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# Fire Management Notes



# Fire Management Notes

An international quarterly periodical devoted to  
forest fire management

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Cover: Forest ranger searching for telltale wisps of smoke from the summit of Mount Taylor, Cibola National Forest, NM, 1922.

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# Prescribed Burning as a Training Exercise in NIIMS

**Curt Bates**

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The past few years have provided very few opportunities for mobilization of class I fire overhead teams (incident teams), especially in the Rocky Mountain Region of the USDA Forest Service. This lack of activity has created some apprehension among the firefighting ranks as to retention of qualifications, performance ability, uncertainty about NIIMS, and a deep-seated discouragement on the part of team members.

Under the NIIMS concept, implemented regionwide in 1984, all Federal fire management agencies had agreed on cooperative use of training, equipment, and manpower following the closest available forces philosophy. In addition, the States involved, with Colorado as the leader, were adherents to the NIIMS concept. This commitment to cooperation is evident in the makeup of both incident teams in the region, which include employees of the USDA Forest Service, USDI National Park Service and Bureau of Land Management (Colorado and Wyoming), States of Colorado and Wyoming, and at least one employee from a fire-oriented county on the Front Range of Colorado.

However, with a track record of no project fires in 3 years, a need to activate the mobilization plan, plus a need for the region's incident management teams to implement the NIIMS concept, it was

obvious that a training program should be set up. If another fire-free year occurred, it would become even more difficult to mobilize and implement the NIIMS concept.

With this purpose in mind, Jim Olson of the National Park Service made a proposal concerning the Devil's Tower National Monument. This proposal was quickly acted upon by Darrell Smith, the Forest Service (R-2) regional fire coordinator.

The Devil's Tower National Monument in northeastern Wyoming had a resource management problem brought on by the exclusion of fire since early settlement of the area.

Pine stands were closing in on the meadows and even obscuring the view of Devil's Tower itself from several points. In addition, the threat of an uncontrolled wildfire was increasing each year. The logical solution was to apply a burn prescription that would thin the pine stands, create new openings, and reduce the fire hazard. But the monument staff was small and did not have prescribed fire expertise.

The solution, developed by Jim Olson and Darrell Smith, was to mobilize the class I incident teams (short team only), just as if they had received a wildfire assignment, and have them apply the prescription and conduct a burn.

The burn was accomplished in mid-May 1984. Both of the region's short teams were ordered and dispatched through the normal procedure and upon arrival at the site were briefed by the park superintendent just as though it were a wildfire situation. The monument headquarters became the incident command post. At the toss of a coin, one team was selected to conduct the burn while members of the other team shadowed their respective positions. The teams organized under NIIMS, operated totally under NIIMS, and successfully completed the project in one day. The project ended with a "hotline critique" by the shadow team. The closest available forces concept was used to pull together forces for the burn from Devil's Tower National Monument, Black Hills National Forest, and the State of South Dakota, as well as the interagency overhead teams.

This project served several purposes very well. It provided a shakedown run for the region's mobilization and dispatch system and gave the two teams a chance to interact in a fire environment and to organize and operate under the NIIMS concept. This project firmly established the interagency concept of NIIMS, as well as accomplishing a major resource management task for the national monument. And it was a morale booster for everyone involved.

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One of the teams later received a dispatch to southern California and subsequently requested an R-5 ICS evaluator to provide a critique under NIIMS/ICS. The ratings were high enough for the team to become ICS qualified without the customary period of coaching.

The success, plus all the benefits, has caused the region to consider this type of activity as a possibility every other year in lieu of an annual overhead team meeting in Denver. In order for this activity to be cost effective for the Park Service, the overhead team members absorbed all costs for salary, some of the travel, and all overtime costs. These costs were less than those that would have been incurred by a meeting in Denver, which would have provided fewer benefits. The region is now looking for other agencies to host the next "Incident Team Burn." ■

### **Computing Costs of Fire Suppression**

The emphasis on economic efficiency in the Nation's fire management programs has led to efforts to develop more accurate cost estimates of those programs. Such estimates are essential in the economic analyses needed in long-term planning.

Current cost estimates available for such planning purposes do not provide accurate economic cost estimates. Nor are they in a form usable in the simulation models being developed to analyze the economic efficiency of fire management programs.

To fill this gap, the Pacific Southwest Forest and Range Experiment Station has developed a cost-aggregation approach for estimating the cost of two major fire management activities: initial attack and large fire suppression. The approach was used to determine the hourly costs of direct fireline production units—termed Fire Management Inputs (FMI)—used in these two activities. All components contributing an FMI are identified, computed, and summed to estimate economic costs. These include crew, equipment, supplies, and overhead.

The cost-aggregation approach was developed and tested by collecting and analyzing cost data from three Forest Service regions (Northern, Pacific Southwest, and

Pacific Northwest) and three State forestry agencies (California, Montana, and Oregon).

This cost-aggregation technique is generalized enough to be useful to any organization with fire protection responsibilities. Details are available in Research Paper PSW-171, "Costs of Fire Suppression Forces Based on Cost-Aggregation Approach." A copy can be obtained from the Pacific Southwest Forest & Range Experiment Station, P.O. Box 245, Berkeley, CA 94701. ■

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# Fire Prevention—An Honest Effort

John E. Roberts

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Traditionally, fire prevention activities have not been viewed as equally important as heroic efforts involved in fire suppression. Obviously persons whose lives were saved or whose homes were not burned are most grateful to everyone who participated in the suppression efforts. But suppose the threat of loss had not existed to start with? Where are the heroes? They are still around; it's just that reporting prevention efforts isn't quite as attractive to newspapers and television as conflagrations. Good news doesn't make headlines.

## Problem Analysis

Roughly 90 percent of the wildland fires are caused by humans, preventable in theory. Obviously if a fire is prevented, there is no damage and no suppression effort. Thus, fire management objectives may be met and in most cases at a reduced cost.

As I was reviewing my duties and assignments for suppression, I began to feel a little twinge of guilt. Why not spend a little more time on fire prevention? What was the real cause behind our fires? Had I failed to educate the public about carelessness? Maybe law enforcement on the ranger district wasn't quite as intense as it should be? In other words, why had I not done a good fire prevention analysis?

Common sense dictates that if in the past 10 years all of the fires in the district were started by careless smokers you don't spend time and taxpayers' money on a campaign about escaped debris burning. But you have to tell the public what the problem is and how to help. Pretty basic, right? Well, how come all of us haven't been doing more in the area of prevention? Have you done or considered doing a job performance analysis in the area of fire prevention? Did you know there is a 115-page book by the National Wildfire Coordinating Group entitled "Job Performance Analysis Wildfire Prevention"? According to this book an interagency task force concluded that as recently as 1974, in the new age of wildfire prevention, *no nationwide commitment* to wildfire prevention existed.

Those who have training in environmental assessments or land management planning could use a similar approach on a wildfire prevention analysis. Although you know the purpose and need for the action and the affected environment, some environments are at higher risk than others or have higher value. Consider your alternatives, decide on the preferred one, then work out implementation within the management constraints.

For instance, suppose you have a municipal watershed that the city

is very concerned about protecting. What are your problems? You recognize two problem areas, carelessness and incendiary fires. Examine the realistic alternatives, then formulate your proposed management direction. For example, evaluate the last time you proposed closing an area to camping. Did you even use the prevention aspect as part of your rationale for closing? Did you think about it? Protection planning should include the following simple tactics:

- Reduce the number of users to reduce the risk.
- Utilize strong law enforcement to instill concern for criminal action to arsonists.
- Educate the public better as to why and how actions are to be taken.

## Personalizing Fire Prevention

An awareness study compiled for the Advertising Council in 1976 found that almost everyone had heard of the slogan "Only you can prevent forest fires," and two-thirds of all those who had heard of this slogan felt that it meant that forest fire prevention was the responsibility of the individual. The older fire prevention message, "Your Forests, Your Fault, Your Loss," had the same personal connotation. Once you have hit upon the problem and chosen a preferred route to a solution, you

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need to sell your message. Repetition, recognition, continuity, and timeliness are all important elements in conveying that message. Planning and coordination are essential to ensure credibility. We've all seen advertisements and heard radio announcements warning "extreme fire danger—be careful," and there is snow on the ground. The same announcement could be better planned to hit the audience at the right time.

Along the line of recognition and education, we could utilize law enforcement more effectively. Granted, some discretion is a must but in most cases civil liability isn't enough. Wildland managers need to be concerned primarily with how much *prevention* can be accomplished through law enforcement. Maybe we need to look at the effectiveness of our fire prevention educational programs. If the public learns that a power company paid \$10,000 in suppression cost, for negligent powerline maintenance that resulted in a fire, that may have an effect. You know the power company will remember. How such situations are handled is your responsibility. Dollars spent, acres burned, wildlife killed—all of this is important to most people and especially the forest user. You just need to reach the people you are trying to reach and let them know you're serious.

### Training

Let us suppose that the road you drive every day to work is full of nails, and every day you have to fix flat tires. You have had 300 hours of training sessions on how to fix flat tires. How come you haven't had any training on how to get the nails out of the road?

We all know we are going to have an occasional flat tire, but why don't we concentrate more on the solution instead of the problem. How much training in fire prevention and law enforcement have you had compared to suppression training? There are materials available to get you started that will add to your knowledge. In addition to the items previously mentioned, there is a "Fire Prevention Guide" that was produced in the Forest Service Southwest Region in 1979. This guide has some real good information and can be a great help in prevention analysis and planning. Another important point is how much emphasis have you yourself placed on trying to get some prevention training. There are opportunities if you just look around.

In addition to the training listed in the aforementioned guide, there is a publication on "Interpersonal Communication" produced by Jerry Robinson and Larry Dolittle. This booklet, cosponsored by USDA Forest Service, Southern Forest Experiment Station, and the

Federal Emergency Management Agency addresses how to improve and learn new communication skills. Your fire prevention field personnel may need improvement in this area.

### A Closing Note

I couldn't in good conscience let this off my desk if I did not include a confession. I would be less than truthful if I said I didn't like fire suppression. We all like feeling heroic now and then, and that is how I feel sometimes on fire suppression assignments. I am also grateful for the amount of training provided concerning suppression because there *are* going to be wildfires no matter what. We have all heard the saying, "There is no honor in fighting a fire that could have been prevented." This might hit closer to home if it read, "There is no honor in fighting a fire YOU could have prevented." The fires that start still must be put out, and we must be prepared to handle them. Suppression is a major part of overall fire management and obviously deserves strong attention. But we should look for improvement constantly in *all* areas of fire management.

If we look at the problems, do our job, and push fire prevention a little more, maybe we can save an acre or a home from the threat of destruction. The heroics are still there, maybe not as glorified, but

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just as much appreciated. So the next time you investigate the cause of a fire and find it was due to lack of knowledge on how and when to properly burn trash, ask yourself if you really gave fire prevention an honest effort. ■

### **Gambel Oak Fuelwood Management**

Gambel oak covers millions of acres in Arizona, Colorado, New Mexico, and Utah, often in accessible stands. It has a high heat value that is making it the current darling of many firewood seekers. But is it practical and economical to manage Gambel oak for fuelwood?

Yes, concludes a study by research economist Fred Wagstaff of the Intermountain Forest and Range Experiment Station, although results from his sample sites in north-central Utah must be applied with caution because of variance in local conditions.

The Utah study showed minimum fuelwood sizes could be reached with rotation ages of 65 years. Current retail stumpage prices for fuelwood ranged from \$115 to \$2,300 per stocked acre. Wagstaff says the value of Gambel oak areas as wood-producing sites could well exceed the value of other uses of the land.

Complete results of the study are available in General Technical Report INT-165, "Economic Considerations in Use and Management of Gambel Oak for Fuelwood." A copy may be obtained from the Intermountain Forest and Range Experiment Station, 507 25th Street, Ogden, UT 84401. ■

### **Bulldozer Fireline Rates Updated**

Much has changed in firefighting technology in recent years, and the bulldozer, that dependable fireline builder, is no exception.

Fire management consultant Clinton B. Phillips and Intermountain Station researcher Richard J. Barney recently completed a study that gives fire managers line production data for bulldozers manufactured from 1965 to 1975, the bulk of the units in use today. The results are in General Technical Report INT-166, "Updating Bulldozer Fireline Production Rates."

The report shows fireline production rates in chains per hour for several slope classes. Production indexes devised by manufacturers for 38 pieces of equipment were analyzed. Machines are grouped into small, medium, and large classes. The work resulted in current graphs that can be used easily by managers to calculate production.

A copy of the report is available from the Intermountain Forest and Range Experiment Station, 507 25th Street, Ogden, UT 84401. ■

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# A Tester for Measuring the Moisture Content of Dead Fine Fuels<sup>1</sup>

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Fire managers use the moisture content of forest fuels to help predict fire behavior when burning or controlling is prescribed for wildfires. In surface fires, dead fine fuels such as grasses, sedges, hardwood leaves, and conifer needles are often the primary fire carriers. Because such fuels dry quickly, fire managers need a fast, accurate, easy-to-use measuring device to determine fuel moisture in the field.

Many methods exist for measuring fuel moisture, but most require special equipment and/or special training. Conventional oven drying (3) requires 24 to 48 hours and a power source (normally 220 volts). Microwave oven drying (5, 6, 7, and 9) requires transporting equipment to field locations. The "Speedy" moisture meter (4) requires a pressurized cylinder and calcium carbide, a source of highly inflammable acetylene gas. Xylene distillation<sup>2</sup> requires a motor vehicle as well as precautions for the safe use of xylene. A small moisture analyzer (8) also requires an outside power source. Because of

these difficulties, the usual methods for estimating fuel moisture in the field have employed fuel moisture sticks as analogs or mathematical models. These methods may not be as accurate as is needed for many fire management applications (10), however, and they require that a weather station or fuel sticks be deployed in advance of being needed.

Recently Clark and Roberts (2) made preliminary tests with a resistance-type moisture meter on redberry juniper (*Juniperus pinchottii*) and honey mesquite (*Prosopis glandulosa* var. *glandulosa*). Blank and others (1) verified the accuracy of an electronic fuel moisture probe for measuring dead jack pine (*Pinus banksiana* Lamb) roundwood, but found that the probe could not measure the moisture content of materials less than one-fourth of an inch in diameter. Therefore, another field instrument was needed for finer fuels. This study tested such an instrument and verified its accuracy in measuring the moisture content of two fine fuels.

## The Grain Moisture Tester

We selected the Model DJGMT Grain Moisture Tester, manufactured for agricultural purposes by the Dickey-John Corporation. It measures 11 x 5 x 8 inches and weighs less than 3 pounds. It costs about \$275, has a built-in carrying handle, and is operated by a 9-volt

transistor battery. It does not require preweighing of the sample. The initial moisture content is indicated on a digital readout that displays a temperature-compensated reading (TCR) after 15 seconds. The TCR is used with a conversion chart to determine the actual moisture content, in percent, of the material used. The manufacturer offers a 100-gram accessory weight to test lightweight (low bulk density) grains. Although the DJGMT is accurate for measuring grain moisture, its accuracy has not been verified with respect to dead fine fuels (fig. 1).

## Methods Used

During the summer of 1983 in Roscommon County, MI, we collected jack pine needles and sedges (a common ground cover in jack pine ecosystems). The latter were collected in open fields adjacent to jack pine stands.

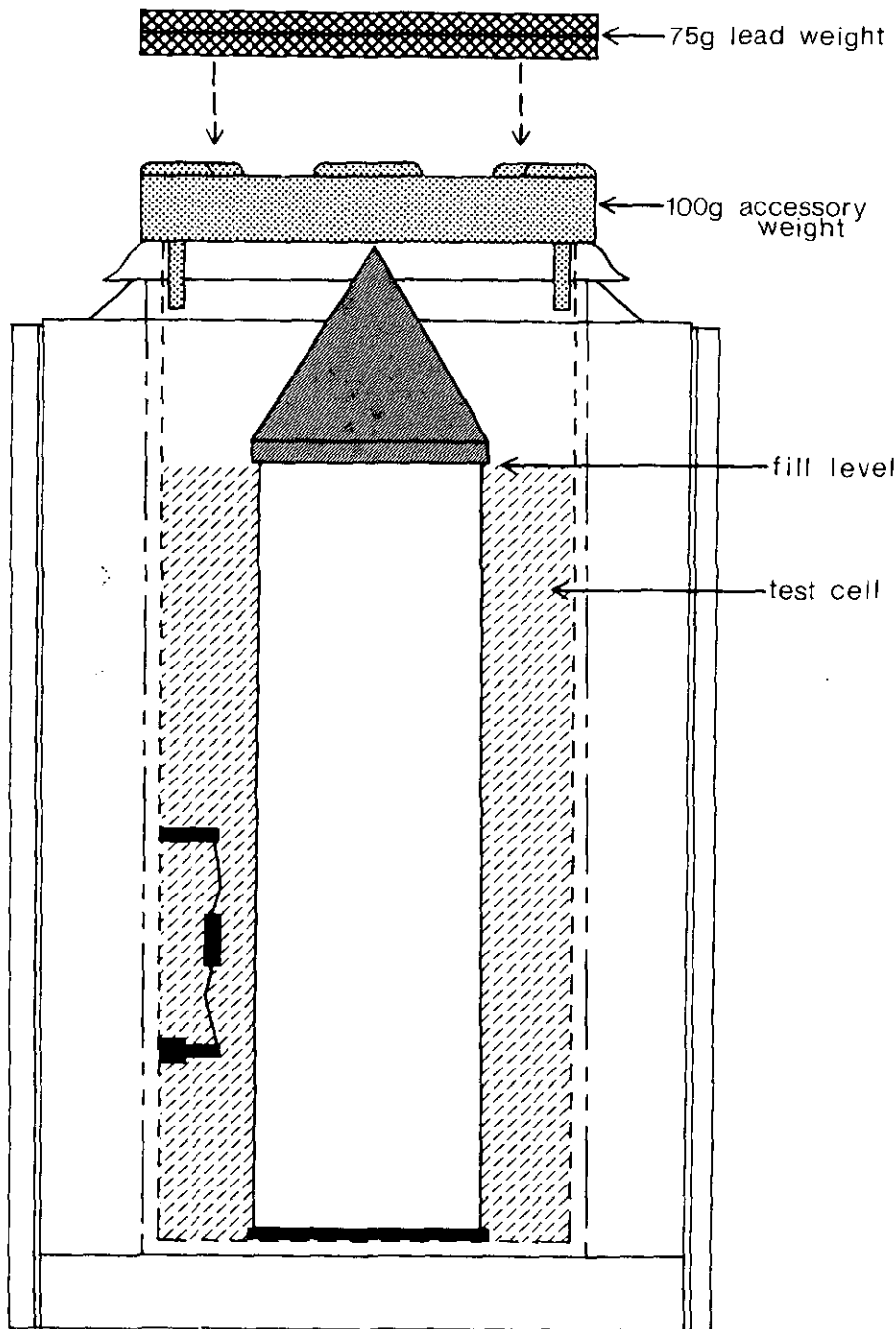
To use the tester, we placed the manufacturer's 100-gram weight on the unit. We also had to construct an extra 75-gram weight so that the tester could measure the moisture content of low bulk density materials such as sedges and needles. (Small variations in the supplemental weight will not affect tester calibration.) The supplemental 75-gram, doughnut-shaped weight matched the size and shape of the manufacturer's weight. It was constructed from two plastic lids from 1-pound coffee cans

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<sup>1</sup> The authors wish to acknowledge the greatly appreciated help of Donna M. Paananen, technical writer, and Livingston Manuel, forestry aide.

<sup>2</sup> Collins, Robert D. Obtaining fuel moisture with portable xylene distillation. Unpublished manuscript on file at the USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Riverside, CA.





Grain Moisture Tester  
(cross section)

Figure 1—Cross section of a grain moisture tester.

from which the centers had been removed. Lead wire rope was coiled between the cutout lids, which were then taped together.

We prepared the sedges for testing by cutting them into approximately 3/8-inch lengths with either a modified paper cutter (for large volume preparation) or scissors (for individual samples). In preliminary studies, we found that successive readings of the same sample were most similar when the material was cut to this size.

The device displays a digital readout when the total test cell load is approximately 200 grams. Therefore, approximately 25 grams of the material is required for each test. The material was poured in slowly, and the initial reading was taken when just enough material had been added to turn the unit on and keep it on. We found that adding more material resulted in erroneous readings. Because the unit weighed the material, there was no need to weigh it separately.

An extra step was needed, however, to assure a relatively uniform sample bulk density because the density of forest fuels, unlike grains, is highly variable. As material was added, it was tamped lightly with a wooden dowel (fig. 2). The tamping was adjusted so that the test cell was filled just to the bottom of the plastic cone on top of the center cylinder (see fig. 1.) If the material was above the fill line when the display turned

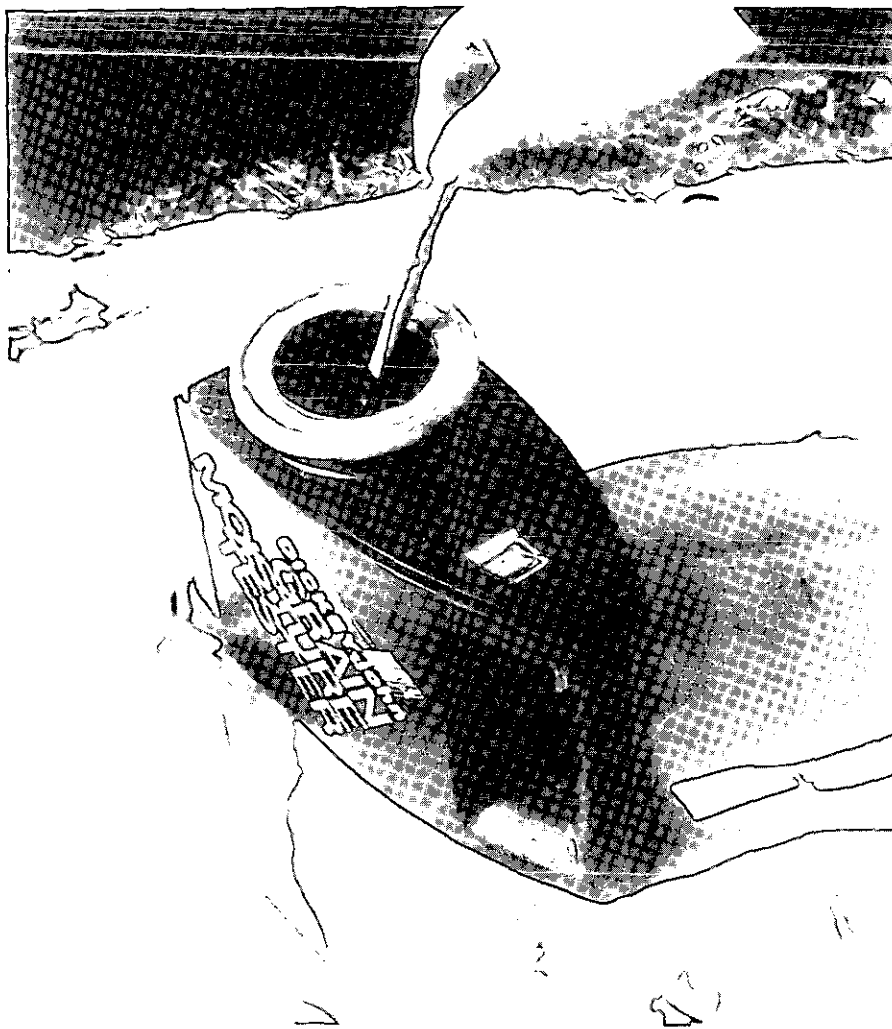


Figure 2—Tamping sedges with a wooden dowel into the test cell of the grain moisture tester.

on, we took it out and poured it in more loosely. After a few trials, the procedure proved to be easier than its description, and we obtained reproducible results. After waiting 15 seconds, we

pressed the temperature compensation indicator to obtain the TCR. We then emptied the material onto a plastic sheet, measured it two more times, and averaged the three readings.

Finally, we placed the material into a previously weighed paper bag and reweighed the sample plus the bag. The material was oven-dried in the paper bag for 24 hours at 105 °F and weighed again. To determine the moisture content of the paper bag, we discarded the sample and reweighed the bag.

This method was used on most of the 102 samples tested. However, to obtain a wider range of moisture contents, we added water to some sedge material and allowed it to stand for at least 24 hours in a closed plastic bag. We cut the material, divided it into samples, and allowed the samples to air-dry for various lengths of time before measuring the moisture content in the same manner previously described.

To evaluate the tester using jack pine needles, we collected several seasons of needle drop from the litter layer of jack pine stands and followed testing procedures similar to those used for the sedges—except that we did not cut the needles. We measured 65 needle samples.

## Results

Our initial analysis disclosed that samples showing high moisture content readings often had surface moisture (for example, field samples that were wet with recent rain) that caused erratic readings. Because lower moisture content

readings are of primary interest to fire managers, we improved our results over the range of greatest concern by deleting all TCR's greater than 9.0.

The remaining TCR's (90 sedge and 46 needle samples) showed high correlations with the oven-dry weights ( $r=0.84$  for sedges and  $0.97$  for needles) (figs. 3 and 4). The regression (calibration) equations are

Sedges:  $M = 1.86 + 11.01 \ln(\text{TCR})$

Jack pine needles:  $M = -4.46 + 7.13(\text{TCR})$

where  $M$  is the moisture content (percent). The standard error in each equation is less than 4.0. Conversion charts were developed from these two equations for ease of use in the field (table 1).

#### Tester Use Guidelines

1. Begin each day's testing by verifying that the unit turns on at  $200 \pm 3$  grams.

2. Follow the manufacturer's maintenance specifications carefully to make certain that the moisture tester is giving reliable readings.

3. When constructing the 75-gram weight, use material that will not absorb moisture. Its diameter should be the same as that of the accessory weight available from the manufacturer.

4. Cut sedges approximately three-eighths of an inch long.

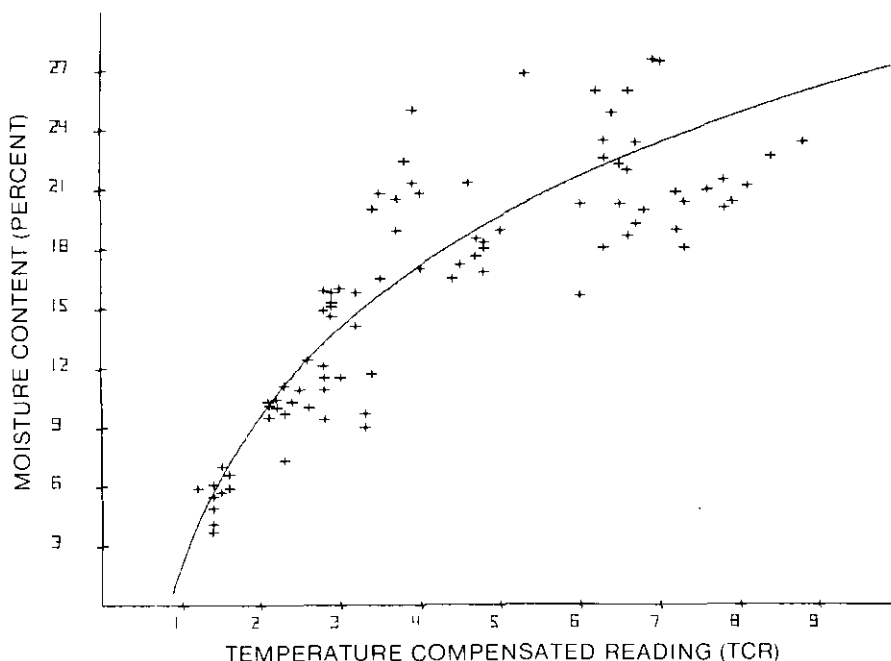


Figure 3—Scattergram and regression curve for sedges.

5. Tamping is extremely important because the tester is sensitive to the bulk density of the material being weighed. When the meter first turns on, the material should fill the test cell to the fill line. If it is too high, tamp further. If it is too low, empty the unit and start again.

6. Measure each sample three times to determine whether it was tamped properly each time. Average the three samples to reduce error.

7. Note that the initial readings are not used; only the TCR readings are used with the conversion chart.

#### Conclusions

The grain moisture tester can be a valuable tool for use in the field to help predict fire behavior. Using the data obtained from field testing, we developed calibration curves for two fuels of interest in the Lake States. Similar curves will have to be developed for other materials before their moisture content can be measured with this unit. Also, if the bulk density of other materials differs significantly from that of the materials used here, a lighter supplemental weight may be needed. At present, the grain moisture tester is the only

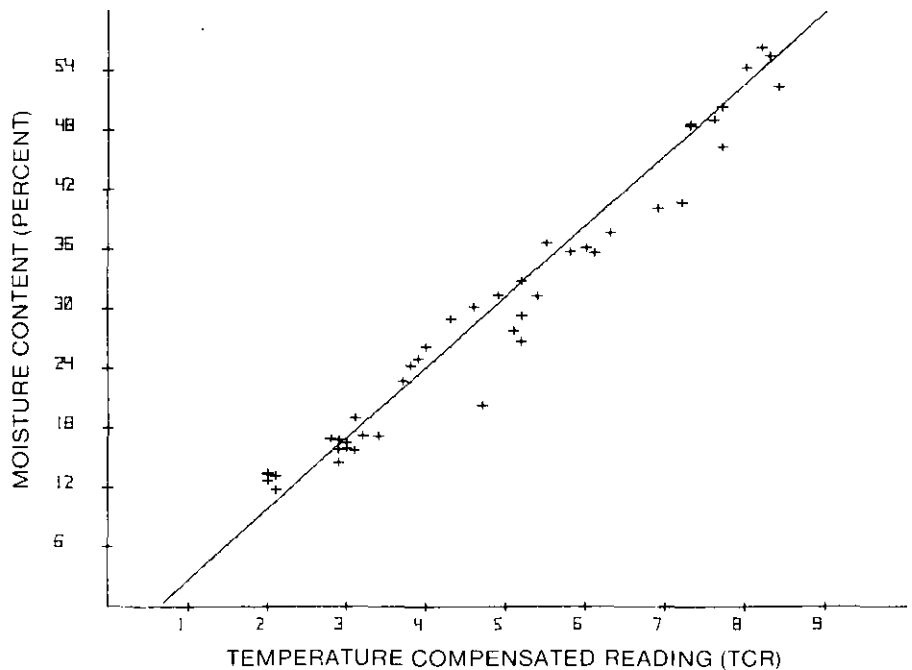
**Table 1**—Conversion of temperature-compensated readings (TCR) to percent moisture content

Sedges		Needles	
Tester TCR	Percent moisture	Tester TCR	Percent moisture
1.0	2	1.2	4
1.1	3	1.5	6
1.2	4	1.7	8
1.3	5	2.0	10
1.5	6	2.3	12
1.6	7	2.6	14
1.7	8	2.9	16
1.9	9	3.1	18
2.1	10	3.4	20
2.3	11	3.7	22
2.5	12	4.0	24
2.8	13	4.3	26
3.0	14	4.6	28
3.3	15	4.8	30
3.6	16	5.1	32
4.0	17	5.4	34
4.3	18	5.7	36
4.7	19	6.0	38
5.2	20	6.2	40
5.7	21	6.5	42
6.2	22	6.8	44
6.8	23	7.1	46
7.5	24	7.4	48
8.2	25	7.6	50
9.0	26	7.9	52
		8.2	54
		8.5	56
		8.8	58
		9.0	60

fast, reasonably accurate, simple, and inexpensive device available for measuring the moisture content of dead fine fuels in the field. ■

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**Figure 4**—Scattergram and regression curve for needles.

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# Using Decision Trees in Escaped Fire Situation Analysis

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The Forest Service objective for wildfire suppression on National Forest System lands is to suppress wildfires at the minimum cost consistent with land and resource management objectives. Suppression strategies to achieve this objective range from prompt control at the smallest acreage possible to confinement by natural features within a defined geographic area.

An escaped fire situation analysis (EFSA) is conducted when a wildfire escapes initial suppression action. Its purpose is to determine the most appropriate suppression strategy for the particular situation. Reasonable suppression alternatives are identified, analyzed, and evaluated. Evaluation criteria include estimated suppression costs and resource damage and environmental, social, and political considerations. The suppression alternative that minimizes the sum of estimated suppression cost plus resource damage is determined and selected by the responsible line officer for implementation unless there are other overriding considerations. In such cases, the least costly alternative meeting the particular considerations is selected. The EFSA is revised as necessary during the suppression period to reflect significant changes in the situation.

## Escaped Fire Situation Analysis

The validity of an escaped fire situation analysis is dependent

upon the accuracy of estimates made. Expected suppression cost, resource damage value, and the probability of a suppression strategy being successful are the primary variables.

Suppression cost estimates are derived by costing out anticipated suppression forces using experienced costs. This estimate is generally reliable if cost determinations are complete and the duration of suppression activity accurately predicted. Historical resource damage estimates have often been subjective and overstated. More reliable damage values developed in the fire analysis during the Forest planning process are becoming available for use in EFSA's. The probability of success of a given suppression strategy is dependent upon a multitude of factors including fuel, weather, topography, fire behavior, and the availability and effectiveness of suppression forces. The probability of success of a given strategy is highly variable, depending upon uncertain conditions and events. Probability of success, therefore, is most often based upon the judgment of fire overhead.

## Decision Tree Analysis

Decision tree analysis provides a simple and useful tool for displaying, evaluating, and documenting an analysis of alternative suppression strategies. Estimated costs,

damage values, and probability of success are integrated and the expected least cost alternative identified.

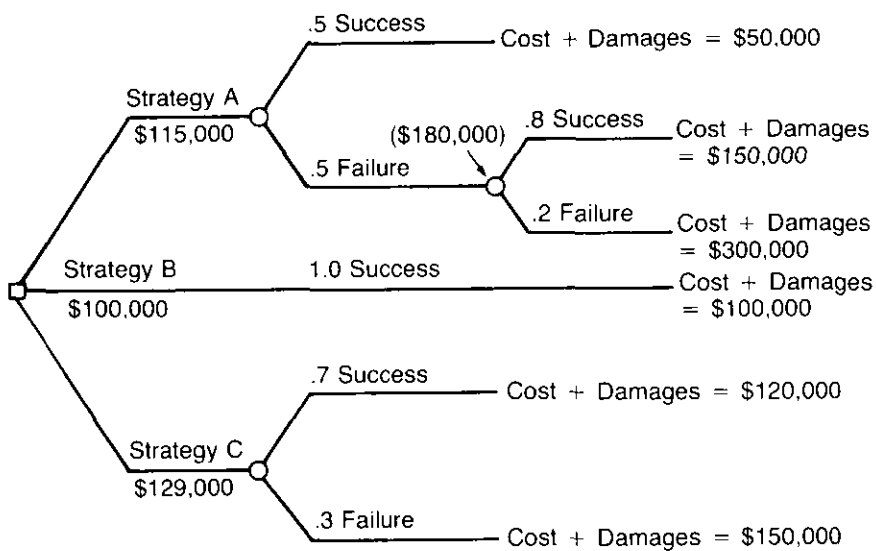
Alternative suppression strategies are developed and suppression cost, burned acreage, and resource damage estimated. The probability of success of each strategy is then determined, ultimately through the collective judgement of top management in the case of a large project fire. A decision tree is then diagramed, having a branch for each alternative strategy.

The costs and probabilities of both success and failure are noted. The costs and probabilities of fall-back strategies in the event of failure of primary strategies may also be diagramed. Once diagramed, the decision tree is "averaged out and folded back" to determine the expected least cost alternative.

## Decision Tree Application

The following example illustrates use of decision tree analysis in an EFSA in which three alternative suppression strategies are identified.

**Strategy A:** Control during the first burning period, minimize burned acreage. Tactics—Direct attack using engines, infrared crew, and airtankers. Estimated burned acreage = 50, cost plus damages = \$50,000, probability of success = 0.5



Escaped fire situation analysis decision tree.

**Fallback strategy:** *Control* by the end of the second burning period. Tactics—activate Forest overhead team, continue direct attack using hand crews, engines, and air-tankers. Estimated burned acreage = 100, cost plus damages = \$150,000, probability of success = 0.8

**Strategy B:** *Containment* by the end of the second burning period. Tactics—Flank with hand crews and engines, hold the head at a natural barrier. Estimated burned acreage = 150, cost plus damages = \$100,000, probability of success = 1.0

**Strategy C:** *Control* during the second burning period. Tactics

—Flank with hand crews and engines, hold the head of the fire at a road using aerial retardant. Estimated burned acreage = 100, cost plus damages = \$120,000, probability of success = 0.7

#### Cost of Alternatives

The decision tree diagram is shown in figure 1. Decisions to be made are represented by a box, each alternative by a branch, and each point of uncertainty by a circle. The estimated sum of suppression cost plus resource damage is shown at the tip of each branch.

The expected cost of each alternative is determined by

“averaging out and folding back.” Beginning at the tips of each branch (right side), the cost of each possible outcome is multiplied by its probability and the products summed at each node, working back to the base of each branch.

Expected cost calculations are as follows:

#### Alternative A.

$$(\$150,000 \times 0.8) + (\$300,000 \times 0.2) = \$180,000.$$

$$(\$180,000 \times 0.5) + (\$50,000 \times 0.5) = \$115,000.$$

#### Alternative B.

$$\$100,000 \times 1.0 = \$100,000$$

#### Alternative C.

$$(\$120,000 \times 0.7) + (\$150,000 \times 0.3) = \$129,000$$

Alternative strategy B is the expected least cost alternative.

Decision trees can be made as simple or as complex as desired. Research Paper RM-244 by the Rocky Mountain Forest and Range Experiment Station (1) illustrates the complexity of analysis possible in modeling the numerous variables and uncertainties.

#### Conclusion

Decision tree analysis (2) provides a useful method for determining and documenting the expected least cost suppression alternative in escaped fire situation analysis. Simplified versions are easily conducted in any suppres-

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sion situation. The method focuses upon and integrates probability of success (and failure) into the decision process better than traditional approaches. Although numerous variables and uncertainties are inherent in the determination of the most appropriate suppression strategy, experienced fire managers can make timely, creditable decisions using simple decision trees based upon sound judgment. ■

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#### A Performance-Based Training Package

A new training program for the ICS position of task force/strike team leader is scheduled for completion by July 1, 1985. This training package will be a prototype for a performance-based qualification system envisioned by the National Wildfire Coordinating Group.

This package has been designed around the six job performance requirements (JPR's) that were developed by the Forest Service and the Bureau of Land Management, Division of Training. The JPR's have been validated by interagency personnel who are qualified and currently performing in the position. The six JPR's are:

- Plan for an assignment.
- Incident check-in.
- Complete "Available" assignment.
- Complete "Tactical" assignment.
- Complete "Out-of-Service" assignment.
- Demobilization.

Any strike team leader or task force leader would be required to perform these six managerial functions on any incident assignment.

The task force/strike team leader training will be delivered in a program consisting of a videotape and student workbook followed by a performance test administered by a supervisor. The test may be a simulation or a training assignment supervised by a qualified individual.

The videotape portion of this package will be available in 3/4-inch VHS, 1/2-inch VHS, or Beta format. Because of these options, training can be done at the trainee's work location, at home, or in a classroom with several students participating.

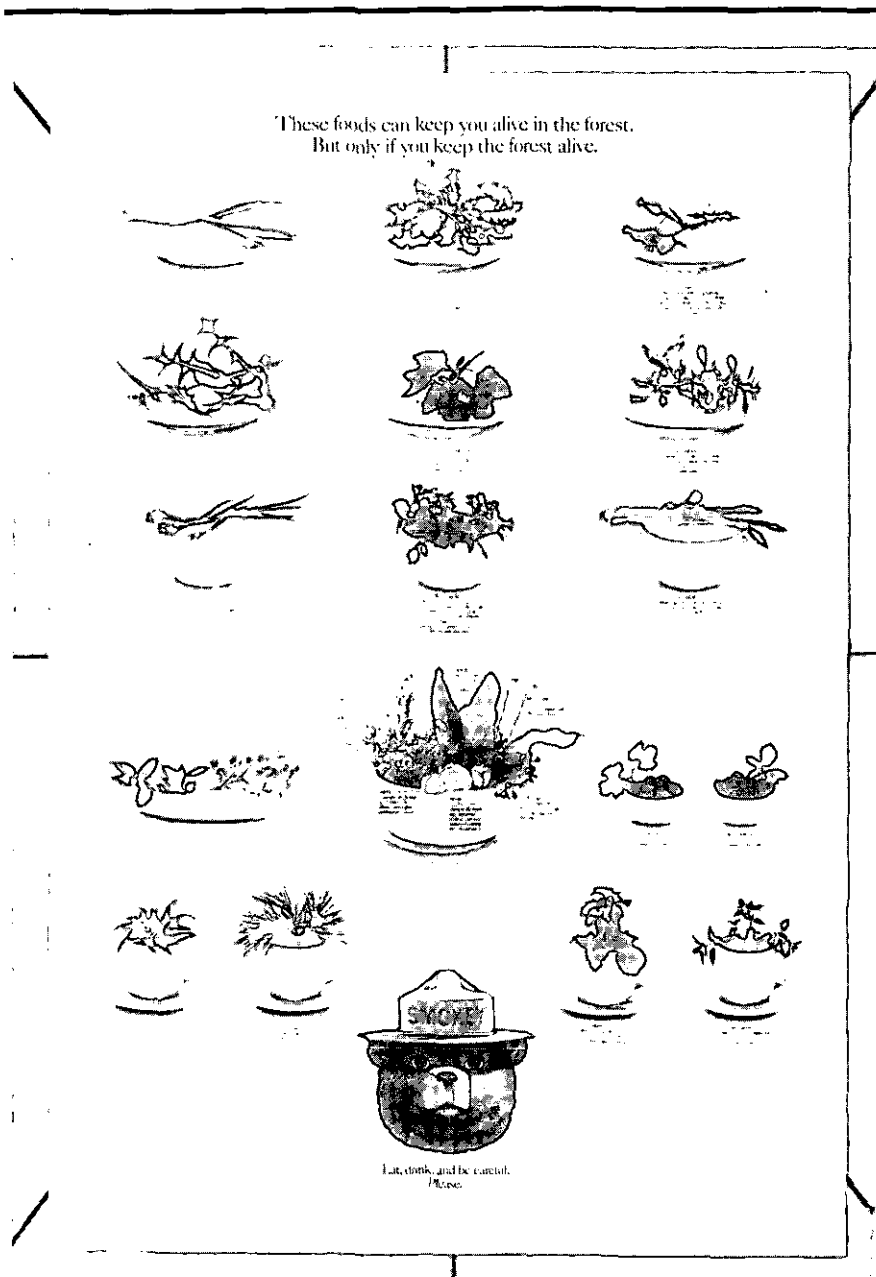
In a performance-based system the unit manager or supervisor must assume a greater responsibility in determining that an individual meets the tactical skill requirements necessary to function in a position or to advance into a new position. The task force/strike team leader package does not teach tactical skills, but concentrates on managing resources as a functional tactical unit. ■

**Jim Whitson**, *Staff Specialist, USDA Forest Service, Boise Interagency Fire Center, Boise, ID.*

# 1985 Forest Fire Prevention Campaign

Patsy Cockrell

Information Assistant, USDA Forest Service,  
Cooperative Fire Protection, Washington, DC.



The 1985 fire prevention poster features edible plants.

With the celebration of Smokey's 40th birthday, 1984 was a big year for the Cooperative Forest Fire Prevention program and a big success. We hope to make 1985 even bigger.

One of the exciting new campaign items for this year is iron-on art of animals conveying the fire prevention message. This campaign item will reinforce Smokey's message in a highly visible way. People of all ages will be affected by seeing the animals and their message on T-shirts, blouses, and other items of clothing.

Each year outdoor activities, such as camping, backpacking, picnicking, and cookouts, increase, and Smokey's message "Remember, only YOU Can Prevent Forest Fires" becomes even more important. Our 1985 catalog includes fiberglass signs for camping and picnic areas that remind us all to be careful with fire.

This year in our series of specialty posters we have a new poster that features edible plants. This poster includes the message "These foods can keep you alive in the forest. But only if you keep the forest alive."

We still have a lot of work to do. There are always new groups of children who need to hear about Smokey Bear and his forest fire prevention message. And there are always people who need to be continually reminded of the need to prevent forest fires.





*Iron-on art conveying the fire prevention message.*

Are people getting Smokey's message? Well, you be the judge. In 1942, over 10 million acres of wildland was burned. In 1982, only 2.4 million acres was burned. This difference represents savings of more than \$21 billion for the American taxpayers. Someone must be listening. ■

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# An Operational Retardant Effectiveness Study

Charles W. George

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Missoula, MT*

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In recent years, considerable attention has been given to the aerial retardant program as a result of rising costs, tight budgets, and general interest in the use of airtankers and fire retardants. "An Evaluation of Fire Retardant Use" prepared by the Forest Service's Policy Analysis Staff (3) identified a number of opportunities to improve the cost effectiveness of retardant use and prompted an "Aerial Retardant Program Improvement Plan" to be developed by Aviation and Fire Management (1).

The analysis of retardant use and action plan both dealt with our inability to answer a basic question, "How much chemical or retardant is needed to do a given fire suppression job?" Fire managers have tried to answer this question in general terms through trial and error. The answers have not, however, been in quantitative terms that lend themselves to further analysis. Detailed answers to more specific questions, such as those discussed in the following three sections, are needed.

(1) What is the optimum tank and gating system? What criteria will provide the best performance? What characteristics provide the most flexibility in terms of performance capability?

There is presently little standardization in the design of airtanker delivery systems and thus in performance. The flow rate of retard-

ant from the tank determines the drop pattern, and flexibility is generally provided only by the number of compartments selected for release. The range of effective retardant coverages an airtanker can provide may be relatively narrow—in other words, it may be quite efficient for some retardant coverage requirements but be incapable of providing others. Knowledge of individual airtanker performance can be utilized to a limited extent in allocation and deployment and in formulating guidelines for onsite use.

(2) What retardant properties (chemical and physical) provide the greatest efficiency? Can these properties be matched or tailored to the delivery system and operating requirements?

The price of retardants can be increased or reduced by simply changing the retardant salt content or other properties. Current levels have been selected through experience; however, a consensus as to the requirements does not exist. For example, do we need a long-term chemical? Can we get by with a short-term (thickened water) retardant? Is it essential to thicken water or retardants?

(3) Do adequate guidelines exist for optimizing the selection, allocation, deployment, and use of airtankers and retardants (including the limits of effectiveness)?

The effectiveness of aerially delivered retardant under varying

conditions and tactical situations is not known with the certainty and precision to allow a thorough assessment. The information necessary to properly make tradeoffs between different sizes and types of airtankers as well as tradeoffs between suppression alternatives (handcrews, bulldozer or plow units, or retardant aircraft, for example) is not available. Figure 1 illustrates retardant effectiveness interrelationships and complexities.

Recommended fire retardant coverage levels for different fuel types have been published in airtanker performance guides and retardant coverage computers (4). The coverage levels were derived from laboratory studies of maximum useful retardant concentration, film thickness, and fluid capture capacities of different fuels. The predictions of the required coverage levels were prepared by Honeywell (9) with guidance from the Intermountain Fire Sciences Laboratory.

These coverage levels are keyed to the fuel models of the National Fire-Danger Rating System (2). The brief general descriptions of the fuel models were provided by H.A. Anderson and the coverage-level values were first identified using the concept of maximum useful retardant concentration (MUC) calculated by Rothermel and Philpot (7). Rothermel added to the computation the retardant film-thickness concept, originated

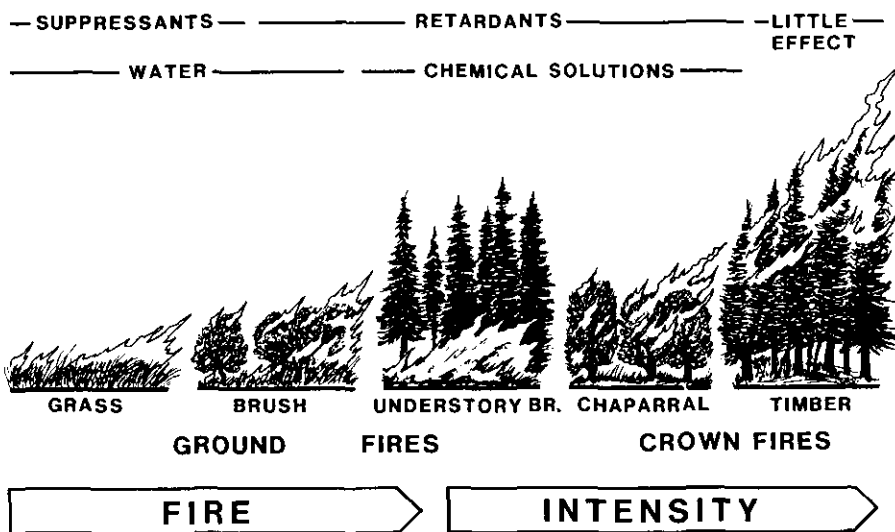


Figure 1—Retardant effectiveness interrelationships and complexities.

Recommended For:		
Coverage Level	Fuel Model <sup>1</sup> (1978 NFDRS)	Description
1	A. L. S	Annual and Perennial Western grasses; tundra
2	C. H. P. U E. R.	Tall grasses; Conifer (with grasses/forbs/needles and/or woody shrubs understory) Hardwoods (winter and summer)
3	K. F <sup>2</sup> . N. T	Light slash (conifer or hardwood); Intermediate brush (green); Sawgrass; Western woody shrubs
4	G	Shortneedle conifer (heavy dead litter)
6	D. Q. F <sup>2</sup>	Southern Rough; Alaska Black Spruce. Intermediate brush (cured)
Greater than 6	B. I. J. O	California mixed chaparral; Medium and heavy slash; High Pocosin

For creeping or smoldering fires, reduction of one coverage level may be considered.  
<sup>1</sup>Fuel models considered to be in flammable condition.  
<sup>2</sup>Coverage level requirements for intermediate brush depend on its stage of curing.

Figure 2—Recommended retardant coverage levels in gallons/100 ft<sup>2</sup> for the fuel models described in the 1978 National Fire-Danger Rating System.

by Grah and Wilson (6), which was later applied to retardant application by Swanson and Helvig (8). The recommended coverage levels in gallons per 100 square feet for the 20 fuel models described in the 1978 National Fire-Danger Rating System are shown in figure 2.

### The ORE Study

In an attempt to determine how much chemical or retardant is needed to do a given fire suppression job and relate the answer to

fuel and fire behavior characteristics, an operational retardant effectiveness study (ORE) was undertaken. A pilot study was conducted in 1983 and expanded in 1984. The evaluation was conducted from Hemet, CA, in cooperation with the California Department of Forestry. Hemet was selected as the study location based on history of use (frequency and total amount), opportunity to work with a variety of fuel types and fire intensities, and relatively accessible areas of high fire fre-

quency. The study was designed to build on existing retardant research programs by taking advantage of recent studies dealing with aerial delivery system performance, retardant characteristics and effectiveness, measurements of drop conditions in the field, and other related topics.

The objectives for the ORE pilot study were:

- (1) Identify methods, techniques, and criteria for the evaluation of onsite retardant effectiveness in actual fuel/fire situations.
- (2) Determine the retardant concentration requirements for specific fuel models in fire situations and validate or refine, if necessary, retardant coverage levels prescribed in retardant coverage computers.
- (3) Evaluate the accuracy and usefulness of retardant coverage computers in selecting the optimum drop conditions (height, speed, tank configuration, and drop sequence, for example). Identify delivery system characteristics that provide the greatest and most efficient control of drop performance and patterns in actual fuel/fire situations.

(4) Develop appropriate guidelines and training materials for the effective application and management of aerial retardants.

The approach to conducting the study under operational conditions consisted of:

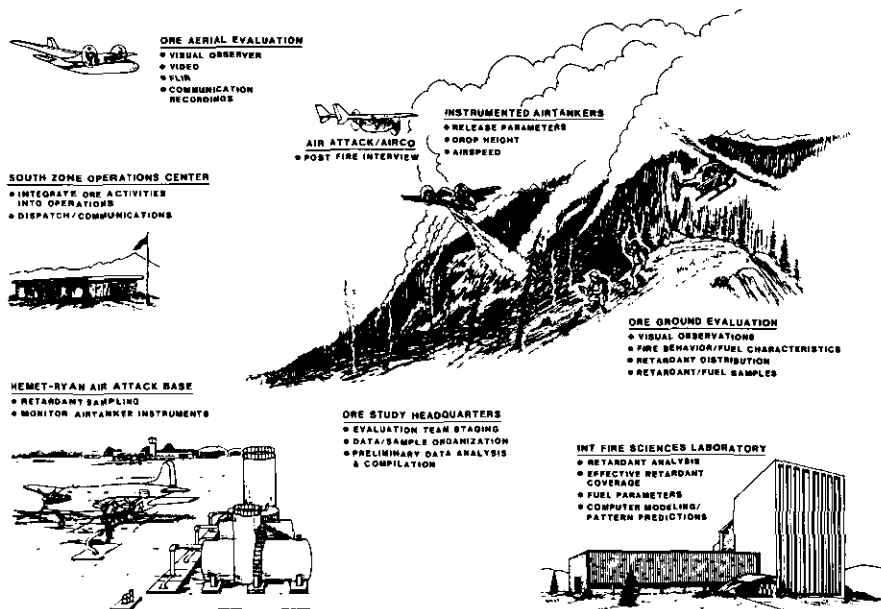


Figure 3—Elements of the ORE Study.

- Instrumenting local airtankers to quantify the retardant release characteristics and the conditions the drops were made under.

- Use of video and FLIR (forward looking infrared) to provide a permanent record of the operation.

- Use of audio recordings of air attack or AIRCO (Air Attack Coordinating Officer), lead plane, airtanker, ground-to-ground, and ground-to-air communications to provide documentation and insight as to air suppression activities and strategies.

- Aerial observation and evaluation of the operation, including effectiveness of retardant use, by a qualified air attack specialist dedicated to the study.

- Ground evaluation, where possible, by a dedicated evaluation team consisting of a fire behavior specialist, experienced line firefighter, and retardant research specialist.

Figure 3 illustrates the basic elements of the study.

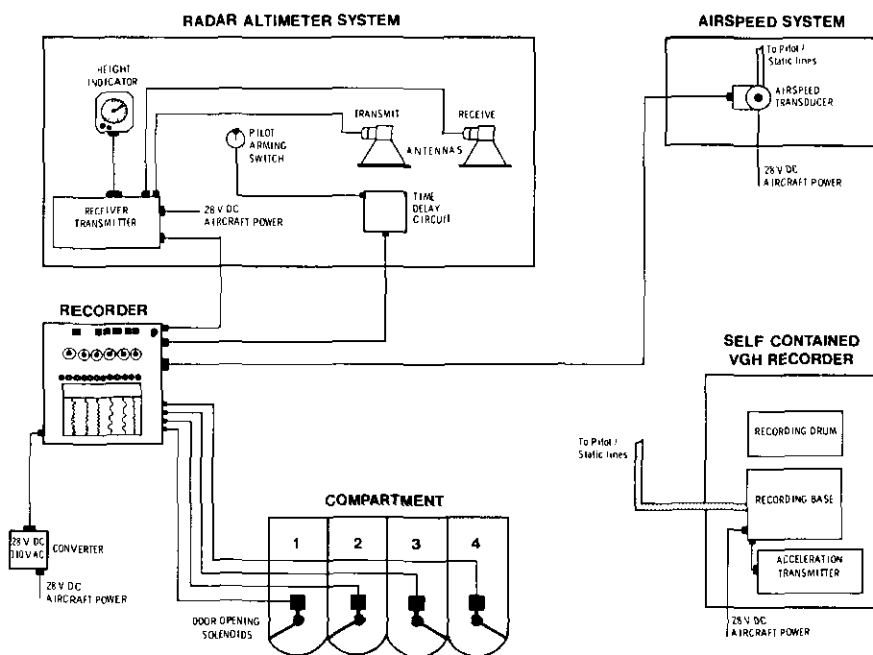


Figure 4—Schematic of onboard airtanker instrumentation.

### Airtanker Instrumentation

Three of the four airtankers on contract to the Forest Service and California Department of Forestry were instrumented with equipment (previously used for measurements of airtanker drop conditions during firefighting operations) to provide definition of retardant release characteristics and drop conditions

(5). The equipment, diagramed in figure 4, consists of a high-precision pulse radar altimeter system to provide a continuous record of drop height during a pass and an airspeed transducer to record airspeed. The electrical circuit from the door-opening system was used so that signals to the door-opening solenoids were recorded,

providing the exact time of door opening, time interval between releases, and thus the drop configuration for any release sequence.

In combination, the recorded information provided height above vegetation during the drop (including minimum drop height and height at release), airspeed at time

of release, release configuration, and release interval. For each precalibrated airtanker delivery system the retardant distribution (pattern lengths and widths at selected coverage levels) can be predicted for a "best case" situation using the airtanker performance guides, retardant coverage computers, or computer simulation programs.

Self-contained NASA VGH recorders were also installed in each airtanker, to provide supplemental information, including *time-history records of aircraft* speed, altitude, and normal acceleration during the entire mission. These recorders are specially built and contain a remote acceleration transmitter for measuring acceleration, two pressure sensitive elements for measuring airspeed and altitude, and a timing mechanism. From the recorded history, information such as flight duration, time to first drop, dash speed to first drop, rate of descent, maneuver acceleration fraction, drops per flight, time between drops, maximum airspeed, and time from last drop to touchdown can be determined. This information is used to help define the overall mission events, as well as to interpret recorded data.

### Video, FLIR, and Audio Recordings

Video and FLIR cameras (fig. 5) were mounted side by side on a fluid head pedestal that was fixed to the floor of fixed-wing air observer aircraft. An Aero Commander and a Cessna 337 were the aircraft used. Imagery from each camera was simultaneously recorded using separate recorders. In addition to recording the time, the audio channel recorded air-to-air communications. The air observer or video operator comments provided a tie between the fire suppression operation and the evaluation. The FLIR imagery enabled evaluation of the retardant drop, including placement and effectiveness in altering the fire behavior, and monitoring when smoke obscured the visual or video observation. The coolness of the retardant drop zone, relative to the surroundings and the fire, for some time after the drop was made (usually 5 to 10 minutes), allowed the drop to be definitely located and effectiveness to be observed.

Audio cassette recorders were used to record additional communications among air and ground fire suppression personnel. Although the communications between the airtanker pilot, lead plane pilot, and air attack supervisor or AIRCO were of primary interest, the ground-to-ground and ground-to-air communications

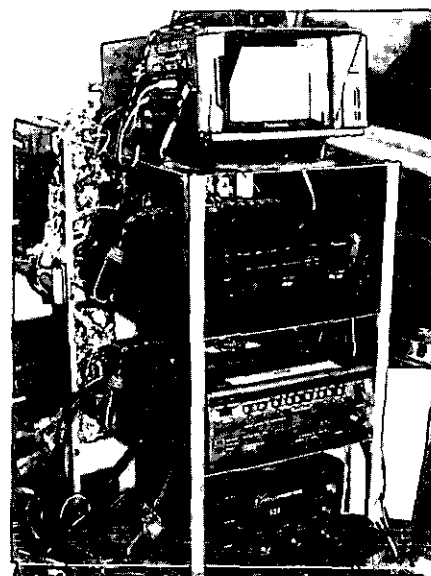


Figure 5—Video and FLIR camera and recording instrumentation mounted in Cessna 337 air observer/evaluator aircraft.

allowed an understanding of the suppression strategy or tactic to be followed. The simultaneous audio recordings also allowed recordings from the various sources (video, FLIR, and audio) to be time matched. Observations of the air evaluator and the video/FLIR camera operator also were put on cassette recorder. Following each mission or incident the evaluation notes were summarized, and contact with operational personnel and the ground evaluation team was made to complete documentation to the fullest extent possible.

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## Ground Evaluation

The ground evaluation team was composed of a fire behavior specialist, an experienced line firefighter, and a retardant research specialist. The helicopter foreman assisted the ground evaluation team on occasions when a dedicated helicopter was used for transportation to fires. Fire behavior measurements were taken when possible, as well as appropriate fuel and fuel moisture samples. Estimates of retardant ground pattern distributions, including retardant coverage, were made.

A postmortem was conducted, if possible, and constituted a primary element of the evaluation. Where the retardant drop was effective in holding or stopping the fire, a representative unburned retardant-treated sample was taken (all the fuel and retardant on a plot 6 inches by 6 inches). Several samples were usually taken for each drop or area of effective coverage. The samples were returned to the Intermountain Fire Sciences Laboratory where they were analyzed for retardant concentration (and hence coverage level) by means of previously developed procedures (10).

Results of this analysis provided the effective retardant coverage level for the specific fuel/fire situation encountered. In some instances, the effective level of retardant coverage was a small

area at the center of the drop (unburned island—usually high coverage and intensity), and in other cases the effective level was at the perimeter of the drop (low coverage and usually low intensity). The technique of fuel sampling/retardant analysis was also occasionally used to determine the peak coverage level of the drop—the concentration in the core or heaviest part. The peak coverage area/concentration is one of the characteristics most easily related to the retardant release and drop conditions.

The study was conducted during 1983 (August–September) and 1984 (mid-July through September). Only limited progress toward meeting the basic objectives was made because of the abnormally slow fire seasons in southern California and the few occurrences and opportunities for evaluation of retardant effectiveness in high fire intensity situations. Few observations could be made in other than light fuels. To the extent possible, quantitative relationships will be developed for the fuel models and fire behavior experienced.

Although limited success was achieved in meeting the primary objective of determining actual fire retardant requirements as a function of the fuel characteristics and fire behavior under operational field conditions, there were several spinoffs. The results of the project and recommendations by the ORE

Task Force/Steering Committee were summarized in a status report to the Chief of the Forest Service<sup>1</sup> and are repeated here.

## Results of Project

1. Retardant coverage computers have been partially validated. There have been no indications of error.

2. The safe drop heights on the retardant coverage computer appear to be accurate. These safe drop heights differ from and frequently exceed the 150-foot minimum in the Forest Service Manual (FSM) and the contract.

3. Video and infrared imagery collected during the ORE Program have proved invaluable in assessing retardant use and effectiveness operationally. Some of the imagery lends itself to training and also demonstrates a potential for providing information to fire managers by use of real-time down link.

4. A weakness in the effectiveness of retardant has been identified and shown to be related to the continuity of the retardant line—in other words, the existence of gaps.

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<sup>1</sup> Products of project and recommendations as summarized in a letter dated October 30, 1984, to Chief, USDA Forest Service, from Dick Cox, Steering Committee Chairman and Director of Aviation and Fire, Southern Region, USDA Forest Service.

This weakness is due to improper selection of the drop sequence, drop interval, or both. Retardant drop selector systems, including intervalometers, contained in contract aircraft are not universally adequate to provide an accurate pre-selectable release. Thus, our ability to apply information contained in retardant coverage computers is limited.

5. Airtanker pilot and air attack personnel interest in using the latest technology is increasing.

6. Many firefighters nationally have been trained in the use of the retardant coverage computer; however, the need for training is still great.

7. Cost concerns are creating more demand for efficient retardant products.

8. Some data have been collected on the effectiveness of short-term retardant.

9. Data gathering methods have been greatly improved.

### Recommendations

1. Standardize a drop selector control including intervalometer.

2. Incorporate airtanker performance training into transitional training for NIIMS. Specific courses which should include this training were identified. Regions are encouraged to include this training in fire management offi-

cers' meetings, instruction of airtanker pilots, and meetings with cooperators.

3. Reconsider policies and contracts to change safe drop height from 150 feet to those shown on the retardant coverage computer. This change will actually raise the minimum safe drop height, which is related to the type of drop (flow rate). For example, a single tank drop from a high-flow-rate airtanker may require a minimum drop height of 160 feet for safety, whereas a split drop may require 200 feet and a salvo 250 feet.

4. Continue the ORE study in fiscal year 1985 as now structured while formalizing an expanded program with interagency support and commitment.

5. Transfer technology from the ORE study to fire managers.

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# Fire Prevention and the Legal System

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Most of us in fire prevention are fully aware of the large number of human-caused wildfires that occur nationwide each year. We also know that damages caused by these fires, as well as presuppression and suppression activities, cost millions of dollars annually—and these costs are escalating.

Such costs are obviously a major concern to wildland management agencies. Any reduction in the number of human-caused fire starts would reduce the wasteful destruction of our Nation's forests and lessen (or at least hold static) the costs of wildland fires to American taxpayers.

One way to reduce human-caused wildfires is through the legal system. When correctly used, it can help prevent people from intentionally or accidentally breaking wildfire laws. A new reference, "The Legal System, the USDA Forest Service, and Human-Caused Wildfires" is now available to help land managers and scientists develop a basic understanding of the legal system.

Using a systems analysis approach to examine this complex subject, this easy-to-consult reference:

- Presents an overview of the American legal system;
- Describes the relations and interactions between the USDA Forest Service and the legal system's components and processes;

- Discusses how individuals enter, move through, and leave the legal system; and

- Describes the current status of Forest Service law enforcement efforts directed at wildfire violations.

More specifically, it defines the American legal system as a set of four interrelated components—legislative groups, legislated laws, enforcement agencies, and courts—and discusses each of these components in detail. The publication covers topics such as:

- Legislated laws (statutes, ordinances, and regulations) and unlegislated laws (common law and equity);
- Federal wildfire statutes and regulations;
- Types of Federal, State, and local law enforcement agencies and their duties and responsibilities;
- Forest Service law enforcement personnel;
- Federal and State court systems;
- The civil process and Forest Service demand-for-payment procedures;
- The criminal process;
- Trends in, and current status of, Forest Service law enforcement; and
- Statistics on Forest Service wildfire violations.

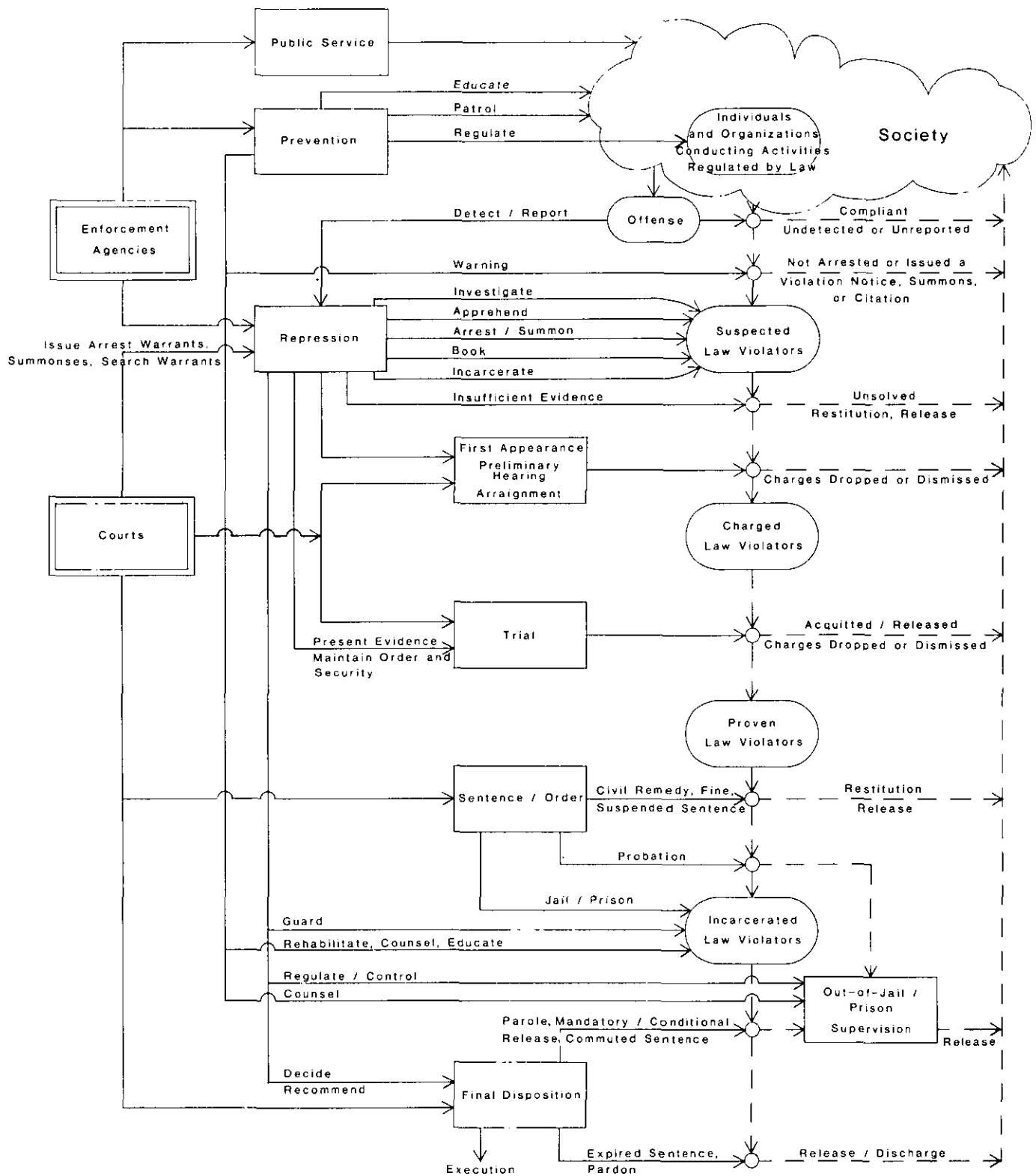
The reference also features detailed flowcharts of the information presented in the text. The figure accompanying this article,

for example, depicts the relations of law enforcement agencies and courts to people who enter and leave the American legal system via the civil or criminal process. Other helpful features include a comprehensive glossary of legal terms, a list of recommended readings for those wishing to pursue a subject in greater detail, and an index that will enable the reader to find topics of special interest.

Our goal in writing this publication was not to supply a comprehensive, indepth explanation of the legal system. Rather, we attempted to explain the system well enough and simply enough so that people new to the subject could understand and apply this information in their daily work, in developing simulation models, for example, or learning how a claim is settled before it gets to court. This reference cannot take the place of advice from Forest Service law enforcement experts or from the USDA attorneys in the Office of the General Counsel (OGC), and it cannot replace law enforcement training. What we hope, however, is that readers will be stimulated to pursue additional study of the American legal system and, once they have a basic knowledge and understanding of the system and its ties to wildfire prevention, use that knowledge to help reduce wildfire occurrence.

For a copy of the publication on the American legal system, contact





Two components of the American legal system—enforcement agencies and courts—and their relations to each other and to people entering and leaving the system via the civil or criminal process.

the North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108 and ask

for "The Legal System, the USDA Forest Service, and Human-caused Wildfires" by Linda R. Donoghue

and Donna M. Paananen; Res. Pap. NC-248. ■

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# BLM Smokejumpers Develop New Parachute

**Robert Mauck**

*Ram-Air Training Coordinator, USDI Bureau of Land Management, Ft. Wainwright, AK*

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For more than 40 years, smokejumpers have used round parachutes to attack wildland fires. The round chutes have been refined and improved since the early days of smokejumping, but the basic idea has remained the same—slow down the jumpers to the point where they won't get hurt on impact.

In 1979, James Veitch of the Bureau of Land Management's Alaska Smokejumpers began to think there might be a better way. Veitch had seen the new high-performance parachutes developed by manufacturers in the private sector. Recognizing the potential for corresponding improvements in smokejumper technology, Veitch approached BLM Smokejumper manager Alan Dunton and proposed that the Alaska Smokejumpers investigate ram-air parachutes for smokejumper use. Dunton, receptive to the idea, directed Veitch to form a study team. Thus began a 5-year project that has provided BLM jumpers with a radically new and improved parachute system, the BLM-A.

## **Advantages of the Ram-Air**

The ram-air or "square" parachute has been around since kite-maker Domina Jalbert invented it in the mid-1960's. Today it is the standard parachute for sport jumpers. A fabric wing with an open leading edge, it is pressurized and made rigid by the air that is

forced, or "rammed," into its nose. Because it is an airfoil, the ram-air parachute has the same properties as any wing—lift, drag, and airspeed. In short, it flies. The ram-air jumper is a pilot, not a passenger. The jumper can pick a landing spot and maneuver to get there. On landing, the pilot/jumper converts airspeed to lift, much as a bird or an airplane would, and lightly touches down. The ram-air parachute gives smokejumpers control over where they land and how hard, reducing the injuries that can occur because of the rugged terrain into which they jump.

With the help of a private manufacturer, the study team obtained four ram-air parachute systems and learned to use them. Every member of the study team was immediately impressed with the flight characteristics of the canopies and convinced that the potential existed to drastically improve smokejumper efficiency.

Besides the prospect of softer and therefore safer landings, other advantages were apparent. With a maximum forward speed of 25 miles per hour, ram-air jumpers could fight fires previously considered too dangerous for smokejumping because of high winds—a common situation with round parachutes. In addition, the square's quick, responsive handling characteristics and variable airspeed (from 0 to 25 miles per

hour) would enable smokejumper spotters (jumpmasters) to get firefighters on the ground more efficiently.

When dropping jumpers with round parachutes, spotters must accurately determine the best exit point at which to drop the jumpers. This takes time—often multiple passes must be made to be sure of the winds. An error could mean a long delay in attack time or injury to the jumpers. Ram-air canopies give the spotter a much greater margin for accuracy, letting the spotter put jumpers safely on the fire with a minimum of delay. In many cases, depending on the size of the jumpspot, the spotter can unload a whole planeload of jumpers at once, rather than the two-jumper sticks normally dropped in the round parachute system.

The potential benefits to a manager of ram-air equipment add up fast—increased safety, a higher percentage of fires attacked, faster attack times, and even savings in flight time.

## **Challenges to Overcome**

The BLM Alaska Smokejumpers had originally hoped to take existing sport parachute equipment and use it for smokejumping. That proved to be a false hope. Given the unique conditions involved with smokejumping, the accepted means of deploying ram-air parachutes would not work. The study

team had to design a deployment system from scratch. There was no precedent either in Government or the private sector for what they were trying to do.

The problem was that the jumper needed to be in a stable position relative to the parachute upon deployment (fig. 1). The sport world accomplished this through free fall. But free fall demanded high altitudes and extensive training to reach an acceptable skill level. Smokejumpers using round parachutes routinely jump as low as 1,200 feet above ground level. The time needed to train an entire base of 100 jumpers in free fall was unacceptable—the smokejumpers' mission is firefighting, not parachuting. The straight static line deployment used in the round parachute system didn't work either. A jumper exiting a high-speed aircraft like those used by Alaska Smokejumpers cannot reliably control body position. If the ram-air canopy deploys as the jumper is tumbling, injury-inflicting opening shock can result. A new deployment system had to be developed.

The study group, which had simply wanted a better parachute, was forced to pursue an indepth operational development approach. They investigated numerous traditional methods of parachute deployment. None of the methods permitted the reliably controlled body position demanded by ram-

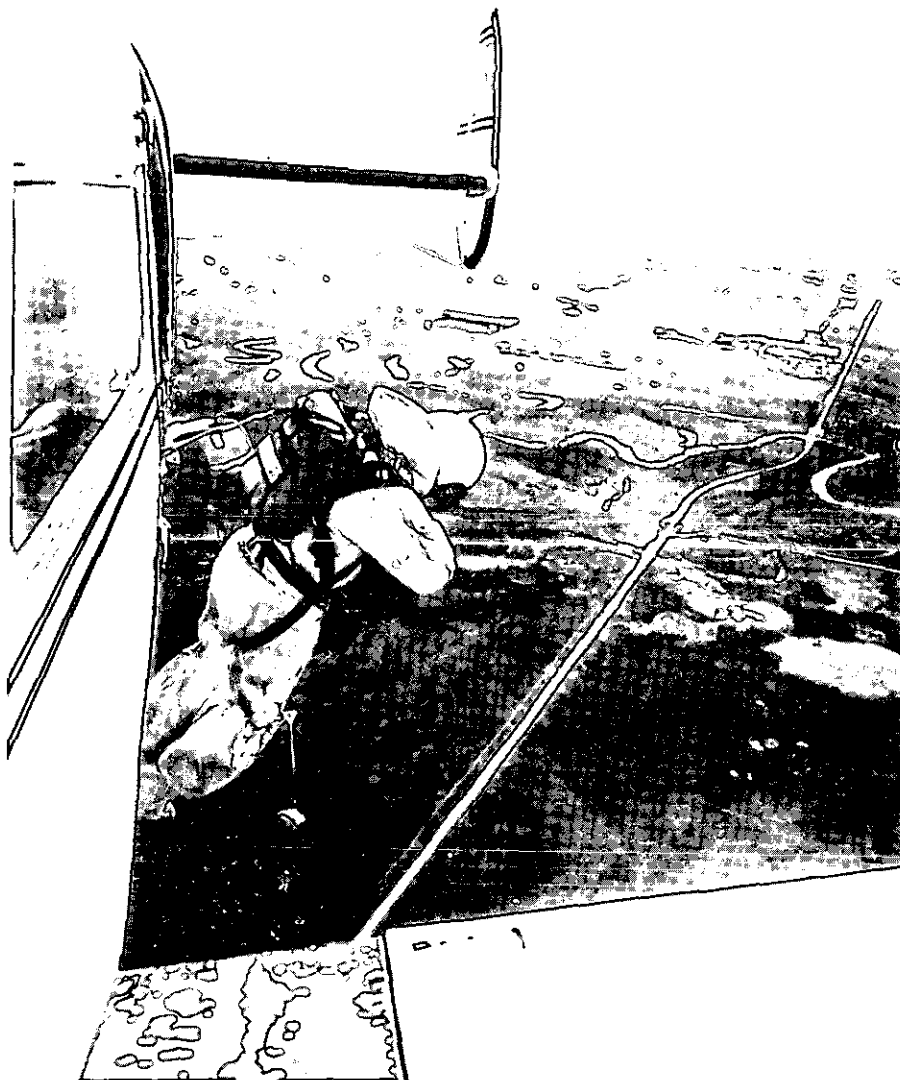


Figure 1—Ram-air equipped jumper exiting aircraft on a practice jump near Fairbanks, AK.

air canopies deployed out of high-speed aircraft.

### Russian Technology

A breakthrough came unexpectedly from the Soviet Union. To solve the stability problem, Russian smokejumpers and military airborne personnel used a drogue, a small parachute that deployed as the jumper left the aircraft, immediately pulling the jumper into a feet-to-earth attitude. A timing device released the drogue, which then deployed the main canopy, an advanced round canopy much like the paracommander used in sport parachuting.

In 1976, a Forest Service delegation from region 6 visited a smokejumper center outside of Moscow. A year later, the North Cascade Smokejumper Base received an example of the Russian smokejumper parachute system. The BLM study team borrowed the system from the Forest Service in 1979. It was soon evident that the drogue concept might be the answer to the deployment problem.

The drogue enabled a jumper to exit an aircraft traveling at 90 to 100 knots and be in the stable body position required for ram-air deployment within seconds of leaving the door. However, once again, it was not simply a matter

of taking an existing system off the shelf and making it work. To adapt the Russian system to ram-air parachutes required several major modifications. Two years of intensive research and development followed in which numerous dummy drops and live test jumps were carefully conducted. By the fall of 1981, the study team had designed a new parachute system, the BLM-A, that was safe, reliable, and relatively easy to use (fig. 2).

### Training

Inventing a new system was only half the battle. The unique deployment system demanded new training techniques, and no precedent existed for training novice jumpers on the high-performance parachutes. By August 1981 training guidelines and procedures had been established. Four new ram-air jumpers were trained, and the study team gained confidence that smokejumper conversion from traditional round canopies to the ram-air canopies could be done efficiently and economically.

Landing with a ram-air proved to be the most difficult flight maneuver for a novice jumper to learn (fig. 3). The timing of the flare, as the landing is called, demanded practice—the better a jumper learned to flare, the softer the landing. Conversely, if the timing was off, the jumper could



**Figure 2**—Smokejumper using Goliath model, 375 square feet in area. Note drogue trailing behind. BLM photo



**Figure 3**—Smokejumper with ram-air parachute about to land near a small fire in Alaska. BLM photo

hit hard, although still not as hard as with a standard round parachute. Because practice jumps were expensive, the number of landings a jumper in training could have would be limited. The BLM-A trainers needed to think of an economical way to teach a jumper how to land.

Parascension was the answer. Parascension is a sport, refined by clubs in England, in which the jumper, under canopy, is towed to altitude by a tow truck and rope.

The jumper is then released to fly the canopy and land as in any parachute jump. The study team contacted the British Association of Parascending Clubs. With their encouragement, the Alaska Smokejumpers started parascending. Using methods learned from the British, as well as innovations of their own, the study team incorporated parascension as a valuable teaching tool in ram-air rookie training. Thanks to parascension, a rookie ram-air jumper could make

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two dozen landings in an afternoon without using any aircraft flight time. First-time ram-air jumpers were saturated with landings in a controlled situation, and the Agency saved the cost of repeated training flights.

By the spring of 1982, 14 BLM smokejumpers had been trained on the BLM-A system. With the subsequent approval of the BLM's Alaska State Director, the system became operational. The ram-air system smoothly coexisted with the traditional round system in day-to-day fire operations. On June 21, 1982, eight BLM-A smokejumpers based on Alaska's Seward Peninsula made the first ram-air fire jump.

A total of 29 ram-air fire jumps were made by BLM Alaska Smokejumpers that season. One fire in particular dramatized the benefits of the BLM-A system. On August 21, 1982, a fire broke out near the village of Koliganek near Bristol Bay, 450 air miles from Fairbanks. Jumpers were dispatched from Fairbanks. By the time the jumpship reached the fire, the winds were in excess of 30 miles per hour. That fire, less than one-fourth of a mile from the village, could not have been attacked using traditional smoke-jumper equipment. Winds greater than 15 miles per hour are considered too dangerous to jump using round parachutes; 30 miles per hour almost guaranteed injury.

Fortunately, four of the eight smokejumpers on board had ram-air parachutes. They were able to safely jump on the fire, averting the need for an expensive and time-consuming alternate means of attack.

#### **Operational Use**

After the success of the first operational season, the State Director gave the approval to expand the program. Additional jumpers have been trained every year. Now more than 75 percent of the Alaska Smokejumpers use the BLM-A.

Refinements to the system continue as better materials and designs become available. Since the earliest days of the BLM-A project, the study team has searched for the canopy that best suits smokejumper requirements. Private manufacturers have begun to produce very large ram-air canopies. These parachutes are easily handled and are designed to carry heavily loaded jumpers. After extensive testing, one of these large canopies has been adopted as the standard BLM-A parachute. Its use has simplified training. Landing technique is easier to learn, thus virtually eliminating the need for parascension.

Operational use of the BLM-A has expanded to Federal lands outside of Alaska. The Alaska Fire Service has sent a smokejumper

crew of 15 to the Great Basin to jump fires in Colorado, Utah, and Nevada. Every jumper on the crew is ram-air equipped. The ram-air has greatly reduced the number of jump-related injuries in areas where extreme altitudes, high winds and temperatures, and rocky terrain are the norm.

The BLM-A system is a major innovation in smokejumping technology. It is a benefit to jumpers and managers alike, all of whom appreciate safe, efficient, timely firefighting. From initial concept to full-fledged firefighting tool, the BLM-A was made possible by openminded Bureau support and the dedication of the BLM Alaska Smokejumpers. ■

# GEOLOC—Geographic Locator System

Jim Whitson and Mike Sety

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All emergency service organizations use some type of locator system for their daily emergency response operations, but few of these systems have broad inter-agency or national application. GEOLOC is a universal map locator system that can be applied by all emergency service agencies for locating and dispatching personnel and equipment to emergency incidents. Although GEOLOC was developed for emergency service agencies, it provides a logical identifying or referencing scheme that has application in many other resource management disciplines (1).

GEOLOC is designed on a single reference grid, based on USGS 7.5-minute series (topographic) quadrangle maps. GEOLOC locates a unique 100-acre cell anywhere in the United States with a seven-element alphanumeric designator.

GEOLOC is designed around the zone concept, with each zone containing 25 degrees of latitude (fig. 1). Zone 1 begins with 125-degree longitude and is lettered A-Z from west to east. The 50-degree latitude begins in the north, and each 30 minutes is lettered from A-Z to the 37-degree latitude. Figure 2 is a 1:1,000,000 map portion of northern Minnesota in Zone 2 in which the letters G and H represent each 30 minutes between the latitudes 46 degrees and 47 degrees. Letter G represents the 1 degree between the 92- and 93-degree longitude. The

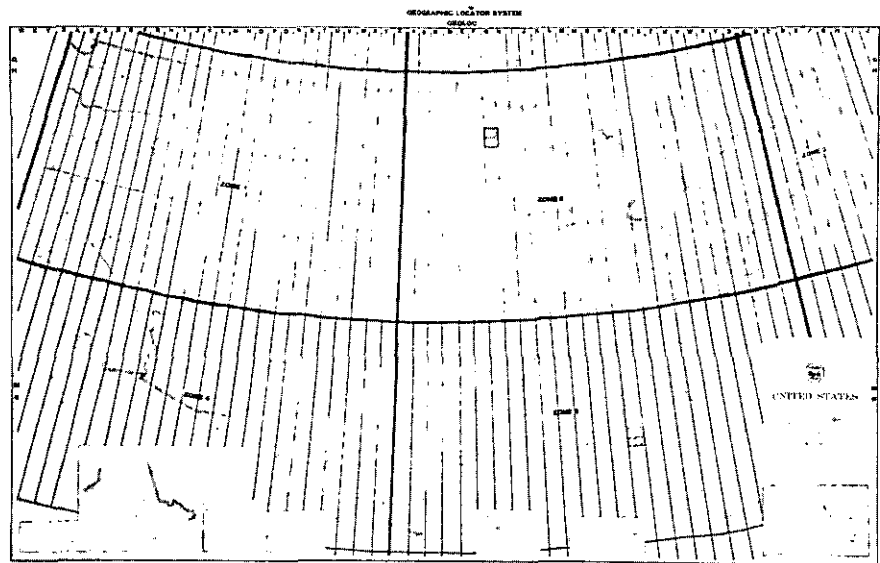


Figure 1—The United States is divided into zones containing 25 degrees of longitude and 13 degrees of latitude.

coordinate GG in Zone 2 indicates this unique portion of the United States. This segment 1 degree by 30 minutes represented by Zone 2 GG will contain thirty-two 7.5-minute quads on a 1:100,000 scale map format (fig. 3). Each 7.5-minute quad may be further divided into eight equal parts and lettered A-H. An additional division is shown in figure 4 by segmenting D, a portion of a standard 7.5-minute quadrangle into 50 equal parts. Thus the coordinate for this division is Zone 2 GG 15 D. This division represents a unique 100-acre cell (fig. 4). Agencies may further subdivide, if necessary. Figure 5 depicts a sim-

plified graphic representation of the process involved.

Dispatching of personnel and equipment to emergencies requires a locator system which can identify a specific incident site and transportation routes so that response time is minimized.

Dispatching air support over long distances may require several levels of information. With the increasing use of Loran C in aircraft, the use of latitude and longitude will be used to a greater extent in dispatching as well as detection. Computers can then rapidly convert latitude and longitude to a GEOLOC grid. GEOLOC lends itself well to dispatch-

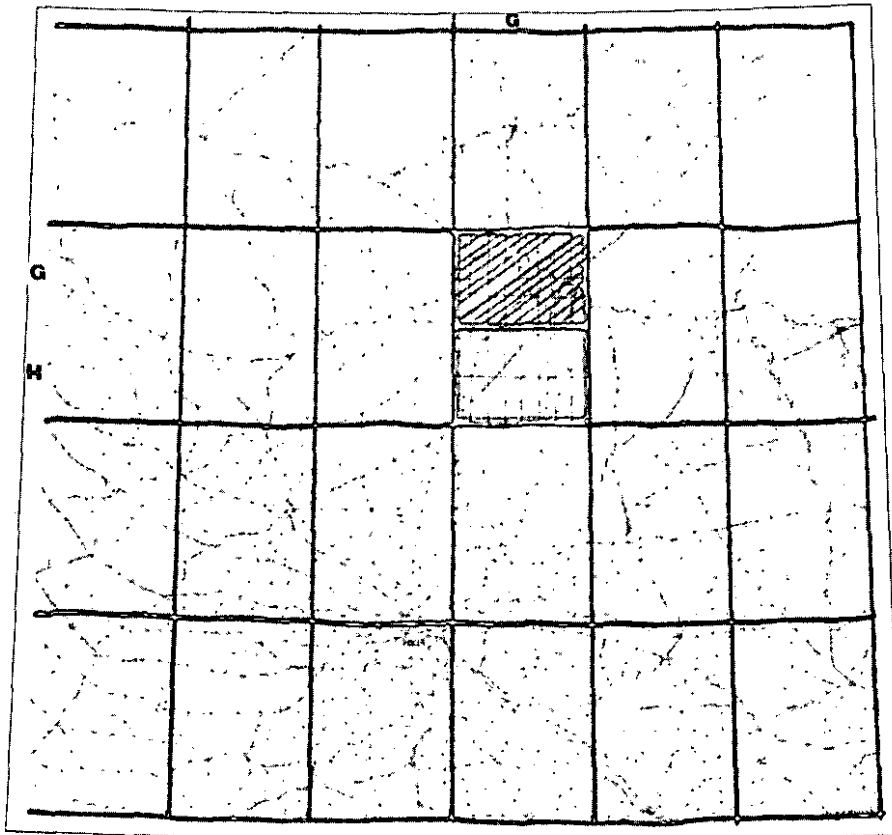


Figure 2—1:1,000,000 map with coordinates for each 1 degree of longitude and each 30 minutes of latitude.

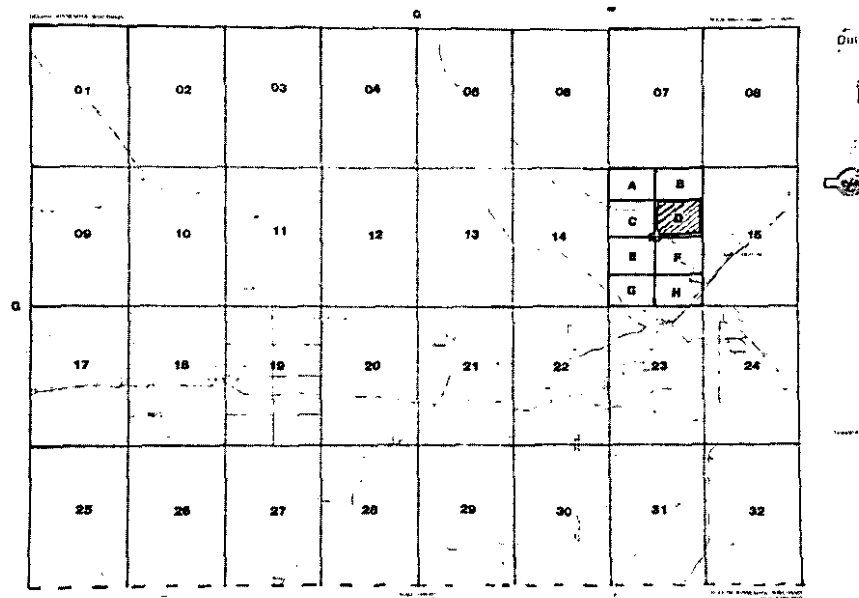


Figure 3—A 1:100,000 scale map divided into thirty-two 7.5-minute quads.

ing at both the local and national levels. The 100-acre cell applies to the urban-residential-wildland interface response, whereas air dispatch utilizes the 8-square-mile cells.

GEOLOC can be readily applied to computer-aided dispatch by encoding GEOLOC cells into microcomputers for in-house systems. Additional data on subjects such as fuels, ownership, or structures can be keyed to each cell. Data bases may be expanded to include information as needed by the agency. In many areas where agencies such as fire, police, sheriff, paramedic, and ambulance services are coordinating their activities GEOLOC can facilitate response.

### Specifications of GEOLOC

- Based upon 7.5-minute quad-range map formats previously established by USGS National Mapping Division.
- Locates easily to within an 100-acre cell.
- Application extends to local, State, and national programs.
- Easily cross-referenced to other coordinate systems, such as Universal Transverse Mercator System and State Plane Coordination System (but *not* to section, township, and range).

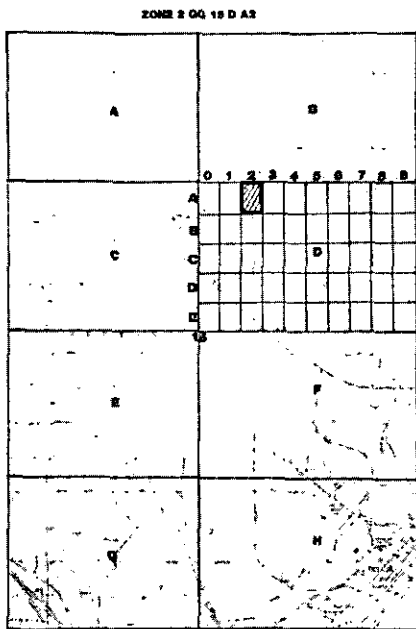


Figure 4—A standard 7.5-minute quad broken down into divisions, each representing a unique 100-acre cell.

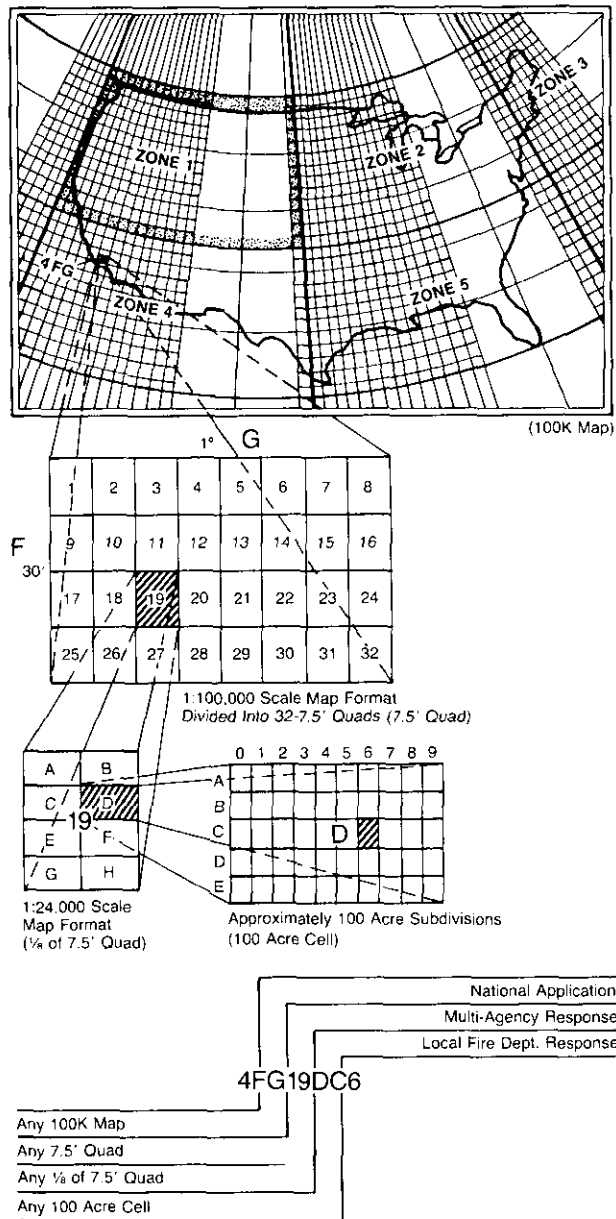


Figure 5—An outline of the GEOLOC process.

### Advantages

- Can quickly and precisely get incident location from computers.
- Gives agencies a common language during mutual aid response.
  - Quickly locates fire resources on map—fire attack, fire hydrants, etc.
  - Provides compatibility for computer storage of agency-specific data.

- Can be quickly and economically updated.
  - Can be quickly and easily taught to and retained by users.
    - Increases efficiency of dispatch.
      - Establishes a locator system not subject to change.
    - Can quickly scale up or down, to 100-acre cells, for example, or 10-acre cells.

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# Is It Time to Fight or Stand Back?

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Moderate to extreme drought conditions are facing many of the fire protection agencies across the country. The accompanying map shows the distribution of moderate, severe, and extreme conditions as of June 1, 1985 (see p. 34). The Drought Severity Index (Palmer) depicts prolonged abnormal dryness or wetness. It changes little from week to week and reflects long-term moisture runoff, recharge, and deep percolation, as well as evapotranspiration (*J*).

But what effect does drought have on accident potential? On January 30, 1985, a fire fatality occurred on the Fort Myers District of the Florida Division of Forestry. The average rate of spread for the fire, up to the time of the accident, was calculated at 75 chains per hour with an average fire line intensity of 3,000 Btu/ft/sec and average flame length of 15 feet or more.

At the time of the accident it was estimated the fire was moving in excess of 1,000 chains per hour with flame length averaging 75 feet and fire intensity 72,000 Btu/ft/sec (2). There was not even time to deploy a fire shelter.

Situations such as these are often referred to as exhibiting unexpected or unusual fire behavior. But under certain conditions are they unusual or unexpected? I think not. Nearly every burn fatality report refers to predictable fire behavior. Also, the accidents often occurred in regions of moderate to extreme drought.

What can be done?

- Recognize drought conditions and the concurrent effect on fire behavior.
- *Expect* unusual or blowup fire behavior. Under drought conditions, it is not business as "usual" but business as "unusual."
- Reestablish a basic fire suppression safety principle—"Establish an anchor and

progress with flank attack *only* at a rate that can be done so safely."

From January 1984 through May 1985 State and Federal wildland firefighting agencies suffered the loss of six experienced firefighters. Of necessity, aggressiveness and urgency have always been an inherent part of firefighting. But there are times when the justifiable desire to take urgent, aggressive action needs to be restrained. Under some conditions, less aggressive actions are understandable, acceptable, and desirable. There is a time to fight, and there is a time to stand back. Being able to tell the difference is an important part of effective, intelligent firefighting.

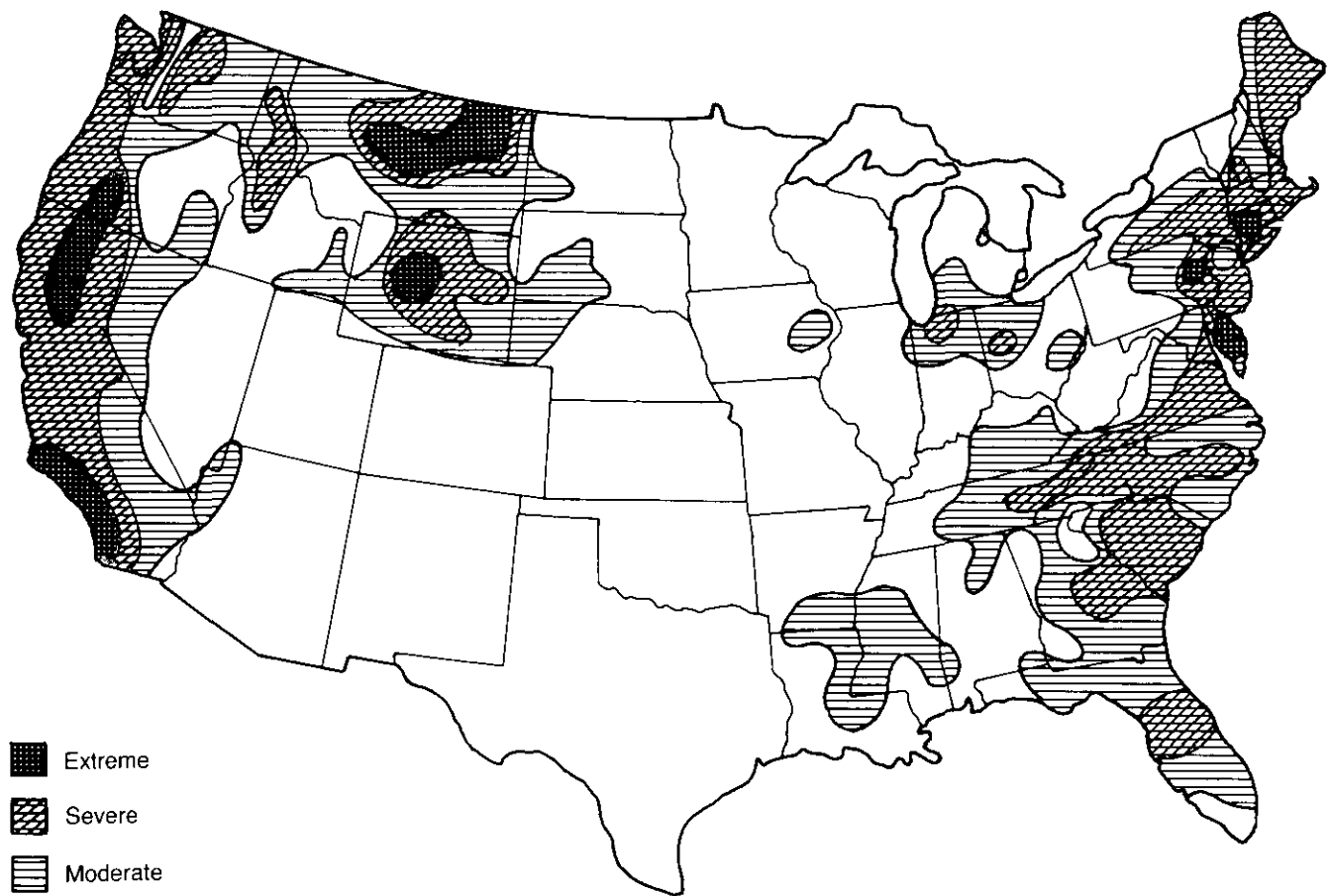
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**Drought Severity**  
(Long Term, Palmer)

JUNE 1



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