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Fire Management Notes

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Contents

Cover: Smokey Bear, America's fire prevention symbol, is *40 years old. Story begins on p. 22.*

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Unified Command: A Management Concept[1]

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More than 90 percent of the emergencies that occur daily in the United States are handled by local agencies in their initial attack responses. In a small percentage of emergencies, the responsible agency exhausts its own resources and calls on neighboring jurisdictions for assistance. Many agencies are adept and experienced in aiding other agencies and assist each other on a routine basis.

However, some 3 to 7 percent of all emergencies become serious enough to require the response of two or more agencies, each with its own legal obligations on the incident. It is on these critical multiagency emergencies that use of the unified command concept can improve coordination.

What Unified Command Is

Unified command is a management concept for coordinating responses to emergency incidents by two or more service agencies. It provides guidelines for agencies with different legal, geographic, and functional responsibilities to work together effectively in any given situation.

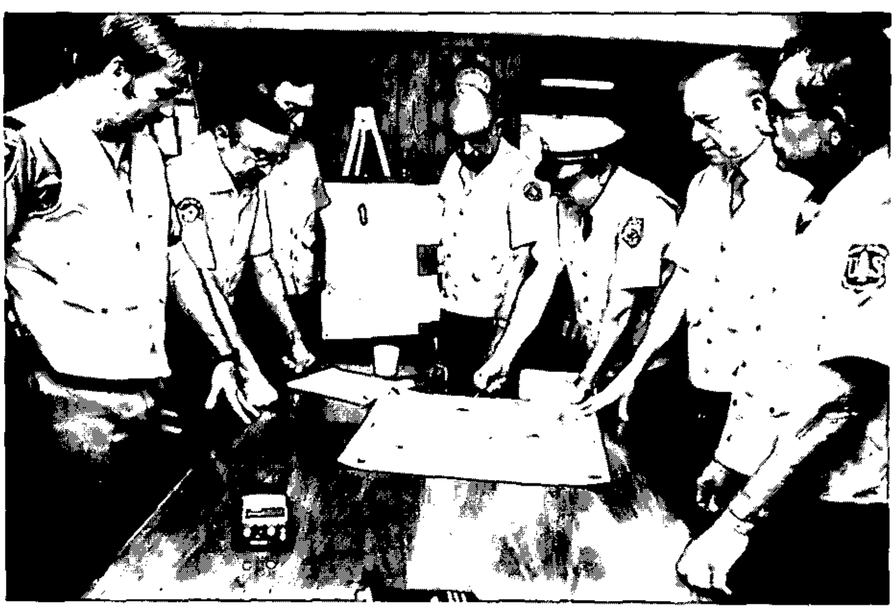
Unified command is the first consistent, systematic means of organizing a variety of agencies into one concerted effort. The concept offers uniform and trackable procedures that enable all emergency response agencies to perform their roles effectively. Unified command overcomes much of the inefficiency and duplication of effort that now occurs when agencies with functional and geographic jurisdictions, or agencies from different government levels, find themselves trying to work together without a common system.

The concept follows all the known and established principles of emergency management. It does not require new or untried approache, or change the way various parts of the actual emergency are handled. The concept is very flexible; there are no hard and fast rules to restrict experienced emergency managers. There are goals, recommendations, and procedural guidelines. These assist in establishing a management framework that fits the size and type of emergency and the agencies involved.

No two emergencies are ever exactly alike. They each have their own characteristics and problems. The unified command concept must be applied in a configuration to meet the needs of any given emergency.

Using Unified Command

We recommend using the unified command concept to: improve the information flow and interfaces among involved agencies; develop a single, collective approach to the incident, regardless of its functional or geographic complexities; ensure that all



Unified commanders representing several agencies with geographic and functional responsibilities meet to develop an action plan.

[1]The authors wish to acknowledge the original work of Bob Irwin, FIRESCOPE Program Manager, retired, USDA Forest Service, Forest Fire Laboratory, Riverside, Calif., and to express appreciation to the many persons who provided input, reviewed, and contributed to the unified command concept and this article.

agencies with responsibility for the incident understand the collective organization's goals, objectives, and restrictions; optimize the efforts of all agencies as they perform their respective missions; and reduce omissions and eliminate duplicated efforts.

In order to use the unified command concept most effectively, the agencies involved should be familiar with the Incident Command System (ICS) training recommended as part of the National Interagency Incident Management System. The Incident Command System is based on commonality. All agencies use the same terminology and the same organizational structure. When they meet on an emergency, there is clear understanding of information and immediate knowledge of the chain of command. ICS procedures should be uniform from agency to agency, thus facilitating every individual's ability to obtain instructions, pass on information or requests, and perform assignments.

ICS has tremendous adaptability. The more it is understood, the easier it will be to establish a command structure that fits the particular character of any incident. Preemergency simulations involving those agencies that may be expected to participate in an actual incident are excellent exercises for learning the system and acquainting the cooperators with each other.

This commonality is a major departure from traditional ways agencies formerly operated, and it creates significant opportunities to improve emergency management. If all involved agencies on emergencies are using the same organization and procedures, there will be few differences in operations.

Establishing one command post on a multiagency incident is basic to the unified command and incident command system concepts. Collocating at one onsite command post where all agencies can operate together avoids the confusion created by separate command, planning, and logistical setups.

Another precept of unified command is starting early. Technically, unified command should begin the moment two or more agencies have jurisdictional responsibilities on an incident. Getting together early in an incident's development, staying together, and sharing intelligence and individual agency decisions help smooth the way for more complex operations if the emergency escalates. It is critical to avoid the idea that unified command begins once an incident becomes a crisis.

Following ICS, collocating, and starting early melds different agencies into one organization. The organization can be directed from one command post, one set of plans can be prepared, and one logistical procedure can be followed. One organizational structure, one incident command post, one planning process, and one ordering process enables a "unified" approach to the management of a multiagency incident.

The Planning Process for Unified Command

The planning process for a unified command incident is the same as that for a "single" command incident, except that more people are involved. The process allows for jurisdictions with either functional or geographic responsibilities—or both—to input and combine objectives and action. The planning process involves: collecting and documenting incident intelligence on weather conditions, status of the emergency, and the like; formulating each agency's objectives and limitations; establishing a single set of objectives by looking at the incident as a whole; preparing an action plan to meet those objectives; reviewing the action plan by all agencies; and activating the plan.

There is a great deal of flexibility in the way this process can be performed. If, for example, only a few minutes are available to save a life or a structure, the objectives and action plan can be formulated in an instant, and all directions and orders will be verbal. On the other hand, if the incident response effort is a major one, then the whole process can be formalized and thoroughly documented. For experienced commanders and staff, the formal process only takes a short time, even on complex incidents.

The process starts with the documentation of the unified commanders' objectives, based upon the character and potential of the incident. It is important to note that the ultimate command and responsibility for each agency involved in a unified command operation is never shared or abdicated. Each agency's senior officer maintains agency authority and accountability throughout the incident.

The objectives stated by the commanders may be widely different, depending on the role of each agency in the incident. For example, commanders of a multiagency incident might have three objectives: to keep the fire from entering a nearby watershed; to protect nearby structures; and to evacuate people from the area. All of the objectives are developed and documented with all agencies present. They are developed recognizing the autonomy of each commander. Planning using unified command is not a committee process that resolves all differences in objectives before any action begins. It is a team process that formulates a single set of collective directions to address the needs of the entire incident. Our experience has shown that this collaboration has led to a voluntary sharing of resources and modification of original objectives to meet overall requirements. The process is a collective, unified effort that exposes, reduces, and eliminates duplications and omissions in incident response strategy.

The objectives developed by the unified commanders are given to the planning section. The staff looks at the objectives and develops an incident action plan that will be responsive to them. Needed resources are ordered and assignments are made to all components of the organization. When the action plan has been drafted, it is reviewed and approved by the unified commanders before it is distributed. In this way, each commander can ascertain that each agency's mission will be met to the highest degree circumstances will permit. If certain objectives have not, or cannot, be met, or if the character of the incident has changed, adjustments to the total plan can be made at this time.

Experienced professionals are probably still wondering who is actually in charge on a multiagency incident, who actually makes the decisions, and who is actually accountable.

The approved action plan containing the objectives, assignments, and orders is presented to the operations section chief to execute. The plan becomes the standard operating procedure for the incident and the operations section chief becomes the officer responsible for carrying out tactical operations for incident control. The operations section chief is responsible and accountable for all changes that may be necessary to comply with the plan. The operations section chief may have one or more deputies who assist with tactics on multifunctional incidents. Finance and logistics receive direction from the plan for their supporting roles.

Responsibilities of Unified Commanders

Unified commanders meet and work in one location. They share information on incident status, character, and their agency's objectives. It is extremely important that they also present the limitations of their agencies.

Unified commanders are responsible for authorizing certain activities and actions. They are responsible to their own agencies for these authorizations and not the other agencies involved. For example, a commander may authorize: the ordering of additional resources in support of the incident action plan; loaning or sharing of agency resources with other jurisdictions involved; and financial arrangements with participating agencies (if such powers are agency policy).

Unified commanders must manage their organizations to support the total operation. This may include: providing sufficient, competent staff and resources; anticipating and resolving problems; delegating tasks and responsibilities; inspecting and evaluating performance; and communicating with their agencies on priorities, plans, and problems.

The most important function of unified commanders is coordination with other members of the unified command team and with local officials, including mayors, county administrators, forest supervisors, and State governors.

Establishing Unified Command Participants

There are two simple guidelines for establishing participants in a unified command incident. Generally only jurisdictional agency personnel will be commanders. Assisting agencies are represented through liaison officers, if necessary. Fiscal authority is a determinant of command because commanders and their agencies must have legal authority to order, transport, and maintain the resources necessary to meet the command objectives.

Conclusion

Unified command is a method for agencies or individuals who have either geographic or functional jurisdiction at an incident to come together in a common organization, determine overall objectives, and select the strategy and action to achieve the objectives. Unified command is an important element in increasing the coordination of service agencies on multijurisdictional/multiagency incidents. ■

Keeping Pace With New Technology: Technical Fire Management Course

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In January 1982, the USDA Forest Service, Pacific Northwest Region, in cooperation with the University of Washington, College of Forest Resources, began offering a new course for fire management technicians and professionals. The program was aimed at well-established fire professionals working at the GS-7/9/11 level. The objective of the course was to present state-of-the-art technology to individuals who could and would put it to use.

Course Justification

A lot of technology has been developed since the days of ground line telephones and transporting fire camps by pack string. The intervening years have seen two attempts to create a nationwide fire danger rating system, with the latest version already twice revised. Current hazard classification systems provide more information than older systems. Pocket computers calculate flame length, rate of spread, and ignition probability while the operator stands watching the fires. "Slash burning" has become "prescribed burning" and is a land manager's tool that goes beyond simple slash abatement. The evolution of tools to tame and use fire as a management option has accelerated in the last decade.

Research has made considerable inroads into understanding fire effects in the natural environment. Congress has demanded that we be more exact in our cost-benefit assessments. New laws place stringent constraints on resource depreciation (for example, air and water quality) and dictate that planning targets be tied to resource production capabilities and protection abilities.

These changes have placed workload burdens on individuals not trained to compete in highly technical areas. More to the point, people who do not understand and cannot apply modern technology to these modern fire management problems cannot be expected to do the kind of job that meets the requirements of the new legislation. Inservice training has helped bridge some of the gaps in areas such as fire behavior, fuels management, fire effects, and fire ecology. These, however, are only stopgap measures and do not place all the available tools in the hands of the people who need them.

The objective of this course was to present new technology, advances in fire science, and concepts of business administration in one experience.

Course Description

The course was designed by a group of fire specialists who met with faculty from the University of Washington, and was organized into five 2-week sessions.

Module 1: Statistics and Numerical Analysis. The topics presented in module 1 include: the 10-step planning process; retrieving archived fire management data; summarizing and describing data; simple probability, probability distribution, and uses in fire management work; decision theory; sampling; predictive models; correlation analysis; simulation; and elementary financial analysis.

After completing module 1, participants should be able to:

- Retrieve fire occurrence and weather data from archived records.
- Summarize, describe, and display gathered data.
- Perform elementary financial arithmetic (for example, compounding and discounting) in preparation to making investment analyses.

Module 2: Fuels and Fuels Management. The topics presented in module 2 include: the interrelation of fire, fuels and land management; elements of acceptable fuel treatment plan; modeling fire behavior; fuel behavior, fuel treatment, and its physical basis; fire environment, fire growth, ignition, fire behavior; and fire hazard, fire danger rating, quantifying site conditions, analyzing treatment alternatives, and preparing fuel treatment plans.

After completing module 2, participants should be able to:

- Discuss and diagram linkages between fuels, fuel treatments, and land management.
- Apply fire behavior prediction system to given input data and identify data needs.
- Define and apply concepts of fire hazard, fire risk, and fire danger, and identify appropriate situations for their use.
- Prepare acceptable fuel treatment plan.

Module 3: Fire Effects and Fire Ecology. The topics presented in module 3 are: basic concepts of fire effects, including heat generation, reception, and interactions; fire's physical effects, including consumption of biomass and effects on vegetation and the microclimate; the role of fire in long-needled and short-needled coniferous ecosystems; methods of fire history investigation; the relationship between fire and insects, pathogens, watersheds, range, air quality, and field studies.

After completing module 3, participants should be able to:

- Recognize the physical evidence of fire's effects on western forests.
- Identify and interpret fire regimes in representative areas in the West.
- Design and conduct monitoring operations for treatments that use fire.
- Report findings of fire history, fire regimes, and fire effects observations.

Module 4: Fire Economics and Business Administration. The topics presented in module 4 are: macroeconomics—credit and money, inflation and depression, wealth and poverty, pareto-optimality; microeconomics—price theory, time preference for money, capital budgeting, theory of the firm; valuation; economics of forest protection; local and regional analysis; decision analysis in fire management; Program Evaluation Review Technique (PERT)/Critical Path Method (CPM); public involvement in land management decisions; Forest Planning computer program (FORPLAN) and fire planning; and legal aspects of fire management.

After completing module 4, participants should:

- Understand, in general, the gross features of the U.S. economy and how production of goods and services from forest lands contributes to it.
- Understand principles of economic decisions, such as investment criteria and capital budgeting.
- Understand the concept of value and how value is determined and measured.
- Understand how business management techniques (PERT/CPM, cost-accounting, and investment analysis) are used to schedule and monitor complex projects.

Module 5: Fire and Land Management. The topics presented in module 5 are: resource valuation and wildfire damage appraisal; fire risk analysis and evaluation; fuel management effectiveness analysis; using National Fire Danger Rating System (NFDRS) data and archival weather records in fire planning; fire prevention analysis; presuppression/suppression analysis; escaped fire situation analysis; fire management direction as it affects project planning and implementation; monitoring project and program performance.

After completing module 5, participants should be able to understand and use specific fire management program and project analysis techniques to:

- Integrate and apply statistical economic, biological, physical, and sociological information into fire and land management planning.
- Act as member of interdisciplinary team in developing management direction via the 10-step rational planning process.

Final Project. Students will conduct an analysis of fire protection needs (or the implementation of an existing or proposed fire protection plan) on an area of their choice, subject to approval of course coordinator. Students will have 6 months following the completion of the fifth module in which to:

- Assemble and analyze information pertinent to fire protection for their study area.
- Identify pertinent management issues and objectives originating from all parties concerned with management of the area.
- Formulate three or more alternative courses of action, and project the consequences of each alternative.
- Select and defend choice of the preferred alternative in writing and before a panel of examiners.

Course Schedule

In order to minimize the impact of technical fire management training on the regular workload of the participants, the five modules were scheduled throughout the year. In 1982, statistics and numerical analysis was offered January 11–22. Fuels and fuels management was taught from March 15–25. Fire effects and fire ecology was presented June 14–25. Fire economics and business administration was offered October 4–15. Fire and land management was presented November 24 through December 10. The final report was due by June 31, 1983.

Prework and pretesting began in August of 1981. Applicants were required to have completed fire behavior training equivalent to the S–390 course, TI–59 fire behavior prediction training, and to have worked in fire management full time for 5 years. These requirements helped ensure that those persons receiving the training could relate what they were learning to real problems.

Thirty-two students participated in the 1982 course. Thirty-one were Forest Service employees; one was an employee of the U.S. Department of the Interior, Bureau of Land Management.

Students in the technical fire management course were exposed to new technology, advances in fire science, and concepts of business administration. As often happens, the participants also developed a list of problems for which no immediate solutions exist. However, they have mastered new methods, concepts, and tools so that they can grapple with and answer fire management questions effectively.

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Using Decision Analysis To Evaluate Fire Hazard Effects of Timber Harvesting[1]

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Timber harvesting activities usually increase the amount of combustible woody residue (fuel) on a site. This residue increases the possibility of damage from wildfires and, thus, poses a potential threat to the future timber stand, nearby structures, and other resources. The increased hazard can be mitigated by treating fuels by methods such as lopping and scattering, crushing, yarding residue, and prescribed burning. Managers need a procedure to evaluate the extent of fire hazard in order to determine the appropriate level of fuel treatment.

The potential for wildfire damage is influenced by the amount and type of fuel, the likelihood of an ignition, weather conditions, fire suppression capability, and resource values. Many of these factors incorporate a degree of uncertainty. For example, there is no guarantee that a wildfire will occur in an area. If a fire should occur, the weather conditions, resulting fire behavior, and ultimate size of the fire would be uncertain. Because of these uncertainties, the resulting fire-related damages, costs, and losses would be uncertain. Therefore, the traditional, deterministic approach to cost and benefit analysis may not be appropriate for evaluating fuel treatments.

[1]Paper presented at the Conference on Timber Harvesting in the Central Rockies, Society of American Foresters, Regional Technical Conference, Colorado State University, Jan. 4–6, 1983, Fort Collins, Colo.

Decision analysis (*1*), a systematic approach for evaluating management alternatives in the face of uncertainty, can be used effectively to evaluate fire hazard. However, before considering the complexity of a fire management decision, it will be helpful to illustrate the application of decision analysis with the simple decision to play a coin-toss game. For $0.60 you can purchase a chance to win $1.00 for a "head" and $0.10 for a "tail." This is a situation where the outcome is uncertain. Should you play? The problem can be represented in a decision tree

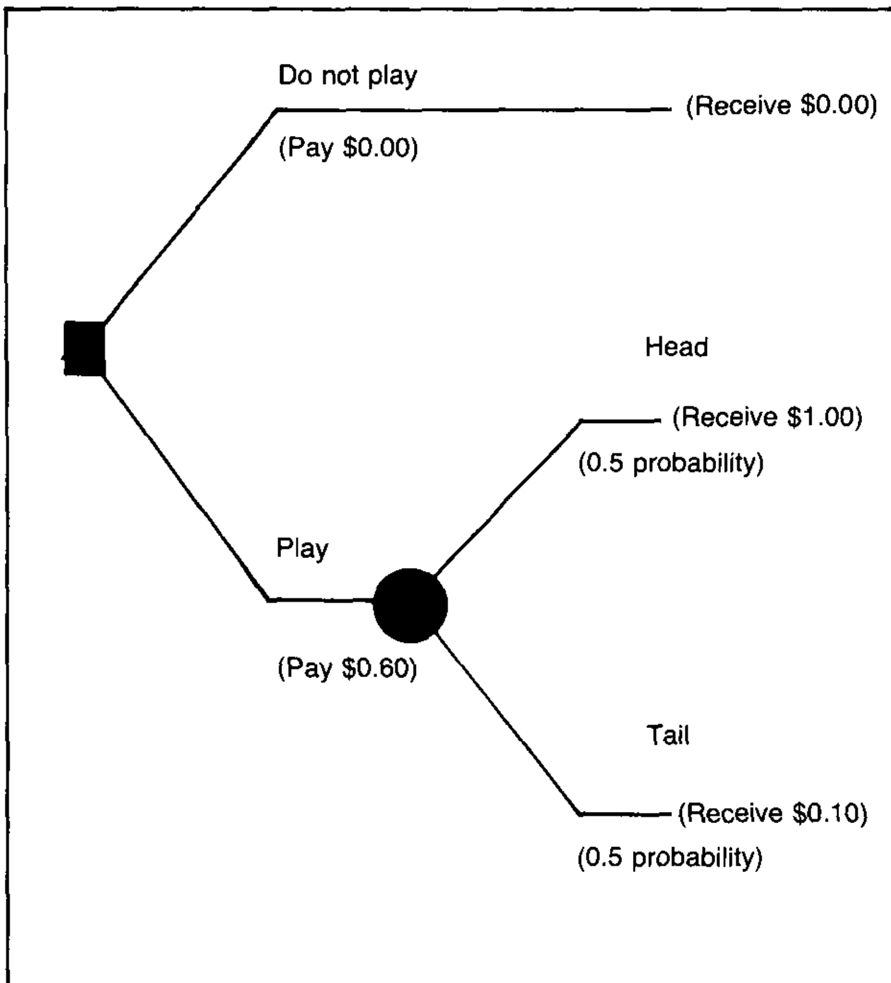

Figure 1—*Decision tree for the coin-toss problem*

diagram (fig. 1). The expected value (a probability-weighted average of the outcomes) of playing the game is (0.5 × \$1.00) + (0.5 × \$0.10) = \$0.55. The net value is \$0.55 − \$0.60 = −\$0.05. If you were to play this game many times, on the average you would expect to lose a nickel for each time you played. The expected value for not playing is \$0.00, so the best choice is to not play.

An important point from this example is that what may have appeared to be a fair game was, in fact, a losing proposition. Similarly, in management situations where uncertainty is involved, the evaluation of alternatives is often not straightforward. Decision analysis can help sort out this complexity.

Decision Analysis of Fuel Treatments

The following analysis of fire hazard from timber cutting on the Black Hills National Forest, South Dakota, illustrates the use of decision analysis for evaluating alternative fuel treatments. The analysis assumes 1,000 acres of ponderosa pine will be cut in blocks scattered throughout part of the Forest. The harvesting plan calls for partial cutting that will result in a total fuel load of about 26 tons per acre. Fire behavior estimates (*3*) for this fuel load and Black Hills weather conditions indicate that wildfires would exceed an intensity of 600 Btu $\times$ ft^{-1} $\times$ s^{-1} 10 percent of the time. (Fire intensity is estimated in British thermal units × feet × seconds.) Fires of this intensity have flames over 8 feet long and are difficult to suppress. Therefore, it may be desirable to treat the fuels to reduce the severity of possible fire behavior.

Two levels of treating the fuels to reduce fire hazard were evaluated. The first level reduces the ninetieth percentile fire intensity to approximately 400 Btu $\times$ ft^{-1} $\times$ s^{-1}. This level can be achieved by lopping the slash to a 1.5-foot maximum depth. The second treatment level reduces the fuel load and depth so the ninetieth percentile intensity is 250 Btu $\times$ ft^{-1} $\times$ s^{-1}. This could be achieved by a broadcast burn designed to remove the highly flammable fine fuels.

The Activity Fuel Appraisal Process—a specific application of decision analysis (*2*)—was used to evaluate the treatment alternatives. The process uses a combination of fuelbed modeling, fire behavior modeling, historical records, and subjective judgement to estimate the area expected to be burned by wildfires.

The analysis for this Black Hills fuel treatment decision is summarized by the decision tree in figure 2. Only the "no treatment" decision is shown in detail, but a similar diagram was prepared for the "lopping" and "broadcast burn" treatments. The three fire intensity levels and the spotting conditions represent different degrees of suppression difficulty. Probabilities for the fire intensity and spotting events were estimated from historical weather records and computer-modeled fire behavior. The fire sizes represent the range of possible wildfire outcomes in the area. Fire size probabilities were subjectively estimated by fire suppression personnel. The expected burned area (expected value) is calculated as the product of the fire size outcome (acres) multiplied by all probabilities (in parentheses in fig. 2) leading to that outcome. For each fire occurrence, about 245 acres would be expected to burn if no treatment were applied to the slash.

For each fire occurrence the area expected to burn under the lopping treatment is 187 acres and the area under the broadcast burn treatment is 23 acres. The diagram shows more than the total area expected to be burned, however. It also shows the contribution to the total expected burned area of potential fires in the various intensity and size classes. This enables economic evaluation of the outcomes because fire effects on resource values are related to the type of fire.

Resource value changes and suppression costs were estimated by Black Hills National Forest personnel.[2] Estimated present values of resource value changes per acre

[2]Personal communication with Al Braddock, Fire Staff Officer, Black Hills National Forest, Fire Management.

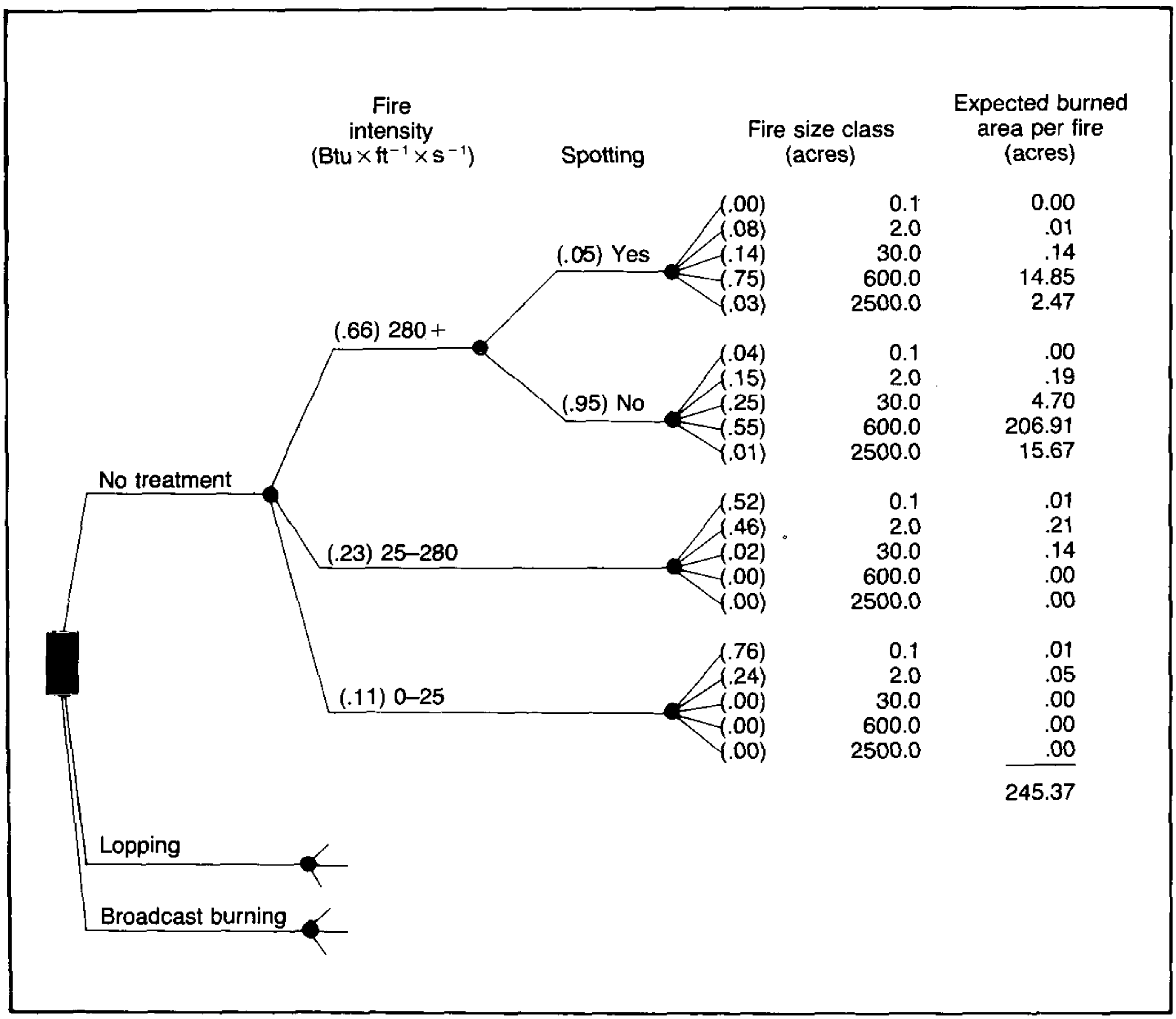

Figure 2—*Decision tree representing the fuel treatment decision. Total expected burned area per fire for the no treatment alternative is about 245 acres.*

Table 1—*Present value (dollars per acre) of resource value changes per acre burned by wildfires in three fire intensity classes*

Resource	Fire intensity (Btu × ft^{-1} × s^{-1})		
	0–25	25–280	280+
	Dollars		
Timber	0.00	−35.00	−110.00
Range	.70	.80	1.10
Wildlife	5.20	6.70	6.60
Esthetics	.60	−.50	−3.95
Recreation	.60	−.55	−4.10
Cultural	−.20	−.20	−.20
Total	6.90	−28.75	−110.55

burned are shown in table 1. These estimates were based on the fact that fires of different intensities have different levels of effects on the various resources. For example, low-intensity fires are likely to have beneficial effects on all resources except cultural resources. High-intensity fires, on the other hand, will have significant negative effects on the timber and recreation resources and esthetic values. Multiplying these values by the corresponding expected area burned estimates gives the expected change in resource values from wildfires shown in table 2.

Suppression costs ranged from $40 per acre for the largest fire size class to more than $5,000 per acre for small fires, although the total suppression costs for large fires are the highest. These cost estimates reflect recent experience on the Forest. Outcome probabilities from the

Table 2—*Expected values of resource value changes and costs per fire occurrence*

Treatment	Fire intensity	Expected values			Total expected value
		Changes in resource values	Suppression costs	Losses from burned houses	
	Btu × ft^{-1} × s^{-1}	Dollars			
No treatment	280+	−27,084	−22,358	−29,558	−79,000
	215–280	−10	−552	0	−562
	0–25	+0.4	−92	0	−92
		−27,094	−23,002	−29,588	−79,654
Lopping	280+	−20,562	−16,877	−22,487	−59,926
	25–280	−20	−1,032	0	−1,052
	0–25	+0.2	−50	0	−50
		−20,582	−17,959	−22,487	−61,028
Broadcast burn	280+	−2,432	−1,974	−2,635	−7,041
	25–280	−37	−2,040	0	−2,077
	0–25	+0.4	−75	0	−75
		−2,469	−4,089	−2,635	−9,193

decision trees and the estimated suppression costs were used to compute the expected values of suppression costs (table 2).

An additional, important impact of wildfires is the possible damage to houses and other structures. Many houses have been built in the area of the Black Hills National Forest considered in this analysis (about 3,540 houses in 553,000 acres). The average value of the houses is $80,000. In this analysis it was assumed only the highest intensity fires (280+ Btu × ft^{-1} × s^{-1}) that exceed 100 acres are likely to threaten houses. The probability that a fire will burn a house was then computed assuming the houses are distributed randomly throughout the analysis area. It was also assumed that not more than one house would be burned per fire. This enabled computing the expected value per fire of losses from burned houses (table 2). The importance of these broad assumptions was tested through sensitivity analysis (see below).

The estimated resource value changes and costs are summarized in table 2. This table shows the expected losses on a per-fire basis. However, there is no guarantee that a fire will burn in any of the blocks comprising the 1,000 acres of slash in any year. During recent years, an average of 0.13 fire start has been recorded annually per 1,000 acres on the Black Hills National Forest. The estimated per-fire losses were multiplied by this annual fire occurrence rate to derive annual loss estimates. These are shown in table 3.

Table 3 also shows the expected annual losses that could be averted by applying the fuel treatments. The values in the column showing present value of total cost savings were computed assuming the benefits from the treatments will persist for 5 years and then discounting the annual values using a 4-percent interest rate. This indicates that up to $11.13 per acre could be spent for lopping or $40.96 per acre for broadcast burning to achieve fire hazard reduction in the slash. Actual costs on the Black Hills National Forest are about $10 per acre for lopping and about $50 per acre for broadcast burning. Therefore, lopping appears to be the favored treatment from a fire hazard point of view. Broadcast burning actually shows an expected loss of about $9 relative to doing no treatment.

The ranking of the alternatives may change if resource benefits in addition to fire hazard reduction are considered. Lopping provides the added benefit of esthetic improvement. Broadcast burning may influence esthetics, tree growth, accessibility for harvesting operations, forage, and wildlife habitat. Table 4 shows the preferred alternatives for various assumptions about the level of ancillary benefits from the treatments. For example, if additional benefits of $15 per acre from broadcast burning and $6 per acre from lopping could be expected, the net value of broadcast burning would be $40.96 + $15.00 − $50.00 = $5.96, and the net value of lopping would be $11.13 + $6.00 − $10.00

Table 3—*Comparison of benefits from the fuel treatments. Values on a per-year basis were computed using the historical fire occurrence rate of 0.13 fire per 1,000 acres per year*

Treatment	Cost + net value change per fire	Cost + net value change per year	Cost + loss savings per acre per year because of treatment	Present value savings per acre over 5 years	Expected burned acres per fire	Expected burned acres per year
	--Thousands of dollars--		*----------Dollars----------*			
No treatment	−79.7	−10.4	0.00	0.00	245	32
Lopping	−61.0	−7.9	2.50	11.13	187	24
Broadcast burn	−9.2	−1.2	9.20	40.96	23	3

Table 4—*Preferred treatment alternative for various levels of benefits in addition to fire hazard reduction*[1]

Additional benefits from lopping	Additional benefits from broadcast burning			
---Dollars per acre---	---Dollars per acre---			
	0	10	15	20
0	L	L	B	B
2	L	L	B	B
4	L	L	B	B
6	L	L	L	B

[1]L indicates lopping is preferred; B indicates broadcast burning is preferred.

= $7.13. Therefore, lopping would still be the preferred alternative. If the expected additional benefits were $15 for broadcast burning and only $4 for lopping, the net values would be $5.96 for burning and $5.13 for lopping, and broadcast burning would be preferred.

The cost resulting from damage to houses represents a highly uncertain aspect of this analysis. A sensitivity analysis was conducted to determine the importance of changing the probabilities that a house would be destroyed in a wildfire event. Present values of expected savings were computed first assuming the probabilities were twice the nominal values and then assuming the probabilities were one-half the nominal values. In addition, expected savings were computed assuming no losses (zero probability) from burned houses. The results (fig. 3) show that the chances of burning a house could influence the feasibility of a treatment, depending on the actual treatment costs. At the nominal probability level, lopping is the preferred alternative. At the lower probabilities, both treatments have expected fire hazard reduction values that are less than the respective treatment costs, so the no treatment alternative is preferred. At the high probability level, broadcast burning becomes the preferred alternative. These results indicate it may be of value to develop improved estimates of the chances of burning a house in a wildfire event.

Summary

Expected fire outcome information, suppression costs, and resource values were combined in a decision analysis model to evaluate fuel treament alternatives. The analysis on the Black Hills National Forest indicated that for each 1,000 acres logged the expected area burned annually by wildfires could be reduced from 32 acres with no treatment, to 24 acres with a lopping treatment, and to 3 acres with a broadcast burning treatment. Estimated present values of benefits from the treatments are $11.13 per acre for lopping and $40.96 per acre for broadcast burning.

Conclusion

A complete analysis of fuel treatment alternatives involves evaluating fire hazard changes and the effects these changes have on costs and resource values. The result shows the benefits (in terms of fire hazard reduction) that can be expected from the various treatments. If benefits are expected in addition to hazard reduction, they should be included in a total economic analysis.

Because of the many uncertainties involved, decision analysis provides a useful framework for analyzing fire hazard changes associated with fuel treatments. In the example, a decision tree model enabled explicitly considering fire behavior and fire size uncertainties in the analysis of fuel treatment alternatives. In a more detailed analysis, uncertainties in components such as fire occurrence rate, probability of burning houses, and resource value changes could also be incorporated in the decision tree.

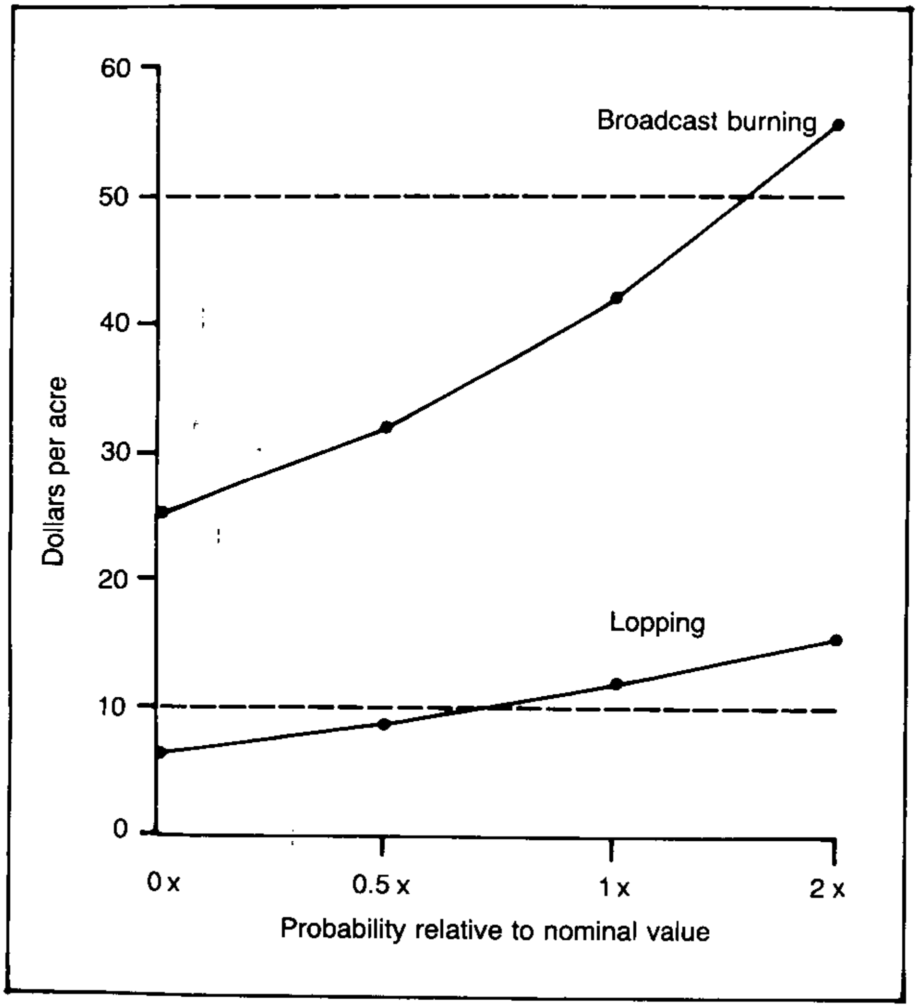

Figure 3—*Results of sensitivity analysis showing present value of savings for various probabilities of burning a house by wildfire. Estimated treatment costs are shown by the broken horizontal lines. The point labeled "lx" on the horizontal axis represents the nominal probability value.*

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Height of Stem-Bark Char Underestimates Flame Length in Prescribed Burns

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Estimates of fire intensity are useful in predicting the effects of fire on trees, lesser vegetation, microclimate, and soils. According to Byram (*3*), fireline intensity (I) is the rate of energy release per unit time per unit length of fire front (Btu/ft-sec) and can be calculated from flame length (L_f), in feet, by the equation:

$$I = 5.67\ L_f^{2.17}$$

Flame length (fig. 1) is measured midway in the zone of active flaming; it is the distance between the tip of the flame and the ground (*10*). Johnson (*6*) observed that flames are random, pulsating, transient phenomena, therefore a large number of observations are necessary to obtain an accurate measure of flame length.

Even though calculation of fireline intensity from flame length is relatively simple, estimating flame length during the course of burning may be logistically impractical on prescribed fires and impossible on wildfires. Consequently, it is desirable to have dependent variables that can be accurately measured in the field after burning is complete and subsequently used for calculation of intensity.

One such variable is height of crown scorch (fig. 1), which can be measured vertically from ground level to the highest point in the crown delineated by yellowing or browning needles. Van Wagner (*12*) used height of crown scorch (H_s) to calculate fireline intensity by:

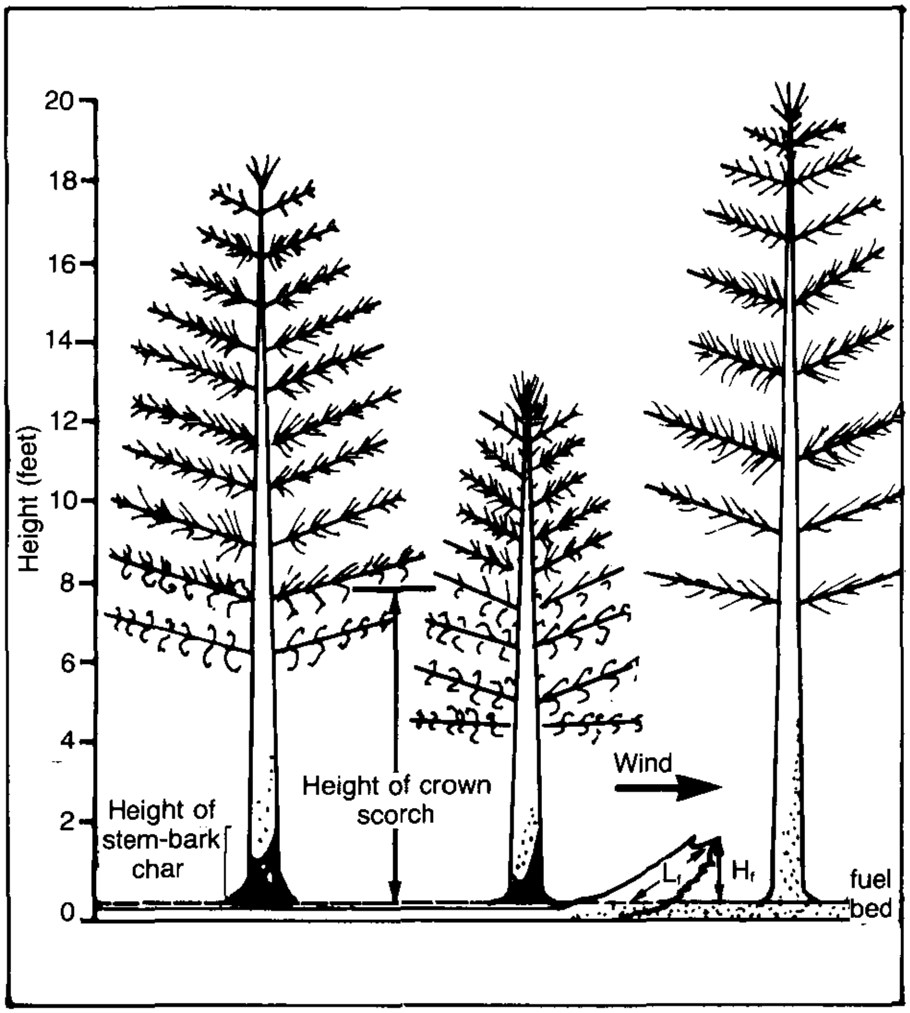

Figure 1—*Schematic diagram illustrating headfire on mechanically thinned plot with mean height of measured variables. (Height of stem-bark char, height of crown scorch, and flame length = L_f; flame height of H_f was not estimated in this study.)*

$$I = 0.85\ H_s^{1.5}\text{(Btu/ft-sec)}$$

A second variable under consideration is height of stem-bark char (fig. 1), or the vertical portion of the outer bark that was blackened by the fire. Height of stem-bark char has been used (*7, 9*) as an estimate of flame height and for calculation of fireline intensity using Byram's equation. Flame height (fig. 1) is defined as the maximum vertical extension of the flame front (*1*); a technique for measuring flame height has been reported by Ryan (*11*). The problem is that no documentation is available to show that height of stem-bark char provides an accurate estimate of either flame length or flame height for substitution into Byram's fireline intensity equation.

As part of a precommercial thinning study in a natural stand of 9-year-old loblolly and shortleaf pine (*Pinus taeda* L. and *P. echinata* Mill.), measurements were taken to correlate observed flame length during a prescribed burn with height of stem-bark char following the burn.

Methods

Study Area—The study area is a 10-acre clearcut strip on the Crossett Experimental Forest in south Arkansas. The area measures 1,320 feet north to south and 330 feet east to west with a gradual slope of about 3 percent from north to south. The soil is silt loam that is usually near-saturated during winter months. The 10-acre strip was cleared to bare ground in 1971 for research purposes. In 1972 pines seeded in from adjacent stands but were mowed in the fall of 1973. In 1974–75 the strip reseeded naturally with loblolly and shortleaf pines and remained undisturbed until 1979 when an inventory revealed an average of 16,600 pines per acre. The species ratio was about 70 percent loblolly and 30 percent shortleaf.

In October 1979, six 0.4-acre plots were mechanically strip thinned by mowing 12-foot-wide swaths that alternated with 1-foot-wide uncut strips. An additional six plots served as controls in a completely randomized design.

In the fall of 1981, thinned plots averaged 2,000 pines per acre and unthinned plots about 14,000 pines per acre. Mean total height of pines in 1981 was about 10 feet for both treatments but ranged from 1 to 25 feet. Pine diameters averaged 1 inch in diameter at breast height on thinned plots and 0.75 inch on unthinned plots.

Prescribed Burn—There were no other treatments or disturbances to study plots until mid-January 1983, when a prescribed fire was used for fuel hazard reduction. Weather information was recorded in an open area between plots using a belt weather kit. During the burn, air temperature averaged 56° F; relative humidity ranged from 31 to 52 percent; and wind was from the northwest, averaging 5 miles per hour (mi/h). There was no precipitation within 7 days before burning, but the month of December (1982) had been unusually wet with a total accumulation of over 18 inches of precipitation compared to a 40-year average of less than 6 inches.

Surface fuels on unthinned plots were mostly pine litter with a moisture content of 48 percent in samples taken down to mineral soil just before fire ignition. Dry weight of surface fuels on these plots was 6.6 tons per acre. Surface fuels on the mechanically thinned, 1-foot-wide uncut strips contained pine litter and grasses; the 12-foot swaths contained mostly grasses, blackberry briars (*Rubus* spp.), and undecomposed wood fiber from the thinning treatment 3 years earlier. Dry weight of surface fuels on thinned plots was 6.0 tons per acre with a moisture content of 28 percent at the time of burning.

On unthinned control plots, the uniformity of surface fuels permitted the use of backfires, which spread at a rate of 1.3 chains per hour. Backfires proved to be ineffective where there had been mechanical thinning. On these plots, the patchiness of combustible surface fuel necessitated the use of headfires to ensure complete coverage; the rate of spread was 5.5 chains per hour. Plots were individually ignited between the hours of 10:00 a.m. and 1:00 p.m. Burning was complete by 3:30 p.m.

Measurements—Flame lengths were obtained by ocular estimation to the nearest foot while burning was in progress. Six people participated in making the observations. There was an average of 32 observations made on each unthinned plot and 33 on each thinned plot.

Within 3 weeks following the burn, height of stem-bark char and height of crown scorch were measured to the nearest 0.1 foot using a telescoping measuring rod. These measurements were taken within systematically preestablished subplots on the 0.2-acre interior of each 0.4-acre grass plot. Line subplots were inventoried on mechanically thinned plots and circular subplots were used on unthinned controls. Total area sampled was approximately 3 percent of each 0.2-acre interior plot. Individual tree data were averaged on a plot-by-plot basis.

Data Analysis—The accuracy of stem-bark char as an estimate of flame length was determined by the standard chi-square (χ^2) test (*5*). For that test, it is necessary to state the accuracy required if the estimator (stem-bark char) is to be considered acceptable. In this study the degree of chosen accuracy was ±1 foot, since flame length could not be assessed in the field to any finer degree of accuracy by visual observation. The accuracy was specified in the form of a hypothesized variance (σ^2) at the 0.05 level. Because the height of stem-bark char might be different in backfires and headfires, data from unthinned controls and thinned plots were analyzed separately.

Flame length, height of stem-bark char as an estimate of flame length, and height of crown scorch were used to calculate fireline intensity. These data were subjected to analysis of variance to determine if mean values differed by method of calculation. Duncan's Multiple Range Test was used to isolate mean differences.

Results and Discussion

The computed χ^2 values for testing accuracy on unthinned controls (27.69) and on thinned plots (46.01) exceeded the tabular value ($\chi^2$6df = 12.59 at the 0.05 level), indicating that height of stem-bark char was not accurate enough to estimate flame length. For both backfires and headfires, mean height of stem-bark char underestimated observed flame length by half (fig. 2).

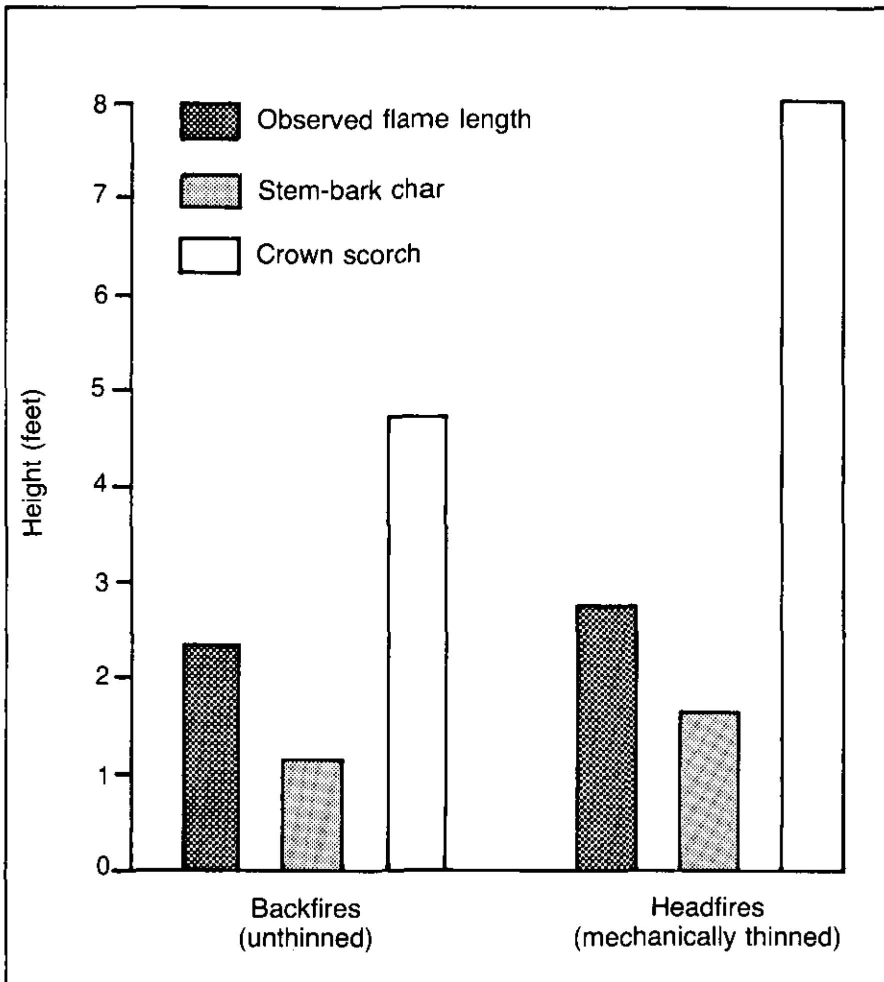

Figure 2—*Mean height of measured variables used to calculate fire intensity by stand condition and method of burning*

For the burning conditions reported here, height of stem-bark char should not be used as a substitute for flame length where a definitive measure of fire intensity is desired.

Fireline intensities derived from height of stem-bark char and height of crown scorch in both thinned and unthinned stand conditions were similar but significantly different from intensities based on observed flame length (table 1). Even so, headfires in the thinned stands were about twice as intense as backfires in the unthinned stands, regardless of whether intensity was determined from flame length, height of stem-bark char, or height of crown scorch. In other words, relative differences between burns in the two stand conditions remained the same regardless of the method of measurement.

Height of crown scorch is a strong indicator of fire damage to southern pines (*2, 4, 8*). Nevertheless, height of crown scorch seriously underestimated fireline intensity in this study when compared to intensity calculated from observed flame length. One reason might be that Van Wagner's equation was derived from burns within red pine, white pine, and jack pine stands of eastern Ontario, where surface fuels and weather variables are different from those of southern pine sites.

Since it is more desirable to have quantitative measures of fire effects than qualitative descriptions, there is a need for estimators of fire intensity that can be measured in postburn situations. Under those circumstances, height of stem-bark char or height of crown scorch may provide adequate measures of relative, but not absolute, fire intensity and may be useful for comparing burns that occurred within different stand conditions. Since heights of stem-bark char are more easily measured in the field than heights of crown scorch, the former would most likely be the measurement of choice in postburn situations. In mature pine stands, the height of the crown may exceed the intensity of a fire to cause scorch, so that no postburn crown measurements could be taken. Although height of stem-bark char is easily determined in stands not previously burned, recurrent use of fire may reduce the measurement accuracy of that estimator because sloughing of charred bark sometimes requires several years.

Table 1—*Calculation of fireline intensity from three variables (flame length, height of stem-bark char, and height of crown scorch)*

Measured variable	Fireline intensity: Unthinned	Fireline intensity: Thinned
	Btu/ft-sec	
Observed flame length[1]	30a[2]	60a
Height of stem-bark char as an estimator of flame length[1]	8b	15b
Height of crown scorch[3]	9b	19b

[1]Relation between intensity (I) and flame length (L_f) in feet, from Byram (*3*): $I = 5.67 L_f^{2.17}$
[2]Within column means followed by the same letter are not significantly different at the 0.05 level.
[3]Relation between intensity (I) and height of crown scorch (H_s) in feet, from Van Wagner (*12*): $I = 0.85 H_s^{1.5}$

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The First 40 Years

Gladys D. Daines

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What famous forest fire prevention symbol will celebrate a 40th birthday in 1984? Smokey Bear, of course.

Across the Nation people have been busy for a long time preparing birthday posters, public service announcements, newspaper and magazine articles, and speaking appearances to celebrate this special year. Why are people so excited about celebrating Smokey's 40th birthday? Because Smokey Bear is one of the most beloved animal characters in the United States, as well as one of the most successful advertising symbols of all time. In a recent study 95 percent of the people surveyed could finish Smokey's motto when given the words, ''Remember, only you ___ ___ ___ ___.''

The same survey found 98 percent of the people surveyed could identify Smokey Bear's picture.

The History of Smokey

In 1942, shelling of the southern California coast by a Japanese submarine caused forestry officials to be concerned about future damaging forest fires. So, the USDA Forest Service organized the Cooperative Forest Fire Prevention campaign to encourage the general public to participate in forest fire prevention.

The supervisor of the Angeles National Forest in California contacted the newly formed public service agency, the Wartime Advertising Council (now the Advertising Council) for help. The Council and the National Association of State Foresters agreed to assist the Forest Service in a nationwide forest fire prevention campaign. Foote, Cone and Belding of Los Angeles, Calif., (now Foote, Cone and Belding/Honig) became the volunteer agency serving the campaign.

Early fire prevention posters used wartime slogans. And in 1944 Walt Disney's animal character Bambi was used with great success. After that, the Forest Service and the Wartime Advertising Council decided to choose an animal to represent forest fire prevention. In a Forest Service letter dated August 9, 1944, Richard Hammett, Director, Wartime Forest FirePrevention Program, described the attributes of the bear: ''. . . nose short (Panda type), color black or brown; expression appealing, knowledgeable, quizzical; perhaps wearing a campaign (or Boy Scout) hat that typifies the outdoors and the woods.''

Albert Staehle, a nationally known cover artist, was asked to paint the first bear. Blue jeans were added to the original painting. And the first poster of the bear pouring water on a campfire was printed in 1944 and distributed in 1945. The bear was named after ''Smokey'' Joe Martin, who was Assistant Chief of the New York City Fire Department from 1919 to 1930. Smokey's public service debut on posters, car cards, newspaper ads, and radio spots grabbed the public's attention. And forest fires decreased markedly in the United States.

In 1946, Rudy Wendelin, a Forest Service artist, began to work closely with the volunteer advertising agency on Smokey Bear posters. Wendelin became one of the best-known Smokey Bear artists. Even after his retirement in 1973, Wendelin continued to paint Smokey and act as a Smokey program consultant. Harry Rossell, another famous Forest Service artist, created four Smokey Bear cartoons a month for many years. In 1972 alone, over 3,000 copies of Rossell's cartoon series were distributed each month in the United States and Canada.

The Living Symbol

In 1950, someone was careless with a match, cigarette, or campfire on the Lincoln National Forest in New Mexico. One second of carelessness started a terrible forest fire and hundreds of firefighters battled the flames. When a strong wind suddenly swept the fire toward the firefighters, 24 of them nearly lost their lives. They ran to a rock slide and lay face down with their faces covered with wet handkerchiefs. The fire raged all around and the smoke choked them. Finally, the fire passed and the smoke cleared. The only living thing those 24 brave firefighters saw was a badly burned cub clinging to a blackened tree. They took the little bear to a ranger station where many people tended to the burns. He was called Smokey after the famous poster bear. After the burns healed, the little bear was sent to live at the National Zoo in Washington, D.C., where he became the living symbol of Smokey and forest fire prevention. Over 3 million people each year visit the National Zoo and the continuing living symbol of Smokey Bear.

The Smokey Bear Act

In 1952, Congress passed the Smokey Bear Act to protect the image of Smokey Bear and the work of the Cooperative Forest Fire Prevention program. The Act: prohibited the use of Smokey Bear without the permission of the Forest Service; permitted the Forest Service to license the use of Smokey Bear and collect royalties; and allowed the Forest Service to keep the royalties and put them into a fund to be used only for forest fire prevention. The Act also prohibited the wearing of a Smokey Bear costume without permission. Violators may be fined or imprisoned. The Smokey Bear program currently has licenses with 50 different businesses and organizations who make and/or sell merchandise associated with Smokey.

In 1952, the Forest Service licensed Ideal Toys to manufacture Smokey Bear stuffed toys. Ideal Toys, with permission from the Forest Service, inserted an application to become "Junior Forest Rangers" in each toy. By 1955, over 500,000 children in the United States were Junior Forest Rangers. Educational packages about forest fire prevention were taken to elementary school classrooms by State forestry and Forest Service people. Children were encouraged to write to Smokey for Junior Forest Ranger Kits and in 1965, Smokey Bear was given his own zip code—20252. Today Smokey receives 150 requests for forest ranger kits each week.

A Year of Festivities

Many national, regional, and local activities are planned to celebrate Smokey's 40th birthday.

A Float in the Rose Bowl Parade. Smokey's birthday celebration began on January 2, 1984, when a float saluting Smokey's volunteers was part of the Tournament of Roses Parade in Pasadena, Calif. The float was cosponsored by the Forest Service and The Square Dancers of America. It was built by C. E. Bent and Son of Pasadena, Calif., and depicted an outdoor forest scene. Woodsy Owl called square dance tips as colorfully costumed dancers danced to Smokey Bear and Woodsy Owl ballads. Ten Dancers from across the Nation were selected by a drawing at the Annual Square Dancers Jamboree.

The Goodyear Blimp wished Smokey a Happy 40th Birthday during the Rose Bowl game and continued to advertise Smokey's birthday for the first 2 weeks in January. The worldwide media coverage of the Rose Bowl parade and the good wishes from the Goodyear Blimp were outstanding ways to bring Smokey's birthday to everyone's attention.

A Stamp. On August 9, 1984, the U.S. Postal Service will issue a commemorative stamp to honor Smokey's birthday.

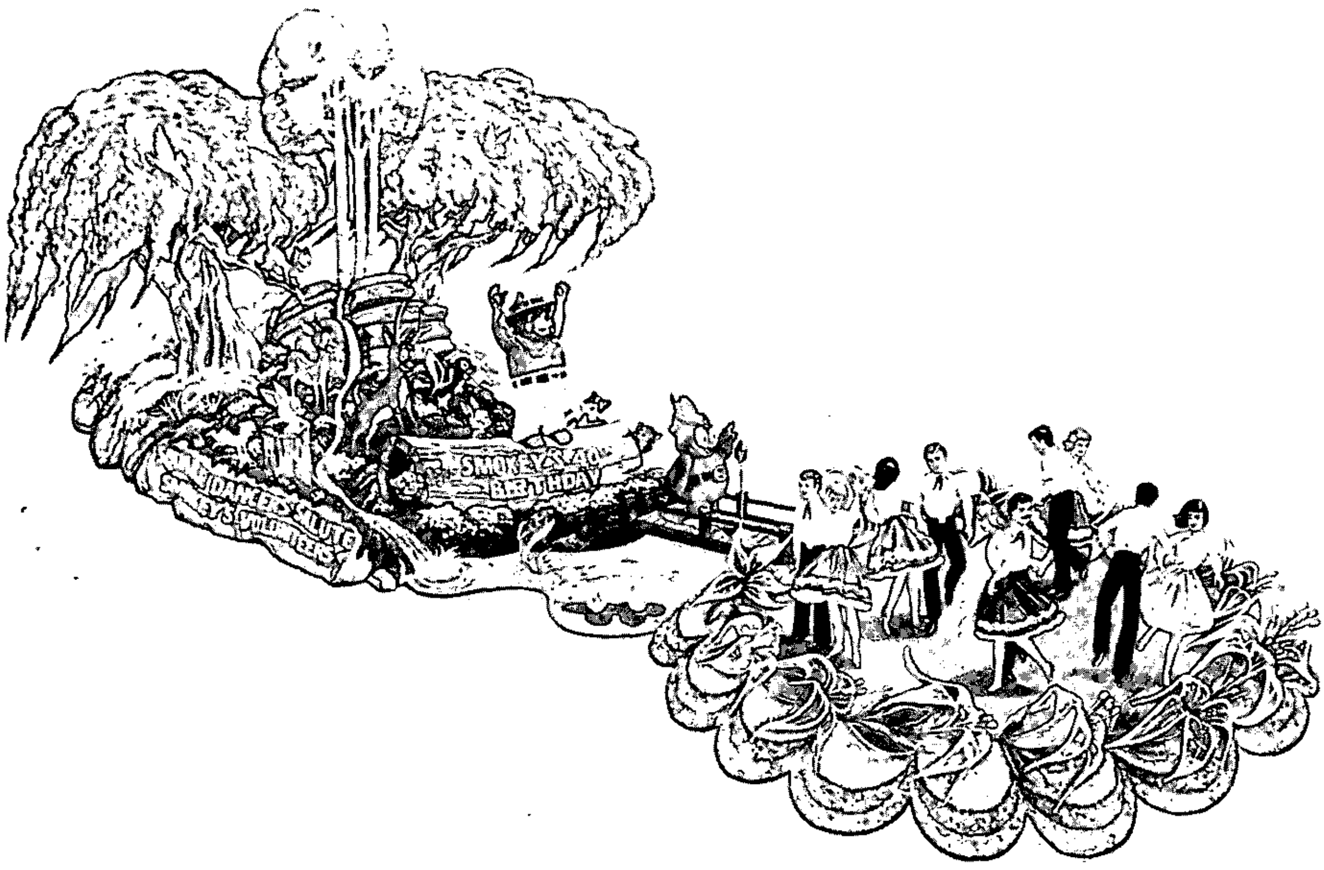
Smokey Bear Days. Smokey will be honored by four California major league baseball teams on special Smokey Bear Days. Smokey will throw out the first ball at each of the games and baseball/Smokey Bear trading cards will be given to all of the children attending the games.

Smokey and the World Series. Smokey will also throw out the first ball in the Little League World Series games held in Pennsylvania.

Smokey Past and Future

The Smokey Bear campaign has been a 40-year success story. And the impact of Smokey's public service campaign is indisputable. In 1942 over 10 million acres of wildland were burned. In 1981, only 3 million acres were burned. Saving forests from fire has saved taxpayers over $20 billion since 1942.

And Smokey's campaign goes on—to children who need to hear about forest fire prevention and adults who need to be reminded that, "Only you can prevent forest fires." ■



Float for the Tournament of Rose Parade 1984 sponsored by the Forest Service and The Square Dancers of America.

Silver Smokey Awarded Posthumously to DeBernardo

Luigi DeBernardo, an employee of the USDA Forest Service until his death in 1980, was honored posthumously at the Annual Western Forestry and Conservation Association meeting in December 1983. DeBernardo's widow, Barbara received the Silver Smokey award from R. Max Peterson, Chief of the Forest Service, at a ceremony in Portland, Oreg.

DeBernardo was selected for the award, the second highest for forest fire prevention, for his years of work as the Nation's leading authority on spark arresters. Spark arresters keep internal combustion engine sparks from starting fires in grass, brush, and forests. He was project coordinator and technical applications advisor at the Forest Service's Equipment Development Center in San Dimas, Calif. His work on

Mrs. Luigi DeBernardo receives a Silver Smokey award from R. Max Peterson.

spark arresters, which use highly specialized screens or other mechanical means to prevent hot carbon from escaping a vehicle's engine, has reduced the number of wildland fires. At the time of his death, DeBernardo was working to obtain a patent on a self-cleaning spark arrester for locomotives that he was instrumental in developing.

Chief Peterson said DeBernardo's expertise was much in demand, and he willingly and enthusiastically shared it with others. His accomplishments include the publication of the Forest Service Spark Arrester Guide, which is used by fire prevention inspectors worldwide.

The Silver Smokey statuette is given periodically to recognize significant contributions of fire prevention professionals. Recipients are selected by the members of the Cooperative Forest Fire Prevention program's executive committee. The committee is made up of representatives of the National Association of State Foresters and the Forest Service. ■

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Research News

Research on Fire Prevention Pays Off in the South

Ten years of research on arson at the USDA Forest Service Southern Station has paid off. Researchers now understand the causes of arson and have discovered a way to solve the problem. Many wildfires in the South are set on purpose: to burn the grass or to improve hunting; because people are made at the landowners; or for other reasons. Research has demonstrated that personal contact with potential arsonists is superior to any other form of communication in delivering the fire prevention message.

The Southern Station has prepared a 16-hour training program to teach the importance of personal contacts in fire prevention and the traits necessary for that type of work. The program has been presented in six workshops across the South. Over 125 participants representing National Forests, State forestry agencies, the forest industry, and volunteer fire departments have attended the sessions. Several participants have conducted workshops in their own organizations; consequently, about 300 people have received the training. More workshops are scheduled.

A self-study manual will soon be published and the training will soon be included in the National Wildfire Coördinating Group's comprehensive training program for fire prevention specialists. Distribution of training materials and coordination of workshop planning is being directed by the Aviation and Fire Staff of the Southern Region. For more information, contact: Ernie Eller, USDA Forest Service, Aviation and Fire, 1720 Peachtree Road, N.W., Atlanta, GA 30367, or telephone (404)881-3734. ■

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