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Contents

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Cover: A PB4Y-2 airtanker making drop on brushpile at McCall Airport, ID. See story on p. 16 .

Fire-Danger Rating: The Next 20 Years[1]

John E. Deeming[2]

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For the next 10 years, few changes will be made to the fire-danger rating system. During that time, the focus will be on the automation of weather observing systems and the streamlining of the computation and display of ratings. The time horizon for projecting fire danger will be pushed to 30 days by the late 1990's. A close alignment of the fire-danger rating system with the fire-behavior and fire-planning systems will occur with the release of the second-generation fire model in the late 1990's. Improved utilization of all of these systems will be delayed until more structured approaches to decision making are adopted by management. By 2007, expert systems utilizing real time directly and remotely sensed weather and fuel moisture data will be on line.

Research to develop a means of evaluating wildland flammability began in the United States more than 60 years ago. Coert du Bois, S.B. Show, E.I. Kotok, and H.T. Gisborne dominated the early fire research scene. Six fire-danger rating "meters" were developed between 1930 and 1946 by Gisborne for use in the Northern Rockies. Programs patterned after that of Gisborne were pursued in many sections of the United States in the 1940's and 1950's. John J. Keetch worked on a national fire-danger rating system from 1958 to 1963. By the late 1960's, researchers M.J. Schroeder (the United States), A. McArthur (Australia), and C.E. Van Wagner (Canada) were setting the pace in fire-danger rating research and development.

Mark J. Schroeder organized the United States national program at Fort Collins, CO, in 1968; I joined the unit in 1970. James W. (Wally) Lancaster, Michael (Mike) Fosberg, R.W. (Bill) Furman, and I worked together until the 1972 version of the National Fire-Danger Rating System (NFDRS) was completed (Deeming and others 1972) and the computerized version (AFFIRMS) on line (Helfman and others 1975, 1978).

From 1973 to 1975, Wally Lancaster and I continued with the NFDRS program at the Boise Interagency Fire Center (BIFC) with the able help of R.J. (Bob) Straub. R.E. (Bob) Burgan, Jack D. Cohen, and I were the key players from 1975 through 1978. We made the 1978 update of the System (Deeming and others 1977). That work was done at the Intermountain Fire Sciences Laboratory (formerly the Northern Forest Fire Laboratory) (Bradshaw and others 1983).

Having "been in the business" for 17 years, looking 20 years into the fire-danger-rating future for this meeting seemed like a reasonable undertaking. However, I sought the views of others with fire-danger rating backgrounds in Canada and the United States, hopefully to balance my own biases. A number of those distinguished people responded, and I have "pooled" their "vision" in this 20-year outlook.

For this exercise, I made a sincere attempt to avoid the "Star Wars" syndrome, limiting my futuring by the "probable" and trying not to be distracted by the "possible." That was not easy in this bells-and-whistles era of dial-up color radar, pull-down menus, 80-megabyte PC hard disks, satellite data relay, and so on. Neither did I intend to restate any of the issues highlighted in my 1983 "reflections" paper on the development, application, and future of NFDRS (Deeming 1983).

This paper addresses the following topics:

- The current state of fire-danger rating research and development.
- The need for fire-danger ratings.
- Understanding the character of fire danger.
- The fire-danger rating system of 2007.
- The practice of rating fire danger.
- Communication and display of rating.

Current State of Fire-Danger Rating Research and Development

No work has been done on the NFDRS since the research project at Missoula, MT, was disbanded in 1978. Forest Service researchers at East Lansing, MI, however, have completed a number of validation studies (Haines and others 1983, 1985; Main and Haines 1983). At the

[1]Reprinted from Proceedings of the Symposium on Wildland Fire 2000. 1987 April 27–30: South Lake Tahoe, CA. Gen. Tech. Rep. PNW-101. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1987. 258 p.

[2]The author thanks the following people who took the time to share their thoughts and ideas: M.E. Alexander, P.C. Andrews, R.E. Burgan, J.D. Cohen, M.A. Fosberg, F.F. Fujioka, R.D. Gale, W.A. Main, R.E. Rothermel, A.J. Simard, and C.E. Van Wagner.

Forest Service's Intermountain Fire Sciences Laboratory, Andrews (1987) is developing a technique for matching fire-danger rating with different measures of fire business.

The NFDRS users' meetings were held in 1985 at Salt Lake City, UT, and in 1986 at Harper's Ferry, VA, to assess the need for additional research (and development). An outgrowth of those meetings is the impending transfer of R.E. Burgan from Missoula, MT, to Macon, GA. His assignment is to resolve NFDRS shortcomings identified by eastern users.

A 4-year contract for AFFIRMS has recently been awarded to the General Electric Company (GE). (AFFIRMS was developed on GE equipment, and GE provided the service until 1980.) A multiyear program to develop a replacement system for AFFIRMS will begin later this year. That system will be called the Weather Information Management System (WIMS).

Dick Rothermel and his staff at the Intermountain Fire Sciences Laboratory are planning a program of research to develop the second-generation mathematical fire model. His project team has also been given an assignment to develop an integrated fire management system inclusive of needs ranging from fire-behavior prediction to fire planning (Rothermel and Andrews 1987).

Dr. Mike Fosberg is embarking on a 5-year program at the Riverside Fire Laboratory to develop medium- and long-range weather forecasts for fire management (Fosberg and Fujioka 1987).

And we are here talking about fire-danger rating.

The Need for Fire-Danger Ratings

The need for a fire-danger rating system will not become less during the next two decades. The range of fire management tasks is expanding, and those tasks require greater understanding and skill. They are increasingly complex (measured suppression response, fire effects), and the consequences of making poor decisions are more costly and politically sensitive.

The time horizon for projecting fire-danger rating will certainly be pushed beyond the current 24 and 30 hours, a lead time sufficient for making decisions that affect local and subregional presuppression activities. The need to share increasingly expensive and scarce suppression resources among widely separated cooperators, however, has caused managers to ask for weather and fire-danger forecasts well beyond a couple of days.

The need for 15- and 30-day fire-danger projections has been documented. Thirty days is a goal for submission of emergency funding requests to the Congress and some State legislatures. The Washington office of the Forest Service requires Forest Service regions to give 2 weeks' notice of a requirement for supplemental presuppression funding. Since May 1985, BIFC has issued an "experimental" regional-scale, 30-day projection of wildfire activity (U.S. Department of Agriculture, Forest Service 1986).

By the mid-1990's, the formats of both short- and extended-range fire-danger predictions will include estimates of uncertainty. The uncertainty resulting from the stochastic nature of the environmental drivers of fire danger, as well as the uncertainty inherent in the forecasting process, will be quantified. The current practice of making single-value, deterministic predictions is not providing users with a complete picture of the actual fire-danger situation.

Though it will not happen in the near future, fire managers will develop and employ structured decision-making systems based in the management sciences, including decision theory. Only then will management be able to consider the natural variability and stochastic character of fire danger properly.

Understanding the Character of Fire Danger

Improvements to the performance and use of the NFDRS during the next several years will be modest. One reason is our poor understanding of the temporal and spatial scales of fire-danger. Getting more to the point, we do not know what scales of fire danger are possible to characterize and/or predict.

For instance, it is impossible to characterize, with a single rating, the fire danger near the ocean where there is a twice-per-day passage of a sea-breeze front. In such situations, the extreme diurnal variability of burning conditions requires an approach more akin to that of predicting fire behavior.

Another shortcoming is our poor understanding of the temporal components of regional fire danger. Once those components are identified each can be tracked and integrated into a set of meaningful and useful ratings.

The components of a region's fire danger are the result of the interactions of a region's fuels and weather cycles—diurnal, synoptic, seasonal, and climatic. Here is an example: The spring fire season in the Lake States is nearly as predictable as spring itself. Its severity does vary, but there are few surprises. The typical spring fire burns in cured grass and reed-like plant debris, hence the key fuels are predominantly in the 1-hour and 10-hour timelag classes. The spring fire danger is determined by the highly transient weather elements, wind and relative humidity.

On the other hand, severe fire seasons such as 1976 are anything but routine. They are typically preceded by one to several years of below normal precipitation resulting in low water tables and exposure of normally saturated organic soils to the atmosphere. The 1976 class of fire season poses a completely different fire-danger rating problem than does the spring fire season. Its cause is a subclimatic shift of precipitation-producing weather events and organic soils that lie at the opposite end of the fuel moisture response spectrum from dead grass. It is not possible for any single fire-danger index to do a good job in both of these situations.

Future Fire-Danger Rating System

The fire-danger system of 2007 will be complicated. Fire danger is a complex, multidimensional concept; its physical character varies tremendously across the range of conditions for which ratings are needed. I am confident that the fire-danger rating system of 2007 will look a great deal like the 1978 NFDRS.

The NFDRS offers the user a choice of six indexes and components. That number could certainly be reduced to four: Ignition, fuel energy, burning, and occurrence.

Fire problems and the needs of the responsible agencies vary so greatly that a range of options must be provided. The menu of choices must include options that index the factors that affect ignitability, fireline intensity, composite fuel moisture (fuel energy), and occurrence.

The fire-danger rating system of 2007 will not be integrated with the fire-behavior and fire-planning systems to the degree that it will lose its identity.

Fuels. The Rothermel fire spread model (Rothermel 1972, Albini 1976) provided the basis for the NFDRS, the Forest Service's National Fire Management and Analysis System (NFMAS) (U.S. Department of Agriculture, Forest Service 1985) and the Fire-

Behavior Prediction System (FBPS) (Rothermel 1983).

The spread model was modified to meet the special requirements of NFDRS and NFMAS. Though the modifications were minor, a unique set of stylized fuel models had to be developed for each processor. This has, unfortunately, confused many users of the three systems.

The standard fire-danger rating fuel model will be a subset of the fuel models used for fire-behavior predictions and fire planning. The most significant change will be the licensing of users to develop their own fire-danger rating fuel models much as they can now do for the fire-behavior prediction system (Burgan 1984).

The fire-danger rating system of the future will account for the variation in fuel moisture responses to weather and plant life processes.

Consider the Lake States example in the preceding section and picture the tundra of Canada and Alaska. Contrast the character of those fuels with a common Great Basin fuel—a pure stand of annual grasses and forbs.

At least one additional fuel class will be added to represent organic soils, tundra, and deep duff and litter. The moisture-response model for this fuel class will account for transpiration as well as evaporation. Drawdown from transpiration may continue long after organic soil moisture reaches equilibrium with the atmosphere.

Live-fuel moisture models will certainly be improved as will dead-fuel moisture models (Rothermel and others 1986). More importantly for some areas of the country there will be a better understanding and modeling of the effects of living plants on fire danger.

A drought index will not be needed if satisfactory moisture models for organic soils and live fuels are developed.

Fire Danger for Extended Periods (2 to 30 Days). What I have discussed, thus far, has been fire-danger rating in the traditional time realm—out to 30 hours. In this section the stickier issue of rating fire danger out to 30 days is addressed.

The capability to produce useful 6- to 10-day fire-danger rating products will lag behind yet-to-be-realized advances in extended range weather forecasting. No breakthroughs are expected for the next 20 years (Harnack 1986), but there is every reason to expect significant progress in the 2- to 6-day range by the mid- to late-1990's.

More to the point of this paper, within 10 years it will be feasible to calculate daily, worst-case fire-danger ratings out to 6 days. I'm talking here about ratings that account for wind, the most elusive and challenging weather element to predict. The National Weather Service is now running its most sophisticated predictive models out to 10 days. They are showing great promise.

Beyond 6 days, an entirely different approach and fire-danger rating format will be needed. The reasons are:

- The list of predicted weather parameters will not include relative humidity and wind.
- The predictions will be expressed as "departures from normal." Weather information of this type is adaptable for fire-danger rating purposes, but it will be usable only if there is a good historical record of fire-danger ratings from which "normal fire danger" can be determined. The required data has been collected and archived since the early 1970's (Furman and Brink 1975, Main et al. 1982).

Integration With Fire-Behavior and Fire-Planning System. Dick Rothermel is looking ahead to a second-generation fire model that will account for the effects of large fuels on fire behavior and, possibly, model the behavior of fires burning in organic soils. That model (or family of models) should satisfy the specific requirements of all the NFDRS, NFMAS, and FBPS. That will make it much easier than now for users to change from one system to another.

The data demands of the second-generation fire model or models will make them unsuitable for direct application in the fire-danger rating beyond the 6-day timeframe discussed in the previous section. I foresee a technological discontinuity at that transition point that will likely persist well beyond 2007.

The Practice of Rating Fire Danger

The Geostationary Orbiting/Environmental Satellite (GOES) and remote automatic weather stations are changing the way fire-weather data is being collected. Since 1978, several hundred stations have been deployed by State and Federal agencies, and more are planned. Almost all are now located in the far West and Alaska, but they will be common in the East before 2007.

Before the next 20 years have passed, fire weather data will be collected from specially designed networks of automatic and manual stations. The numbers and locations of stations making up those networks will be determined by requirements passed down by management. Management will have finally determined how good the "answers" must be.

Some users will locate stations in the "woods," a practice commonly followed by our Canadian colleagues. This will be an improvement for some. The "worst case" standard for taking the basic weather observation will be continued. More attention will, however, be given to the time the "worst" conditions actually occur.

More use will be made of weather data taken at nonwildland sites such as airports. Factors will have been developed to convert a 1- and 3-minute, 10-meter windspeed to an equivalent 10-minute, 20-foot windspeed. Neither will there be a need to weigh fuel sticks.

Communication and Display of Fire-Danger Ratings

Automated fire-weather stations will replace more than half of the manual stations by 1997. The replacement system for AFFIRMS will be in place by 1992. That will just about do it for the first half of the 20-year outlook.

No one knows what WIMS will look like; that will, however, not be known until the contract is completed. Because of a consulting agreement with a private company I will not discuss my vision of WIMS, except that it will very likely make good use of micro-computers and will have limited "expert system" capabilities.

During the second half of the 20-year outlook, local data bases will allow each fire management unit to do its own planning, calculate and interpret its own fire danger, and make detailed fire behavior predictions for large, multiperiod fires. Uncertainty of both fire-danger and fire-behavior predictions will be quantified and that information incorporated in sophisticated computer-generated decision aids.

By 2007, the moisture contents of tundra, organic soils, and the full range of vegetation will be monitored from satellites, and those data sent directly to the primary users. High resolution precipitation data from the weather radar network will be automatically integrated, along with the satellite moisture data, into operational fire-danger rating and fire-behavior prediction systems.

Summary

The following observations can be made about the future of fire-danger rating systems in the next two decades:

- The need for fire-danger ratings will not disappear.
- Only modest technical improvements will be made to the NFDRS during the next 10 years.
- The 2007 NFDRS will look much like the 1978 NFDRS.
- A better understanding of the character of each region's fire danger will be the key to improved fire-danger rating system usage.
- Detailed, 6-day projections and regional trends of fire-danger ratings will be feasible by the mid-1990's.
- The format of predicted fire danger, beginning in the late 1990's, will include ranges of uncertainty.
- Fire-behavior, fire-danger rating, and fire-planning systems will be closely integrated, but not fully integrated.
- Satellite observations of vegetation and soil moisture conditions will be integrated into the fire-danger rating process.
- Weather radar will be the source of high resolution precipitation data for rating fire danger. ■

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Using NFDRS-Predicted 1000-Hour Fuel Moisture as a Daily Management Tool

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Introduction

The National Fire-Danger Rating System (NFDRS) (Deeming et al. 1977) includes a 1000-hour timelag fuel-moisture model (NFDR-Th), which is routinely available to most fire managers. The predictions from this model can be used for daily fire-management planning.

The NFDR-Th was intended to be a nationally applicable, trend-predicting tool. Through modifying NFDR-Th model methodology, an adjusted model can be developed that predicts, with daily accuracy, regional, fuel-type specific 1000-hour fuel moisture (Ottmar and Sandberg 1985). Thousand-hour fuel moisture can be used to predict consumption of woody fuels and duff by broadcast burning (Little et al. 1986, Sandberg and Ottmar 1983). Specifying desired levels of fuel consumption has become common practice in prescribing conditions for prescribed fires; now, a quantitative system can be developed that is based on 1000-hour fuel-moisture predictions. Predicting fuel consumption is important because it converts directly to fire duration. Fire duration can be related to bole damage in residual trees, soil heating, residual smoke production, and mop-up effort.

Obtaining Regional Accuracy

Two basic approaches are used to estimate 1000-hour fuel-moisture content. The first is the direct measurement of fuel-moisture from samples of material in the field. The second method is the modeling approach, which requires that a periodic correction calculated from weather measurements be applied to a running moisture value. In 1978, the NFDRS was updated to include a 1000-hour timelag fuel-moisture model to serve as an indicator of long periods of fire danger and below-normal precipitation. The model computes fuel moisture from maximum and minimum daily relative humidities and temperature and precipitation duration, which are obtained from Remote Automated Weather Stations (RAWS). A study measuring the accuracy of the NFDRS 1000-hour moisture model (Ottmar 1980) found that, for clearcut and partial cut units in western Washington and Oregon, the NFDRS underpredicted measured values by an average of 7 percent. This underprediction results because the NFDRS is species specific, having been developed theoretically and tested against western redcedar samples only, and because the extreme low fuel-moisture value (rather than a unit average) is desired for fire-danger rating purposes.

To predict fire effects, a mean unit fuel moisture is required. In response to this need, an adjustment model (ADJ-Th) was developed that is similar in structure to the NFDRS model but is calibrated to predict a mean unit fuel moisture for fuels characteristic of western Washington and Oregon. The ADJ-Th, available through nomographs, is nearly as good a predictor as measured moisture and clearly superior to the NFDR-Th for this region. Similar adjustment models could easily be developed for other regions to better represent species type variations.

The necessary inputs to the adjustment model are sometimes unavailable. This situation may occur when archived data are analyzed or because maximum-minimum humidity data are not obtainable from manual weather stations. In these cases, adjusting the known NFDRS prediction upward by 7 percent is acceptable.

Predicting Consumption of Large Woody Fuels

Scheduling prescribed fire to achieve desired effects depends on the ability to predict large-fuel consumption. A 1983 study measured fuel consumption and fuel moisture on logged units including old-growth and second-growth clearcuttings and shelterwood regeneration cuts (Sandberg and Ottmar 1983). By use of linear regression analysis, three equations were derived to estimate fuel consumption for various large-fuel size classes. The only variable necessary in the equations was the 1000-hour fuel moisture. Each of the three equations developed uses one of the three 1000-hour fuel-moisture values mentioned previously (NFDR-Th, ADJ-Th, and measured).

These predictive equations are expected to be useful in other regions where short-needled conifers dominate the harvested stands. In regions where this does not describe the dominant species type, similar equations can be developed.

Although measured fuel moisture produces the most accurate results, it is operationally impractical to obtain. NFDRS has the advantage of routine availability, but it is not regionally specific. By using a regionally adjusted 1000-hour fuel-moisture model such as the ADJ-Th, accuracy and easy availability can be combined.

Daily Applications

Fuel consumption and emissions from prescribed slash burning are being measured in ongoing studies of the Fire and Air Resource Management team in Seattle. These studies require accurate estimates of fuel consumption so that burning can be scheduled on days that will fulfill study objectives. A computer program has been developed that uses the ADJ-Th to give daily fuel-moisture predictions and then calculates the associated, expected fuel consumption. By assuming maximum and minimum relative humidity and temperature values and no precipitation, the 1000-hour fuel-moisture values can be projected into the future to indicate the approximate number of days required before specific study units will fall into prescription. Table 1 shows sample output produced from the computer program. Columns 2 through 6 are input variables used in the models to calculate predicted fuel moisture.

Columns 7 and 8 are 1000-hour fuel-moisture predictions resulting from the NFDR-Th and the ADJ-Th, respectively. Both moisture models are calibrated to give accurate daily results rather than representing trends. This calibration is accomplished by changing the way one variable in the equation is handled. This variable—the boundary value—is the equilibrium moisture content corresponding with the temperature and relative humidity of the air in immediate contact with the fuel and precipitation events of the previous 24 hours. The original NFDRS model uses a 7-day-average boundary value, which weights the weather events of 7 days ago equally with the weather events of the current day. This makes the daily fuel-moisture prediction less likely to change much in response to short-term, extreme weather. This effect is desirable if predicting trends but is undesirable if daily accuracy is needed. For this reason, a 1-day boundary value has been used.

Column 9 uses the ADJ-Th in the predictive equation derived to use this fuel-moisture value to predict the 1000-hour diameter reduction that would occur in a unit prescription-burned on that day. Columns 10 and 11 are the percentages of consumption of the 3- to 9-inch (7.6 to 22.5 cm) and 9- to 20-inch (22.5 to 50.8 cm) fuels, respectively, associated with the predicted diameter reduction. Diameter reduction is converted to percentage of consumption by using an average diameter of the fuels existing in each of these two size classes. The average diameters used were those calculated from 33 experimental units in western Washington and Oregon.

Conclusion

The 1000-hour fuel-moisture value is an extremely useful tool for making predictions necessary in daily fire-management planning. The NFDRS provides a convenient source of 1000-hour fuel-moisture predictions; however, a species-specific model can be developed that combines convenience and a greater degree of regional accuracy. The 1000-hour fuel-moisture predictions can be calculated by using a daily rather than a 7-day boundary value and used for making consumption predictions for large woody fuels. Fuel-moisture values can be projected a week or more in advance by using predicted or assumed weather conditions as inputs in either model. This knowledge can be used by fire managers to improve the success of daily management activities. ■

Working With Inmate Fire Crews

The California Department of Forestry and Fire Protection has just issued a self-paced instructional guide entitled "Working with California Inmate Fire Crews." This guide is designed for non-State employees who may be assigned supervisory responsibilities for these crews or who will work near these crews. It covers the "do's" and the important "don'ts" of working with inmates, especially those that pertain to State laws.

If you are interested in obtaining a free copy of this instructional aid, contact: Camps Coordinator, California Department of Forestry and Fire Protection, P.O. Box 944246, Sacramento, CA 95814. ■

Table 1—*NDFR-Th and ADJ-Th modeled fuel moisture predicted by using weather variables as shown; diameter reduction and percentage of consumption are calculated with ADJ-Th*

Date	Temperature (°F)		Percent humidity		Precipitation	Percent fuel moisture		Diameter reduction	Percent consumption	
(July)	Maximum	Minimum	Maximum	Minimum	(hrs)	NFDR-Th	ADJ-Th	(in)	3–9 in	9–20 in
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	62	46	100	78	4	30	37	1.59	53	23
2	53	42	100	82	11	32	38	1.49	51	22
3	59	40	100	56	0	31	38	1.53	52	23
4	53	46	100	82	14	33	39	1.39	48	21
5	61	44	100	71	7	33	39	1.36	47	20
6	66	44	100	62	0	33	39	1.40	48	21
7	61	43	100	65	0	32	39	1.44	49	22
8	69	49	81	40	0	31	38	1.52	52	23
9	70	51	86	50	0	30	37	1.58	53	23
10	73	51	100	52	0	30	37	1.62	54	24
11	72	50	100	49	0	29	37	1.66	56	25
12	76	54	97	52	0	29	36	1.71	57	25
13	58	48	100	70	1	30	37	1.62	54	24
14	62	38	100	52	0	30	37	1.65	55	24
15	63	39	100	51	0	29	37	1.69	56	25
16	68	54	97	62	0	28	36	1.73	57	26
17	74	54	76	45	0	28	36	1.80	59	26
18	75	44	96	45	0	27	35	1.85	60	27
19	77	56	68	43	0	26	35	1.92	62	28
20	77	45	100	51	0	26	35	1.95	63	28
21	66	43	100	56	0	26	34	1.98	64	29
22	77	49	79	38	0	25	34	2.04	65	30
23	76	53	80	45	0	24	33	2.10	66	30
24	78	57	80	47	0	24	33	2.15	68	31
25	79	60	85	51	0	23	33	2.20	69	32
Predicted with assumed weather variables as shown										
26	75	55	100	50	0	23	32	2.23	69	32
27	75	55	100	50	0	23	32	2.25	70	32
28	75	55	100	50	0	23	32	2.28	70	33
29	75	55	100	50	0	22	32	2.30	71	33
30	75	55	100	50	0	22	32	2.32	71	33
31	75	55	100	50	0	22	31	2.35	72	34
Predicted with assumed weather variables as shown										
26	75	55	65	35	0	23	32	2.27	70	33
27	75	55	65	35	0	22	31	2.33	72	33
28	75	55	65	35	0	21	31	2.40	73	34
29	75	55	65	35	0	21	30	2.46	74	35
30	75	55	65	35	0	20	30	2.52	75	36
31	75	55	65	35	0	20	30	2.58	77	37

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McClellan Receives Golden Smokey

Harry R. "Punky" McClellan, group leader of the Smokey and the Pros Program, was awarded the Golden Smokey Award for sustained outstanding national service in wildfire prevention. This award is the highest fire prevention recognition that can be bestowed.

The award was presented at a National Smokey Bear Workshop in Orlando, FL, on behalf of the Chief by Bill McCleese, an Assistant Director in the Fire and Aviation Management Staff, Washington Office. It was given for Punky's outstanding efforts and accomplishments in managing and administering the Smokey wildfire prevention program in professional sports. This program has taken Smokey into major league baseball stadiums throughout the United States and Canada. It has also been the catalyst to start teaming Smokey with other professional sports activities.

Punky has served in a variety of fire management positions in the Pacific Southwest Region of the Forest Service. He is currently detailed to the Washington Office from his position as deputy fire management officer on the Sierra National Forest. Punky is now the proud recipient of all three Smokey awards; he also received the Silver in 1978 and the Bronze in 1986. Congratulations! ■

Harry R. "Punky" McClellan (left) receives Golden Smokey Award from Bill McCleese, Assistant Director, Fire and Aviation Management, Washington, DC.

Wildland Fire Engine Standards

J.P. Greene

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Within the past few months, a number of fire and fleet managers have been asked to respond to surveys dealing with the number of wildland fire engines in their fleets and the specifications they want their fire engines to meet. This short report attempts to provide feedback to the survey respondents regarding the use made of the data collected.

The majority of fire responses made in the United States are to wildland fires, not structural fires. Wildland fire suppression tactics are quite different from structural fire tactics and, therefore, require different equipment. Vehicles used in wildland fire suppression must operate reliably under a wide variety of extreme conditions.

The Problem

The wildland fire community, consisting of Federal, State, and local agencies, is currently encountering severe difficulties in obtaining vehicles that perform satisfactorily in this adverse environment. The present wildland fire fleet is conservatively estimated to number 25,000 trucks. Problems encountered include unavailability of all-wheel drive in certain size classes, inadequate suspension systems, and overloaded electrical systems. These problems were identified as early as 1973 by the General Services Administration-sponsored National Fire Equipment Conference and were reaffirmed by that group in 1985.

Under the auspices of the National Wildfire Coordinating Group—an interagency advisory body—a wildland fire engine study committee was formed to seek remedies to these performance problems. Composed of Federal and State representatives, this committee first convened at the Boise Interagency Fire Center in the summer of 1986. At that meeting, a decision was made to develop Federal specifications or a standard for wildland fire engine cab and chassis units that could be used by all agencies, including State and local organizations. These specifications, it was decided, would be tailored to the special needs of the wildland fire community and would, in essence, consolidate the agencies' purchasing power.

Information Gathering

Before the development of these specifications, both quantitative and qualitative data were required to judge agencies' market size and specific truck needs. To this end, two surveys were made: One to fleet managers to ascertain the number of vehicles in use and the other at a cross-section of users and managers to determine performance needs.

The survey of 64 fleet managers revealed an engine population among the Federal and State agencies of some 7,800 vehicles. This is a very conservative number. The survey did not include the largest segment of the wildfire fleet—the 20,000 rural and municipal fire departments. The total fleet of wildland engines is estimated to be 25,000 to 30,000.

The number of wildland fire engine cab and chassis units purchased each year probably does not provide sufficient incentive to a major manufacturer to build a custom product. A united purchasing front by agencies and local fire departments, however, may well influence the availability of certain options and provide the final impetus for some manufacturers to make changes to their engines.

The Results

The users' survey generally confirmed the group's guess regarding specification preferences. The 1,166 respondents highlighted such problems as the lack of all-wheel drive availability, weak suspensions, inadequate braking, low ground clearance, insufficient fuel capacity, and poor cooling.

The survey results were summarized in a report presented to representatives of the major truck manufacturers at a meeting conducted by the General Services Administration in Washington in mid-June. At the meeting, the operating environment of the wildland fire engine was discussed in some detail to give the manufacturers an idea of the extreme conditions under which their equipment is required to function. Problem areas and the desires of the engine users were also reported. Finally, estimates of potential market numbers were provided, based upon the fleet managers' survey. The manufacturers were asked to provide their reactions to the report and discussion by late summer. The group will meet again in late 1988 to begin work on a purchasing standard, which will, it is hoped, be available for use in fiscal year 1989. ■

Communications Cooperation: Wildland Fire Agencies in the Northwest

Emilio R. Sibayan

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After countless hours devoted to planning meetings that spanned many years, not to mention the numerous memorandums that were sent between committees and working groups, the Pacific Northwest Fire Interagency Coordination Group (PNIFCG) finally adopted the Northwest Incident Command System (NICS) organizational guidelines on communications planning. Perseverance and hard work by the group members paid off. Their labor culminated in a communications plan put to use in the 1988 fire season.

Background

In the early part of 1984, the Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and National Park Service (NPS) of the U.S Department of the Interior and the Forest Service (FS) of the U.S. Department of Agriculture, together with the Oregon State Department of Forestry (OSDF) and the Washington Department of Natural Resources (WDNR) became signatory agencies to a Memorandum of Understanding. This group of agencies, thereafter known as the Pacific Northwest Interagency Fire Coordination Group, defined the need to establish a platform for agreement or a common understanding among themselves. The participants to this agreement are wild-land natural resource management agencies with the fire management responsibilities in autonomous jurisdictions and in those where one agency's responsibility overlaps with another's. The group saw the need to maintain ongoing close awareness, coordination, and exchange of new technology, concepts, and organizational changes and procedures.

The 1984 Points of Agreement

The points of agreement from which the signatories worked and continue to work to implement NICS, part of the National Interagency Incident Management System (NIIMS), and the timeframe within which some of those goals were to be accomplished are as follows:

- Define what full NIIMS implementation is and ensure that it provides a framework on which interagency wildfire suppression cooperation can be maintained and improved.
- Initially, focus the interagency effort on wildland and fire suppression based on current (1984) level of eooperation.
- Aceept participating agency standards on such matters as equipment, training, and physical fitness by March 1986.
- By March 1986, agree to train primary firefighters and overhead in basic Incident Command System (ICS).
- By March 1986, move project fires on Federal lands and those fires which are primarily Federal multijurisdictional under ICS.
- Inform agency management regarding implementation of NIIMS through organizational training and seminars for managers.
- Carry out future training program through those agencies having wildland responsibility.
- Qualify an individual for a comparable ICS position on the basis of present agency qualification with I–220 and transition training. Transition training is defined as interim training that is structured to move an individual now serving in a fire suppression organization laterally to a similar position in the ICS organization.
- By March 1986, use NIIMS in BIA, BLM, NPS, and Forest Service operations. (Some components of fire subsystems may not be implemented, such as orthophoto mapping.)
- Maintain fire protection agreements according to existing established standards.
- Establish committees to deal with the issue of common communications by radio and coordination of telecommunications using teletype, computer, and so on.

Recommendations and Evolution

With those broad points of agreement, the PNFICG Steering Committee set out to form subgroups and subcommittees responsible for establishing guidelines to implement the accepted concept of NIIMS; namely, the Operation Working Group, Training Working Group, Technical Communications Review Committee with subgroups in technical communieations and radio, and Nomenclature/Categories Working Technical Committee.

The PNFICG, recognizing that a sound communications system is a key element in effective fire control, addressed the need for common interagency radio frequency for initial call-up and contact and a need for a frequency available for tactical use by all agencies responding to a multijurisdictional wildfire. PNFICG charged the Operations Group with the task of identifying common interagency radio frequencies. In November 1986, it agreed to recommend BLM's 168.550 MHz for use as the initial contact (call-up) frequency. At the same time, the group discussed future undertaking to explore the following:

- Feasibility of incorporating a long-range calling channel—a dispatcher's net for directing or redirecting forces enroute to an incident.
- Availability of a scene-of-action frequency or frequencies which could be used in the build-up phase of an Incident Command System.

In March 1987, the Radio Working Group proposed a solution to the problem of how to provide interagency radio communications for multiple agencies responding to a joint initial attack on an incident. In making its recommendations, the group carefully considered the scene of fire, availability of frequencies, capability of some firefighting organizations, and fire size.

Each agency in the PNFICG was to make available one of its assigned frequencies for tactical or scene-of-action use. Tactical or scene-of-action frequency means that such frequency would be used for interagency initial attack (local) communications by all agencies on the incident. The specific tactical frequency to be used would depend on whose jurisdiction the fire is in. For instance, if a fire is on OSDF lands, use the OSDF tactical frequency; if on BLM lands, use BLM's.

It would be the responsibility of the local incident commander to maintain communications with dispatchers on the dispatch channel. Dispatchers would not monitor the tactical radio communications channels.

When an incident is attacked by only their forces, the agency involved will use its own frequency. This frequency may or may not be the tactical frequency. For example, if the Forest Service responded to an incident within its jurisdiction, the frequency used will probably be the Forest Net or Project frequency. However, if another agency joins the attack, all will switch to the tactical frequency.

The rural fire departments, because of equipment capability limitations, are not expected to place all the tactical frequencies in their radios. In an incident in which rural fire departments are involved, interagency communication shall be on the Fire Marshal tactical frequency.

When an incident reaches project fire size, interagency communications will be dictated by the incident communications plan.

The group identified and recommended the following frequencies, agencies to whom licensed, and usage in accordance with the NICS plan:

Frequency and Group		*Usage*
168.550 MHz	(BLM)	Initial Contact
159.240 MHz	(OSDF)	Tactical
151.415 MHz	(WDNR)	Tactical
154.280 MHz	(Oregon Fire Marshal)	Tactical
150.150 MHz	(BLM)	Tactical
168.200 MHz	(FS)	Tactical

Conclusion

In late 1987, the same agencies became signatories to an addendum to the master Memorandum of Understanding, establishing guidelines for use of the frequencies by participating agencies, fire equipment rental rates, and development of training requirements and schedules. The full intent of the master Memorandum of Understanding was scheduled for implementation before the 1987 fire season. However, for one reason or another, that was delayed a year. Still to be resolved is the requirement to provide for long range dispatching.

The impact of joint fire management operations in Oregon and Washington would be to eliminate, or at least minimize, potential problems and fully use available resources. In effect, these agencies will fulfill the primary function for which they were created—that of protecting lives and property. ■

McCall Smokejumper Base Dedication

Dan Dzuranin

Volunteer, USDA Forest Service, McCall, ID

Among cheers and applause, Payette Forest Supervisor Veto J. LaSalle and McCall Mayor John Allen cut a ribbon June 25 to formally open the new $2.9 million McCall Smokejumper Complex. The complex is located in the Intermountain Region (Region 4) on the Payette National Forest in McCall, ID.

A crowd of about 2,500 people listened to speeches and then watched an impressive aerial demonstration of how smokejumpers and aircraft are used to suppress a fire. Following the ceremony, the public viewed 15 displays and toured aircraft and the new base. The dedication continued on Sunday, June 26, with an open house featuring exhibits on all aspects of fire suppression and fire safety—even food bags used for initial attack.

The reactions from the crowd were extremely enthusiastic. Forest Service employees working at the exhibits unanimously reported several compliments about the dedication and the work of the smokejumpers.

In conjunction with the dedication ceremony, a reunion for those smokejumpers who served in McCall was held June 24 to 26. More than 200 active and retired smokejumpers swapped fire stories to celebrate the 45 years of smokejumping in McCall. It was the first smokejumper reunion since McCall became a base in 1943.

LaSalle was the dedication's master of ceremonies. Guest speakers included Mayor John Allen; Pat Sullivan, Idaho Executive Assistant for Senator James McClure; George Leonard, Associate Chief of the Forest Service; Al West, Deputy Chief of State and Private Forestry; and Stan Tixier, Regional Forester for the Intermountain Region. Special guests included Mic Amicarella, Washington Office Director of Fire and Aviation Management and Doug Bird, Intermountain Region Director of Fire and Aviation Management.

A portion of the crowd of 2,500 watching air show at McCall Smokejumper Base dedication.

In honor of their service in fire management, plaques were awarded to 15 people. Three people were given awards for being firsts in Forest Service history. Earl Cooley received an award for making the first fire jump in 1940. Deanne Schulman was honored for being the first woman smokejumper, and Charlotte Larson received a plaque for being the first woman smokejumper pilot.

Plaques were also awarded to seven current and former fire branch chiefs for the Payette National Forest and to five McCall Smokejumper Unit Managers who now fill or previously filled that role.

A 1-hour aerial demonstration began after the speeches were given and the ribbon was cut. A brush pile at the McCall airport was ignited and the "fire bell" sounded. Six smokejumpers ran out of the loft, put on their jump gear, and loaded a DC–3. After dropping streamers, they parachuted from the plane to the delight of the large crowd. Paracargo was then dropped from the DC–3. Then a helicopter with a water bucket dropped two loads of water on the burning pile. After the water drop the Beech Baron lead plane led a PB4Y–2 airtanker, which dropped a load, mostly of water, over the fire. The helicopter returned to retrieve smokejumper gear by means of a long line. A Twin Otter completed the air demonstration by showing its ability to take off and land in a short distance.

Several people in the audience commented after the air demonstration that they had frequently seen the

Deanne Schulman, first woman smokejumper, at new McCall Smokejumper facility.

airplanes leave and return, but now they better understood what happened while the aircraft were gone.

The new complex marks the first time the smokejumper facilities have been located at the airport. Since 1943, the McCall base was located three-quarters of a mile from the airport. The dispatch office, tanker base, and smokejumper ready room were at different areas around the airport.

The complex includes a new paraloft, airtanker base, off-site housing with barracks for 40 single jumpers, and 8 modular homes which can house 10 married jumpers and their families.

The paraloft has a storage and fire-pack assembly area, ready room, a 40-foot-high drying and inspecting tower, sewing room, rigging room, first aid and whirlpool room, weight room, 80-person classroom, conference room, and administrative offices.

The Forest Dispatch Office, which is on the second floor of the main building, overlooks the new 2,200-foot parallel taxiway, a large ramp area for smokejumper, airtanker, and leadplane aircraft parking and helibase. Also included in the facility is a mixmaster's office, tanker pilots' ready room, and aircraft maintenance building.

The complex is located on 20 acres along the west side of the McCall Airport. The site for the base was acquired in a State land exchange in 1985.

The building was designed by Forest Service architects Bruce Crockett of McCall and Wilden Moffitt of Ogden, UT. The Russell Corporation, based in Boise, began construction in 1986 and completed work in November 1987. A total of 23 subcontractors worked on the project. The McCall city administrators were also very helpful in assisting the project through its completion.

Native building materials were used to fit the decor of the local area and to give the large structure an aesthetically pleasing appearance. The 17,000-square-foot building has a cedar shake roof, cedar siding, and a base of native rock from the Salmon River.

During the remainder of this year, more than 2,000 people are expected to visit the newest smokejumper complex in the National Forest System. The base is noted in the latest Rand-McNally atlas. ■

Animal Inns (There's Life in Dead Trees!)

A national public education campaign to create awareness about the importance of dead trees and downed logs for wildlife habitat will be formally kicked-off next spring. Dubbed the "Animal Inn" program, the Forest Service-sponsored campaign is designed to improve understanding of the habitat needs of cavity-nesting birds and animals. First target will be firewood cutters and others who directly affect this resource. The message is not aimed at stopping the cutting and removal of this material, but rather at recognizing and saving those trees that have particular wildlife values.

Other Federal and State resource management agencies, as well as conservation groups and interested commercial organizations, will be joining in support of the program, which has been developed from a successful local cooperative venture initiated in central Oregon in 1986 by the Deschutes National Forest and the State Department of Fish and Wildlife. A variety of media will be used to launch the campaign, with materials distributed to Forest Service offices and cooperators in the early spring. ■

Teaching Old Dogs New Tricks[1]

Linda Knowlton

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In the Beginning

Given the innovative approaches to fire suppression that the fire management community is well known for, it is not surprising that computers should have worked their way into the firefighter's toolkit. One of the first attempts by the USDA Forest Service to put computer technology in fire camps was in its Pacific Southwest Region (Region 5) in the late 1970's. The concept of using dumb terminals communicating to the FIRESCOPE computer proved to work well; but the initiative did not take hold for various reasons—cost and availability of hardware and software, among others.

Several years later the Forest Service was in the midst of installing Data General (DG) minicomputer systems at all its offices, from the Chief's to the Ranger District's. And, always on the lookout for a better way to do a job (in this case, process information), some fire management people had a bright idea. The story goes that late one night, during a major fire bust in August 1984, some folks from the Region 1 office in Missoula, MT, were looking for a better way of tracking the resource status and situation status created by the 17 large fires underway. Someone suggested putting together some DG workstations and using them to communicate to a host computer. A short time and a lot of work later, it was done. Region 1 first used these "fire camp computer kits" in 1984 at an interagency incident on the Flathead National Forest and Glacier National Park. The use of the computer provided accurate information on deployed resources and allowed for adjusting resources to fit suppression priorities.

The computer kits typically have three workstations and a printer. Because the DG workstations are not intelligent, they must communicate back to a host DG processor using a modem, phone lines, and a multiplexer (a device that allows separate transmissions over the same line at the same time).

And Then There Were Micros

Microcomputers also began to show up in fire camps, especially in the Pacific Southwest and Pacific Northwest Regions (Regions 5 and 6). The micros used Lotus 1–2–3, DBase III, and RBase software to perform functions like cost accounting, cost apportionment, resource status keeping, and shift assignments. Everybody was doing something a little different; but, to the extent that the needs of the incident were being met, it was all of value. Most of all, it became clear that computers could play a valuable role in incident management.

The Fire Management Activity Review of the 1985 fire season recommended an expansion and improvement in the use of data processing and communications for fire suppression. An example of the value of this technology was demonstrated the next summer at the Enterprise Area Command in northeastern Oregon. The area command team

A Data General workstation on the Red Owl Fire in 1984, Flathead National Forest. Use of the Data General at this fire marked its first use at a fire camp.

[1]The author would like to thank the following people for helping with this article: Mike Calvin, computer specialist, Region 6; Troy Kurth, fire planning and program officer, Region 1; Howard Nickelson, computer specialist, Region 5; and Steve Simon, computer programmer/analyst, Region 1.

A DaCK in use on the 1987 Silver Fire, Siskiyou National Forest.

estimates savings there of $1.5 million because better information allowed sharing of forces between incidents and demobilization of forces in a timely manner. The computer-generated data tables also served other functions, such as scheduling rest and relaxation days for fire crews and demobilization of crews based on length of time in the field. The electronic mail capability provided for faster and more accurate transmission of messages over a single telephone line than the traditional voice method.

By 1987, Region 6 decided to field some computer kits, too. This added four more kits to the six available for dispatch from Region 1. Region 1 sent all of its kits to California in 1987 and chalked up even more impressive statistics in time and money saved. The performance of the new Region 6 systems also was far better than expected for their first year of operation.

We're All in This Together

At the end of the 1987 season, several things were clear. First, computers had proved their worth and were in the fire camp to stay. Second, it would benefit everyone to have standard software, procedures, and training to make full use of the computer kits. And, third, if California ever had a fire season again like the one in 1987, it had better be prepared with some computer equipment of its own.

Accordingly, in the fall of 1987, Regions 1, 5, and 6 agreed to combine their efforts in time for the 1988 season. The three regions agreed to a set of standard data elements, like request number and resource assigned, to be reported in a standard format, from the incident through Boise Interagency Fire Center. They agreed to standardize the hardware in the computer kits as much as possible and to use common terminology when referring to all the hardware, software, and personnel involved. Joint training sessions have been held. While all of this sounds very reasonable and simple, it represents a lot of work and the overcoming of all the usual NIH (not-invented-here) feelings.

Region 5 is in the process of putting together 10 computer kits for use in 1988. Region 8 also has a kit, making a total of 21 available Forest Service-wide. Applications that will be supported are: Word processing, electronic mail, AFFIRMS/Telemail access, Incident Resource Status System (IRSS), BEHAVE, and data management tools. Many other applications are in the planning stage.

Meanwhile, Back in Washington

Meanwhile, back in Washington, the Forest Service and the U.S. Department of the Interior Bureau of Land Management (BLM) and other National Wildfire Coordinating Group (NWCG) members were working on a project, called INCINET, to standardize equipment, software, and communications for use in the interagency arena. The BLM had been using computers and satellites on fires, too,[2] as had several States, and there was general agreement that computer support for fire suppression should be part of the Incident Command System. A benefit/cost analysis showed that the greatest benefit could be gained by using networked, information-sharing processors at the incident site, linked to agencywide communications systems.

This summer the INCINET concept will be tested by two different types of systems, one a networked microcomputer system, the other a small minicomputer. The performance of both systems will be evaluated, and a decision made on how to proceed for further testing in 1989. The INCINET plan calls for procurement of equipment and development of software to take place from 1990 through 1993.

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[2]Wiklund, Natalie. Computers and satellites on fires. Fire Management Notes. 48(4) 15-16; 1987.

INCINET minicomputer being used on the Centrella Fire in 1988, Coronado National Forest. The Data General MV 1400 is under the printer on the table at the right.

There isn't much question now about the value and effectiveness of taking the power of the computer into fire camp. In fact, the NWCG this year commissioned a study to determine position descriptions, job performance requirements, and the best place in the Incident Command System to locate the technical specialist in charge of the fire's computer support. It won't be long before computers are as common a support item as radios—and as necessary as showers.

Glossary

Computer people are often accused of using "jargon" to confuse or impress others. This glossary should help to clarify some of the computer terms used in incident support.

CAIM—*Computer Applications in Incident Management.* Former name of the system used in Region 6.

CTS—*Computer Technical Specialist.* Title of the InSysT person who works for the Communications Unit Leader and sets up and maintains the DaCK.

DaCK—*Data Communications Kit.* The hardware component of Regions 1, 5, and 6 computer support system used beginning in 1988. Each DaCK can support 1 to 6 terminals and 1 to 2 printers. A DaCK costs about $8,500, including everything from the packing case to the tools needed to set it up.

FIS—*Fire Information System.* Former name of the system used in Region 1.

Host site—The Data General minicomputer, usually at a Forest Supervisor's office, that acts as host, via a communications link, to the terminals being used at the incident site.

INCINET—*Incident Network.* The interagency project to standardize the hardware, software, and communications to be used for incident support. Prototype testing in 1988 and 1989.

InSysT—*Incident Systems and Telecommunications.* The overall system of automation and data communications used by Regions 1, 5, and 6 to support incidents beginning in 1988. ■

Correction

In the article entitled "Correcting an Error in the HP–71 B Fire Behavior CROM" (Fire Management Notes. 49(2) 31), a change should be made to the line beginning with the characters 80 in column 3. The line should read:

80 M (1)=M (1)+O1@
M (4)=M (4)−O1

This correction deletes a character, the third equals sign, as published. ■

Fuels Treatment Assessment—1985 Fire Season in Region 8

George G. Martin

Fuels management group leader, USDA Forest Service, Region 8, Atlanta, GA

In 1986, Region 8 of the USDA Forest Service developed an assessment with the best available data to evaluate the effects of fuels treatment upon wildfire intensity, size, suppression cost, and damage. The analysis was based upon fire occurrence during the severe 1985 fire season in the Southeast.

The assessment was conducted in that portion of Region 8 in which fuels treatment prescribed burning is, and has been, traditionally practiced—the Coastal Plains and portions of the Piedmont. The National Forests in Texas, Louisiana, Mississippi, Florida, Alabama, South Carolina, and portions of Georgia and North Carolina were included. The assessment area encompassed approximately 4.9 million acres (2 million ha) of the Southern Region's 12.5 million acres (5 million ha). A total of 576,522 acres (233,410 ha) of this area had received fuels treatment prescribed burns during fiscal years 1983 through 1985.

The Process

The National Forests were asked to list the names and acreages of wildfires that occurred during the 1985 fire season. Since fuels treatment over the previous 3-year period (1983–85) would have an effect on the behavior of wildfires in 1985, the forests were asked to report whether the wildfires occurred in the following areas:

- An area that had been burned by prescribed fire in the past 3-year period.
- An area that had not been burned by prescribed fire during the past 3 years but was eligible for prescribed burning if funding and manpower were available.
- An area that had not been burned by prescribed fire and was ineligible for prescribed burning because of environmental or natural resource or other consideration.

Individuals intimately familiar with the individual wildfires responded. If the specific area of occurrence was not well defined, that is, if wildfires burned in areas prescribed for burning which had been burned and those that had not been burned, Forest staff members provided narrative explanations of each area category or followup by telephone to insure the wildfire was appropriately classified.

The assessment dealt only with fuels treatment prescribed burning and fuels treatment dollars. The Forests were not asked to specifically identify fuels treatment prescribed burning areas in the assessment. It is recognized that at least a portion of the wildfires may have been affected by prescribed burns funded from other sources; however, discussions with the involved Forests indicated these would have had little effect upon the results.

The assessment compared data related to wildfires that occurred in areas that had been burned by prescription with data related to wildfires which occurred in unburned areas that were eligible for prescribed burning if funding and manpower had been available. While some comparisons were made with those wildfires which occurred in areas ineligible for prescribed burning, the assumption was, of course, that without a prescribed fire option, the size of wildfire and the cost of suppression in these areas could not be altered.

The Results

Fire Occurrence. A total of 935 wildfires occurred in the assessment area during the 1985 fire season. Of these, 282 (30%) occurred in areas that had been burned by prescription in the previous 3-year period, while 317 (34%) occurred in areas that were eligible to burn but had not been burned because of budget or manpower constraints. The balance, 336 (36%), occurred in areas ineligible for prescribed burning because of resource constraints (table 1).

The effect that prescribed burning had upon fire occurrence (number of fires) is, at best, speculative. While the Region 8 assessment made assumptions and included occurrence data, the discussion and results are not included here.

Size and Intensity. An analysis of the wildfire sizes in areas burned by prescription and unburned areas eligible to burn provided the most significant indicator of the effects of prescribed burning upon wildfires during the 1985 fire season.

Table 1—*The 1985 fire season—wildfire statistics for three categories of area prescribed for burning*

Forest Administrative Unit	Area burned by prescribed fire: Number of fires	Acreage: Total	Acreage: Average	Unburned eligible area: Number of fires	Acreage: Total	Acreage: Average	Unburned ineligible area: Number of fires	Acreage: Total	Acreage: Average
Alabama	33	1,096.6	33.2	49	2,277.05	46.5	44	461	10.5
Kisatchie	22	296.2	13.5	32	174	5.4	22	162.8	7.4
Texas	6	21.3	3.6	40	243.2	6.1	17	203.8	11.9
Mississippi	90	1,699.85	18.9	99	2,044.1	20.6	29	294	10
Francis Marion and Sumter	87	1,161	13.4	31	818.5	26.4	57	4,419.05	77.5
Florida	38	1,540.90	40.6	38	8,255.5	217.25	115	5,463.8	47.5
Chattahoochee and Oconee	3	1.75	0.6	11	25.25	2.3	41	978.75	23.19
North Carolina	3	75.75	25.25	17	5,940.9	349.5	11	247.45	22.5
Total	282	5,893.4	20.9	317	19,778.5	62.39	336	12,230.05	36.4

Wildfires burned 37,902.55 acres (15,345 ha) in the assessment area during the 1985 fire season. Of the total acreage burned, 5,893.4 acres (2,386 ha) (16%) were in prescribed-burned areas and 19,778.5 acres (8,007 ha) (52%) were in unburned areas eligible for prescribed burn treatment (the remaining 32%, in areas ineligible for prescribed burning).

Table 2—*Average size (acres) of wildfires by size classes A through E*

Area Category	Class A (0–1 acre)	Class B (1–10 acres)	Class C (10–100 acres)	Class D (100–300 acres)	Class E (300 acres or more)
Area burned by prescribed fire	0.7	4.55	34.3	150.2	1,028.5
Area unburned by prescribed fire (eligible and ineligible)	0.55	4.67	32.9	191.8	2,231.1

Large Fires. It becomes apparent from the acreage data that the significant effect of prescribed burning is most pronounced in large wildfires. A comparison by wildfire size class of areas burned by prescription and unburned prescribed fire areas actually revealed slightly larger average wildfire sizes in the burned areas for Classes A, B, and C than in the unburned. However, for Classes D and E and larger fires, the effects of prescribed burning become pronounced in that smaller acreages are burned (table 2). Comparisons of Class E and larger fires are discussed separately in the following section.

During the 1985 fire season, 12 wildfires, Class E and larger, occurred in the areas of Region 8 in which prescribed burning is a prominent practice. Only two of these (17%) occurred in areas that had been burned by prescription during the previous 3-year period. In addition, while these large fires burned a total of 24,368 acres (9,866 ha), only 2,057 acres (833 ha) (8.5%) burned in areas that had been previously burned by prescribed fire. The majority of the large-fire acreage burned, 15,021 acres (6,081 ha) (61.6%), occurred in areas that were eligible for prescribed burning but had not been burned during the previous 3-year period (table 3).

It is significant that 91.5 percent of the acres burned in large wildfires occurred in areas that had not been burned by prescribed fire in the previous 3-year period.

Prescribed Burning Benefits

Those fires that occurred in areas that had been burned by prescribed fire during the previous 3-year period averaged 20.9 acres (8.46 ha) in size, while those occurring in eligible unburned areas averaged 62.39 acres (25.26 ha), a difference of 39.49

Table 3—*Wildfires occurring in areas burned by prescribed fire, in areas eligible for prescribed burning but where prescribed burning did not take place, and in areas ineligible for prescribed burning*

Prescribed-burn status and area of fire	Number of acres	Average acreage	Percent of large fire acreage
Burned by prescribed fire			
Miranda (AL)	680	—	—
Orchid (FL)	1,377	—	—
Total	2,057	1,028.5	8.5
Eligible for burning but not burned			
Oakey (AL)	1,360	—	—
Range (FL)	3,926	—	—
Henderson (FL)	4,040	—	—
Bogue Road (NC)	5,695	—	—
Total	15,021	3,755.25	61.6
Ineligible for burning			
Halfway Creek (SC)	403	—	—
Herberta Siding (SC)	810	—	—
Morris Bay (SC)	761	—	—
Maupes Island (SC)	796	—	—
Mud Lake (FL)	920	—	—
Dean (FL)	3,600	—	—
Total	7,290	1,215	29.9
Total (unburned area)	22,311	2,231.1	91.5
Grand total	24,368		

The Mud Lake Fire occurred in an area ineligible for prescribed burn. This wildfire reached 920 acres (372.5 ha) because of heavy fuel loading.

acres (16 ha). On all national forests within the assessment area except the Kisatchie National Forest in Louisiana, wildfire average size was greater in the areas that were not burned by prescribed fire. Although it is understood that this result may be affected by numerous variables, it can be inferred that prescribed burning significantly reduced the average size of wildfires in the assessment area.

Although no specific data was collected in this assessment regarding intensity level of individual fires, a preliminary study was conducted on the National Forests in Texas during fiscal years 1985 and 1986 to evaluate the use of the National Fire Management Analysis System (NFMAS) for economic analysis of the fuels management program. Portions of this study yielded a strong pattern related to intensity levels of wildfire occurring in areas prescribed for burning where burning had taken place and where it had not. Generally, fires occurring in unburned areas behaved at intensity level 3. Based upon this data related to intensity levels, suppression and damage costs were calculated for the wildfires that occurred in the areas burned by prescribed fire and the unburned-eligible areas. The per-acre costs used in this calculation had been developed through the NFMAS for individual national forests in Region 8.

The application of fuels treatment prescribed burning essentially saved more than 11,000 acres (4,453 ha) from consumption by wildfire in the 1985 fire season. In addition, prescribed burning had resulted in lower

Gallberry-Palmetto rough burned by prescribed fire after 3-year fuel accumulation.

savings could be realized with expansion of treatment into additional acreage eligible for burning. Prescribed fire also has potential for reducing wildfire threats to structures in the urban/wildland interface with its very real emerging fire problems. ■

intensity burning of the 5,893 acres (2,386 ha) of wildfire in those areas that had been treated. Computations showed that for each $1.00 expended for fuels treatment prescribed burning, $1.76 in suppression and damage costs were saved.

Conclusions

The Region 8 assessment clearly depicted the positive benefits of fuels treatment prescribed burning in the Southeast. The assessment, of course, addresses only those benefits to fire management and does not include other resource side benefits. The expansion of aerial ignition in recent years has already resulted in reduced per-acre costs of prescribed burning and reduced risks associated with smoke management. Additional

First year following prescribed fire in Florida. Periodic prescribed fire maintains light fuel loads. Unplanned ignitions within a 3- to 5-year period result in lower suppression costs and damage.

Helicopter Foam System

Art Trask

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Background

To compare the effectiveness of helicopter-dropped foam-water with water only in its fire protection program, the California Department of Forestry and Fire Protection (CDF) equipped two UH–1F helicopters with a foam injection system. The system is used in conjunction with the 324-gallon Bambi water bucket (SEI Industries, Inc., Model No. 2732).

Results

During the 1987 fire season, the two foam system-equipped helicopters dropped approximately 600,000 gallons of foam. In addition, several commercial "call-when-needed" helicopters dropped similar amounts of foam. The effectiveness of foam in test studies and firefighting programs has been reasonably well documented in other publications and articles. The following summarizes CDF's experience:

- Foam with water can be up to three times more effective than water alone, particularly during mop-up operations.
- Except for unusual situations, the ratio of foam concentrate to water was gradually reduced to approximately 50 percent of manufacturer's recommendation with no apparent loss in effectiveness. The average ratio of foam concentrate to water was approximately 1 to 2 pints per 300 gallons of water.
- In tests for water pollution from the foam, the CDF analyzed water samples from two small "livestock ponds" where two foam-equipped helicopters had dipped considerable amounts of water. A thorough analysis, following EPA specifications, revealed no significant findings.
- The possibility of corrosion, particularly in the helicopter tailboom area, which contains magnesium, was a prime concern. The CDF protocol covering the use of foam requires a thorough water rinse at the conclusion of each day's flight activity. In some cases, the crew reported spillage or leakage of foam concentration solution from the externally mounted tank and pump area. Rotorwash then spread the solution along the tailboom. An extensive postseason inspection of both helicopters used in the foam operation, including removal of the tailboom, revealed no evidence of corrosion. The CDF will, however, closely monitor for any sign of corrosive side effects.

System Design

The foam system is simple in design, consisting of the following:

- An externally mounted, 15-gallon storage tank attached to the attaching points located on the left side of the helicopter fuselage. (Some operators have elected to mount the tank internally; however, we did not want to compromise crew or cabin space and, therefore, mounted the tank externally.)
- A 28-volt pump (Shurflo, Model No. 2173 or equivalent).
- An anti-siphon, 28-volt shutoff solenoid (may not be required depending on type of pump used).

Fifteen-gallon foam tank.

Foam tank externally mounted on helicopter.

- A 28-volt relay.
- A control panel and timer unit mounted on instrument pedestal.
- Sufficient 5/8-inch garden hose to run down shroud lines into the Bambi bucket approximately 1 foot below water level.
- Slipjoint hose fitting for emergency breakaway.

Operation

The operation of the system is as simple as the design. When the bucket is full and clear of the water source, the pilot activates the foam unit by pushing a control panel button that starts the pump sequence. Since the operating duration of the pump determines the mixture ratio, a timer unit that can be adjusted by the pilot has been built into the control head. Mixture adjustments are made within "seconds" of the start of the pump operation.

To insure thorough mixing, some commercial operators are using a circulation pump mounted in the Bambi bucket (similar to an electric trolling motor used for fishing). The CDF experience, however, has shown the foam and water mix very well even without a circulation pump. The flexing action and drop mechanism of the Bambi bucket helps in the mixing process.

Problems and Future

Overall, the foam injection system worked very well. One relay failed and required replacement. The anti-siphon solenoids were added to prevent static "run through" of the pump. Until these solenoids were added, excessive foam was consumed, and there was increased foam residue left on the surface of the pond when the bucket was filled.

Due to the program's success, the CDF is in the process of equipping the remaining UH–1F fleet with foam systems.

Foam components can be obtained from Crew Concepts, Inc., 3815 Rickenbacker Street, Boise, ID 83705 (208-344-4691); Egor Fire Systems, 2566 Christian Lane, Redding, CA 96002 (916-223-3598); and most recreational vehicle parts stores. ■

Contracted Fire Detection Services—a Savings

Rod Chaffee and Francis Mohr

Respectively, fire suppression technician, LaGrande Ranger District, and assistant fire management officer, Wallowa-Whitman National Forest, USDA Forest Service, Baker, OR

Contracting fire detection services saved the LaGrande District, Wallowa-Whitman National Forest, $19,444 in 1986 and approximately $29,750 in 1987. The LaGrande District operates a three-lookout fire detection system—two are accessible by road (Point Prominance and Johnson Rock), and one (Mule Peak) is remote. (See fig. 1 regarding location of LaGrande District and lookouts.)

The contract calls for 75 8-hour days of coverage—starting July 1 and extending through September 15—7 days per week, 9:00 a.m. to 6:00 p.m. It is mandatory that lookout services be provided at the lookout

Point Prominance Lookout Tower, Wallowa-Whitman National Forest, LaGrande, OR.

Johnson Rock Lookout Tower, Wallowa-Whitman National Forest, LaGrande, OR.

station on days that are above a "3-Low" fire danger rating, a moderate rating on the National Fire Danger Rating System. However, lookout services may also be needed during off-hours or on days less than "3-Low," if predicted or existing fire activity warrants. In these cases, the contractor needs to provide service within 24 hours of being called.

The contract guarantees 40 days of pay at the bid price for Point Prominance and Johnson Rock lookouts and 30 days at the bid price for Mule Peak. Bid prices per day, per lookout are listed in the following tabulation:

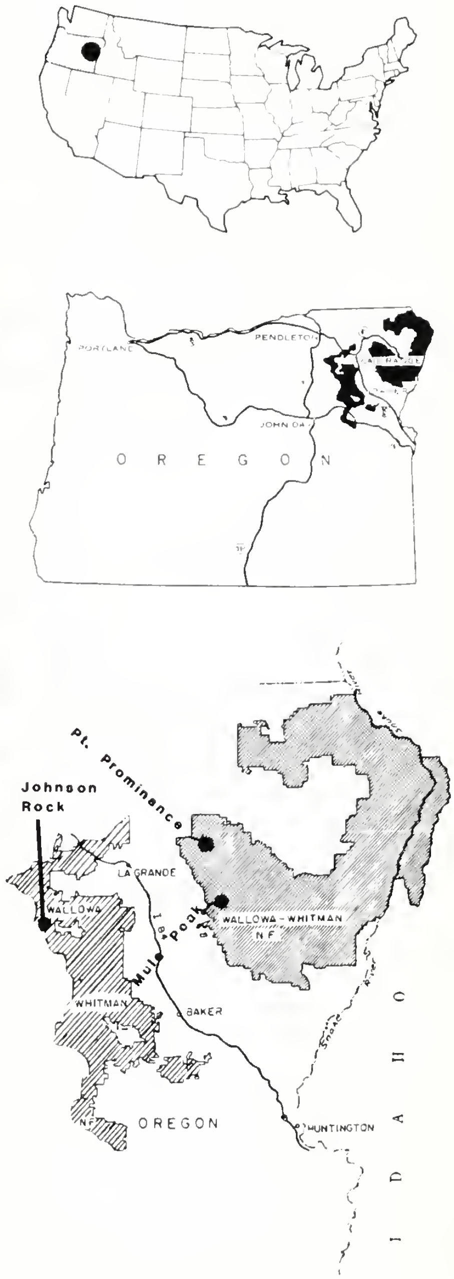

Figure 1—*Location of Wallowa-Whitman National Forest and Fire Detection Lookouts on LaGrande District.*

Lookout	*1986*	*1987*
Point Prominance	$53.30	$39.95
Johnson Rock	52.90	50.00
Mule Peak	67.45	57.50

The contractor also includes a per-hour bid to cover overtime hours worked.

Both 1986 and 1987 were above-average fire danger years for north-eastern Oregon. Actual cost for fire detection in 1986 was $12,266 and for 1987, $15,733 (table 1). An experience in the 1987 fire season dramatically highlights the savings obtained in using contract lookouts. When one of the contract lookouts had to terminate a contract early and it was necessary for the district to hire a seasonal employee for 60 days to finish out the fire season, it cost the district $4,200 for the 60-day appointment, whereas the initial 45 contracted days cost $1,800.

If the lookouts had been operated in 1986 and 1987, using Forest Service employees, the cost for these years would have been $31,710 and $45,480, respectively (table 2).

Benefits

Major benefits associated with contracted fire detection are as follows:

- Allows flexibility to obtain detection assistance as required by weather conditions and better manage funds. If weather is less than a normal fire season, a greater savings can be anticipated.
- Directly contributes to staying within established personnel ceilings. ■

Table 1—*Actual cost for the 1986 and 1987 fire seasons*

Lookout	1986	1987
Point Prominance		
Number of days at lookout		
(67 days at $53.30/day)[1]	$3,571.49	
(45 days at $39.95/day)		$1,797.75
Number of Forest Service employee days at lookout		
(60 days)		4,500.00
Overtime hours		
(93.75 hr at $6.75/hr)	632.81	
(30 hr at $6.65/hr)		199.50
Total	4,204.30	6,497.25
Johnson Rock		
Number of days at lookout		
(69 days at $52.90/day)[2]	3,650.10	
(109 days at $50.00/day)		5,450.00
Overtime hours		
(93 hr at $6.75/hr)	627.75	
(11 hr at $10.50/hr)		115.50
Total	4,277.85	5,565.50
Mule Peak		
Number of days at lookout		
(49 days at $67.45/day)[3]	3,305.05	
(60 days at $57.50/day)		3,450.00
Overtime hours		
(51.5 hr at $9.30/hr)	478.95	
(21 days at $10.50/day)		220.50
Total	3,784.00	3,670.50
Grand total	12,266.15	15,733.25

[1]Fifteen of the 67 days were days less than the 3-L Fire-Danger Rated Day.
[2]Fifteen of the 69 days were days less than the required 3-L Fire-Danger Rated Day.
[3]Five of the 49 days were days less than the required 3-L Fire-Danger Rated Day.

Table 2—*Estimated cost for lookout detection using Federal employees for 1986 and 1987 fire seasons*[1]

Item	1986	1987
Salary for 4 employees: 1 GS-4 employee per lookout plus relief lookout for Point Prominance and Johnson Rock[2]		
(80 days)	$16,896.00	
(115 days)		$24,288.00
Overtime hours		
(80 hr × 4 employees or 320 hr/$9.24)	2,956.80	
(115 hr × 4 employees or 460 hr/$9.24)		4,250.40
Per diem at $23/day for relief employee		
(32 days)	736.00	
(46 days)		1,058.00
Mileage for relief employee		
(100 mi/trip × 8 trips or 800 mi at .205/mi)	164.00	
(100 mi/trip × 11 trips or 1,100 mi at .295/mi)		225.50
Administrative: $85.70/day for GS-7 level employee		
(10 days)	857.00	
(13 days)		1,114.10
Supplies (propane)	100.00	144.00
Unemployment		
($2,500 × 4 employees)	10,000.00	
($3,600 × 4 employees)		14,400.00
Total	31,709.80	45,480.00

[1]The 1987 fire season required the same cost items, except lookout services were necessary for approximately 35 additional days.

[2]Seven-day coverage that allows 4 days off every 10 days worked requires four employees. The historic length of time required for lookout detection is 80 days (75 at the lookout, 5 for opening and closing the lookout).

Standard Fire Orders

Standard Fire Orders

F —Fight fire aggressively but provide for safety first.

I —Initiate all action based on current and expected fire behavior.

R —Recognize current weather conditions and obtain forecasts.

E —Ensure instructions are given and understood.

O —Obtain current information on fire status.

R —Remain in communication with crew members, your supervisor, and adjoining forces.

D —Determine safety zones and escape routes.

E —Establish lookouts in potentially hazardous situations.

R —Retain control at all times.

S —Stay alert, keep calm, think clearly, act decisively.

How To Estimate Tree Mortality Resulting From Underburning

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Prescribed burning beneath standing timber is widely used to accomplish objectives such as preparing land for reforestation, reducing fuels, improving livestock range, and modifying wildlife habitat. Such burning is usually guided by written plans that set forth general objectives and a firing pattern to accomplish them. The plan typically specifies acceptable levels of mortality in standing trees and describes desired fire behavior, particularly flame length. This article offers two nomograms to facilitate effective planning and successful burning. One nomogram is intended for estimating levels of mortality for various scorch heights among tree species common to the Northwest. A second nomogram is useful for determining the flame length that will keep tree mortality within specifications. The nomograms can also be used to estimate numbers, sizes, and species of trees to leave in a partial cut and also to identify trees that will die and should be salvaged after an unplanned fire.

How the Nomograms Were Developed

The mortality nomogram was derived from a study of 2,356 trees from 43 prescribed fires in Washington, Idaho, Oregon, and Montana. Species included were both Pacific Coast and Intermountain varieties of Douglas-fir (*Pseudotsuga menziesii* (Mirb) Franco), western larch (*Larix occidentalis* Nutt.), western red cedar (*Thuja plicata* Donn.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), Englemann spruce (*Picea engelmannii* Parry), lodgepole pine (*Pinus contorta* Dougl.) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.). Tree height ranged from 20 to 220 feet (6.1 to 67 m) and tree diameter, from 3 to 65 inches (7.6 to 165 cm). Based on species, diameter at breast height, and published equations, computed bark thickness ranged from 0.1 to 4.3 inches (0.25 to 10.9 cm). Crown volume scorched was measured visually in the field and ranged from 0 to 100 percent. Fuels ranged from light natural accumulations to moderate logging slash. Fire behavior fuel models (Anderson 1982) included 8, 11, and 12. The 10-hour time lag National Fire Danger Rating System (Deeming et al. 1977) moisture content ranged from 5 to 25 percent, and the 1000-hour moisture content, from 11 to 30 percent. Fires were conducted from May through October. Mortality was monitored for at least 2 years following the fires. Mortality on the 43 individual plots ranged from 0 to 97 percent. Mortality for the individual species ranged from 15 percent for western larch to 87 percent for western hemlock and Engelmann spruce.

How Fire Kills Trees

Fire kills trees in several ways: crown injury, cambium injury, and root injury. Trees of different species and ages vary in resistance to fire injury. Larger trees have proportionately more foliage above lethal scorch height in a given fire. The amount of crown injury a tree receives depends on scorch height, tree height, and crown base height. Species differ in the timing of bud break and also in the degree to which their buds are shielded from heat. Species with large buds and twigs tend to be more resistant to fire injury. Shallow-rooted species have greater susceptibility to root injury than deep-rooted species.

Fire resistance among trees of different species and sizes mainly depends on differences in bark thickness. Large trees of thick-barked species may have bark 100 times as thick as small trees of thin-barked species. Field determination of bark thickness is time consuming and may be impractical in operational situations, but bark thickness can be estimated from species and diameter.

The Model

The model assumes that differences in mortality between species are due only to differences in bark thickness. We used published equations to compute bark thickness from species and diameter. Computed bark thickness was then used with observed crown volume scorched (percent) to predict tree mortality.

The prediction equation generated was:

$$P_m = 1/(1 + exp(-(1.466 - 4.862\,B + 1.156\,B^2 + 0.000535\,C^2)))$$

where P_m is the predicted probability of mortality, B is bark thickness in inches, and C is percentage of crown volume scorched. For each species the difference between predicted and observed mortality was less than 15 percent, except Engelmann spruce, which was 30 percent. Predicted mortality was within 20 percent of observed mortality for all except 5 of the 43 sample fires. The model has

Moderate logging-slash area being prescribed burned.

Area prescribed burned, approximately 1 year ago. Note low scorch height on trees.

an underlying assumption of a fire of average duration. Fires of very long duration can kill cambium through even the thickest bark and can result in higher than predicted mortality. Thick layers of dry duff may result in long periods of smoldering even after the flame front has moved through the stand. Heavy concentrations of logs near trees will also result in extended duration of burning and a corresponding underprediction of mortality. Conversely, mortality will likely be overpredicted in light, patchy surface fires.

Mortality Nomogram

The equation was used to develop the mortality nomogram (fig. 1). The nomogram allows the manager to determine the maximum scorch height compatible with a chosen level of mortality, using inputs of species, diameter, tree height, and crown ratio.

The lower left quadrant of the nomogram shows diameter and bark thickness for the seven species studied. These relationships were taken from the literature (Ryan 1982). The upper left quadrant shows the relationship between bark thickness, percentage crown volume scorched, and tree mortality. This is the graphical representation of the mortality prediction equation. The curved lines are mortality contours showing probability of mortality for various combinations of bark thickness and crown volume scorched.

The right side of the nomogram shows the relationship between percent crown volume scorched, crown ratio (upper right quadrant), and tree

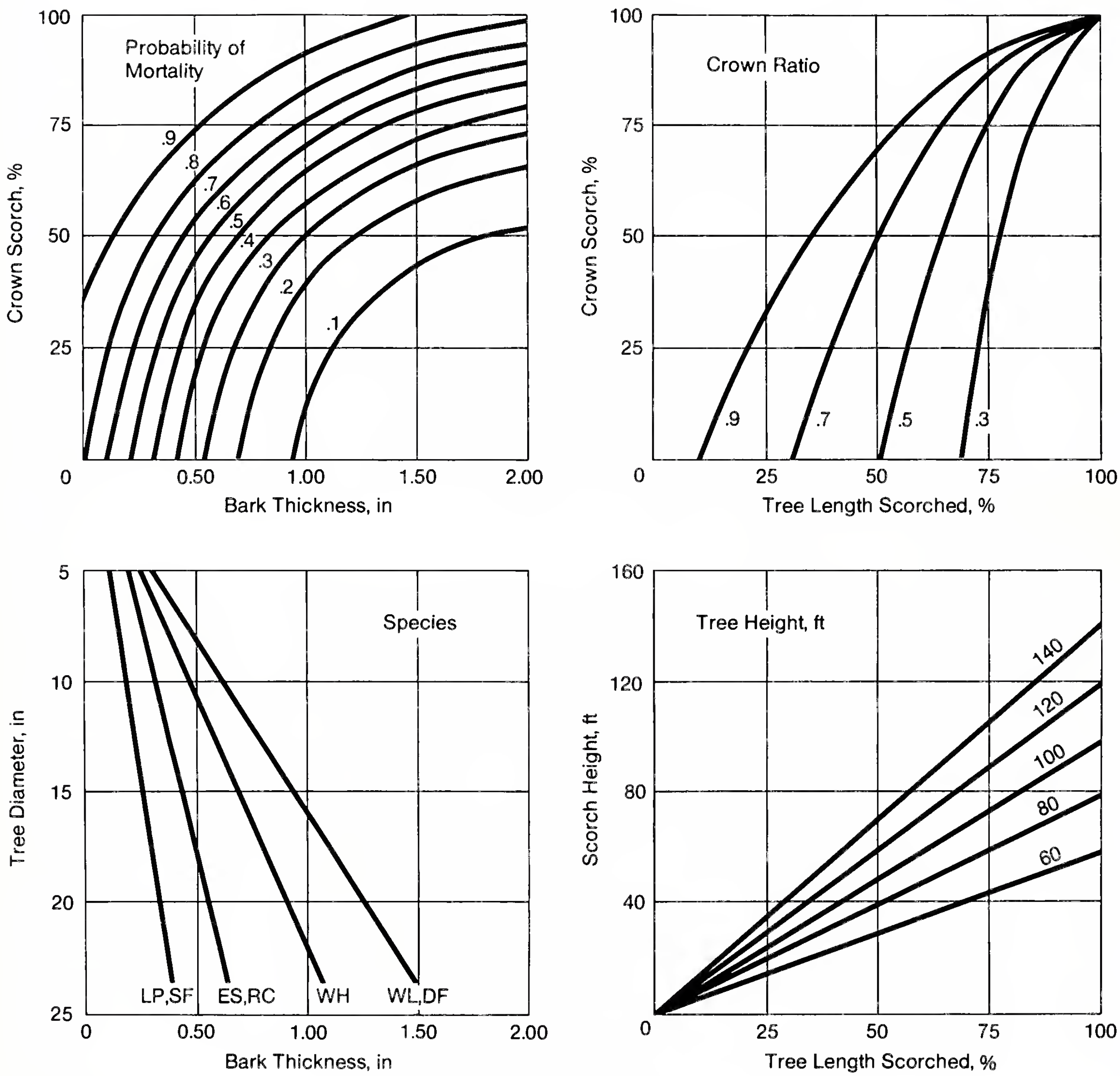

Figure 1—*Tree mortality nomogram for use in prescription development. Key to symbols is as follows: LP identifies lodgepole pine; SF, subalpine fir; ES, Englemann spruce; RC, western red cedar; WH, western hemlock; WL, western larch; and DF, Douglas fir. Figure can be enlarged on copier for field use.*

height and average scorch height (lower right quadrant). We assumed that tree crowns take the form of symmetric parabolas and that scorch heights are uniform within a tree.

Scorch Height Nomogram

Figure 2 is a nomogram for predicting scorch height. The nomogram is based on Van Wagner's (1973) equation for predicting crown scorch height from air temperature, windspeed, and Byram's (1959) fireline intensity. The relationship is shown in terms of both fireline intensity and flame length, based on Byram's (1959) relationship between the two. The figure was developed for midflame windspeeds of 5 miles per hour (8 km/h), an average value for prescribed underburns. Higher windspeeds result in lower levels of crown scorch height for a given flame length or fireline intensity. The differences are small for windspeeds between 0 and 10 miles per hour (0 and 16 km/h). Managers who are interested in solutions for other windspeeds should refer to Van Wagner's equation or graphical representations by Albini (1976).

How To Use the Nomograms

To use the mortality nomogram (fig. 3), choose an acceptable level of mortality (e.g. 20 percent or a 0.2 probability of mortality). Acceptable mortality will depend on the value of the trees and the objectives of the fire. Successful underburning involves choosing and staying within a reasonable level of mortality. Data from these fires indicate that it is unreasonable to expect to underburn without some mortality, so it is not possible to select zero mortality.

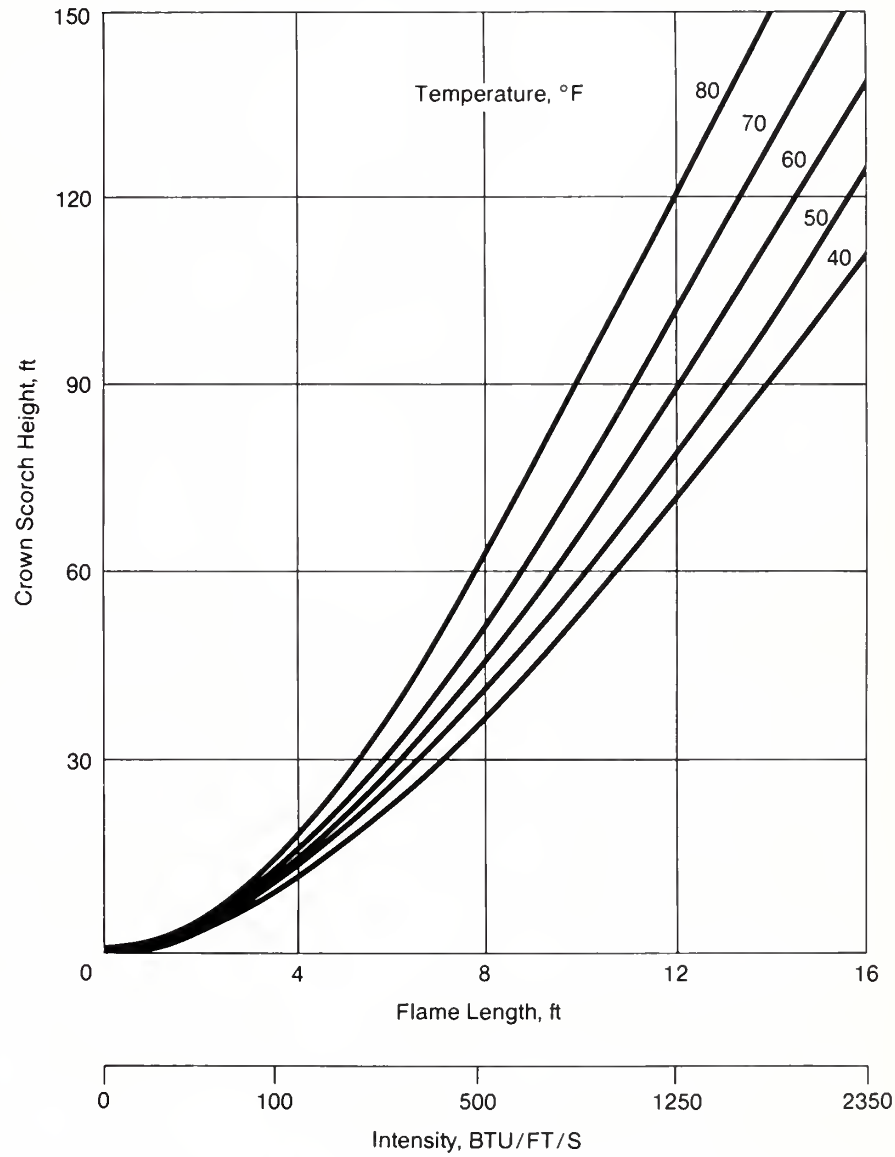

Figure 2—*Van Wagner's crown scorch height model, shown for a midflame windspeed of 5 miles per hour (8 km/h) and a range of ambient temperatures. Figure can be enlarged on copier for field use.*

Once an acceptable level of mortality has been chosen for a particular species, the nomogram can be used

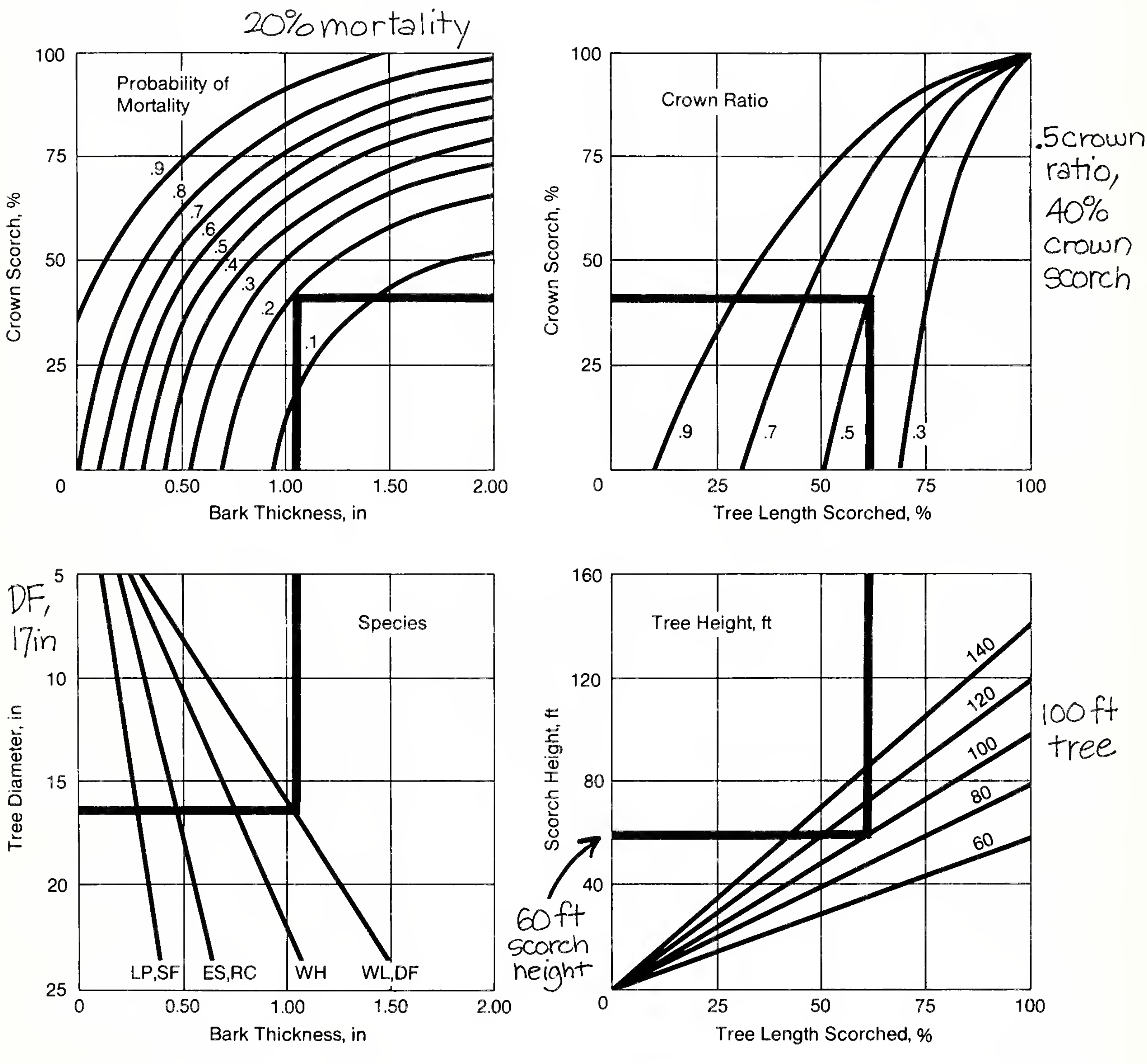

Figure 3—*This figure illustrates the use of the mortality nomogram to set scorch height limits for a prescribed underburn in which the target leave trees are Douglas fir, 17 inches (43.2 cm) in diameter at breast height, 100 feet (131 m) tall with a crown ratio of 0.5, and an acceptable mortality of 20 percent.*

to develop a burning prescription. For example, consider a shelterwood harvest with Douglas-fir leave trees averaging 17 inches (43.2 cm) in diameter, 100 feet (13.1 m) tall, with a crown ratio of 0.5. Entering the nomogram at the lower left at observed tree diameter, draw a horizontal line until you intersect the correct species line. Then turn a right angle and draw a line straight up. Where the line crosses the top edge of the lower left box, bark thickness can be read, if desired, but it is not necessary to do so. In this example, bark thickness of a 17-inch (43.2 cm) Douglas-fir is seen to be about 1.1 inches (2.8 cm). Continue the line straight up until it intersects the target mortality rate curve (0.2). At this point, turn a right angle again, to the right. This time, when passing from the upper left to the upper right quadrant, it is possible to read off crown volume scorched (percent). This example shows that a little more than 40 percent of the crown volume of these trees may be scorched without exceeding the target mortality of 20 percent. If that is all you want to know, stop there.

To convert percentage crown volume scorched to scorch height, continue working clockwise through the nomogram. Make a right angle turn down intersecting the curve representing the appropriate crown ratio, and then continue down to the appropriate tree height curve. Make another right angle turn to the left. Read allowable scorch height (in this example 60 ft or 18.2 m) off the vertical axis of the lower right quadrant. This is the maximum scorch height that can be had and still limit the mortality to the desired level.

If desired, continue on to figure 4, and determine the maximum allowable flame length. To keep scorch heights to 60 feet (18.2 m) on a 60 °F day, flame lengths should be kept between 9 and 10 feet (2.7 and 3 m). This value can be used in conjunction with fuel models and fire behavior predictions to develop a prescription for burning (Puckett

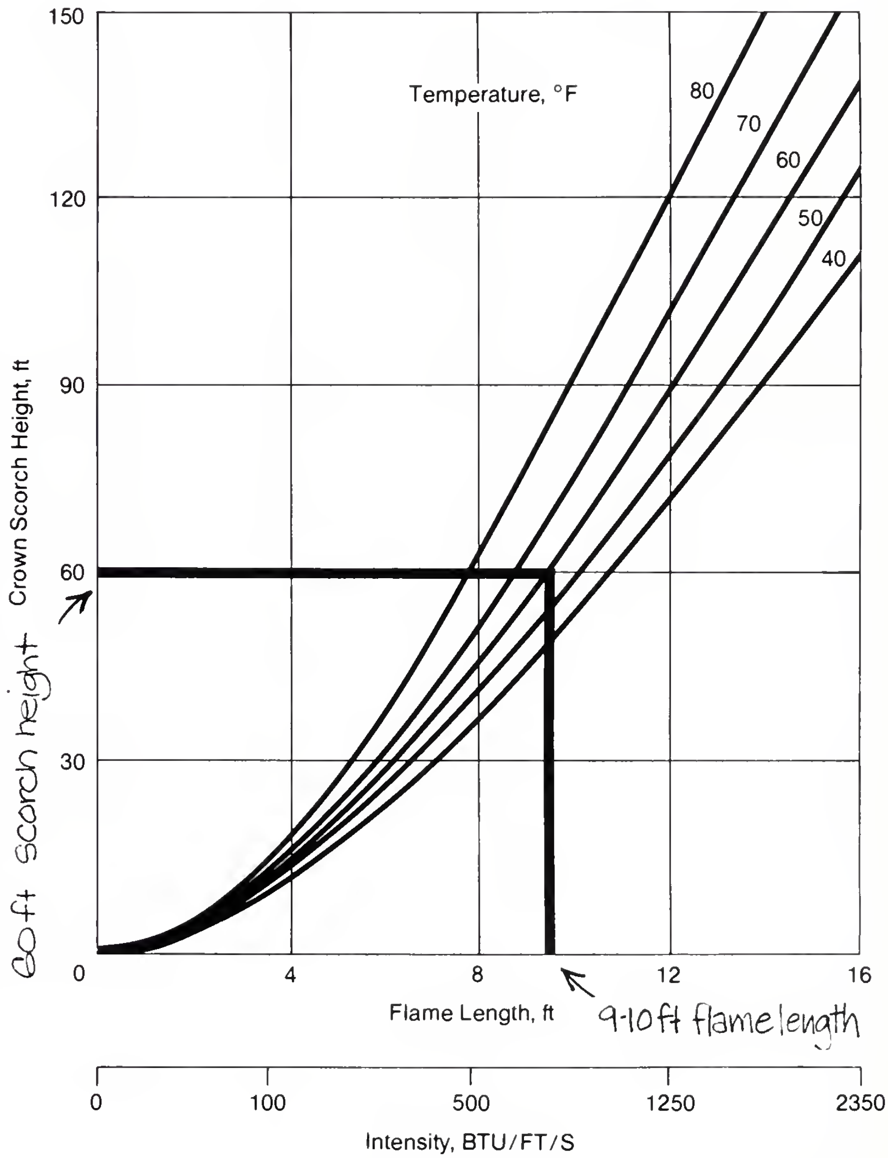

Figure 4—*This figure illustrates the use of the scorch height nomogram to set flame length limits for a prescribed underburn on a 60 °F day, in order to limit scorch height to 60 feet (18.2 m).*

et al. 1979; Rothermel 1983; Andrews 1986). Field crews can attempt to limit the flame length to this level through ignition pattern modifications.

Additional Applications

In some applications of prescribed fire, tree mortality is desired. For example, a manager may wish to eliminate encroaching Douglas fir from a grassland. In these situations, a nomogram can be used to determine the minimum flamelengths necessary to achieve the fire objectives.

A nomogram can also be used earlier in the planning process, at the time of developing the silvicultural prescription. One can determine how many trees of each species to leave in order to achieve the desired number and species proportions after fire treatment. To do this, select a reasonable expected crown scorch height, and for each component of the stand work in from both sides to find the expected mortality level in the upper left quadrant of the nomogram (fig. 1).

The nomogram can be used to develop a marking guide for a salvage sale after fire injury has occurred. In this case, crown volume scorched can be observed; therefore, the right side of the nomogram is not needed. Work backward through the left half of the nomogram to find the minimum diameter for leave trees. ■

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Seven C–130A Aircraft To Be Used as Airtankers

On June 10, 1988, USDA Forest Service Chief F. Dale Robertson, along with General Jack Sheppard of the U.S. Air Force and Administrator John Alderson of the General Services Administration, signed a property transfer for seven Lockheed C–130A aircraft. This agreement authorized the transfer of these aircraft from the U.S. Air Force to the Forest Service through the General Services Administration. The C–130A aircraft will be converted to airtankers by Hemet Valley Flying Service for use in firefighting operations.

These aircraft will replace Fairchild C–119 aircraft. There have been four inflight structural failures of C–119's on retardant missions in recent years, with seven fatalities in three of those accidents. As a followup of the last accident that occurred in 1987, the C–119 has been permanently grounded as an airtanker.

(Left to right) General Jack Sheppard, U.S. Air Force; John Alderson, Administrator, General Services Administration; and F. Dale Robertson, Chief, USDA Forest Service; sign agreement transferring C–130 aircraft to Forest Service.

The Forest Service started using surplus World War II aircraft converted to airtankers in the 1950's. As parts became hard to find and aircraft and components wore out, these aircraft were replaced, mostly with military surplus C–119's, P2V's, and the DC series of 4, 6, and 7. These aircraft are starting to experience the same problems now that the World War II aircraft had experienced.

In January 1985, the Forest Service identified the need to advance into the next generation of aircraft for airtankers. Preferably, they would be turbine powered due to the lack of 130/145 fuel and have cruise speeds in the 300- to 400-knot range.

The C–130A is the first aircraft available through military excess that could meet the Forest Service's requirements for its airtankers. Through an exchange agreement, Hemet Valley Flying Service will operate the airtankers. Through contracts with many wildland firefighting agencies, Hemet Valley has been providing airtankers for over 20 years and currently has contracts with the California Department of Forestry and Fire Protection.

If the C–130's are operated in the same manner as most of the previous airtankers, the cost per gallon of retardant delivered to a fire will be reduced. ■

Fred A. Fuchs, *assistant director, USDA Forest Service, Fire and Aviation Management, Washington, DC*

Texas Big Country Fire Puts ICS to the Test

Bill Terry

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It was late Thursday night on March 10, when the call finally came from the courthouse in Albany, TX, a small central Texas ranching community. Since about 2 p.m., a fire had been raging out of control. Dry southerly winds fanned the flames with gusts near 40 miles (65 km) per hour. Relative humidity hung in the low teens or below.

Every piece of equipment in the area was in use. The local counties only had a handful of brush trucks, and they were in need of repair. Ranchers used cattle sprayers to try to control the flames, but the 30-foot (9-m) high flames proved too much for the minuscule water supplies.

After a lengthy conversation with the county judge, the Texas Forest Service Fire Control Department head, Pat Ebarb, realized that this was a fire to be dealt with. Within the hour, the Fire Control Overhead Team was on its way to the besieged west Texas community.

By morning, the fire would have a 50-mile-wide (81-km) front. Cattle, rangeland, homes and other structures were threatened. Nothing in its path was sacred.

Just after sunrise, the 12-member Texas Forest Service overhead team, Mobile Command Post, as well as firefighting equipment, rolled into Albany. As with any disaster, things were in a state of chaos. How big is the fire, where is it located, what is in its path? All these questions needed answers before any action could be taken.

Incident Commander Joe Fox immediately held a briefing with his staff and local firefighters. Scouts were assigned to find the location of the fire fronts and to determine if Albany or any other town was in jeopardy. Before the day was out, over 200 firefighters and 70 pieces of equipment would be working on what would eventually be a 300,000-acre (121,457-ha) fire.

This all may sound common to anyone who routinely uses the Incident Command System (ICS). But for the people of Texas and the Texas Forest Service, this was the first time ICS was to be used on a fire of this magnitude. Without doubt, this was a multiple command situation that within 2 days would become two separate complexes.

ICS Training Strategy

It was 1986, when the Texas Forest Service began its switch from the Large Fire Organization (LFO) to the ICS. This required a number of changes—new terminology, definitions, forms, and procedures. Although Texas Forest Service personnel were experienced in LFO and fire tactics, this change required inservice training as well as extensive cooperative training for volunteer fire departments to make the system functional at all levels.

The ICS system is being accepted nationwide. Starting in California, it has been installed by many Federal and State agencies. Through the National Fire Academy and other training institutions, the system has quickly become ingrained in all parts of the fire community.

Making the change in any organization requires both an acceptance and installation period. The psychology of organization dictates that change will come only after those people who would use an item come to accept it. This acceptance must be carefully cultivated and followed with an installation period. Here a nucleus of people learn to use the item sufficiently to replace the old.

The Training

The Texas Forest Service had an established training committee to oversee the training needs within the Service. By discussing the ICS within the committee, it was decided to try the change. Since the Texas Forest Service already had two overhead teams in place, they would receive the first training.

Using the standard ICS training materials from both the Federal courses and International Fire Service Training Center (IFSTA), students were asked to review job descriptions before attending class. Lecture was brief and covered job responsibilities within the system and other procedures such as the use of radios, locating resources, and report writing.

The course placed primary emphasis on realistic role playing. In the scenarios, attention was given to making situations real. No time was spent with paper situations. Rather, a simulator in an isolated room states the problem. Role players, in a separate room, are exhausted and need help already as the students begin to work on the problem. Unable to see the simulator or even talk directly to the crews upon arrival, students need to know where the fire is located, what is in danger, and what actions need to be taken.

To keep the problems as real as possible, the personnel are sent into unfamiliar areas by using maps. They need scouts, aerial surveillance, and additional resources that were not available upon arrival. The object of this training exercise is to make the students "smell the smoke." Only by getting them mentally and emotionally involved in the resolution of a difficult and uncommon situation can they learn to deal with the stress and learn to make decisions quickly.

What happened at Albany in March 1988 was all the right things. The trained people who responded knew what to do because they had already experienced these problems. They knew what questions to ask, where to locate resources, how to set up communications, and how to formulate a plan. What came out of them was training—training that was not theoretical, but practical and meaningful.

Perhaps you have already established ICS in your organization or maybe it is in just the thinking stage. No matter where you are, remember to make the training practical. Adults do not learn for the sake of learning like children; they learn what they can apply. If they are intimidated by a meaningless classroom routine, they may miss the point and the training is ineffective.

Tips for Building a Realistic Program

Here are just a few ideas to bring realism to any ICS training program:

- Use problems that are realistic, but challenging, and big in scale. One student commented that the Albany fire was a duplicate of some of the problems confronting them in simulation.
- Make the overhead team members perform all the functions of their job. For example, if someone is responsible for filling out the resource locator cards, make sure that person does so.
- Have coaches in the simulation to answer questions and keep things from breaking down. It is better to answer a question and take care of a problem in the simulation than to frustrate the students by letting the entire problem deteriorate because some do not understand their jobs.
- Throw all the problems of media, calls from the Governor, breakdowns, lack of resources, injuries, and constant interruptions at them. It is better to deal with those problems in practice than to be overwhelmed during a fire.
- Demand that they develop a written plan. Even go so far as to make them copy it for distribution. This will be a real problem out on the fireline.
- Use real radios and real communications. We have communications trailers we call "Mobile Command Posts." They are used on incidents, and we use them for training to make sure trainees are familiar with them.
- Follow every simulation with a critique. Give the trainees a chance to talk about their problems. Have the coaches or an umpire offer constructive suggestions, but do not let it degenerate into a "rag chewing session." If improvements are needed, point them out.
- Give trainees a chance to learn by giving them two or three simulations of 3 hours each. This allows time for planning, organization, and problem solving.
- Schedule trainees to retrain with 1-day simulations annually. This keeps everyone fresh concerning how the system works.

By now, you probably think the Texas Forest Service has the world's largest training budget. The truth is we have a very small training budget. For ICS training, imagination, the use of the actual forms and tools, and a realistic situation is what is required.

Through the Rural Community Fire Protection Program, the Texas Forest Service has conducted training programs in ground cover for over 1,500 volunteer fire departments. Our advanced ground cover training is ICS training. By using a six-person training team composed of Texas Forest Service overhead team members, we bring the same type of training to the volunteers.

During the Albany incident, we found that those departments trained in ICS by the Texas Forest Service were able to assist us effectively. Several of their personnel assisted with overhead positions. Others worked on divisions. Our objective, although ambitious, is to have every department in Texas well indoctrinated in ICS.

More and more people are building homes where wildlands and urban areas interface, and the rural population is expanding. More local people are involved in fire suppression. This means that when an incident strikes, everyone must be ready to act. Only a universal system like ICS can overcome the problems and lead to organization and ultimate control. Installing or reinforcing ICS training in your organization may only be a matter of making it more real. ■

Light Aerial Delivery System

The USDI Bureau of Indian Affairs (BIA) with logistical support from the USDI Bureau of Land Management (BLM) will conduct a proof of concept project using a Conair fixed-water/retardant tank fitted to the Aerospatial AS–355F helicopter supplied through a call-when-needed USDI Office of Aircraft Services contract with ERA Helicopters, for the 1988 fire season. The project is a joint interagency effort with BIA, BLM, and the USDA Forest Service.

This helicopter equipped with the light aerial delivery system (LADS) brings a multimission capability to the fire team in the field. The helicopter equipped with the LADS can quickly respond with helitack rappellers and then back them up with water or foam retardant in a matter of minutes using a self-loading drafting system that will fill the 200-gallon tank in approximately 30 seconds. The tank has a segregated reservoir that holds up to 1 hour of foam concentrate and hardware to allow onboard mixing after tank fill.

The cycle time from refill to drop and subsequent refill is minutes. Water comes from a variety of sources such as collapsible water tanks, shallow slow-running streams, rivers, lakes, and, if in the urban interface, swimming pools. In a very short time, the helicopter can be reconfigured from the LADS mode to transport passengers and cargo. The tank is easily removed; however, passengers and cargo can be transported with the tank installed. The LADS was to be installed on the AS–350B–1, but when it was unavailable the AS–355 was substituted. ■

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The Virginia Department of Forestry's Tracking Dog Program

Virginia experienced an unusually heavy incendiary fire problem in the spring of 1985 and again in 1986. From a regionwide discussion of the problem, the use of a tracking dog was identified as the most important way to attack this problem. Many local governments own tracking dogs, but they are usually unavailable to the Department of Forestry due to heavy local demand. The State Forester fully supported the Tracking Dog Program, and Arthur Cox, a technician, was selected to manage the program.

Initially, the Department of Corrections, which raises bloodhounds, was to transfer a puppy to the Department of Forestry. Unfortunately, the litter was so small, a puppy was unavailable for the Department of Forestry. However, Cox was able to obtain a 6-year-old, trained female named "Dutchess" without cost, so the Department of Forestry began the tracking dog operation in the spring of 1987.

The handler needs as much training as the dog. The handler must be committed and dedicated to the program and must be in good physical condition. Certification may be obtained eventually from the National Police Bloodhound Association.

Although a tracking dog is valuable in tracking a person or persons on foot away from a fire scene, it is most valuable as a fire prevention resource. For example, in November 1987, a 16-year-old juvenile confessed to setting a fire when he learned that Dutchess had been dispatched and saw the pickup truck arrive with the dog in full view.

Dutchess with tracking dog trainer and program manager, Arthur Cox.

On April 9, 1988, Dutchess followed a 6-hour-old trail from a fire scene a distance of 3 miles through the woods into a town, ending at a door in an apartment complex. Two juveniles there admitted leaving the fire burning. They further confessed to setting another fire 2 weeks earlier.

Cox was able to secure a 6-month-old puppy in late 1987. He is intensively training her for the time when Dutchess will no longer be able to work. The Department reimburses Cox for room and board for the dog.

The Department never misses an opportunity to display Dutchess and with media exposure is letting people know that she and Cox are available and ready for dispatch on short notice to a wildfire of suspicious origin. Early results are encouraging. ■

Is the Water Safe? Think Before You Drink

A Hidden Hazard. There is nothing like a cool drink from a clear mountain stream. But is it as good as you think it is? A hidden hazard you should know about is a disease that may be contracted from drinking untreated "natural" water. The disease is an intestinal disorder called giardiasis (gee-ar-dye-a-sis). It can cause you severe discomfort.

The disease is caused by a microscopic organism, *Giardia lamblia.* The eystic form of *Giardia* may be found in mountain streams and lakes. These natural waters may be clear, cold, and free-running; they may look, smell, and taste good. You may also see wildlife drinking without hesitation from these sources. All of these indicators sometimes lead people to mistakenly assume that natural waters are always safe to drink. Unfortunately, that may not be true.

The Disease Symptoms and Treatment. After ingestion, *Giardia* normally attach themselves to the small intestine. Disease symptoms usually include diarrhea, increased gas, loss of appetite, abdominal cramps, and bloating. Weight loss may occur from nausea and loss of appetite. These discomforts may first appear a few days to a few weeks after ingestion of *Giardia* and may last up to 6 weeks. Most people are unaware that they have been infected and often have returned home before the onset of symptoms. If not treated, the symptoms may disappear on their own, only to recur intermittently over a period of many months. Other diseases can have similar symptoms, but if you have drunk untreated water you should suspect giardiasis and so inform your doctor. Although giardiasis can be incapacitating, with proper diagnosis, the disease is curable with medication prescribed by a physician.

Protect Yourself. You can take steps to avoid the problem so a visit to a doctor will not be needed.

There are several ways for you to treat raw water to make it safe to drink. The most certain treatment to destroy *Giardia* is to boil water for at least 1 minute. Boiling also will destroy other organisms causing waterborne disease. At high altitudes, you should maintain the boil for 3 to 5 minutes for an added margin of safety.

Chemical disinfectants such as iodine or chlorine tablets or drops are not yet considered as reliable as heat in killing *Giardia,* although these products work well against most waterborne bacteria and viruses that cause disease. The amount of iodine or chlorine necessary to kill *Giardia* depends on water temperature, pH, turbidity, and contact time between the chemical and the parasite. Until current research determines the right amount of chemical and duration of contact time that will work against *Giardia* under a variety of water conditions, chemicals cannot be recommended for routine disinfection of water for this organism. ■

Excerpts from U.S. Department of Agriculture Forest Service FS-359, 1981.

The one that got away.

Structure Fire Demonstration

The Chemeketa Community College Fire Protection School, in cooperation with the St. Paul Rural Fire Protection District, held a fire attack training session on a farm outside St. Paul, OR. The purpose was to demonstrate firefighting procedure, training firemen for attacks on large structures, specifically a house and a 144,000-cubic-foot barn. The procedure was to make the initial attack with wildland compressed air foam. The second attack or back-up would be made with straight water.

Compressed air foam was applied to the barn fire after the barn became completely engulfed in flame. The barn dimensions were 60 by 80 by 30 feet. According to the Iowa formula for water attack requirements, 1,440 gallons per minute (144,000 ÷ 100) would be required to extinguish this fire with conventional water methods.

Figure 2—*Intensified fire before control.*

The compressed air foam was made with a 40-cubic-foot-per-minute air compressor mixing air with 0.5 percent Silv-ex foam solution. The concentrate was injected into the water line. Water flow as foam was 70 to 100 gallons per minute through one 1.5-inch woven rubber hose. The nozzle had a 1.25-inch bore.

The attack began on the ground level, with applications to the upper air space, the ceiling, and the walls. Application continued to the upper loft. Exactly what processes were occurring is not clear. However, blackout was achieved in 50 seconds. Thus, less than 100 gallons of water from one 1.5-inch line was necessary to extinguish this fire. ■

Figure 1—*Initial attack on barn engulfed with fire.*

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