.0342	6.84	.03115	6.23	.02995	5.99
100	.4632	46.32	.2776	27.76	.2746	27.46	.2734	27.34
50	—	—	.4632	23.16	.4634	23.17	.4638	23.19
10	.222	2.22	.222	2.22	.228	2.28	.231	2.31
Total		119.77		62.01		61.17		60.86

ing combines the weather and fuel information to estimate fireline intensity. Expert judgment is used to develop estimates of fire size and to reflect the effect of special types of fire behavior such as spotting. These inputs are combined in a decision/event tree to estimate the annual expected burned area. This estimate can be used with resource production functions and values to evaluate fuel management alternatives. As a side benefit, the approach clearly documents the decision process.

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Trends in Rural Fire Prevention and Control—Expenditures, Acres Protected, and Number of Fires

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Introduction

The Rural Fire Prevention and Control (RFPC) program provides fire protection on non-Federal rural lands. Rural lands are defined to include towns with populations of less than 10,000 persons. The Cooperative Forestry Assistance Act of 1978 (Public Law, 95–313) authorizes the Secretary of Agriculture to "provide financial, technical, and related assistance to State foresters or the equivalent State officials, and through them to other agencies and individuals for the prevention, control, suppression, and prescribed use of fires on non-Federal forest lands and other non-Federal lands. The fire protection program includes all 50 States, Puerto Rico, Guam, and the Virgin Islands.

The economic efficiency of providing fire protection on non-Federal rural lands has been questioned. The purpose of this article is to provide a better understanding of the program. This will be done by reviewing background trends in program expenditures, area protected, and number of fires on lands protected under the RFPC program.

Trends in RFPC Expenditures

Trends over the 30-year period from 1950–80 provide a long range background against which recent changes can be evaluated. Program expenditures are divided into two categories, Federal RFPC expenditures and State expenditures for rural fire protection. Expenditures are converted to 1980 dollars to compensate for inflation.[1]

In terms of real 1980 dollars (dollars of equal purchasing power), total Federal RFPC expenditures plus State rural fire protection expenditures increased from $137 million in 1950 to $237 million in 1980. During the same period Federal expenditures declined from $40.6 million to $22.6 million. In summary, the Federal RFPC program was cut in half between 1950 and 1980 while the total Federal and State program increased by $100 million during this period (see fig. 1).

[1] The implicit price deflator for Federal and State purchases of goods and services is used to deflate the expenditures to 1980 dollars. (Source: Economic Report of the President, January 1981.)

Federal Share of Rural Fire Protection Expenditures

The percentage of total rural fire protection expenditures from Federal sources declined from about 30 percent in 1950 to 9 percent in 1977. This percentage increased

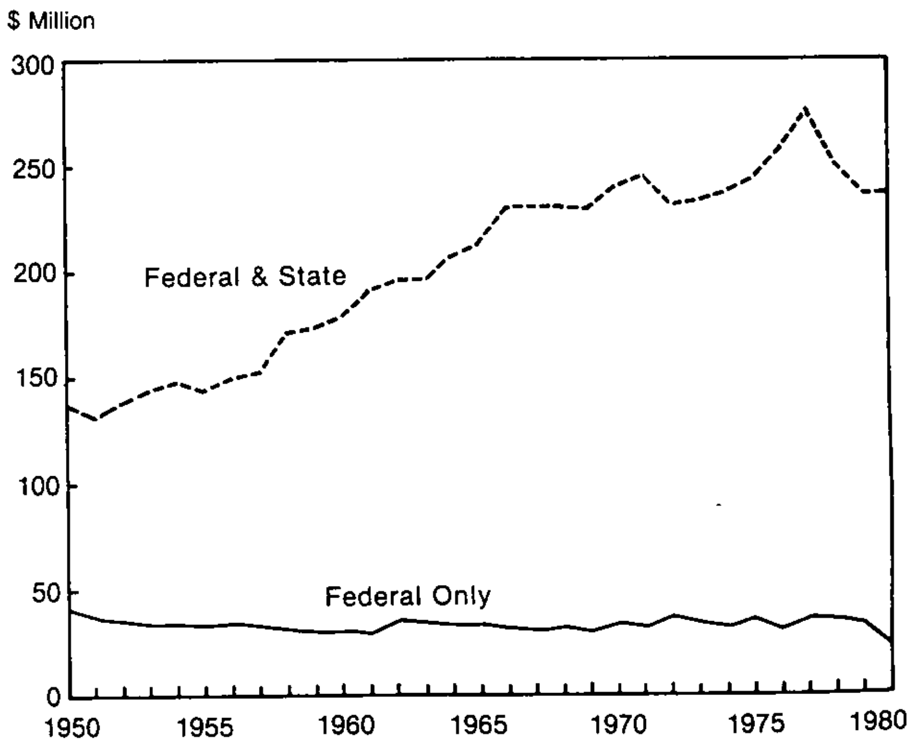

Figure 1.—*Rural fire protection expenditures in constant 1980 dollars.*

again to 14 percent in 1978 and 1979 and dropped to 9 percent in 1980 (see fig. 2).

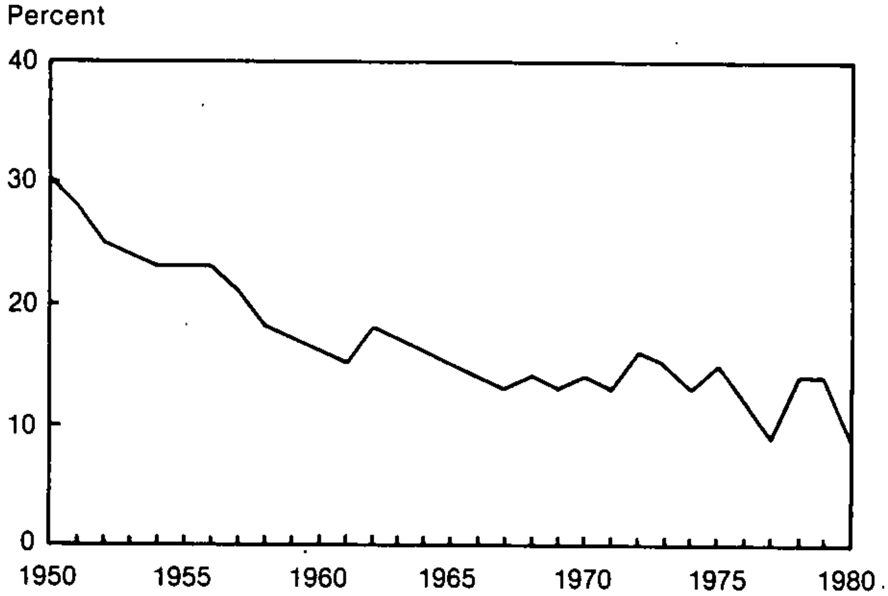

Figure 2.—*Federal share of rural fire protection expenditures (percent).*

Number of Fires

Numbers of fires on protected State and private lands vary considerably from year to year. In order to dampen the yearly variation, the average number of fires that burned in the previous 5-year period was used. The trend in 5-year averages increased from 75,000 fires in 1950 to 125,000 in 1979, an increase of 67 percent. This increase was no doubt due to population increases and increased use of woodland areas. Some of the increase may have been due to better statistical reporting. The large increase in number of fires suggests the need to strengthen rural fire prevention programs.

Expenditures in real dollars increased proportionately with the number of fires. The similar trends resulted in costs per fire of $1,896 in 1979, almost the same as the $1,827 cost in 1950.

Cost Per Acre Protected

The cost per acre protected in real 1980 dollars increased from $.38 in 1950 to a high of $.49 in 1966 (See table 1). Since then it has declined to $.30 in 1979. Part of the reason for the decline has been the rapid increase in protected area, from 469 million acres in 1966 to 784 million acres in 1979.

Table 1.—*Area protected under the Rural Fire Prevention Program, number of fires, and total Federal and State fire protection costs in 1980 dollars*

Year	Protected area	Number of fires—5-yr. average	Cost	Cost per acre
	Million acres	Thousands	Millions of real 1980 $	Dollars
1950	361	75	$137	.38
51	363	81	131	.36
52	369	90	138	.37
53	374	97	144	.38
54	382	105	148	.39
55	387	102	144	.37
56	390	99	150	.38
57	396	87	153	.39
58	398	82	172	.43
59	401	74	174	.43
60	403	73	181	.45
61	412	71	191	.46
62	418	78	196	.47
63	431	91	197	.46
64	446	94	208	.47
65	472	97	214	.45
66	469	102	230	.49
67	480	103	231	.48
68	486	98	231	.48
69	512	99	230	.45
70	521	101	240	.46
71	574	100	245	.43
72	631	96	232	.37
73	627	90	234	.37
74	708	92	238	.34
75	726	90	244	.34
76	737	103	258	.35
77	749	115	276	.37
78	774	125	251	.32
79	784	125	237	.30
80	—[1]	—[1]	237	—[1]

[1] Not available.

Summary

Trends in the Rural Fire Prevention and Control program on non-Federal rural lands are summarized below.

- Federal RFPC expenditures in real 1980 dollars have declined from $40.6 million in 1950 to $22.6 million in 1980.
- Total State and Federal expenditures for rural fire protection on non-Federal rural lands increased from $137 million in 1950 to $237 million in 1980.
- The share of expenditures from Federal sources declined from 30 percent in 1950 to 9 percent in 1980.
- The area protected from fire more than doubled, from 361 million acres in 1950 to 784 million acres in 1979 (the last year data were available.)
- Expenditures declined from $.38 per protected acre in 1950 to $.30 in 1979.
- Expenditures per fire were about the same at the beginning and end of the period: $1,827 in 1950 and $1,896 in 1979.

Conclusions

States have assumed a larger proportional role in fire protection over the last 30 years. What should the Federal role in rural fire protection be?

Even though the numbers of fires and acres protected have increased greatly, the cost per fire has been held about the same in 1979 as in 1950, and the cost per acre has been reduced. This suggests that the rural fire protection program has been effective in controlling fires but not preventing them. Many questions could be asked: Will it be possible to bring additional areas under protection as protected acreage approaches the total acreage available for protection? Has the cost per acre protected been held constant by bringing acres into the program that were less susceptible to fire damage? Have program improvements in some States or regions offset deficiencies in other areas?

The purpose of this article is not to answer these questions but rather to provide background trends that suggest the questions and provide a long-range national trend for comparison purposes. ■

Index to Tall Timbers Fire Ecology Conference Proceedings Available

Tall Timbers Research Station is dedicated to a quest for ecological understanding. Among other things, this quest has resulted in the publication of the proceedings of annual fire ecology conferences held during the station's first 17 years of existence.

These proceedings contain 4,918 pages of fire ecology information. Unfortunately, as is the case with most conference proceedings, this information is not indexed for easy retrieval. Consequently, the information has not been used to its full potential.

An easy-to-use index to the contents of the 15-volume Proceedings of the Tall Timbers Ecology Conferences has recently been published.

The primary purpose of this index is to help forest and range managers acquire the information they need to write ecologically sound fire-use and fire-management prescriptions and to better integrate fire considerations in land management planning.

The format of the index closely parallels the way information is stored and retrieved by FIREBASE, the fire information segment of the computer-assisted Renewable Resources Technical Information System developed by the Forest Service.

All of the papers published in the proceedings are listed by author, date, and title. The contents of these papers can be searched by using the five-part index provided (actually five separate indexes): the geographic area index, the natural resource area index, the vegetative type index, the subject index, and the plant and animal index. The index was prepared by Bill Fischer.

To obtain copies write to Intermountain Forest and Range Experiment Station in Ogden.

Index to the Proceedings of the Tall Timbers Fire Ecology Conferences: Numbers 1–15, 1962–1976, U.S. Department of Agriculture, Forest Service. General Technical Report INT-87 (July 1980). ■

An Inexpensive Anemometer Frame

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Accurate measurement of windspeed is an integral but difficult part of evaluating fire behavior. Wind measuring devices employed on wild and prescribed fires range from elaborate anemometer-recorder arrangements to hand-held windmeters. Elaborate arrangements are expensive and often delicate and cumbersome. Windmeters are not entirely satisfactory because, although instrument precision is sufficient for most burning applications, the observer must subjectively average windspeed over time. Totalizing anemometers are a good compromise between these two extremes because they provide an accurate account of windspeed over time, especially when wind is not highly variable. Most vane-type anemometers, however, are directional and not designed for use in the field.

A second problem with windspeed measurement is the height at which measurements are taken. Windspeed near the top of vegetation may provide more insight into fire behavior than at the standard 20 foot (Fischer and Hardy 1976) height. For example, Rothermel's (1972) rate-of-fire spread model utilizes midflame windspeed rather than windspeed at the standard height, and Albini's (1979) spot fire model is based on windspeed at treetop height.

To minimize these problems on grassland prescribed burns, windspeed was measured with totalizing anemometers at two heights, 1.6 and 6.4 feet. These measurements were used to determine the effect of windspeed on forward rate-of-fire spread and to develop a wind profile for relating fire behavior to other fires where windspeed was determined at the standard height.

The Frame

The wind measuring system used had to be portable and inexpensive.

Using the Frame

The anemometer frame has been used satisfactorily on 40 prescribed test fires with winds up to 30 miles per hour. Because the totalizing anemometers measure total wind travel, a stop watch was used to provide elapsed time. These data can be converted to windspeed in miles per hour. An example of experimental data from test fires in weeping lovegrass *(Eragrostis curvula)* is given in table 1. Measured windspeed was obtained at 1.6 and 6.4 feet above the soil surface. The 1.6-foot windspeed corresponded to the top of the fuel layer, and was used to estimate the standard 20-foot windspeed using the following equation (Albini and Baughman 1979):

$$U_{20+H} = U_H \left(\ln \frac{20 + 0.36H}{0.13H}\right)$$

where,

H = vegetation height in feet,
U_H = windspeed at vegetation height in miles per hour,
U_{20+H} = windspeed at 20 feet.

Table 1.—*Windspeed for 10 test fires in weeping lovegrass; values were obtained by measurement at 1.6 and 6.4 feet, and estimated for 21.6 feet (U_{20+H}) from measurements at 1.6 feet*

Fire type	Windspeed 1.6 ft	6.4 ft	21.6 ft
	Miles per hour		
Head	3.6	6.5	17.4
Head	6.1	9.3	27.9
Head	718	12.1	35.6
Back	12.5	20.8	57.1
Head	4.7	7.8	21.5
Back	8.0	11.9	36.5
Head	6.0	10.1	27.4
Head	11.0	16.6	50.3
Back	11.4	16.6	52.1
Head	9.6	15.7	43.9

The anemometer frame is durable, easily moved by one person between test fires, and fits conveniently into a pickup bed. The anemometers used are Air Meter model 131 supplied by Weather Measure Corporation. The bearings are readily available from most bearing suppliers. Total cost of the frame, which can be constructed in about 2 hours, including bearings but excluding anemometers, is about $50.00.

To meet these needs a frame was constructed to support two vane-type totalizing anemometers. The frame consisted of rigid support with a wind-rotated mast supporting 2 anemometers (fig. 1). The mast was free to rotate so the anemometers always faced directly into the wind. The frame was constructed from 0.75-inch black iron water pipe, two tees, and one 90-degree elbow. Braces of aluminum tubing in two corners of the frame increased rigidity. Support chains anchored in the soil were added on either side to maintain stability in high winds.

The rotating mast was constructed of 0.5-inch black iron pipe and supported at the top and bottom by Fafnir LFST 0.5-inch bearings. The upper bearing was bolted to the top surface of the frame and attached to the mast extension by drilling an access hole vertically through the pipe. The lower bearing was bolted to a base plate welded to the upper surface of the pipe tee. A 0.25-inch-thick (18 inches long × 12 inches × 8 inches) plywood vane was attached to the mast with three conduit wall clamps.

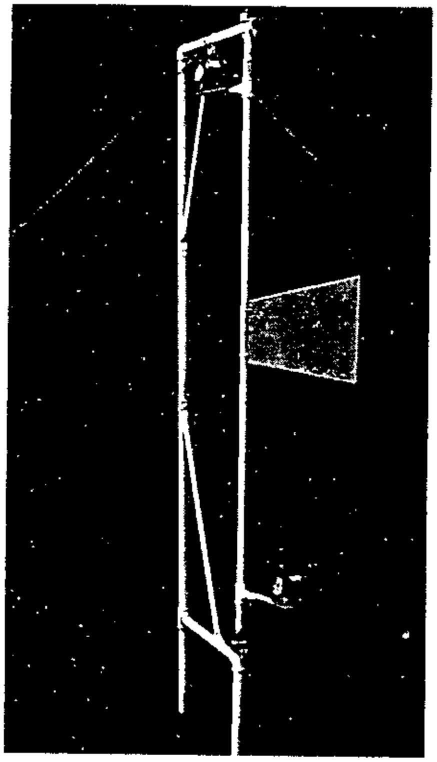

Figure 1.—*Anemometer frame, complete with 2 totalizing anemometers, ready for field use.*

The mast was cut at two heights above the ground surface (1.6 feet and 6.4 feet) and tees were inserted to provide anemometer supports. A 3-inch pipe nipple was placed in the horizontal tee connection and a 10-inch-long steel anemometer support plate was welded to the top surface of the nipple. A bolt, brazed to the bottom of the anemometer stand, anchored the anemometer through a hole drilled in the support plate.

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A Training Program in Interpersonal Communication

Larry Doolittle

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The Southern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, in cooperation with the Federal Emergency Management Agency, U.S. Fire Administration, has developed a 16-hour workshop on interpersonal communication for fire prevention and wildland management personnel. Dr. Jerry W. Robinson, Jr., professor of sociology at the University of Illinois, prepared the training materials and led five sessions of the workshop at various sites across the South.

Two books are used in the training—a participant workbook and a leader's guide. Color slides and audio cassette tapes also aid instruction.

Training is developed around the concept of *indirect persuasion*. Six steps are identified and illustrated: (1) initiating a contact (see fig. 1), (2) involving a client in conversation, (3) assimilating facts and feelings, (4) reinforcing agreements, (5) negotiating disagreements, and (6) solidifying a contact. Several specific topics are covered within this framework. These topics include contact planning, questioning techniques, active listening, dealing with resistance and hostility, and recording and analyzing contacts.

Fifteen learning activities are the heart of the training. These range from a "get-acquainted" exercise to plays that use scenarios likely to be encountered by fire prevention contactors. The activities assure that all participants practice the concepts introduced during the brief lecture periods.

The five workshops are presented in two different formats, depending upon the participants. In three workshops, participants are instructed in workshop leadership, which prepares them to train personnel in their own organizations. The other two workshops deal exclusively with contactor skill development.

Persons interested in more information about the training or in having a workshop conducted in their agency should contact: the author

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Figure 1.—*Forest Service fire prevention specialist makes contact with local family.*

Stage Underburning in Ponderosa Pine

John Maupin

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Underburns are conducted for range and wildlife habitat improvement, silvicultural objectives, visual resource management, and fuel reduction. Fuel reduction underburns are used for disposing of thinning, timber slash, and natural fuels.

Underburning is cost competitive with other methods of fuel treatment and provides other benefits, such as nutrient recycling, browse regeneration, and pruning of the residual stand. Also, burning avoids the adverse effects, such as soil compaction, of machine treatment methods.

The Ochoco National Forest, located in central Oregon, has embarked on a major underburning operation. In 1980, the forest conducted first entry underburns on about 4,000 acres of ponderosa pine. Plans call for increasing the program to about 8,000 acres in the next few years.

Historically, pine stands on the Ochoco were visited by low-intensity fires at invervals of 2–15 years. These fires kept natural fuel levels low. However, effective fire suppression has resulted in a buildup of natural fuels such as litter, heavy logs, brush, reproduction, and snags.

Under present conditions, first entry underburns in ponderosa pine present a challenge to the fire manager since, in many cases, natural fuels may total 30 tons per acre (fig. 1). Also, the lower canopy level of the overstory is close to the ground and therefore very susceptible to

Figure 1.—*Fuels of 30 tons per acre, prior to first stage burn.*

Figure 2.—*Fuels remaining after second stage burn.*

scorch. Consequently, the prescribed fire manager must use techniques that limit damage to the residual stand.

After heavy fuels are reduced, the second stage burn can be conducted with a prescription that will produce desired fuel reduction throughout the unit (fig. 2).

The prescription for stage burning usually centers around control of flame length. Maximum permissible flame length in any given stand depends on ambient air temperature, canopy windspeed, and slope. Flame length can be largely controlled by firing technique. For instance, narrow strip head fires will produce shorter flame lengths than wide strip head fires.

First entry underburns require strong commitment from the resource manager. Burning costs and damage potential will be high on first entry burns. After the first entry, however, costs of maintenance burns fall off dramatically and damage potential is negligible. ■

Computer Software Program Aids

The following computer software program aids will soon be available:

Fuels Appraisal Software Package.—Four computer programs presently make up the Fuel Appraisal Software Package:

- FUELBED—Fuel Bed
- FIREWX—Fire Weather
- FIREBHV—Fire Behavior
- DECTREEZ—Decision Tree

This user package will be detailed in a USDA Forest Service Intermountain Forest and Range Experiment Station General Technical Report, due to be published in Spring 1982. Meanwhile, Dave Radloff is available to help with your activity-fuel management decisions.

Slide/Tape Tutorial Program.—A slide/tape tutorial program titled A Decision Process For Activity Fuels will soon be available from the National Audiovisual Center. The National Fuels Inventory Project, headquartered at Ft. Collins, Colo., prepared the program. ■

Fire Prevention Publications

In a cooperative effort, the California Department of Forestry; the Forest Service, U.S. Department of Agriculture; and the Bureau of Land Management, U.S. Department of the Interior, have produced a series of Fire Prevention Field Guides.

The Powerline Fire Prevention Field Guide, published in 1977, was the first in the series.

In 1978, the Railroad Fire Prevention Field Guide was published, and in 1980, the Industrial Operations Fire Prevention Field Guide was published. The California Department of Forestry (CDF) has distributed all three guides. CDF has revised and published another publication entitled Fire Safe Guides for Residential Development in California. All four of these publications were developed in response to California needs, but they also apply to many other areas of the country. The Wildfire Prevention Handbook was developed by the Wildfire Coordinating Group. It was designed for use with hunter safety training programs throughout the Nation and is directed at teenagers. Copies may be obtained from Cooperative Fire Protection, Forest Service, or directly from the publisher:

> Outdoor Empire Publishing, Inc.
> P.O. BOX C-1900
> 511 East Lake Ave.
> East Seattle, WA 98109 ■

Is Your Vehicle Fire Safe?

Forest fires are caused not only by carelessly thrown matches or unattended campfires, but are also often started by motor vehicles. Regular maintenance inspections should be performed on all motor vehicles to insure safe operation and fire safety. Gasoline vapors can be ignited by sparks from loosely connected wires or an imporperly secured battery. Items such as the electrical wiring system, battery, air cleaner, and brakes should be checked. Tips are listed in a new fire prevention leaflet, *How To Prevent Vehicle Fires*. One free copy of the leaflet can be obtained from the U.S. Department of Agriculture, Forest Service, Publications, 370 Reed Road, Broomall, PA 19008. ■

Research Summaries Available

Each year, the Forest Fire and Atmospheric Sciences Research staff of the Forest Service publishes a list of available publications and a resume of ongoing research programs. These are available at no charge from the Director, FFASR, U.S. Department of Agriculture, Forest Service, P.O. Box 2417, Washington, DC 20013. ■

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The Forest Service

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple-use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

The Forest Service:

. . . Conducts forest and range research at more than 75 locations from Puerto Rico to Alaska and Hawaii.

. . . Participates with all State forestry agencies in cooperative programs to protect and improve the Nation's 395 million acres of State, local, and private forest lands.

. . . Manages and protects the 187-million-acre National Forest System for sustained yields of its many products and services.

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